

Geologic Resources Inventory Scoping Summary George Washington Carver National Monument, Missouri

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a Geologic Resources Inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for George Washington Carver National Monument on April 6, 2011 at the park's Visitor Center. Jason Kenworthy (NPS Geologic Resources Division) presented an overview of the Geologic Resources Inventory and led the discussion regarding geologic issues, features, and processes at George Washington Carver National Monument. After Bill Duley (Missouri Department of Natural Resources) presented an overview of Missouri's geology, Tim Connors (NPS Geologic Resources Division) facilitated the discussion of map coverage at the park. Other non-park personnel attending the meeting included Jerry Prewett (Missouri Department of Natural Resources), Rick Horton (Missouri Department of Conservation), and Charles Nodler (Missouri Southern State University). In addition to Superintendent Jim Heaney, George Washington Carver National Monument staff at the meeting included Diane Eilenstein, Curtis Gregory, Lana Henry, Tim Van Cleave, and Johanna Wheeler. In the afternoon, Lana Henry led the participants on a field trip throughout the park. A complete list of participants and contact information is included in Table 2 at the end of this report. This scoping summary highlights the GRI scoping meeting for George Washington Carver National Monument including the geologic setting, the plan for providing a digital geologic map, a description of geologic resource management issues and significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

George Washington Carver National Monument lies southeast of Joplin, Missouri, and commemorates the life of George Washington Carver. Almost dying from whooping cough as a child, George's health was frail as a boy so he was relieved from many of the daily chores. Instead, he spent hours wandering through the woods, collecting rocks and plants and developing a set of values that would shape his life. The landscape at George Washington Carver National Monument, and the geology beneath the landscape, provided a foundation for the environment that transformed a frail George Washington Carver into a pillar of strength, wisdom, and perseverance that rivals any of the many awe-inspiring vistas found in our nation's parks and monuments. George Washington Carver National Monument not only preserves the historic landscape of George Washington Carver's childhood but also the intangible serenity he must have felt while exploring the woods and experiencing "the Great Spirit of the universe."

The monument's landscape is part of a geological province known as the Springfield Plateau, a region primarily underlain by relatively flat-lying layers (beds) of limestone, dolomite, and chert. These layers were deposited approximately 350 million years ago (during the geologic period known as the Mississippian) when southwestern Missouri was covered by a shallow sea. The Springfield Plateau forms a subprovince of the Ozark Plateau that includes most of southern Missouri and contains the most extensive outcrop area of Ordovician-age (488 to 461 million years ago) rocks in the country. However, only Mississippian-age rocks are exposed in the vicinity of George Washington Carver National Monument and Newton County (Missouri Department of Natural Resources 2009).

Glacial deposits from the Pleistocene Ice Ages carpet northern Missouri but do not extend into southern Missouri. However, at least two glacial advances farther north produced Pleistocene loess (wind-blown silt) that was transported and deposited into southwestern Missouri (Castillon 1984).

Dissolution of the limestone on the Ozark Plateau produced "karst" topography, characterized by sinkholes, caves, and underground drainage systems. Two of the many datasets available at the Missouri Department of Natural Resources document sinkholes and springs. The sinkhole dataset indicates that the area around Joplin, Missouri, does not contain as many sinkholes as near Springfield and the Wilson's Creek National Battlefield to the east. Groundwater in the region is relatively shallow and the monument contains two springs. Carver Spring emerges from the base of a hill and drains into Carver Branch (fig. 1). Williams Spring is located at the northeastern end of Williams Pond.

Sinkholes in southwestern Missouri are primarily "cover collapse" sinks in contrast to "roof collapse" sinkholes in which the roof of a cave suddenly collapses and leaves a large hole in the ground. Development of a "cover collapse" sinkhole begins with the dissolution of limestone along vertical and horizontal fractures in the bedrock and the development of subterranean openings and caves. The overlying "cover" of weathered bedrock and soil, called residuum, begins to collapse into these openings and is subsequently washed away by groundwater. The openings expand upward in a process known as stoping. Residuum continues to collapse into the void, and groundwater continues to transport the collapsed residuum away from the opening until the surficial residuum finally collapses, resulting in a sinkhole. Sinkholes vary considerably in size. At Wilson's Creek National Battlefield, for example, the recently discovered Sigel's Sink is only about 0.6-0.9 m (2-3 ft) in diameter whereas in 2007, a sinkhole in Nixa, Missouri, engulfed an entire garage. Sinkholes may be quite shallow or quite deep, and they seem to occur in areas where groundwater is rapidly replenished by water from the surface. Consequently, they are also areas of potential groundwater contamination.

