RICHMOND NATIONAL BATTLEFIELD PARK

GEOLOGIC RESOURCE MANAGEMENT ISSUES

SCOPING SUMMARY

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View of the James River from Drewrys Bluff at Richmond National Battlefield Park. Photograph by Robert Koch, 1998, http://usa- civil- war.com

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Executive Summary

A Geologic Resources Evaluation scoping meeting for Richmond National Battlefield Park took place at Petersburg National Battlefield in Petersburg, VA on April 13, 2005. The scoping meeting participants identified the following list of geologic resource management issues. These topics are discussed in detail on pages 13- 19.

1. Erosion of bluffs along the James River the rate of which is unknown and should be quantified to understand how to protect the culutral resources near the shoreline

2. Surface water quality and sediment loading

3. Stream channel morphology and connections with the historic landscape

4. Hydrogeologic characterization and groundwater quality to protect drinking supplies and understand how contaminants are moved through the system

5. Geologic hazards including effects of seismcity and storm events

6. Connections between geology and the Civil War history to appeal to visitors interested in a deeper connection to the landscape

7. Human Impacts including an old county landfill on park property, agricultural drainage ditches, and farm roads, nearby urban development

8. Mine- related features such as sand and gravel borrow pits

Introduction

The National Park Service held a Geologic Resource Evaluation scoping meeting for Richmond National Battlefield Park in Petersburg National Battlefield in Petersburg, Virginia on Wednesday, April 13, 2005. The purpose of the meeting was to discuss the status of geologic mapping in the park, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: (1) Digitized geologic maps covering the park; (2) An updated and verified bibliography; (3) Scoping summary (this report); and (4) A Geologic Resource Evaluation Report which brings together all of these products.

Richmond National Battlefield Park was established during Franklin D. Roosevelt's administration on March 2, 1936. The park's many units protects Civil War battlefield sites around Richmond, Virginia, the Confederate capital city only 177 km (110 miles) from Washington, DC. During the Civil War, this city was in almost constant threat of attack. Richmond National Battlefield Park covers 2,517 acres of eastern piedmont near Richmond, VA. It is one of the larger military parks in the eastern United States. It protects some of the intriguing rocks in the Piedmont physiographic province, a variety of threatened habitats, ancient Native American traces, not to mention the historical battlefields.

Richmond National Battlefield Park identified 6 quadrangles of interest. Two of these quadrangles are contained within the 30'x60' 1:100,000 Richmond sheet, and the other 4 are located on the Petersburg sheet. The Virginia Department of Mineral Resources(VDMR) (publication 165, 2002) has mapped the western portion of the Richmond sheet. Mapping in the area continues with the Richmond and Seven Pines 7.5'x7.5 quadrangles nearing completion. VDMR Report of Investigations 38, plate 3 of 13 covers the Richmond quadrangle and plate 4 of 13 covers the Seven Pines quadrangle (1:24,000, 1974). The park recognized Dutch Gap, Roxbury, and Drewrys Bluff as the most important quadrangle mapping targets.

Many other maps exist for the region that include coverage of the geology, oil and gas features, surficial geology, topography, groundwater features, land use, Landsat imagery, geochemical features, aeromagnetic- gravity, mineral and mineral potential, hazard features, stratigraphy, hydrogeology, structures, glacial features, karst features, etc. The maps are available from agencies such as the U.S. Geological Survey, the Virginia Division of Mineral Resources, the Geological Society of America, the American Geological Institute, the Maryland Geological Survey, the West Virginia Geological and Economic Survey, and the West Virginia Geological Survey. Additional mapping at a smaller scale within park boundaries will be more helpful for park resource management and interpretation.

Physiography

Richmond National Battlefield Park lies within the Piedmont Plateau and Atlantic Coastal Plain physiographic provinces along the Fall Line. In the area of Richmond, Virginia, the eastern United States is divided into 5 physiographic provinces with associated local subprovinces. These are, from east to west, the Atlantic Coastal Plain, the Piedmont Plateau, the Blue Ridge, the Valley and Ridge, and the Appalachian Plateaus provinces.

