National Park Service
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Natural Resource Stewardship and Science

Herbert Hoover National Historic Site

Geologic Resources Inventory Report

Natural Resource Report NPS/NRSS/GRD/NRR—2017/1479

ON THE COVER
Birthplace cottage of Herbert Hoover, Herbert Hoover National Historic Site. Photograph by John Graham (Colorado State University), taken in 2011.

THIS PAGE
Hoover Creek in Herbert Hoover National Historic Site.
Photograph by John Graham (Colorado State University), taken in 2011.

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Executive Summary

The Geologic Resources Inventory (GRI) provides geologic map data and pertinent geologic information to support resource management and science-informed decision making in more than 270 natural resource parks throughout the National Park System. The GRI is one of 12 inventories funded by the National Park Service (NPS) Inventory and Monitoring Program. The Geologic Resources Division of the NPS Natural Resource Stewardship and Science Directorate administers the GRI.

This report synthesizes discussions from a scoping meeting held in 2011 (Appendix A). Sections of this report discuss the geologic setting, distinctive geologic features and processes within Herbert Hoover National Historic Site, highlight geologic issues facing resource managers, describe the geologic history leading to the present-day landscape, and provide information about the previously completed GRI map data. Posters (in pocket) illustrate these data.

Established in 1965 to commemorate the life of the 31st President of the United States, Herbert Hoover National Historic Site encompasses 75.6 ha (187 ac) of surficial, unconsolidated sediments. The historic site lies near the northern boundary of the Southern Iowa Drift Plain, a landform region in Iowa consisting of rolling hills and some of the most productive agricultural land in the world. During the Pleistocene ice ages, continental glaciers advanced several times into the region, depositing unconsolidated mixtures of clay, silt, sand, gravel, and boulders. These heterogeneous deposits are known as till.

The most recent major glacial advance produced the Des Moines Lobe. The ice lobe did not extend into the present-day historic site, but the glacier ground the underlying sediment into fine-grained silt, which the wind deposited across the landscape. During the past 11,000 years, the rivers and streams of Iowa's drainage systems have modified the landscape. Hoover Creek, a tributary of the West Branch of Wapsinonoc Creek, flows through the historic site and deposits alluvial sediments.

Herbert Hoover, the only geologist to have become president of the United States, was a prominent mining geologist prior to becoming a public servant. He had been fascinated with geology since childhood. Hoover's administration had a profound impact on the National Park Service and the land designated for national parks and monuments increased by 40%.

Geologic features and processes in Herbert Hoover National Historic Site include the following:

- Fluvial (river) deposits of unconsolidated loam and loamy sand exposed along the banks of Hoover Creek.
- Loess (glacially derived windblown silt) deposited on upland divides, ridge tops, and side slopes.
- Till deposited during the Pleistocene ice ages and which now forms the oldest unconsolidated unit in the historic site.

Bank instability caused by incision and erosion of Hoover Creek's channel was identified as the primary geologic resource management issue during the GRI scoping meeting. Concerns associated with bank instability include:

- Slumping and an increased sediment load in the stream.
- Incision of Hoover Creek's channel.
- Runoff and seasonal flooding that accelerates bank erosion.
- Damage to known Euro American archeological sites from the late 19th and early 20th centuries and potential American Indian sites that have yet to be found.

The preferred alternative in the *Final Hoover Creek Stream Management Plan and Environmental Impact Statement* includes the construction of a storm water detention pond that would protect the historic site from flooding, including exceptional flood events that might occur only once every 50 years.

Although no bedrock is exposed at the surface of Herbert Hoover National Historic Site, a bedrock map accompanies the surficial geologic map with this report. The youngest bedrock is found approximately 30–60 m (100–200 ft) below the surface of the historic site and consists of 393.3 million to 382.7 million year old (Middle Devonian) dolomite. Older carbonate strata underlie the Devonian layers. The fossiliferous limestone and dolomite in these Silurian Period formations represent episodes of sea level rise when the region was submerged beneath shallow seas.

Products and Acknowledgments

The NPS Geologic Resources Division partners with the Colorado State University Department of Geosciences to produce GRI products. Geologists from the Iowa Geological Survey developed the source maps and reviewed GRI content.

GRI Products

The GRI team undertakes three tasks for each park in the Inventory and Monitoring program: (1) conduct a scoping meeting and provide a summary document, (2) provide digital geologic map data in a geographic information system (GIS) format, and (3) provide a GRI report (this document). These products are designed and written for nongeoscientists.

Scoping meetings bring together park staff and geologic experts to review and assess available geologic maps, develop a geologic mapping plan, and discuss geologic features, processes, and resource management issues that should be addressed in the GRI report. Following the scoping meeting, the GRI map team converts the geologic maps identified in the mapping plan to GIS data in accordance with the GRI data model. After the map is completed, the GRI report team uses these data, as well as the scoping summary and additional research, to prepare the GRI report. The GRI team conducts no new field work in association with their products.

The compilation and use of natural resource information by park managers is called for in the 1998 National Parks Omnibus Management Act (§ 204), 2006 National Park Service Management Policies, and the Natural Resources Inventory and Monitoring Guideline (NPS-75). The "Additional References" chapter and Appendix B provide links to these and other resource management documents and information.

Additional information regarding the GRI, including contact information, is available at http://go.nps.gov/gri. The current status and projected completion dates of products are available at http://go.nps.gov/gri_status.

Acknowledgments

Special thanks to: Ray Anderson, Deborah Quade, and Stephanie Tassier-Surine of the Iowa Geological Survey for sharing their geologic experience and knowledge during the field trip associated with the 2011 scoping workshop. Thanks to Cary Wiesner and Pete Swisher (Herbert Hoover NHS) for shepherding the report for review among park staff.

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Figure 1. Map of Herbert Hoover National Historic Site in West Branch, Iowa. The site is about 15 km (9.5 mi) east of Iowa City and 65 km (40 mi) west of Davenport. Bank instability caused by incision and erosion of Hoover Creek's channel was identified as a primary geologic resource management issue. Thompson Farm is located west of the gravesite and is not present on this map. National Park Service map available at: https://www.nps.gov/hfc/cfm/carto-detail.cfm?Alpha=HEHO (accessed 23 August 2016).

Geologic Setting and Significance

This chapter describes the regional geologic setting of the historic site and summarizes connections among geologic resources, other park resources, and park stories.

Geologic Setting

Herbert Hoover National Historic Site was established in 1965, shortly after it became a National Historic Landmark (fig. 1). The site encompasses 75.6 ha (187 ac) of surficial, unconsolidated sediments deposited by rivers or glaciers over the past approximately 800,000 years (Quaternary Period, in part). The unconsolidated sediments bury fossiliferous carbonate rocks that record life in an ancient ocean, which inundated present-day Iowa hundreds of millions of years ago during the Paleozoic Era (fig. 2).

The historic site lies near the northern boundary of the Southern Iowa Drift Plain, a landscape of rolling hills and farms (fig. 3). During the Pre-Illinoian glacial cycle (table 1), a period of time ranging from approximately 2.6 million to 500,000 years ago, glaciers advanced several times over the Southern Iowa Drift Plain (Mickelson and Colgan 2004; Bettis III et al. 2010). When the glaciers melted, they left behind heterogeneous mixtures of unconsolidated clay, silt, sand, gravel, and boulders. These deposits are classified as "till." At least seven till units have been recognized in the region.

The till in the historic site area has been divided into the Alburnett Formation and the younger Wolf Creek Formation (table 2). The unsorted sediments in these units are difficult to differentiate in the field, so the formations have been mapped as one unit (geologic map unit **Qwa3**). The Alburnett Formation tills were deposited over 790,000 years ago (Bettis III et al. 2010). At the type section in Alburnett, Iowa (a "type section" is where a formation is first described) the Alburnett is 10 m (30 ft) thick, but the thickness can range from less than 1 m (3 ft) to 76 m (250 ft) in east-central Iowa (Hallberg 1980).

The Wolf Creek Formation consists of fluvial sediments and paleosols, as well as till (Quade et al. 2008; Witzke and Anderson. 2008; Bettis III et al. 2010). The tills in the Wolf Creek Formation are massive, and uniform in texture and composition. The fine-grained sediment and abraded stones are known as "basal" tills, meaning the sediments were dragged along and deposited at the base of a glacier.

The most recent continental glacier entered Iowa between 14,000 and 12,000 years ago during the Wisconsinan glacial cycle (table 1). At this time, an ice lobe, called the Des Moines Lobe, flowed as far south as present-day Des Moines, Iowa, but did not extend into Herbert Hoover National Historic Site (fig. 3). However, two loess (windblown silt) deposits in eastern Iowa resulted from this glacial episode, the Pisgah and the Peoria Formations.

Table 1. Summary of Quaternary glacial and interglacial stages in Iowa.

Epoch	Name	Inter/Glacial	Age Range	Units mapped in Herbert Hoover NHS (map symbol)
Holocene	Hudson	interglacial	present–12,000	DeForest Formation (**Qal**)
Pleistocene	Wisconsinan	glacial	12,000–110,000	Peoria Formation (**Qps**)
Pleistocene	Sangamonian	interglacial	115,000–130,000	None
Pleistocene	Illinoian	glacial	130,000–200,000	None
Pleistocene	Pre-Illinoian	interglacial	374,000–424,000	None
Pleistocene	Pre-Illinoian	glacial	424,000–478,000	None
Pleistocene	Pre-Illinoian	interglacial	478,000–563,000	None
Pleistocene	Pre-Illinoian	glacial	621,000–790,000+	Wolf Creek or Alburnett formations (**Qwa3**)

"Glacials" are time periods when massive ice sheets advanced over large areas of the planet ("ice ages"). "Interglacials" are warmer periods (similar to today) when ice sheets are restricted to polar regions.