Paradoxically, dye traces indicate that groundwater flow through these underground systems is quite rapid and may flush any contaminants relatively quickly. Groundwater quality in the karst region of southern Missouri remains superior to any other region in the state. Dye traces have also shown how difficult it is to map and predict groundwater flow in fractured bedrock. The complexity of these underground systems can be further illustrated by the appearance, and disappearance, of the threatened Ozark Cavefish (*Amblyopsis rosea*). This 5.72 cm (2.25 in) long cavefish lives in the underground conduits and caves of the Springfield Plateau of Missouri, Arkansas, and Oklahoma. If a cave dries up, the cavefish disappear into the intricate labyrinth of groundwater flow and may

reemerge in another cave (Rick Horton, Biologist, Missouri Department of Conservation, verbal communication, April 6, 2011).

The Mississippian-age Burlington-Keokuk Limestone (undivided) and overlying Warsaw Formation are the dominant bedrock units in the region of George Washington Carver National Monument and Joplin, Missouri (Plymate et al. 2003). They were originally deposited in a warm, shallow sea when the area was near the equator. The sea was an ideal environment for marine invertebrates, especially crinoids, brachiopods, and bryozoans now found as fossils throughout the region. The block of Burlington-Keokuk Limestone beneath the statue of the Boy Carver contains fragments of these invertebrate marine fossils, especially crinoids (fig. 2).

A break, or gap, in the sedimentary record (known as an “unconformity”) separates the Burlington-Keokuk Limestone from the Warsaw Formation (Hagni 1986). The Warsaw Formation contains beds of limestone, dolomite, and relatively large amounts of chert. In the Griesemer Quarry, north of Joplin, the upper 15 m (50 ft) of Warsaw Formation consists of dark gray limestone that has been stained by petroliferous matter (McFarland et al. 1986). In contrast to the rest of the unit, chert is rare in these upper beds. In 1986, liquid petroleum oozed from the limestone in some portions of the quarry, and the Missouri Highway Department used the limestone as blacktop aggregate.

Southwestern Missouri is part of a tri-state zinc-lead mining district that also includes Kansas and Oklahoma. The mining boom began in Joplin, Missouri, around the turn of the twentieth century and continued in Missouri until 1957. At one time, the Tri-State District was the world’s largest zinc producer (Hagni 1986; Dressel et al. 1986). In general, northwest-trending fold structures and faults, impermeable shale layers above and below the Mississippian limestones, and karst topography funneled zinc- and lead-rich fluids into Mississippian-age chert breccias (angular broken rock fragments) (Hagni 1986). Around 1900, a mine opened on the Shartel property, south of the monument. Tailings from the defunct Shartel mining site were reclaimed in 2006, and mining activity does not currently impact the monument.

Geologic Mapping for George Washington Carver National Monument

During the scoping meeting, GIS Facilitator Tim Connors (NPS GRD) showed some of the main features of the GRI Program’s digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, a Windows HelpFile that captures ancillary map data, and a map document that displays the map, and provides a tool to access the HelpFile directly from the map document. Final data products are posted at the NPS Natural Resource Information Portal at <http://nrinfo.nps.gov/Home.mvc>. The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park’s area of interest. Because of the influence of karst features and processes in the area of

the park, the 7.5-minute quadrangles that would be useful to resource managers at George Washington Carver National Monument include the Granby quadrangle, which contains the park lands, and the surrounding Fidelity, Joplin East, and Tipton Ford quadrangles (fig. 3). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). Table 1 lists the existing geologic maps that were identified by the scoping participants as appropriate source maps for the digital geologic data.

Useable maps appear to be available for the Fidelity and Joplin East 7.5' quadrangles, but the Granby and Tipton Ford quadrangles have never been mapped at a 1:24,000 scale.