The eastward- sloping Piedmont Plateau is located between the Blue Ridge province along the eastern edge of the Appalachian Mountains and the Atlantic Coastal Plain province to the east. It formed through a combination of folds, faults, uplifts, and erosion. The resulting landscape of eastern gently rolling hills starting at 60 m (197 ft) in elevation becomes gradually steeper westward toward the western edge of the province and reaches 300 m (984 ft) above sea level. The Piedmont Plateau is composed of hard crystalline, igneous, and metamorphic rocks such as schists, phyllites, slates, gneisses, and gabbros. Soils in the Piedmont Plateau are highly weathered and generally well drained. The “Fall Line” or “Fall Zone” marks a transitional zone where the softer, less consolidated sedimentary rock of the Coastal Plain to the east intersects the harder, more resilient metamorphic rock to the west to form an area of ridges, waterfalls, and rapids.

The Atlantic Coastal Plain province is primarily flat terrain with elevations ranging from sea level to about 100 m (300 ft) in Maryland. Sediments eroding from the Appalachian Highland areas to the west formed the wedge- shaped sequence of soft sediments that were deposited intermittently during periods of higher sea level over the past 100 million years. These sediments are now more than 2,438 m (8,000 ft) thick at the Atlantic coast and are reworked by fluctuating sea levels and the continual erosive action of waves along the coastline. Large streams and rivers in the Coastal Plain province, including the James, York, Rappahannock, and Potomac, continue to transport sediment and to extend the coastal plain eastward. Beyond the province to the east is the submerged Continental Shelf province for another 121 km (75 miles).

The Blue Ridge contains the highest elevations in the Appalachian Mountain system. These are in Great Smoky Mountains National Park in North Carolina and Tennessee. Precambrian and Paleozoic igneous, sedimentary, and metamorphic rocks were uplifted during several orogenic events to form the core of the mountain range. Today this comprises the steep, rugged terrain now exposed after millions of years of erosion. Characteristics of the Blue Ridge province include steep terrain covered by thin, shallow soils, resulting in rapid runoff and low ground water recharge rates.

Geologic History of Central Virginia

Proterozoic Era – In the mid Proterozoic, during the Grenville orogeny, a supercontinent formed which included most of the continental crust in existence at that time. This included the crust of North America and Africa. The sedimentation, deformation, plutonism (the intrusion of igneous rocks), and volcanism associated with this event are manifested in the metamorphic gneisses in the core of the modern Blue Ridge Mountains (Harris et al., 1997). These rocks were deposited over a period of a 100 million years and are more than a billion years old, making them among the oldest rocks known from this region. They form a basement upon which all other rocks of the Appalachians were deposited (Southworth et al., 2001).

The late Proterozoic, roughly 600 million years ago, brought a tensional, rifting tectonic setting to the area. The supercontinent broke up and a sea basin formed that eventually became the Iapetus Ocean. In this tensional environment, flood basalts and other igneous rocks such as diabase and rhyolite added to the North American continent. These igneous rocks were intruded through cracks in the granitic gneisses of the Blue Ridge core and extruded onto the land surface during the break- up of the continental land mass (Southworth et al., 2001). Today these flood basalts comprise the Catoctin Greenstone. The Iapetus basin collected many of the sediments that would eventually form the Appalachian Mountains and Piedmont Plateau.

Early Paleozoic Era –

From Early Cambrian through Early Ordovician time orogenic activity along the eastern margin of the continent began again. The Taconic orogeny (~440- 420 Ma in the central Appalachians) was a volcanic arc – continent convergence. Oceanic crust, basin sediments, and the volcanic arc from the Iapetus basin were thrust onto the eastern edge of the North American continent. The Taconic orogeny involved the closing of the ocean, subduction of oceanic crust, the creation of volcanic arcs and the uplift of continental crust (Means, 1995). Initial metamorphism of the Catoctin Formation into metabasalts and metarhyolites, as well as the basin sediments (graywackes) into quartzites and phyllites occurred during this orogenic event.

In response to the overriding plate thrusting westward onto the continental margin of North America, the crust bowed downwards to the west creating a deep basin that filled with mud and sand eroded from the highlands to the east (Harris et al., 1997). This so- called Appalachian basin was centered on what is now West Virginia. These infilling sediments are today represented by the shale of the Ordovician (450 Ma) Martinsburg Formation (Southworth et al., 2001).

During the Late Ordovician, the oceanic sediments of the shrinking Iapetus Ocean were thrust westward onto other deepwater sediments of the western Piedmont. Sandstones, shales, siltstones, quartzites, and limestones were continuously deposited in the shallow marine to deltaic environment of the Appalachian basin. These rocks, now metamorphosed, currently underlie the Valley and Ridge province (Fisher, 1976).