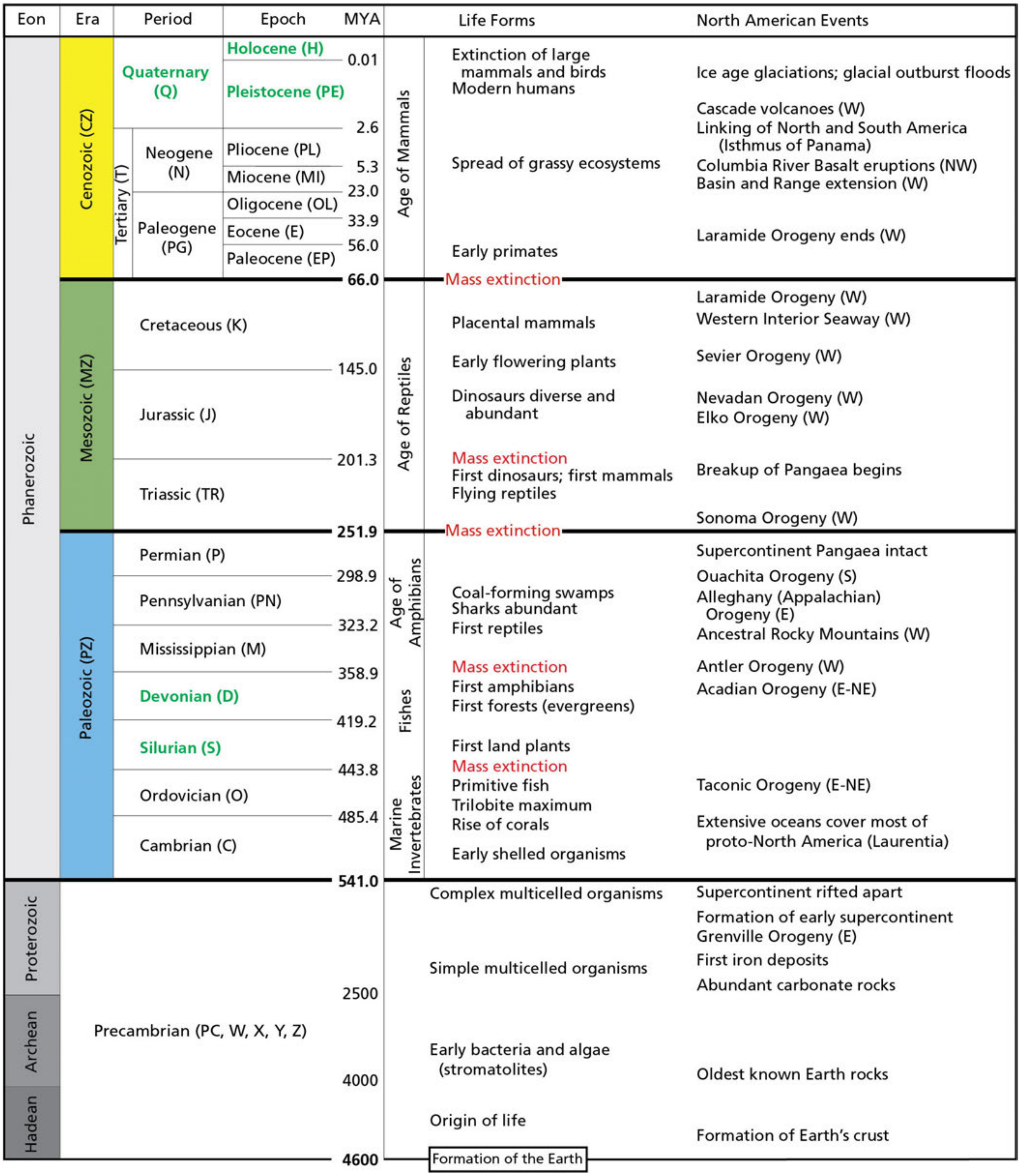

Figure 2. Geologic time scale. The divisions of the geologic time scale are organized stratigraphically, with the oldest divisions at the bottom and the youngest at the top. Time periods representing strata mapped at the surface and in the subsurface in the Herbert Hoover National Historic Site area are in green. GRI map abbreviations for each time division are in parentheses. Compass directions in parentheses indicate the regional locations of events. Boundary ages are millions of years ago (MYA). National Park Service graphic using dates from the International Commission on Stratigraphy (http://www.stratigraphy.org/index.php/ics-chart-timescale).

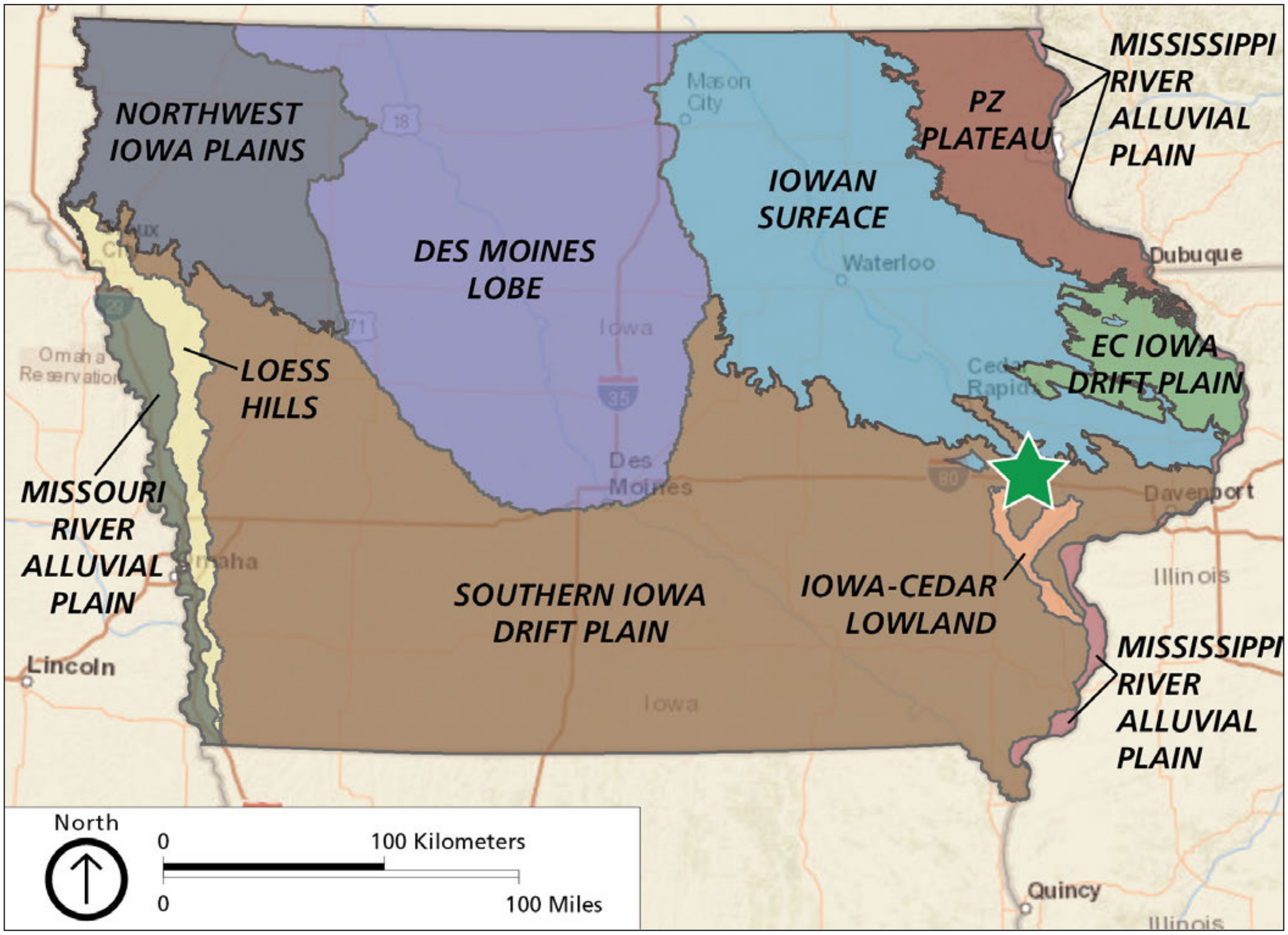

Figure 3. Landform regions of Iowa. Herbert Hoover National Historic Site (green star) lies on the Southern Iowa Drift Plain. Loess deposits associated with the Des Moines Lobe mantle upland areas. Over the past 10,500 years, the landscape has been modified primarily by fluvial processes. PZ= Paleozoic; EC = East-Central. Map by Jason Kenworthy (NPS Geologic Resources Division) using "Landform Regions" data available from the Iowa Geological and Water Survey's Natural Resources Geographic Information Systems Library at https://programs.iowadnr.gov/nrgislibx/. Metadata are available at: ftp://ftp.igsb.uiowa.edu/gis_library/IA_state/Geologic/Landform/Landform_Regions.html. Basemap is "ESRI World Street Map" using data from Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.