Table 1. GRI Mapping Plan for George Washington Carver National Monument

Covered Quadrangles	GMAP ¹	Citation	Scale	Format	Assessment	GRI Action
Fidelity, Missouri 7.5'	75454	Smith, D.C. and D.M. Work. 1988. Bedrock geologic map of the Fidelity 7.5' quadrangle, Missouri. Missouri Department of Natural Resources, Division of Geology and Land Survey, unpublished.	1: 24,000	paper	GRI staff will digitize this map from image supplied by the Geology Division of the Missouri DNR.	Acquire and evaluate this map.
Joplin East, Missouri 7.5'	75453	Robertson, C.E. 1982. Geology of the Joplin East 7.5' quadrangle, Missouri. Missouri Department of Natural Resources, Division of Geology and Land Survey, Open-File Map OFM-82-71-GI.	1:24,000	paper	GRI staff will digitize this map from image supplied by the Geology Division of the Missouri DNR.	Acquire and evaluate this map.
Missouri state geology	74114	Stoeser, D.B., G.N. Green, L.C. Morath, W.D. Heran, A.B. Wilson, D.W. Moore, and B.S. Van Gosen. 2005. Preliminary integrated geologic map databases for the United States: central states -- Montana, Wyoming, Colorado, New Mexico, Kansas, Oklahoma, Texas, Missouri, Arkansas, and Louisiana, U.S. Geological Survey, Open-File Report OF-2005-1351 (73916).	1:100,000	digital	Coarse polygons, but is digital and likely best available map for the area.	Convert this dataset for interim use for park resource management.

¹GMAP numbers are unique identification codes used in the GRI database.