This shallow marine to fluvial sedimentation continued for a period of about 200 My during the Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian Periods. This resulted in thick piles of sediments. The source of these sediments was from the highlands that were rising to the east during the Taconian orogeny (Ordovician), and the Acadian orogeny (Devonian).

The Acadian orogeny (~360 Ma) continued the mountain building of the Taconic orogeny as the African continent approached North America (Harris et al., 1997). Similar to the preceding Taconic orogeny, the Acadian event involved land mass collision, mountain building, and regional metamorphism (Means 1995). This event was focused further north than central Virginia.

<u>Late Paleozoic Era</u> – Following the Acadian orogenic event, the proto- Atlantic Iapetus Ocean was completely destroyed during the Late Paleozoic as the North American continent collided with the African continent. This formed the Appalachian mountain belt we see today and a supercontinent named Pangaea. This mountain building episode is called the Alleghanian orogeny (~325 – 265 Ma), the last major orogeny of the Appalachian evolution (Means, 1995). The deformation by folding and faulting produced the Sugarloaf Mountain anticlinorium and the Frederick Valley synclinorium in the western Piedmont, the Blue Ridge- South Mountain anticlinorium, and the numerous folds of the Valley and Ridge province (Southworth et al., 2001).

During this orogeny, rocks of the Great Valley, Blue Ridge, and Piedmont provinces were transported as a massive block (Blue Ridge – Piedmont thrust sheet) westward onto younger rocks of the Valley and Ridge along the North Mountain fault. The amount of compression was extreme. Estimates are of 20-50 percent shortening which translates into 125–350 km (75- 125 miles) of lateral translation (Harris et al., 1997).

Deformed rocks in the eastern Piedmont were also folded and faulted and existing thrust faults were reactivated as both strike slip and thrust faults during the Alleghanian orogenic events (Southworth et al., 2001). Paleoelevations of the Alleghenian Mountains are estimated at approximately 6,096 m (20,000 ft), analogous to the modern day Himalaya Range in Asia.

Mesozoic Era – Following the Alleghenian orogeny, during the late Triassic, a period of rifting began as the deformed rocks of the joined continents began to break apart from about 230- 200 Ma. The supercontinent Pangaea was segmented into roughly the continents that persist today. This episode of rifting or crustal fracturing initiated the formation of the current Atlantic Ocean and caused many block- fault basins to develop with accompanying volcanism (Harris et al., 1997; Southworth et al., 2001). These Mesozoic basins are scattered around the park area.

Thick deposits of unconsolidated gravel, sand, and silt were shed from the eroded mountains. These were deposited at the base of the mountains as alluvial fans and spread eastward to be part of the Atlantic Coastal Plain (Duffy and Whittecar 1991; Whittecar and Duffy, 2000; Southworth et al., 2001). The amount of material inferred from the now- exposed metamorphic rocks is immense. Many of the rocks exposed at the surface must have been at least 20 km (~10 miles) below the surface prior to regional uplift and erosion. The erosion continues today with the Potomac, Rappahannock, Rapidan, James, and Shenandoah Rivers, stripping the Coastal Plain sediments, lowering the mountains, and depositing alluvial terraces of the rivers, creating the present landscape.

Cenozoic Era – Since the breakup of Pangaea and the uplift of the Appalachian Mountains, the North American plate has continued to drift toward the west. The isostatic adjustments that uplifted the continent after the Alleghenian orogeny continued at a subdued rate throughout the Cenozoic Period (Harris et al., 1997). These adjustments may be responsible for occasional seismic events felt throughout the region.

Though glaciers from the Pleistocene Ice Ages never reached the central Virginia area (the southern terminus was in northeastern Pennsylvania), the intermittent colder climates of the ice ages played a role in the formation of the landscape at Richmond National Battlefield Park. Freeze and thaw cycles at higher elevations led to increased erosion of large boulders and rocks by ice wedging. Sea level fluctuations during ice ages throughout the Pleistocene caused the baselevel of many of the area's rivers to change. During lowstands (sea level drops), the rivers would erode their channels exposing the deformed bedrock of the Piedmont Plateau. During oceanic highstands, the river basins flooded and deposition resulted in deposits of beach sediments just east of the park.