The Pisgah Formation, which is not in the GRI GIS data, is the older of the two units and consists of a thin sheet of loess that has been reworked by rainfall, sheetwash, and downslope creep (collectively known as colluvial processes). The Pisgah loess has been altered by soil-forming processes to become slightly more dense and grayer than the Peoria Formation.

Accumulation of the Peoria Formation (**Qps**) began about 23,000 years ago and continued until approximately 11,000 years before present (Bettis III et al. 2010). Rapid deposition of the Peoria Formation occurred from about 21,000 to 16,000 years ago during the coldest and driest portion of the late Wisconsin glacial period. Both loess units were deposited on the uplands of eastern Iowa and have been subjected to post-glacial and Holocene (11,000 years ago to present) erosion. The Peoria Formation in the Herbert Hoover National Historic Site ranges from 2 m (6 ft) to 8 m (25 ft) thick.

Following the final retreat of glaciers at the end of the Pleistocene, Iowa's rivers and streams have modified the landscape. Alluvial and valley fill sediments deposited in stream channels and floodplains form the Holocene DeForest Formation (**Qal**). East-flowing Hoover Creek,

Table 2. Summary of geologic map units within Herbert Hoover National Historic Site.

Period Age in MYA	Formation (map symbol)	Description
Deposits mapped on the surface at Herbert Hoover National Historic Site		
Quaternary 2.58–0.0117	DeForest Formation (**Qal**)	Undifferentiated alluvium consisting of grayish brown to brown loam, silt loam, clay loam, or loamy sand. Massive to weakly stratified. The Roberts Creek Member of the DeForest Formation is exposed in the banks of Hoover Creek. Thickness: 1–7 m (3–23 ft).
Quaternary 2.58–0.0117	Peoria Formation (**Qps**)	Loess. Yellowish to grayish brown, massive, jointed calcareous or noncalcareous silt loam to silty clay loam. Mapped on upland divides, ridge tops, and convex side slopes. Thickness: 2–8 m (6–25 ft).
Quaternary 2.58–0.0117	Wolf Creek or Alburnett formations (**Qwa3**)	Very dense, massive, fractured, loamy till consisting of a heterogeneous mixture of clay, silt, sand, and gravel. Mapped on narrowly dissected interfluves and side slopes, and side valley slopes. Thickness: 10–35 m (33–115 ft).
Bedrock mapped in the subsurface beneath Herbert Hoover National Historic Site		
Middle Devonian 393–383	Wapsipinicon Group (**Dw**)	*Otis Formation*: dolomite, some of which contains vugs (holes). *Pinicon Ridge Formation*: laminated and argillaceous (containing clay) dolomite, and dense, partly to wholly brecciated limestone. Contains minor amounts shale, chert, and sandstone. Maximum thickness of **Dw**: 18–34 m (60–110 ft).
Lower Devonian 419–393	None mapped	Regional unconformity
Silurian 444–419	Gower Formation (**Sg**)	Dolomite, which may be laminated, fossiliferous, or contain vugs. Minor amounts of nodular chert. Form mounds composed of carbonate. Maximum thickness: 40 m (130 ft).
Silurian 444–419	Scotch Grove Formation (**Ss**)	Dense, cherty to very cherty dolomite, which may contain vugs and molds of fossils. Fossil crinoids are present in some layers. Some of the dolomite forms mounds. Minor lithologies include argillaceous dolomite, quartz crystals, and chalcedony (cryptocrystalline silica). Maximum thickness is generally less than 49 m (160 ft), but the unit may be as much as 75 m (250 ft) thick where large carbonate mounds have developed.

Units include those mapped on the surface at the historic site, and units mapped beneath the historic site not exposed at the surface. The surficial units are approximately 30–60 m (100–200 ft) thick atop the bedrock units. MYA: millions of years ago. Period colors are standard colors approved by the US Geological Survey to indicate different time periods on geologic maps. Formation colors correspond to those on the geologic map posters (in pocket). Descriptions derived from Quade et al. (2008) and Witzke and Anderson (2008). Full list of map units is available in GRI GIS data (heho_geology.pdf).

a tributary of the West Branch of Wapsinonoc Creek, flows through the historic site (fig. 4). Many of the historical buildings and at least 17 known archeological sites lie within the floodplain of Hoover Creek. The archeological sites are Euro American, dating primarily from the 1870s to the mid-1900s (Finney 2005; Cary Wiesner, Herbert Hoover National Historic Site, historian, written communication, 16 August 2016). Hoover Creek flooding poses a significant issue for resource management.

Approximately 30–60 m (100–200 ft) of surficial, unconsolidated deposits overlie fractured Devonian Wapsipinicon Group strata (**Dw**), the youngest bedrock units encountered beneath the surface landscape (table 2). The contact between the unconsolidated Quaternary deposits and Devonian bedrock represents about 390 million years of missing geologic record. Fossiliferous limestone and dolomite in the Wapsipinicon Group record the incursion (transgression) and retreat (regression) of normal marine seawater into this part of Iowa.

A gap of at least 25 million years separates the Wapsipinicon Group from the underlying Silurian Gower Formation (**Sg**) (table 2). Similar to the Wapsipinicon Group, the Silurian units document a transgressive–regressive sequence. The older Scotch

Figure 4. Hoover Creek flows through Herbert Hoover National Historic Site. Incision has produced steep banks, which are now overgrown. Erosion of the cutbanks in the historic site and upstream has resulted in a high sediment load in the creek, noted by the dark brown color of the water. Photograph by John Graham (Colorado State University), taken in 2011.

Grove Formation (**Ss**) records a sea level rise and influx of normal marine environments into the area. When sea level fell, restricted marine environments developed, which are now represented by the overlying strata of the Gower Formation (**Sg**). Rising from the sea floor in both the Scotch Grove and Gower Formations were distinctive mounds and reefs.

The Devonian and Silurian rock units contain abundant fossils of invertebrate marine organisms, including brachiopods, trilobites, corals, crinoids, stromatoporoids, stromatolites, ostracods, and worm burrows. Similar fauna from the Devonian Cedar Valley Group, which overlies the Wapsipinicon Group, are displayed in the remarkable Devonian Fossil Gorge in the Coralville Dam Emergency Spillway, approximately 24 km (15 mi) west of the historic site. In 1993, the worst flood in Iowa history swept through the spillway, eroded a deep channel, and exposed the underlying bedrock (Zogg 2014). Typically, bedrock features in Iowa are only exposed in vertical road cuts and quarries, but the Devonian Fossil Gorge offers visitors the rare opportunity to observe the diverse Devonian sea life that populated a relatively shallow sea approximately 375 million years ago.

Horizontal and vertical fractures cut the limestone strata in the spillway and provide conduits for water to flow into the subsurface. Groundwater in these fracture systems provides an important water source for the region.

A piece of petrified wood and invertebrate fossils in two limestone fragments found in unconsolidated sediments were discovered in Herbert Hoover National Historic Site (Justin Tweet, National Park Service, paleontologist, written communication, 24 February 2016). The petrified wood was recovered from 8 m (22 ft) below the surface when a water well was drilled on the Isaac Miles farm in 1983 (see Graham 2011). The wood may be from spruce forests that grew in the area during the Pre-Illinoian glacial cycle.

Herbert Hoover's Connections to Geology

In his memoirs, Herbert Hoover mentions spending hours at a grindstone, polishing the agates and fossil coral he picked out of the glacial gravel along the railroad tracks in West Branch, Iowa (Cary Wiesner, written communication, 16 August 2016). Hoover's fascination with rocks and fossils was bolstered by the local dentist, Dr. Walker, who also had a geology collection.

Herbert Hoover continued his interest in rocks and fossils when, orphaned in 1885 at age 11, he went to live with his uncle in Oregon (Lane 1920; Smith et al. 2007). When Hoover was working in his uncle's Oregon Land Company, he caught the attention of a visiting engineer. The engineer, like Hoover, was a Quaker and was instrumental in enrolling Hoover in Stanford University's first graduating class.

At Stanford, Hoover majored in geology and earned his way through school by typing material for Professor John Caspar Branner. Branner found Hoover a summer job with the US Geological Survey mapping the terrain in the Ozark Mountains, and the next summer, Hoover worked in Yosemite National Park. It was in Branner's geology lab where Hoover met his future wife, Lou Henry, a banker's daughter from Waterloo, Iowa (Smith et al. 2007).

After graduating from Stanford, Hoover began his geology career by shoveling ore in Nevada City, California, for two dollars per ten hour shift. Hoover soon convinced the London firm of Bewick, Moreing and Company to hire him as a geologist. The company sent Hoover to the Australian Outback where he discovered a gold deposit that would become the Sons of Gwalia mine and resulted in $65 million for Bewick, Moreing and Company. By 1898, Hoover was making $10,000 a year (about $287,000 in 2015 dollars) (Smith et al. 2007).