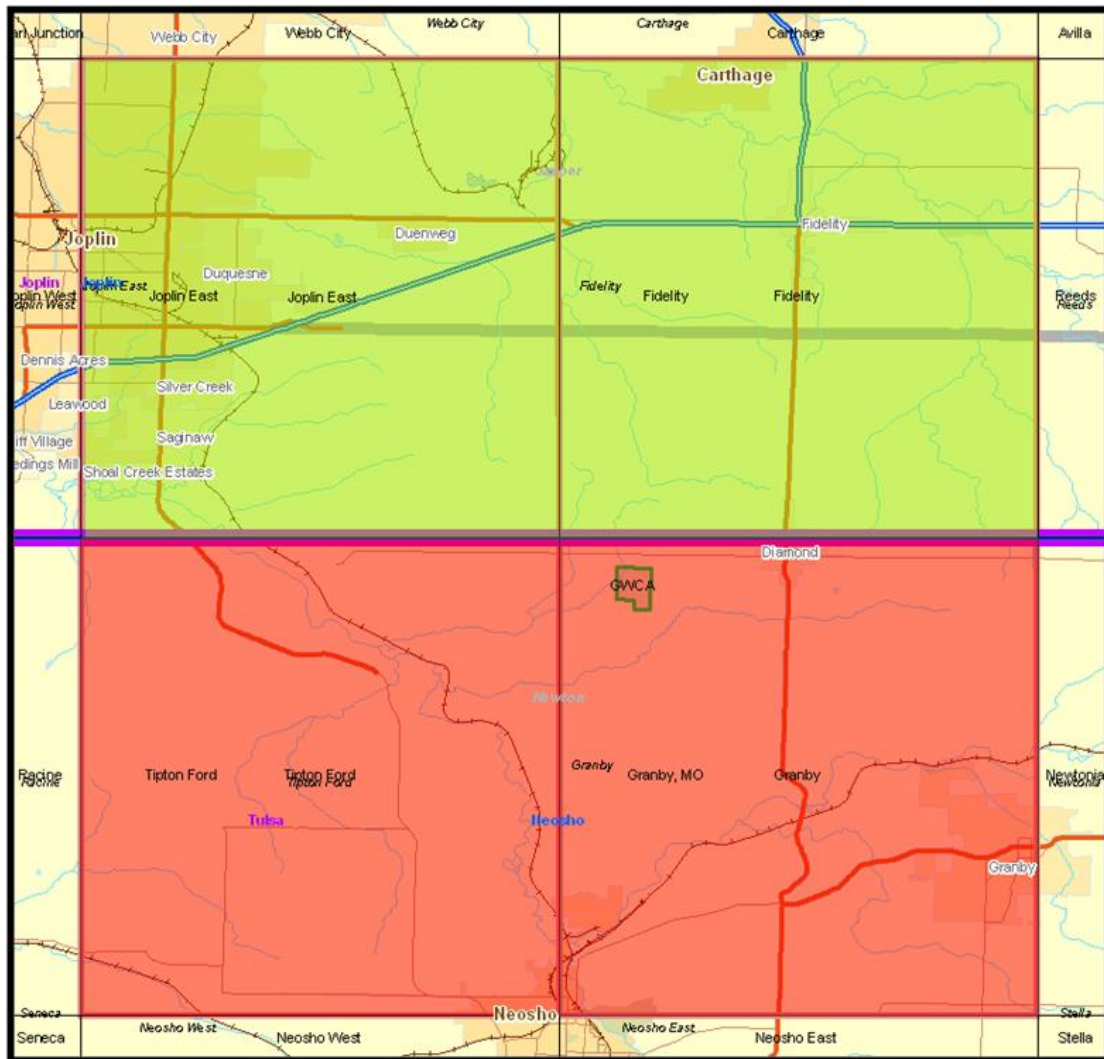


Figure 3. Area of interest for George Washington Carver National Monument, Missouri. The 7.5-minute quadrangles are labeled in black. Green outlines indicate monument boundaries. Solid lighter green indicates known 7.5' published geologic mapping available; solid red indicates no known 7.5' geologic mapping available.

At the present time, it was agreed that the two northern quadrangles of interest (Fidelity and Joplin East) were adequately covered and could be digitized for inclusion in a George Washington Carver National Monument digital geologic database. However, for the Granby and Tipton Ford 7.5' quadrangles, there is no available large-scale geologic map coverage, and the currently best available dataset is the statewide map compilation (from GMAP 74114; see fig. 4 below). It was suggested to solicit mapping proposals to produce new large-scale mapping for both the Tipton Ford and Granby 7.5's by the Missouri Division of Natural Resources and proceed from there.