Stratigraphy

Richmond National Battlefield Park sits on the Fall Line, the boundary between the Atlantic Coastal Plain and Piedmont Plateau physiographic provinces. The term Fall Line, is a bit of a misnomer since the boundary is actually a zone of fluctuating width along the eastern edge of the Piedmont. The Fall Zone is the term used herein to describe the transition from unconsolidated Coastal Plain deposits to hard, metamorphosed rocks of the Piedmont. Piedmont rocks are present at great depths below the thick, wedge- shaped deposits. In the Richmond area, the Fall Zone is where rivers such as the James that rise and fall with tides hit zones of rapids and waterfalls.

Bedrock exposures within the park are rare. The oldest rocks in the Richmond National Battlefield Park are exposed along the deepest eroded reaches of the area's rivers. The ~300 Ma Petersburg Granite is probably the oldest unit within the park (Clark, meeting communication, 2005). This rock is comprised of foliated to non- foliated, granite to granodiorite containing lenses of biotite gneiss and amphibolite (Berquist, 2003). To the west of the park and beneath the coastal plain sediments are granitic gneisses and diorite gneiss as well as several intrusive rocks including granite, quartz monzonite, and granodiorite. These gneissic rocks are Late Proterozoic to Early Paleozoic in age (Mixon et al., 2000).

Several Mesozoic age extension basins including the Richmond Mesozoic Basin exist around the park area. These basins formed during crustal extension accompanying the formation of the Atlantic Ocean. These basins were usually bounded by linear normal faults. These basins flooded and filled with sediments and were occasionally intruded by diabase dikes. The Richmond Mesozoic Basin contains dinosaur footprints in sediments more than 762 m (2,500 ft) thick on the western side. These sediments include sands, gravels, silts, and muds eroded from the Appalachian highlands.

Surrounding the battlefield units of the park are younger deposits of Atlantic Coastal Plain rocks. The Lower Cretaceous Potomac Formation is exposed by erosion along many of the rivers and streams in the area. This formation is comprised of feldspathic quartz sand and sandstone, silty channel- bar deposits, and lignitic sandy silt and clay layers. Atop the Potomac Formation is the upper Paleocene Aquia Formation of glauconitic sands, silts, clays, and containing some scant fossil layers. Nanjemoy Formation deposits from the lower Eocene overlie the Aquia Formation. These are glauconitic sands, clays, silts, and mixed layers. This unit is as much as 64 m (210 ft) thick. Miocene age sands and gravels as much as 10 m (33 ft) thick overlie the Aquia and Nanjemoy Formations in the park area (Dischinger, 1987; Mixon et al., 2000).

The upper Miocene Eastover Formation is exposed by erosion along local rivers. This formation is comprised of fine quartzose sand layers interbedded with clayey silts. Younger deposits include the Yorktown Formation and Pliocene sands and gravels. The Yorktown Formation is a maximum of 25 m (82 ft) thick and contains quartz and feldspar sands mixed with lesser clays and silts. Beach sediments within these two units attest to glacially induced marine highstands where the shoreline was near present day Richmond 4 Ma (Berquist, meeting communication, 2005). These beach sediments contain heavy minerals sparking mining interest to the southeast.

The upper Pliocene Bacons Castle Formation includes gravelly sand and sandy-silty- clayey upper layers. These are often found in high- level terrace areas. The more recent deposits at the park include various Quaternary age units. The fine to coarse sand, gravel, silt and clay of the Windsor Formation is of lower Pleistocene to upper Pliocene age. The gravelly Charles City Formation, the sands and silts of the Chuckatuck Formation as well as the Shirley Formation of coarse sands, gravels, pebbles and occasional boulders are of the middle Pleistocene (Mixon et al., 2000). The Shirley Formation deposit has basal units of sand and gravel, grading to muds in the upper beds. This 200 Ka unit is also from an interglacial highstand (Berquist, meeting communication, 2005). The upper Pleistocene Tabb Formation contains sands, gravels, silts and clays and has three members: the Poquoson, the Lynnhaven, and the Sedgefield Members (Mixon et al., 2000).

The youngest deposits at Richmond National Battlefield Park include thick alluvium deposits of sand, gravel, silt and clays as much as 15 m (49 ft) thick, marsh and swamp deposits along larger rivers, shelly sands, and artificial fill from construction of roads, dams, bridges, landfills, and highways.

Structure

The Richmond Mesozoic Basin dominates the structural features present west of Richmond National Battlefield Park. This feature is bounded by high angle normal faults. To the west, across a broad zone of sheared mylonite and phyllonite are Middle Proterozoic metamorphic gneisses of the Goochland Terrane. To the east of the basin are intrusive rocks, including granites, quartz monzonite, and granodiorite (VDMR, 1993).