Two days after his marriage to Lou Henry in 1899, Hoover was sent to Tientsin, China, where he became known for finding ways to make old mines profitable. That same year, the Boxer Rebellion, a violent anti-foreign and anti-Christian uprising, spread across China. In 1900, Chinese nationalists besieged Tientsin. Hoover and other westerners built barricades around the residential section of the city, while Lou volunteered at the hospital. One day, an artillery shell crashed into the front hall of Hoover's house, destroying part of the staircase. A few days later, Lou was surprised to read her obituary in a California newspaper. After an international coalition of troops rescued the Hoovers and the other westerners, Herbert Hoover was made a partner at Bewick, Moreing and Company.

Geology carried Herbert Hoover, the only geologically-trained president, around the globe several times over. He was a familiar figure on four continents. He lived in London, caught malaria in Asia, and backed out of a mine in Burma after seeing fresh tiger tracks (Smith et al. 2007). For three years, Hoover and Lou travelled by ship to almost forty nations. While at sea, they translated *De Re Metallica* (*On the Nature of Metals*). Published in 1556 by the 'father of mineralogy' Latin mining scholar Georgius Agricola, this book remained the authoritative text on mining for 180 years.

In 1908, Hoover quit Bewick, Moreing and Company to start his own international consulting firm. He employed 175,000 workers from Siberia to Peru. He joined Stanford's Board of Trustees. By 1914, the 40-year old Hoover was worth $4 million (about $95 million in 2015 dollars). Hoover's geology career ended when the Austrian Archduke Franz Ferdinand was assassinated in August, 1914, igniting World War I and propelling Herbert Hoover away from an engineering career and into public life (Smith et al. 2007).

At the beginning of WWI, 120,000 Americans were trapped in Europe, many of them in Belgium. Hoover received an urgent request for help from Walter Hines Page, the US ambassador to Britain. Within 24 hours, Hoover had assembled 500 volunteers and transformed the ballroom of the Savoy Hotel into a distribution center for food, clothing, steamer tickets, and cash. Asked to undertake a relief effort for Belgium, Hoover accepted the challenge under two conditions—that he received no salary, and that he be given a free hand in organizing and administering what became known as the Commission for Relief in Belgium (CRB) (Smith et al. 2007). The CRB is credited for saving 10 million people from starvation during World War I (Rubin 2013). By 1918, Hoover had become an international hero for his humanitarian work, and as he later realized, his prospecting days were over.

When Hoover became President, his administration increased the land designated for new national parks and monuments by 40% (table 3; National Park Service 2016a). As President, Hoover built Rapidan Camp, his presidential getaway in Virginia. Recently restored to its 1929 appearance, Rapidan Camp is located within Shenandoah National Park (see GRI report by Thornberry-Ehrlich 2014).

In 1928, President Coolidge authorized the building of a dam in the Black Canyon of the Colorado River that would control flooding, provide irrigation water, and produce hydroelectric power. In 1931, President Hoover ordered dam construction to start in March, rather than October as in the original timetable. The dam put thousands of white males to work during the Great Depression. In 1947, Congress officially named it Hoover Dam.

When Hoover died in 1964, he was buried alongside Lou in West Branch (fig. 5). Two plain slabs of Vermont white marble mark the gravesites, located on a hillside west of the Herbert Hoover Presidential Library and Museum (fig. 1). Designed by Iowa architect William Wagner, the markers not only commemorate Hoover's life but also the Quaker ideal of simplicity.

This simplicity is also illustrated by the Herbert Hoover birthplace cottage (fig. 6). The original foundation for the house was constructed from "boulders from the prairie" (Cary Wiesner, written communication, 16 August 2016). The cottage was moved when R. Portland and Jennie Scellers purchased it in 1889, but when the Hoover family acquired the property in 1934, the cottage was restored to its original location. The cottage now has a poured concrete foundation with a full basement.

The Hoovers purchased land and developed the surrounding area with the objective of inspiring visitors with a re-creation of Hoover's early life. Part of the development included a retaining wall for Hoover Creek. The retaining wall was constructed in 1940 from stones that had once formed the foundation of the blacksmith shop at the abandoned Cedar Valley Quarries, located about 16 km (10 mi) northeast of West Branch. The stone probably came from Cedar Valley (Cary Wiesner, written communication, 16 August 2016).

Herbert Hoover, the first president born west of the Mississippi River and who signed the congressional resolution making The Star Spangled Banner the national anthem, lived what he believed, that anyone could start from simple beginnings and accomplish great things (National Park Service 2016b).

Table 3. National Park Service areas proclaimed, established, authorized, or with boundaries changed during President Herbert Hoover's administration (1929–1933). Table continues on next page.

Park	State	Year	Action*	Comments
Arches National Park	Utah	1929	Proclaimed (NPS)	Redesignated as Arches National Park in 1971.
Holy Cross National Monument	Colorado	1929	Proclaimed (US Forest Service)	Transferred to NPS in 1933. Abolished in 1950, lands returned to US Forest Service administration.
George Washington Birthplace National Monument	Virginia	1930	Established (NPS)	N/A
Sunset Crater National Monument	Arizona	1930	Proclaimed (US Forest Service)	Transferred to NPS in 1933. Renamed Sunset Crater Volcano National Monument in 1990.
George Washington Memorial Parkway	Virginia Maryland Wash. DC	1930	Authorized (Office of Public Buildings and Public Parks of the National Capital)	Transferred to NPS in 1933.
Appomattox Battlefield Site	Virginia	1930	Authorized (War Department)	Transferred to NPS in 1933. Authorized as a national historical monument in 1935. Redesignated as Appomattox Courthouse National Historical Park in 1954.
Colonial National Monument	Virginia	1930	Authorized (NPS)	Redesignated as Colonial National Historical Park in 1936.
Craters of the Moon National Monument	Idaho	1930	Boundary change	Proclaimed in 1924. National preserve designated in 2002.
Aztec Ruins National Monument	New Mexico	1930	Boundary change	Proclaimed in 1928.
Hot Springs National Park	Arkansas	1930 1931	Boundary changes	Established as Hot Springs Reservation in 1832; redesignated in 1921.
Bryce Canyon National Park	Utah	1930 1931	Boundary changes	Proclaimed in 1923.
Rocky Mountain National Park	Colorado	1930 1932	Boundary changes	Established in 1915.
Yosemite National Park	California	1930 1931 1932	Boundary changes	Established as a national park in 1890.
Yellowstone National Park	Wyoming, Montana, Idaho	1930 1932	Boundary changes	Established as world's first national park in 1872.
Carlsbad Caverns National Park	New Mexico	1930 1933	Redesignation; boundary change	Proclaimed as Carlsbad Cave National Monument in 1923. Redesignated to national park from national monument in 1930.

Table 3 (continued). National Park Service areas proclaimed, established, authorized, or with boundaries changed during President Herbert Hoover's administration (1929–1933).

Park	State	Year	Action*	Comments
Canyon de Chelly National Monument	Arizona	1931	Proclaimed (NPS)	N/A
Isle Royale National Park	Michigan	1931	Authorized (NPS)	N/A
Fort Necessity National Battlefield Site	Pennsylvania	1931	Established (War Department)	Transferred to NPS in 1933. Redesignated as Fort Necessity National Battlefield in 1961.
Kings Mountain National Military Park	South Carolina	1931	Established (War Department)	Transferred to NPS in 1933.
Katmai National Monument	Alaska	1931	Boundary change	Proclaimed in 1918. Established as Katmai National Park and Preserve in 1980.
Pinnacles National Monument	California	1931	Boundary change	Proclaimed in 1908. Redesignated as Pinnacles National Park in 2013.
"Second" Grand Canyon National Monument	Arizona	1932	Proclaimed (NPS)	Original Grand Canyon National Monument proclaimed in 1908. National park established in 1919. "Second" monument, and a variety of other lands, incorporated into expanded Grand Canyon National Park in 1975.
Great Sand Dunes National Monument	Colorado	1932	Proclaimed (NPS)	Redesignated as Great Sand Dunes National Park and Preserve in 2000.
Theodore Roosevelt Island	Wash. DC	1932	Authorized (Office of Public Buildings and Public Parks of the National Capital)	Transferred to NPS in 1933.
Bandelier National Monument	New Mexico	1932	Boundary change	Transferred to NPS in 1932 from US Forest Service.
Scotts Bluff National Monument	Nebraska	1932	Boundary change	Proclaimed in 1919.
Waterton-Glacier International Peace Park	Montana	1932	Proclaimed (NPS)	Glacier National Park established in 1910. International Peace Park authorized by US Congress and Canada's Parliament in 1932 to incorporate Glacier and Waterton Lakes national parks.
White Sands National Monument	New Mexico	1933	Proclaimed (NPS)	N/A
Death Valley National Monument	California and Nevada	1933	Proclaimed (NPS)	Redesignated as Death Valley National Park in 1994.
Saguaro National Monument	Arizona	1933	Proclaimed (US Forest Service)	Transferred to NPS in 1933. Redesignated as Saguaro National Park in 1994.
Black Canyon of the Gunnison National Monument	Colorado	1933	Proclaimed (NPS)	Redesignated as Black Canyon of the Gunnison National Park in 1999.
Morristown National Historical Park	New Jersey	1933	Authorized (NPS)	N/A

*National monuments can be created via Presidential Proclamation ("proclaimed") and administered by a variety of agencies; those are listed in the "Action" column (NPS = National Park Service). National Park Service areas can also be authorized or established legislatively by Congress. Major boundary changes (expansions) generally require legislative action.