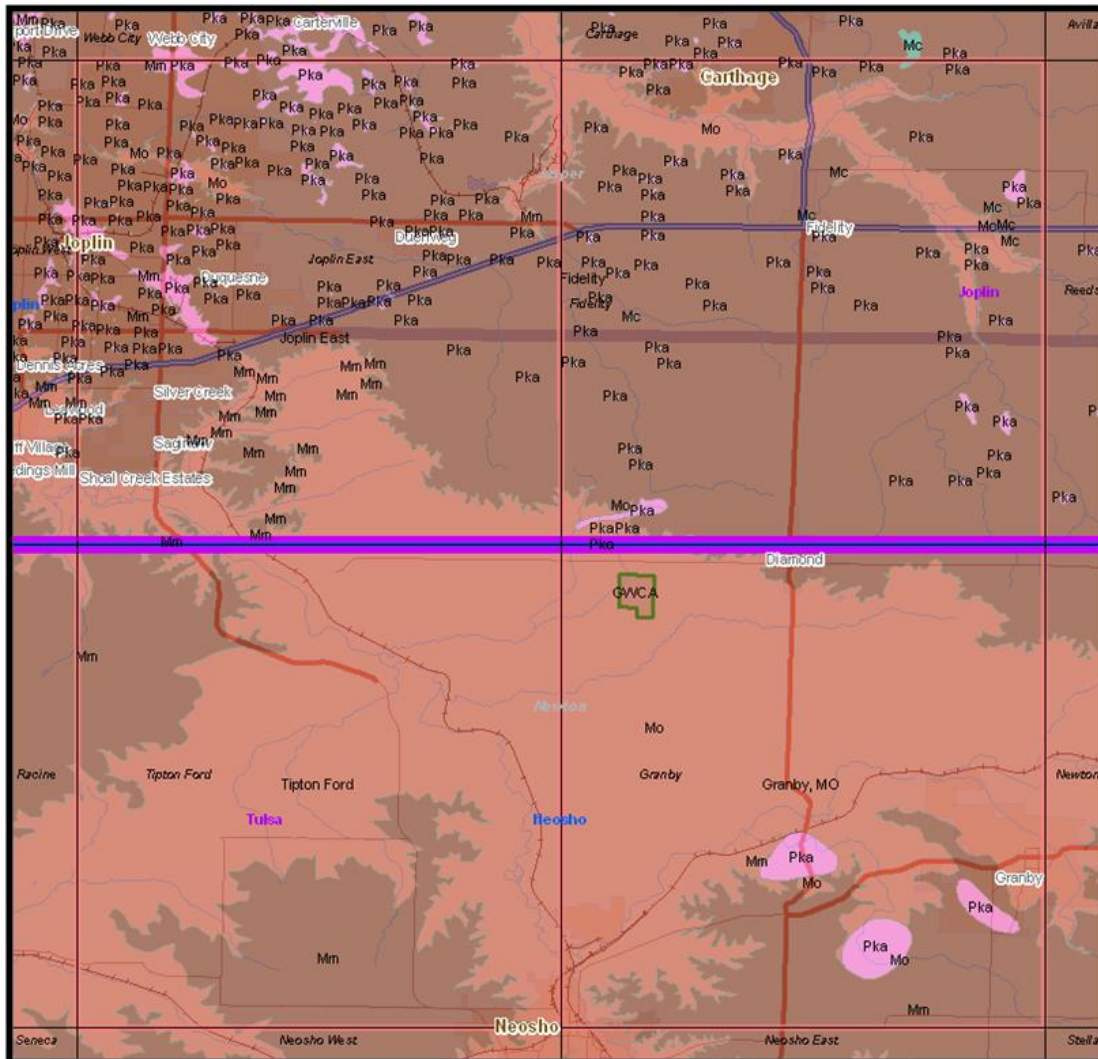


Figure 4. Footprint of statewide geology of Missouri from USGS of-2005-1351 (GMAP 74114); middle Pennsylvanian-Atokan stage (Pka) and Early Mississippian Osagian Series (Mo) are predominant units shown in George Washington Carver National Monument area.

Geologic Resource Management Issues

At this time, George Washington Carver National Monument does not have any significant geologic issues that require resource management attention. The development of sinkholes, which are common in karst terrain, presents a potential minor issue for monument staff. The last sinkhole in the area opened near a park residence two years ago (Lana Henry, Chief Ranger, NPS George Washington Carver National Monument, personal communication, April 6, 2011).

Lateral erosion of the banks along Carver Branch is a natural process for a meandering stream, especially during seasonal flood events, but presents a minor issue for park management. In a

meandering stream, the stream's current flows faster around the outside bend of a meander, cutting into the unconsolidated material and forming a steep bank, known as a "cutbank" (fig. 5). Opposite the cutbank, channel velocity decreases and becomes unable to transport heavier material such as sand and gravel. These heavier materials accumulate to form a "point bar." Erosion may threaten archaeology sites, but no sites appear to be threatened in the monument.

Perhaps the major issue for the monument involves groundwater. If groundwater withdrawal increases with increased agricultural or development activity, groundwater levels may drop, causing the springs in the park to become dry. The Water Resources Division of the NPS should be consulted for any surface or groundwater advice.

Features and Processes

The following table lists geologic features and processes that were identified at the scoping meeting. These features and processes will be further explained in the GRI report.

Feature/Process	Brief Description
Bedrock Features	Bedrock is not exposed in the park, but rocks in the rock walls are from local formations and were collected from nearby fields.
Windblown (aeolian)	Loess (wind-blown silt) is present in fields north of the park and may be present in the park, also. Thickness is probably not more than 0.6 m (2 ft) in this area. Advantageous for growing crops, loess was probably present on the original farm.
Caves/Karst	Groundwater from underground caves and conduits discharges from two springs in the park. One of the springs discharges at 416 liters/min (110 gallons/min), while the other spring dries up during the year. Two years ago, a sinkhole opened in the back yard of a nearby residence.
Stream (Fluvial)	Carver Branch is a meandering stream. It is also a "gaining" stream, which means it receives water from springs and surface runoff.
Paleontological Resources	Fragments of crinoid, bryozoan, and brachiopods are the principal invertebrate fossils found in the rock walls. Fossils are documented from the Warsaw Formation and Burlington-Keokuk Limestone outside the park boundaries (Hunt et al. 2008).
Geothermal	Geothermal resources are used to heat the Visitor's Center at George Washington Carver National Monument.
Other significant or unique geologic features	1. Boundary markers that pre-date the park consist of local rocks. 2. The "chinking" material (the broad white bands between logs in a log home) at George Washington Carver's birth site contained lime from local formations.
Disturbed lands (mining, grazing, logging) or severe erosion	Tailings from the old Shartell mining site were removed in 2006 and the site was reclaimed. Recommendations have been made to remove some riprap that had been placed along the Carver Branch for erosion control in the 1970s.