Faults within the park area have had a pronounced influence on landform development. Most of these are not well exposed. Several large, parallel, low- to high- angle thrust faults dipping to the southeast are present to the west trending northeast- southwest. These thrust faults moved large masses of Piedmont rocks and associated plutons atop younger rocks to the west. Many of these older faults were brittlely reactivated during crustal extension accompanying the opening of the Atlantic Ocean. Most of these faults have not been mapped due to lack of exposure, but most rock quarries in the area have one or more large scale faults (Berquist, meeting communication, 2005).

Closer to the park are several smaller scale faults surrounding the Mesozoic basin and further east into the Coastal Plain sediments. High- angle reverse faults are present along the eastern side of the Piedmont. Faulting within the Coastal Plain, though relatively small in scale is significant because it reveals very recent tectonic activity in the area. A north- trending zone of reverse faults was mapped by Dischinger (1987) as the Dutch Gap fault zone. This zone extends at least 13 km from the southeastern corner of the city of Hopewell, VA northward across the James River. In measurements of offset on the contact between the Cretaceous Potomac Formation and the Paleocene Aquia Formation, up to 20 m (* ft) of displacement is observed.

Highpoints near Bailey Creek and the southward reach of the James River from Richmond to Drewrys Bluff indicate the possible presence of other faults, parallel to the Dutch Gap fault zone. An increase in sediment thickness north of the James River may indicate the presence of a fault downdropped block to the north that would be perpendicular to the Dutch Gap system (Dischinger, 1987).

Significant Geologic Resource Management Issues in Richmond National Battlefield Park

1. Erosion and slope processes

One of the major goals of the park is to present the historical context of the area; this includes preserving and restoring any old buildings and the landscape around them. Maintaining this battle landscape often means resisting natural geologic changes, which presents several management challenges. Geologic slope processes such as landsliding, slumping, chemical weathering, and slope creep are constantly changing the landscape at the park. Bluffs along the James River, including one atop which sits Fort Darling are sloughing, threatening to undermine the cultural resources there.

Runoff erodes sediments from any open areas and carries them down streams and gullies. Erosion naturally diminishes higher areas such as ridges and hills, foundations, earthworks, degrades bridge foundations, erodes streams back into restoration areas, and fills in the lower areas such as trenches, railroad cuts and stream ravines distorting the historical context of the landscape. Earthworks at the park are small. These 140- year- old features are eroding away.

Maximum relief for Richmond National Battlefield Park is only about 45 m (150 ft) total, but this relief occurs over a steep slope on the bluffs facing the river. For park resource management, an awareness of the possibility for additional slides and slumps is necessary in protecting visitors and preserving cultural resources. Areas of higher slope should be monitored for continuous slope creep. Areas likely to fail during intense seasonal storms should be identified.

Research and monitoring questions and suggestions include:

- Identify areas prone to slope failure during intense storm events.
- Investigate remedial techniques to reduce sloughing beneath Fort Darling.
- Monitor erosion rates along the James River and compare to previous conditions using aerial photographs where available.
- What are the effects of increased erosion on aquatic ecosystems at the park?
- Is runoff in the park increasing due to surrounding development? If so, are there any remedial efforts the park can undertake to reduce this impact?
- How should earthwork erosion be reversed?

2. Surface water quality and sediment loading

Richmond National Battlefield Park protects reaches of the James and Chickahominy Rivers, White Oak Swamp, Western Run, Boatswain and Powhite

Creeks, as well as other local streams. As such, the quality of the surface water at the park is very important to park management and by extension, the surrounding communities. Flooding and channel erosion are naturally occurring along most of the streams and rivers within the park. This flooding and erosion can threaten wetlands and visitor facilities. Surface water quality at the park is threatened by ground compaction due to increased use as well as impervious surfaces such as parking lots. These features increase the amounts of seasonal runoff as sheet flow.

Alterations to park vegetation along the steep, exposed slopes lead to changes in the hydrologic regime at the park. For example, clearing of trees and their stabilizing roots for historical restoration, can lead to increased sediment load in nearby streams and could potentially contribute to slumps and landslides. Many riparian wetlands exist within the park and are threatened by increased flow and floods, as well as by sediment loading. Though small in scale, wetlands are typically considered indicators of overall ecosystem health and should be researched and monitored periodically.