Information from https://www.nps.gov/articles/herbert-hoovers-national-parks.htm and *The National Parks: Index 2012–2016* ("Redbook"), available at https://www.nps.gov/aboutus/publications.htm.

Figure 5. Gravesite of Herbert Hoover and his wife, Lou. Grave markers are made from Vermont white marble. NPS photograph by Steve Lonergan, available at https://www.nps.gov/heho/learn/historyculture/gravesite.htm (accessed 9 August 2016).

Figure 6. Herbert Hoover birthplace cottage. Local stone was quarried and used to set the foundation upon which the house was built. Both the two-room cottage and the Herbert Hoover Presidential Library-Museum (across the creek, behind the trees) lie in the floodplain of Hoover Creek. Figure 1 shows the course of Hoover Creek though the historic site. NPS photograph by John Eicher, available online: http://www.nps.gov/heho/learn/historyculture/birthplace.htm (accessed 23 August 2015).

Geologic Features, Processes, and Resource Management Issues

These geologic features and processes are significant to the historic site's landscape and history. Some geologic features, processes, or human activities may require management for human safety, protection of infrastructure, and preservation of natural and cultural resources.

During the 2011 scoping meeting (see Graham 2011), participants identified the following geologic features and processes in the park (table 4).

- Fluvial (river) deposits exposed along the banks of Hoover Creek.
- Loess deposited on upland divides, ridge tops, and side slopes.
- Till deposited during the Pleistocene ice ages.

Scoping meeting participants also identified resource management issues associated with the bank instability of Hoover Creek. These issues included (table 4):

- Slumping and an increased sediment load in the stream.
- Incision of Hoover Creek's channel.
- Runoff and seasonal flooding that accelerates bank erosion.
- Damage to known Euro American archeological sites from the late 19th and early 20th centuries and potential American Indian sites that have yet to be found.

Geologic Resource Management

The Geologic Resources Division provides technical and policy support for geologic resource management issues surrounding geologic heritage, active processes and hazards, and energy and minerals management. Contact the division (http://go.nps.gov/geology) for assistance with resource inventories, assessments and monitoring; impact mitigation, restoration, and adaptation; hazards risk management; law, policy, and guidance; resource management planning; data and information management; and outreach and youth programs (Geoscientists-in-the-Parks and Mosaics in Science).

Resource managers may find *Geological Monitoring* (Young and Norby 2009; http://go.nps.gov/geomonitoring) useful for addressing geologic resource

Table 4. Geologic map unit properties.

Map Unit (symbol)	Features and Processes	Potential Resource Management Issues
DeForest Formation (**Qal**)	**Fluvial Features** Massive to weakly stratified deposits resulting from overbank flooding and sedimentation within the creek channel.	**Incision of Hoover Creek and Seasonal Flooding** Agricultural practices, residential and commercial development, and seasonal flooding have resulted in bank instability, increased runoff, and severe incision of Hoover Creek's channel (figs. 7 and 8). **Slumping and Increased Sediment Load** Incision has steepened and undercut stream banks, causing slumping and an increased sediment load in the stream (fig. 8). A drain tile, installed in 1994, is now exposed and part of it has collapsed into the creek (fig. 9). **Damage to known Euro American archeological sites** Known archeological sites along the stream may be damaged by channel incision and associated bank erosion.
Peoria Formation (**Qps**)	**Eolian (wind) Features** Loess (silt deposited by wind).	**Abandoned Mineral Lands** A borrow pit excavated into a side hill on the Thompson Farm in the western edge of the historic site has been abandoned and overgrown with grasses (fig. 10). About 2 m (7 ft) of loess is exposed in the pit.
Wolf Creek or Alburnett formations (**Qwa3**)	**Glacial Features** Unconsolidated sediment deposited by glaciers (till).	**Bank Instability, Incision, and Erosion** Poor drainage resulting from clay and silt in the till may contribute to increased runoff, incision of Hoover Creek, and flooding.

management issues. The manual provides guidance for monitoring vital signs—measurable parameters of the overall condition of natural resources. Each chapter covers a different geologic resource and includes detailed recommendations for resource managers, suggested methods of monitoring, and case studies.

Resource Management Guidance for Geologic Features and Processes

The east-central Iowa landscape of rolling hills and river channels, as well as the world-renowned Iowa soils, owe their origin to the Pleistocene ice ages, soil-forming processes, and drainage networks that developed during the Quaternary Period. Glacial debris, wind, and stream flow combined to form the eolian, fluvial, and glacial features in Herbert Hoover National Historic Site. Fossiliferous limestone fragments and petrified wood found at the site suggest the potential for additional paleontological resources.

Eolian Resources

Eolian processes refer to wind-blown erosion, transportation, and deposition of sediments (Lancaster 2009). Features created by eolian processes include depositional landforms and deposits such as dunes, loess, sand sheets, as well as erosional forms such as desert pavement, yardangs, and ventifacts. In the Herbert Hoover National Historic Site area, loess is the primary feature associated with eolian processes. The NPS Geologic Resources Division Aeolian Resource Monitoring website, http://go.nps.gov/monitor_aeolian (accessed 24 April 2017), provides additional information.

Fluvial Geomorphology

In the *Geological Monitoring* chapter about fluvial geomorphology, Lord et al. (2009) described methods for inventorying and monitoring geomorphology-related vital signs, including: (1) watershed landscape (vegetation, land use, surficial geology, slopes, and hydrology), (2) hydrology (frequency, magnitude, and duration of stream flow rates), (3) sediment transport (rates, modes, sources, and types of sediment), (4) channel cross section, (5) channel planform, and (6) channel longitudinal profile. These methods may be utilized on any size of river or stream, from large rivers such as the Mississippi to creeks as small as Hoover Creek.

Figure 7. Hoover Creek flood waters in 2008. Compare the size of the creek in this image to that of figure 4. National Park Service photograph.

The Iowa Geological Survey at the University of Iowa, http://www.iihr.uiowa.edu/igs/ (accessed 24 April 2017), and the Iowa Water Center, http://www.water.iastate.edu/ (accessed 24 April 2017), headquartered at Iowa State University, encourages interdisciplinary water research, education, and outreach that addresses Iowa's water resources.

Glacial Deposits and Erosional Features

The massive continental ice sheets that flowed from the Arctic into Iowa during the Pleistocene Epoch (2 million to approximately 20,000 years ago) scoured and reshaped the landscape. In general, glacial deposits and features include those created or carved by glaciers, those deposited by rivers flowing beneath or out of glaciers ("glaciofluvial"), or deposited in lakes near glaciers ("glaciolacustrine"). In the Herbert Hoover National Historic Site, glacial deposits of till form the primary record of glacial advances into the area.

Paleontological Resources

Herbert Hoover National Historic Site is one of 267 NPS areas with paleontological resources (as of July 2017). Paleontological resources (fossils) are any evidence of life preserved in a geologic context (Santucci et al. 2009). Body fossils are any remains of the actual organism such as bones, teeth, shells, or leaves. Trace fossils are evidence of biological activity; examples include burrows, tracks, or coprolites (fossil dung). Fossils in NPS areas occur in rocks or unconsolidated deposits, museum collections, and cultural contexts such as building stones or archeological resources. Paleontological resources collected at Herbert Hoover National Historic Site include the piece of petrified wood and fragments of fossiliferous limestone. The NPS Fossils and Paleontology website, http://go.nps.gov/fossils_and_paleo (accessed 24 April 2017), provides more information.

Slumping and Slope Movements

Slope movements are the downslope transfer of soil, regolith, and/or rock under the influence of gravity. In Herbert Hoover National Historic Site, slope movements are concentrated in Hoover Creek where incision has led to slumping of bank material into the creek (figs. 8 and 9). In other NPS units, soil creep, rockfalls, debris flows, and avalanches are common types of slope movements. These processes and the resultant deposits are also known as "mass wasting" and commonly grouped as "landslides." Slope movements occur on time scales ranging from seconds to years and may create geologic hazards and associated risk in many parks.

Resource Management Guidance for Potential Geological Issues

The primary resource management issues in the park include seasonal flooding of Hoover Creek and Hoover Creek bank instability. Channel incision encourages slumping and potential damage to known archeological sites. The borrow pit in the western section of the historic site should be added to the Abandoned Mineral Lands (AML) database, but the pit

Figure 8. Incision of Hoover Creek has resulted in slumping and bank collapse. Incision has exposed the dark gray Roberts Creek Member and the underlying yellowish Gunder Member of the DeForest Formation. Geologists for scale. Photograph by John Graham (Colorado State University).

Figure 9. Erosion and incision has undercut the bank and exposed a previously buried drain tile, causing part of it to collapse into the creek. Photograph by John Graham (Colorado State University).

poses an insignificant issue for resource management. Paleontological resource issues may become more significant if future excavations occur.

Hoover Creek Bank Instability and Seasonal Flooding

The National Park Service's *Final Hoover Creek Stream Management Plan and Environmental Impact Statement* (2006) recommended five alternatives designed to reduce the impacts of periodic high flows, to restore Hoover Creek to a more historic appearance, and to restore the functional characteristics of the stream. The preferred alternative includes the construction of a storm water detention basin that would protect the historic site from a 50–year flood event and the installation of waterproof door shields to protect the Visitor Center. While planning for such infrastructure, the park should consult NPS planning documents including Director's Orders 77–1 (Wetland Protection) and 77–2 (Floodplain Management), as well as the other laws, regulations, and policies listed in Appendix B and available at https://www.nps.gov/applications/npspolicy/index.cfm (accessed 29 March 2016).