Field Trip

Some of the geologic features, processes, and potential issues at George Washington Carver National Monument were identified on the afternoon field trip that was led by Chief Ranger Lana Henry. The field trip stops are plotted on the National Park Service map for George Washington Carver National Monument (fig. 6).

Stop 1: Rock Wall at “View of Boy Carver Statue”

The rock wall, constructed in the 1950s, contains blocks of limestone and dolomite from the surrounding area (fig. 7).

Stop 2: Carver Spring

Carver Spring, the spring from which George Washington Carver drew his water, emerges from the base of a slope that forms the south bank of Carver Branch (fig. 1). Downstream from the spring, flood events have eroded the bank of the stream, forming a “cutbank” (fig. 5).

Stop 3: Boy Carver Statue

The statue of the young George Washington Carver sits on an upturned block of Burlington-Keokuk Limestone (fig. 8). The vertical beds of limestone, which were originally deposited in horizontal layers, contain fossils of crinoids, brachiopods, and corals, as well as some chert nodules. Fossil debris can also be found in the rocks that form the wall surrounding the statue.

Stop 4: Williams Pond

Built in the 1930s, Williams Pond is fed by a spring at its northeastern end and discharges into Williams Branch (fig. 6). The man-made lake ranges from 0.6-2.4 m (2-8 ft) deep and offers a serene, contemplative retreat for the park visitor.

Stop 5: 1881 Moses Carver House

The renovated Moses Carver House contains a border foundation of rock pieces collected from the Burlington-Keokuk Limestone or Warsaw Formation (fig. 9). This house was Moses Carver’s second home, and although George never lived in this house, he did stop by to visit. The Williams Branch, which flows past the Moses Carver House, has incised only 0.6-0.9 m (2-3 ft) into the surrounding floodplain.

Stop 6: Carver Cemetery

Most of the graves in the Carver Cemetery are marked with fresh limestone grave markers (fig. 10A). However, some of the markers are blocks of local Burlington-Keokuk Limestone or Warsaw Formation limestone with original names and dates carved into them (fig. 10B). Most of the rocks that were used to construct the wall around the cemetery were reportedly collected from local fields. Some of the blocks of limestone contain fossils of crinoids, brachiopods, and bryozoans.

Stop 7: Big Spring, Neosho, Missouri and the Neosho National Fish Hatchery

Big Spring, in Neosho, Missouri, lies approximately 13 km (8 mi) south of George Washington Carver National Monument. Located in a city park, the spring emerges from a bedrock ridge of Burlington-Keokuk Limestone or Warsaw Formation. Part of the ridge has eroded to provide a “window” into the underground cave and groundwater conduit system that feeds Big Spring. Neosho also contains the Neosho National Fish Hatchery, which was established in 1888 and is the

oldest hatchery operated by the U.S. Fish and Wildlife Service. In 1989 hatchery staff discovered the endangered Ozark cavefish in one of the four springs that supplies water to the hatchery.

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Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Connors, Tim	NPS Geologic Resources Division	Geologist	303-969-2093	tim_connors@nps.gov
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Wheeler, Johanna	NPS George Washington Carver National Monument	Facility Manager	417-325-4151	johanna_wheeler@nps.gov



Figure 1. Carver Spring, Field Trip Stop 2, emerges from the base of a slope and drains into Carver Branch. George Washington Carver drew his water from this spring. Photograph by John Graham, Colorado State University.



Figure 2. Fragments of crinoid stems (the black arrow points to one stem segment) litter the surface of this block of Burlington-Keokuk Limestone at the Boy Carver Statue, George Washington Carver National Monument. Crinoids, which may still be found in today's oceans, consist of a mouth and feeding arms attached to a column of disk-like segments that stack one on top of the other, like checkers. As seen in this photograph, these segments often disarticulate upon death. A crinoid (*Delocrinus missouriensis*) is the state fossil of Missouri. Photograph by John Graham (Colorado State University).