Sediment loads in the smaller streams and creeks at the park seem unnaturally high. This may be due in part to agricultural clearing and farming practices in nearby areas.

Research and monitoring questions and suggestions include:

- Research stream sediment loads to determine their effects on aquatic and riparian biota. Is sediment loading in the park streams following a seasonal pattern?
- Monitor water and soil quality in wetlands to establish as basis for comparison of future conditions.
- Use aerial photographs to study changes to wetland distribution through time.
- Accurately map park use areas and target streams and areas of erosion for remediation.
- Determine any hotspots for water contamination. Remediate and monitor results.
- Cooperate with local agricultural entities to promote farming methods conducive to reducing sediment lost to erosion and thereby reducing sediment load in park streams and creeks.
- Research planting new vegetation along vulnerable reaches of park streams to prevent excess erosion and sediment loading.

3. Stream channel morphology

The James River is cutting slopes and bluffs near park cultural resources. Fort Darling was built atop Drewrys Bluff as a Confederate stronghold. This historically relevant area (along the James River western shore) is threatened to be washed away by sloughing and flooding of the James River. The river and other local streams are changing position constantly as part of natural meandering river flow. These shoreline changes threaten existing park facilities and the historical context of the landscape.

Many open fields with streams existed during the time of the battles fought around Richmond National Battlefield Park. These areas are now mostly forested or developed and for cultural interpretation needs, plans are being discussed to clear these areas. The resulting increase in soil erosion and subsequent sediment loading into these streams must be taken into account during resource management decision making.

Research and monitoring questions and suggestions include:

- Monitor shoreline change using aerial photographs.
- Research methods to maintain current shoreline positions where the waterway threatens historic features.
- Should the park preserve (recreate) historic landscapes at the expense of natural processes?
- Should the park target certain areas for restoration and leave others to natural processes?
- Develop an interpretive program detailing the balance between cultural context and natural processes at Richmond National Battlefield Park.

4. Hydrogeologic characterization and groundwater quality

The resource management needs to understand how water is moving through the hydrogeologic system into, under, and from the park. This is critical to understanding the impacts of human induced contaminants on the ecosystem. The interaction between groundwater flow and the overall water quality should be quantitatively determined at the park. Little data regarding the nature of the hydrogeologic system at the park exists. Park resource personnel also need to understand how the water table might change over time to manage water resources. Municipal water and a few wells and water tanks are the primary drinking water supply sources for the park. There are several wells throughout the park that could be used for monitoring of ground water quality. It would be useful to perform tracer studies in these wells to see how quickly and in what direction water is moving through the system.

Research and monitoring questions and suggestions include:

- Inventory groundwater levels at all park units.

- Test for and monitor phosphate and volatile hydrocarbon levels in the groundwater at the park, focusing on areas near facilities.
- Are CFC levels elevated in the groundwater at Richmond National Battlefield Park?
- Inventory and map any existing springs in the park, especially with regards to their potential historical importance.
- Test water quality at any existing springs in the park.
- Create hydrogeologic models for the park to better manage the groundwater resource and predict the system's response to contamination.

5. Geologic hazards

Seismic events are not unheard of at Richmond National Battlefield Park. In 2003, a 4- 4.8 magnitude earthquake occurred in the area. Possibly due to crustal relaxation (isostatic adjustment), earthquakes are not uncommon in the eastern United States. In addition to the ground shaking associated with earthquakes are landslides, damage to buildings and other manmade structures, ground and surface water disturbances, etc. Though the probability of a destructive seismic event at the park is low, resource management should be made aware of the potential.

During storm events, such as Hurricane Gaston in 2004, flooding of the James River inundates the city of Richmond with mud and debris. These types of storms also trigger landslides and slumps along cliff faces and bluffs in the area. Knowledge of fracture patterns, for instance those that parallel cliff faces, is important in understanding and predicting which features are more prone to failure following a storm event.

Research and monitoring questions and suggestions include:
- Work with local universities and government agencies to monitor seismic activity in the area.
- Perform stability measurements of local slopes and bluffs to help predict possible responses to seismic events.
- Inventory fracture geometries and determine risk for rockfall using kinematic models that predict which fracture sets are likely to fail in a given outcrop.
- Compare fracture studies with cliff lithologies to pinpoint areas of most vulnerability to failure.