Relatively small scale slope movements occur along the channel of Hoover creek (figs. 8 and 9) and are unlikely to impact visitor safety. However, they could damage cultural resources.

Channel morphology and rates of change may be quantified using repeat photography at designated photo points. Refer to http://go.nps.gov/grd_photogrammetry for information about using photogrammetry for resource management.

Abandoned Mineral Lands

Abandoned mineral lands are lands, waters, and surrounding watersheds that contain facilities, structures, improvements, and disturbances associated with past mineral exploration, extraction, processing, and transportation, including oil and gas features and operations, for which the NPS takes action under various authorities to mitigate, reclaim, or restore in order to reduce hazards and impacts to resources.

In larger NPS units, AML features may pose a variety of resource management issues such as visitor and staff

Figure 10. Vegetation has overgrown an abandoned borrow pit on the Thompson Farm. Loess from this small pit was used for fill. Park ranger for scale. Photograph by John Graham (Colorado State University).

safety and environmental quality of air, water, and soil. According to the NPS AML database and Burghardt et al. (2014), Herbert Hoover National Historic Site does not contain any AML features. The National Park Service considers abandoned borrow pits to be AML features. Although no resource impacts or hazards are currently documented at the borrow pit within the park, park staff should consider documenting the feature in the NPS AML database. Refer to Burghardt et al. (2014) and http://go.nps.gov/grd_aml for information about AML in the National Park System, as well as a comprehensive inventory of sites, features, and mediation needs.

Paleontological Resource Inventory, Monitoring, and Protection

All paleontological resources are non-renewable and subject to science-informed inventory, monitoring, protection, and interpretation as outlined by the 2009 Paleontological Resources Preservation Act (see Appendix B). As of July 2017, Department of the Interior regulations associated with the Act were being finalized.

Currently, the paleontological resources at Herbert Hoover National Historic Site consist of a piece of petrified wood and two limestone fragments containing invertebrate fossils. However, any further excavations at the site may uncover additional fossil resources, which should be documented.

In the *Geological Monitoring* chapter about paleontological resources, Santucci et al. (2009) described five methods and vital signs for monitoring in situ paleontological resources: (1) erosion (geologic factors), (2) erosion (climatic factors), (3) catastrophic geohazards, (4) hydrology/bathymetry, and (5) human access/public use.

Geologic History

This chapter describes the chronology of geologic events that formed the present landscape.

530 Million to 300 Million Years Ago (Paleozoic Era): Life in an Ancient Ocean

Although currently located approximately 1,500 km (950 mi) from the nearest ocean, Herbert Hoover National Historic Site was once inundated by extensive, shallow seas that covered most of what is now North America (fig. 11). From approximately 530 million to 300 million years ago, throughout most of the Paleozoic Era, sediments were deposited in marine and shoreline environments that advanced and retreated across Iowa as relative sea level rose and fell. These sediments eventually lithified into the sandstone, limestone, and dolomite that now form the bedrock beneath the state. At the time, Iowa was located south of the Equator (fig. 11), and the invertebrate marine fossils such as trilobites, brachiopods, corals, and crinoids found in the rocks attest to a warm, subtropical environment that resembled today's Caribbean climate.

When sea level fell, erosion stripped many rock units from Iowa. For example, beneath Herbert Hoover National Historic Site, the bedrock surface consists of Silurian rocks that formed approximately 430 million to 420 million years ago (geologic map units **Sg** and **Ss**) and Devonian rocks deposited approximately 397 million to 390 million years ago (**Dw**). Although younger Paleozoic rocks (and even Mesozoic rocks) can be found in other parts of Iowa, they have been eroded from the Herbert Hoover region as a result of millions of years of subaerial exposure.

No bedrock is exposed in Herbert Hoover National Historic Site. The surface of the Scotch Grove Formation (**Ss**), the oldest unit mapped from the GRI GIS data, lies about 69 m (225 ft) beneath the historic site. Deposited approximately 430 million to 426 million years ago during the Early Silurian Period, the Scotch Grove Formation contains a variety of carbonate rocks including flat-lying, sparsely fossiliferous, cherty dolomites and dolomitized carbonate buildups, or mounds. These carbonate mounds are reef-like structures containing a core of carbonate mud and an assortment of skeletal debris and molds from crinoids, corals, and stromatoporoids, an extinct class of marine sponges (Witzke 1981).

The overlying Gower Formation (**Sg**) consists of both flat-lying, very thin layers (laminations) of dolomite and carbonate buildups similar to those in the Scotch Grove Formation. However, while the Scotch Grove mounds are dominated by echinoderm fossils (primarily crinoids), the mounds in the Gower Formation contain abundant brachiopod fossils. Sedimentary structures and a dearth of fossils suggest that the laminated, flat-lying dolomite was deposited in a subtidal, hypersaline environment. The fossiliferous mounds originated in shallow water that maintained open marine circulation conducive to a rich variety of benthic organisms. The formation represents a time when relative sea level fell, leaving a marine embayment in east-central Iowa (fig. 11; Witzke 1981).

Sea level continued to fall, and subaerial exposure resulted in erosion and the creation of an extensive unconformity, or gap, in the stratigraphic succession between the Gower Formation and the Middle Devonian Wapsipinicon Group (**Dw**). A water well drilled in West Branch in 1969 encountered the Wapsipinicon Group at a depth of 30 m (100 ft). The Wapsipinicon Group in Iowa consists of three formations. From oldest to youngest, the formations include the Bertram Formation, which is restricted to a small area in east-central Iowa that adjoins northwestern Illinois, the Otis Formation, and the Pinicon Ridge Formation (Witzke and Bunker 2006).

Carbonate strata in the Otis Formation contain normal marine fauna, including brachiopods, trilobites, corals, and stromatoporoids. The marine fauna indicate a transgression in which sea level rose and Devonian seas entered eastern Iowa (fig. 11; Witzke et al. 1988). Following deposition of the Otis Formation, sea level fell again and an episode of erosion and carbonate dissolution formed a karst surface upon which the Pinicon Ridge Formation was deposited. East-central Iowa remained located in the tropics, so that evaporitic conditions resulted in thick deposits of gypsum and anhydrite. Subsurface, economic deposits of gypsum have been mined near Sperry, Iowa (Witzke et al. 1988).

In general, the Pinicon Ridge Formation represents highly restricted environments of deposition

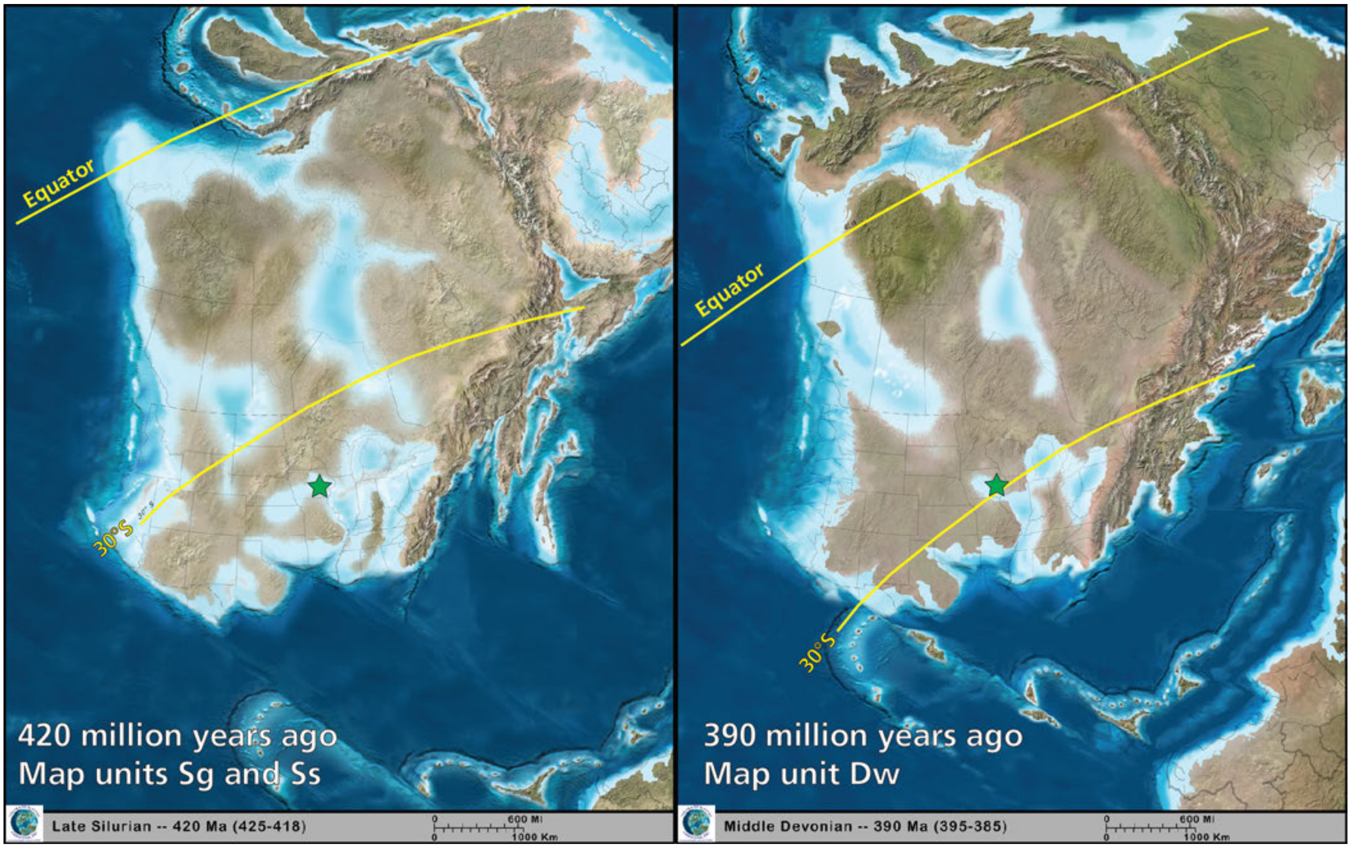

Figure 11. Silurian (left) and Devonian (right) paleogeographic maps of North America. Shallow seas inundated the area of Herbert Hoover National Historic Site (green star) during both time periods. The yellow lines denote the equator and 30°S latitude. Basemaps are "North American Key Time Slices" © 2013 Colorado Plateau Geosystems, Inc; used under license. Refer to http://deeptimemaps.com/ for additional information.