Figure 5. A “cutbank” along Carver Branch. During times of flooding, the increased velocity of the stream’s channel will erode the bank, forming a steep slope, or cutbank. Photograph by John Graham (Colorado State University).

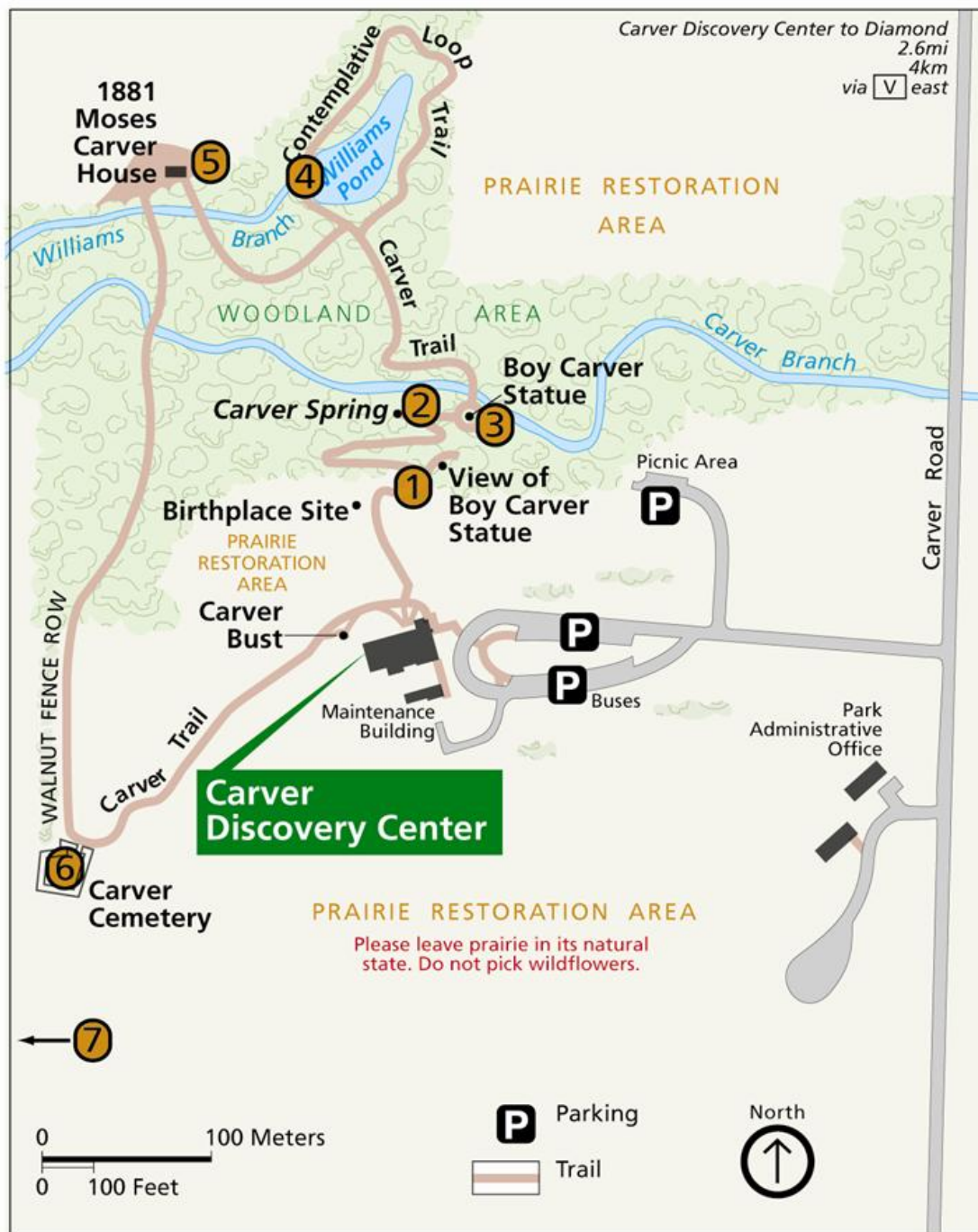


Figure 6. Location of field trip stops (labeled 1-7). Stop #7 was at Big Spring in Neosha, Missouri.