6. Connections between geology and the Civil War history

Interpreters make the landscape come alive for visitors and give the scenery a deeper meaning. Because geology forms the basis of the entire ecosystem and is directly responsible for the unique history at Richmond National Battlefield

Park, geologic features and processes should be emphasized to improve the visitor's experience. The website for the park needs to be updated for geologic content and connections with other scientific and cultural disciplines.

In many Civil War battles, it was the advantage that familiarity with terrain, preparation to utilize of the natural features of the area, and the manipulation of the focal points, the gaps, ravines, cuts, hills, and ridges gave to one side or another that was to decide the outcome. The rolling hills and gentle landscape and topography at Richmond National Battlefield Park are defined by the geology. This setting dictated the placement of the towns, strategy and encampment of troops, and the development of outlying areas including Frayser's Farm, Fort Darling, Savage's Station, Ellerson's Mill, Watt House, Deep Bottom, Graine's Mill, Garthright House, the Mechanicsville Turnpike, various railroads, Fussell's Mill, New Market Heights, Wills Church Road, Fort Harrison, etc. In addition to influencing battles, the landscape and topography also affected how troops and supplies were transported during the Civil War.

Research and monitoring questions and suggestions include:

- Create interpretive programs concerning geologic features and processes and their effects on the battleground history of the park.
- Encourage the interaction between geologists and the interpretive staff to come up with a list of features and programs to execute.
- Create a general interest map with simple explanatory text on geologic battle and settlement influences for visitors to the park.
- Update the park website relating geology with other resources.

7. Human Impacts

The area surrounding Richmond National Battlefield Park is becoming increasingly populated. As development continues, conservation of any existing forest- meadow community types becomes a critical concern. Understanding the geology beneath the biotic communities becomes vital to their management. Park management of the landscape for historic preservation purposes compliments the preservation of these forests.

Humans began settling the Richmond area in the late 1600's to early 1700's, stemming from the earliest settlements along the James River at Jamestown in 1607. Their farming and homestead activities created an unnatural landscape that persists today at Richmond National Battlefield Park. Minor irrigation features, removal of soil and rocks, stone fences, grazed pastures, extensive logging, and other homestead features dot the landscape.

In the more recent past, an old county landfill was given to the park for preservation. This property is adjacent to the Drewrys Bluff unit along the James

River. This landfill was active before regulations (including lining and capping landfills) were put in place to control water contamination by chemicals and other leachate waste. A stream near the landfill has an unnatural reddish color and is not currently being monitored or studied (Allen, meeting communication, 2005).

Human impacts continue today as pipelines, power lines, roads, buildings, trails, visitor use areas, imported (invasive species), acid rain, and air and water pollution take their toll on the landscape. Resource management of these impacts is an ongoing process.

Research and monitoring questions and suggestions include:

- Should old agricultural drainage ditches and farm roads be remediated or restored?
- Perform acid rain measurements and correlate with the underlying bedrock to determine if any buffering effects occur. Relate this information to the water quality for the park.
- Monitor stream near old landfill and install monitoring wells around the site to measure the amount of waste contamination being introduced into the groundwater.
- Research remediation methods applicable to the old landfill site?
- Should the unnatural landscapes created by early settlers be remediated?
- Are soils becoming more acidic due to acid rain?
- Monitor chemical alterations in bedrock.
- Cooperate with local developers to minimize impact near park areas.
- Consult conservation groups regarding cooperative efforts to increase the areas of relevant parklands and protect more of the region around the battlefields from development.
- Promote environmentally sound methods of developing land parcels including partial clearing of trees and proper construction of stable slopes.

8. Mine- related features such as sand and gravel borrow pits

Small- scale abandoned sand and gravel pits and quarries dot the landscape within the units at Richmond National Battlefield Park. The park filled most of the sand pits in the Malvern Hill area. Across Picnic Road is a sand pit that is now filled with water. This feature may help with hydrogeologic modeling. The Army Corps of Engineers maintains a nearby gravel pit. The state of Virginia has an inventory of mine features such as small open pit mines. Mines are constantly being identified and scanned into their database.

These features pose several concerns for resource management. Visitor safety is a constant concern wherever open pits occur. Most mine features, accessible to the public have been blocked or filled.

Research and monitoring questions and suggestions include:

- Comprehensively inventory mine- related features at Richmond National Battlefield Park, consulting aerial photographs and historic records if necessary.
- Consult the Virginia Department of Mineral Resources database for abandoned mine information.
- Perform a stability survey, focusing on any open gravel and sand pits.

Scoping Meeting Participants

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