that formed when sea level fell and the shoreline retreated from the region (regression). The lack of invertebrate fossils, such as those common to the Otis Formation, the presence of burrows, and the occurrence of stromatolites and ostracods, typically found in restricted environments, record deposition within a basin of elevated salinity. Organic-rich layers indicate environments that lacked oxygen and the microorganisms that typically decompose organic material. When freshly broken, the organic-rich units emit a distinctive fetid odor (Witzke and Bunker 2006).

The Wapsipinicon Group (**Dw**) forms the youngest bedrock unit beneath Herbert Hoover National Historic Site, but roughly 1 km (0.6 mi) southeast of the monument, the younger Middle-to-Upper Devonian Cedar Valley Group forms the bedrock surface at a depth of approximately 61–69 m (200–225 ft). The northeast-to-southwest trending Iowa City–Clinton Fault Zone (fig. 12 and map poster [in pocket]) separates the Wapsipinicon Group from Cedar Valley Group strata (fig. 12). The fault is mapped on the GRI GIS bedrock map. This fault zone parallels the Amana–Plum River Fault Zone, located approximately 27 km (17 mi) north of Herbert Hoover National Historic Site. When the faults were active, strata on the south side of the faults moved down relative to strata on the north side of the faults, juxtaposing younger strata against older rocks. The faults are currently not active.

Bedding surfaces of the Cedar Valley Group exposed in the Devonian Fossil Gorge display a variety of invertebrate marine fossils, including stromatoporoids, solitary and colonial corals, brachiopods, crinoids, cephalopods, trilobites, bryozoans, placoderms (primitive fish), and worm burrows. The fossil communities thrived in normal, well-circulated marine water and represent another transgressive episode.

2.6 Million to 500,000 Years Ago (Pleistocene Epoch): Blanketed by Ice

Beneath Herbert Hoover National Historic Site, the

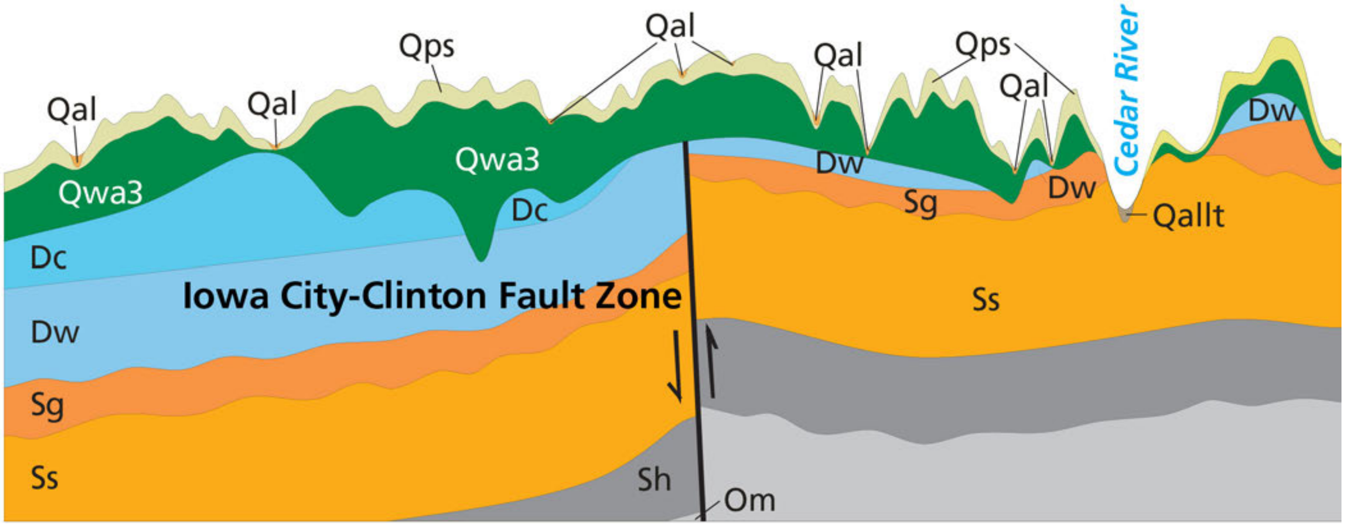

Figure 12. Schematic north-south cross section showing the Iowa City-Clinton Fault. North is to the right of the figure and total thickness is approximately 150 m (500 ft). The fault does not displace Qwa3, indicating that the fault has been inactive for at least the last approximately 790,000 years. Rocks north of the fault (on the right side) have moved up relative to those south of the fault, juxtaposing older Silurian rocks (e.g., Ss and Sg) against younger Devonian rocks (e.g., Dw and Dc). Note the thick mantle of Quaternary units atop the Paleozoic bedrock units. Colors correspond to those on the GRI map posters (in pocket). The approximate location of this cross section is also indicated on the posters. Redrafted by Jason Kenworthy (NPS Geologic Resources Division) from cross section C–D in Quade et al. (2008). A snapshot of the full cross section is available in the GRI GIS data (heho_geology.pdf).

unconformity between till and the Wapsipinicon Group represents approximately 390 million years of missing stratigraphic record. This extended period of non-deposition and erosion produced the irregular bedrock topography buried beneath most of Iowa's landscape today. During the early and middle Pleistocene Epoch (about 2.6 million years ago to 500,000 years ago), glaciers flowed across Iowa and into Missouri, and upon melting, left thick deposits of glacial debris (till) on the eroded bedrock surface (fig. 13; Mickelson and Colgan 2004; Roy et al. 2004; Bettis III et al. 2010).

The unconsolidated, Pre-Illinoian Alburnett and Wolf Creek formations (**Qwa3**) include multiple tills and paleosols (old soils) that record several glacial and interglacial episodes. The formations also display contrasting magnetic polarities (Bettis III et al. 2010). Earth's geomagnetic field reverses at random intervals ranging from 100,000 years to 50 million years. The Bruhnes–Matuyama reversal, named for the scientists who discovered it, is the most recent magnetic reversal, occurring about 790,000 years ago. Because sediments in the Alburnett Formation record reversed polarity, deposition must have occurred over 790,000 years ago. In contrast, the Wolf Creek Formation records today's "normal" polarity, meaning its sediments are younger than approximately 781,000 years (Hallberg et al. 1980; Hallberg et al. 1984; Kemmis et al. 1992; Bettis III et al. 2010).

The lobe of the most recent continental glacier associated with the Wisconsin glaciation, which ended about 12,000 years ago in Iowa, flowed as far south as Des Moines, Iowa, but did not extend as far east as Herbert Hoover National Historic Site. Loess originating from this Des Moines Lobe formed the thin, grayish brown Pisgah Formation and the younger Peoria Formation (**Qps**). Peoria Formation loess accumulated from about 23,000 years to approximately 11,000 years before present, with rapid deposition occurring from about 21,000 to 16,000 years ago during the coldest and driest portion of the late Wisconsin glacial period (Bettis III et al. 2010).

The Past 10,500 Years (Holocene Epoch): After the Ice

Over the last approximately 10,500 years, downcutting and headward extension of drainage systems have been the main processes modifying Iowa's landscape. The alluvial and valley fill sediments of the DeForest Formation (**Qal**) provide information on the changing Holocene paleoclimate and paleoenvironment (Bettis III et al. 1992).

Figure 13. Pleistocene paleogeographic map of North America showing the approximate glacial extent during the ice ages. Continental ice sheets advanced from the northern latitudes and alpine glaciers formed in the mountains. The green star denotes the approximate location of Herbert Hoover National Historic Site. The yellow lines denote the equator, 30°N, and 60°N latitude. Basemap is from "North American Key Time Slices" © 2013 Colorado Plateau Geosystems, Inc; used under license. Refer to http://deeptimemaps.com/ for additional information.

Geologic Map Data

A geologic map in GIS format is the principal deliverable of the GRI program. GRI GIS data produced for the park follows the source maps and includes components listed here. Posters (in pocket) display the data over imagery of the historic site and surrounding area. Complete GIS data are available at the GRI publications website: http://go.nps.gov/gripubs.