Figure 7. Rock walls, such as this one at Field Trip Stop 1, were constructed using local rock probably from either the Warsaw Formation or the Burlington-Keokuk Limestone. Photograph by John Graham (Colorado State University).

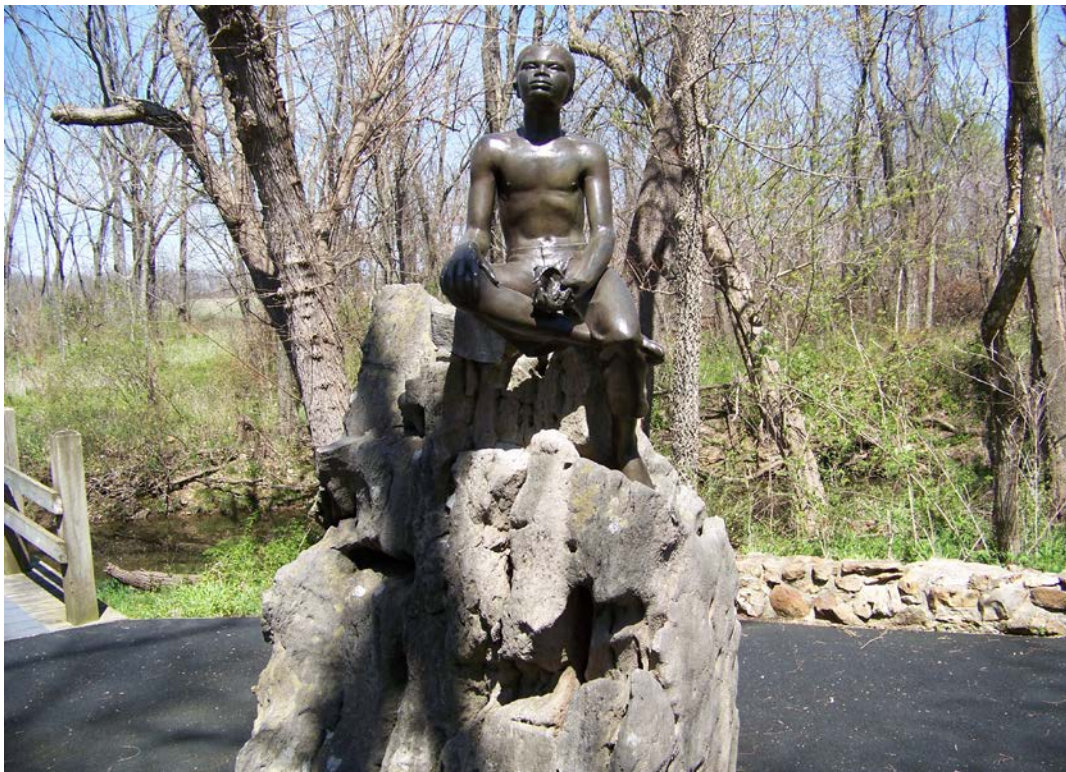


Figure 8. The statue of the young George Washington Carver sits atop a block of Burlington-Keokuk Limestone that has been rotated 90° so that the original horizontal beds are now vertical. The limestone contains fossils of invertebrate marine fauna, such as crinoids, brachiopods, and corals. Fossils can also be found in the rocks that form the wall behind the statue. Photograph by John Graham (Colorado State University).



Figure 9. The underlying foundation and border around the 1881 Moses Carver House consist of local rocks quarried from the local Burlington-Keokuk Limestone or Warsaw Formation. Photograph by John Graham (Colorado State University).



A) Moses Carver headstone, Carver Cemetery.



B) Grave stone of "T. W. Ellis" (1879?)

Figure 10. Carver Cemetery, George Washington Carver National Monument, Missouri. A) Many of the headstones have been replaced with newly carved limestone markers. The rock wall was constructed from local blocks of limestone and contains marine invertebrate fossils. The Visitor Center can be seen in the distance. View is to the northeast. B) The name "T. W. Ellis" has been carved into this piece of local limestone and is probably an original marker. Pencil is 14 cm (5.5 in) for scale. Photograph by John Graham (Colorado State University).