Geologic Maps

Geologic maps facilitate an understanding of an area's geologic framework and the evolution of its present landscape. Using designated colors and symbols, these maps portray the spatial distribution and temporal relationships of rocks and unconsolidated deposits. The American Geosciences Institute website, http://www.americangeosciences.org/environment/publications/mapping, provides more information about geologic maps and their uses.

Source Maps

The GRI team digitizes paper maps and converts digital data to conform to the GRI GIS data model. The GRI digital geologic map product includes essential elements of the source maps such as map unit descriptions, a correlation chart of units, a map legend, map notes, cross sections, figures, and references. The GRI team used the following sources to produce the digital geologic data set for Herbert Hoover National Historic Site. These sources also provided information for this report.

Quade, D. J., S. Tassier-Surine, J. D. Giglierano, and E. A. Bettis III. 2008. Surficial geology of Cedar County, Iowa final phase: surficial geologic map of Cedar County (scale 1:100,000). Open-File Map OFM-08-8. Iowa Geological Survey, Iowa City, Iowa.

Witzke, B. J., and R. R. Anderson. 2008. Final phase: bedrock geologic map of Cedar County (scale 1:100,000). Open File Map OFM-08-7. Iowa Geological Survey, Iowa City, Iowa.

GRI GIS Data

The GRI team implements a GIS data model that standardizes map deliverables. The data model is available at http://go.nps.gov/gridatamodel. This data model dictates GIS data structure, including layer architecture, feature attribution, and relationships within ESRI ArcGIS software. The GRI team digitized the data for the park using data model version 2.1. The GRI Geologic Maps website, http://go.nps.gov/geomaps, provides more information about GRI map products.

GRI GIS data are available on the GRI publications website http://go.nps.gov/gripubs and through the NPS Integrated Resource Management Applications (IRMA) portal https://irma.nps.gov/App/Portal/Home. Enter "GRI" as the search text and select a park from the unit list. The following components are part of the data set:

- A GIS readme file (heho_gis_readme.pdf) that describes the GRI data formats, naming conventions, extraction instructions, use constraints, and contact information;
- Data in ESRI geodatabase GIS format;
- Layer files with feature symbology (table 5);
- Federal Geographic Data Committee (FGDC)–compliant metadata;
- An ancillary map information document (heho_geology.pdf) that contains information captured from source maps such as map unit descriptions, geologic unit correlation tables, legends, cross-sections, and figures;
- ESRI map documents that displays the surficial (heho_geology.mxd) and bedrock (hhbr_geology.mxd) GRI GIS data; and
- A KML/KMZ version of the data viewable in Google Earth (table 5).

GRI Map Posters

Posters of the bedrock and surficial GRI GIS data draped over shaded relief images of the historic site and surrounding area are included with this report. Not all GIS feature classes are included on the posters (table 5). Geographic information and selected park features have been added to the posters. Digital elevation data and added geographic information are not included in the GRI GIS data, but are available online from a variety of sources. Contact GRI for assistance locating these data..

Use Constraints

Graphic and written information provided in this report is not a substitute for site-specific investigations. Ground-disturbing activities should neither be

Table 5. GRI GIS data layers for Herbert Hoover National Historic Site.

Data Layer	On Poster?	Google Earth Layer?
Surficial: Mine Point Features (drill holes)	Yes	No
Surficial: Eolian Sand Deposit Boundaries	Yes	Yes
Surficial: Surficial Contacts	No	Yes
Surficial: Eolian Sand Deposits	Yes	Yes
Surficial: Surficial Units	Yes	Yes
Bedrock: Faults	Yes	Yes
Bedrock: Geologic Contacts	Yes	Yes
Bedrock: Geologic Units	Yes	Yes

permitted nor denied based upon the information provided here. Please contact the GRI team with any questions.

Minor inaccuracies may exist regarding the locations of geologic features relative to other geologic or geographic features on the poster. Based on the source map scales (1:100,000) and US National Map Accuracy Standards, geologic features represented in the GRI GIS data are expected to be horizontally within 51 m (167 ft) of their true locations.

Literature Cited

These references are cited in this report. Contact the Geologic Resources Division for assistance in obtaining them.

Bettis III, E. A., R. G. Baker, W. R. Green, M. K. Whelan, and D. W. Benn. 1992. Late Wisconsinan and Holocene alluvial stratigraphy, paleoecology, and archaeological geology of east-central Iowa. Guidebook 12. Iowa Geological & Water Survey, Iowa City, Iowa.

Bettis III, E. A., S. Tassier-Surine, and D. J. Quade. 2010. Quaternary geology of the Iowa City area. Pages 143–161 in T. Marshall and C. L. Fields, editors. The geology of Klein and Conklin quarries, Johnson County, Iowa. Guidebook 87. Geological Society of Iowa, Iowa City, Iowa.

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Additional References

This section lists additional references, resources, and websites that may be of use to resource managers. Web addresses are valid as of February 2017. Refer to Appendix B for laws, regulations, and policies that apply to NPS geologic resources.

Geology of National Park Service Areas

- NPS Geologic Resources Division—*Energy and Minerals, Active Processes and Hazards, and Geologic Heritage*: http://go.nps.gov/geology/
- NPS Geologic Resources Inventory: http://go.nps.gov/gri
- NPS Geoscientist-In-the-Parks (GIP) internship and guest scientist program: http://go.nps.gov/gip
- NPS Views program (geology-themed modules are available for Geologic Time, Paleontology, Glaciers, Caves and Karst, Coastal Geology, Volcanoes, and a variety of geologic parks): http://go.nps.gov/views

NPS Resource Management Guidance and Documents

- 1998 National Parks Omnibus Management Act: http://www.gpo.gov/fdsys/pkg/PLAW-105publ391/pdf/PLAW-105publ391.pdf
- Geologic monitoring manual: http://go.nps.gov/geomonitoring
- Management Policies 2006 (Chapter 4: Natural resource management): http://www.nps.gov/policy/mp/policies.html
- NPS-75: Natural resource inventory and monitoring guideline: http://www.nature.nps.gov/nps75/nps75.pdf
- NPS Natural resource management reference manual #77: http://www.nature.nps.gov/Rm77/
- NPS Technical Information Center (TIC) (Denver, Colorado; repository for technical documents): http://www.nps.gov/dsc/technicalinfocenter.htm http://etic.nps.gov/

Climate Change Resources

- NPS Climate Change Response Program Resources: http://www.nps.gov/subjects/climatechange/resources.htm
- US Global Change Research Program: http://globalchange.gov/home
- Intergovernmental Panel on Climate Change: http://www.ipcc.ch/

Geological Surveys and Societies

- Iowa Geological Survey: http://www.iihr.uiowa.edu/igs/
- US Geological Survey: http://www.usgs.gov/
- USGS Publications: http://pubs.er.usgs.gov/
- Geological Society of America: http://www.geosociety.org/
- American Geophysical Union: http://sites.agu.org/
- American Geosciences Institute: http://www.americangeosciences.org/
- Association of American State Geologists: http://www.stategeologists.org/

US Geological Survey Reference Tools

- Geologic glossary (simplified definitions): http://geomaps.wr.usgs.gov/parks/misc/glossarya.html
- Geologic names lexicon (Geolex; geologic unit nomenclature and summary): http://ngmdb.usgs.gov/Geolex/geolex_home.html
- Geographic names information system (GNIS; official listing of place names and geographic features): http://gnis.usgs.gov/
- GeoPDFs (download searchable PDFs of any topographic map in the United States): http://store.usgs.gov (click on "Map Locator")
- National geologic map database (NGMDB): http://ngmdb.usgs.gov/
- Publications warehouse (many publications available online): http://pubs.er.usgs.gov

Appendix A: Scoping Participants

The following people attended the GRI scoping meeting for Herbert Hoover National Historic Site, held on 17 June 2011. Discussions during this meeting supplied a foundation for this GRI report. The scoping summary document is available on the GRI publications website: http://go.nps.gov/gripubs.

2011 Scoping Meeting Participants

Name	Affiliation	Position
Ray Anderson	Iowa Geological and Water Survey	Geologist
Andrea Croskrey	NPS Geologic Resources Division	Geologist/GIS Analyst
Michael Edwards	NPS Herbert Hoover National Historic Site	Gardener
John Graham	Colorado State University	Geologist and GRI Report Writer
Bruce Heise	NPS Geologic Resources Division	Geologist and GRI Program Coordinator
John Holding	NPS Herbert Hoover National Historic Site	Biological Technician
Daris Honemann	NPS Herbert Hoover National Historic Site	Maintenance Mechanic
Mari Mathews	NPS Herbert Hoover National Historic Site	Administration
Deb Patty	NPS Herbert Hoover National Historic Site	Administration
Deborah Quade	Iowa Geological and Water Survey	Supervisor and Geologist GW
Pete Swisher	NPS Herbert Hoover National Historic Site	Superintendent
Stephanie Tassier-Surine	Iowa Geological and Water Survey	Geologist
Cary Wiesner	NPS Herbert Hoover National Historic Site	Historian

Appendix B: Geologic Resource Laws, Regulations, and Policies

The NPS Geologic Resources Division developed this table to summarize laws, regulations, and policies that specifically apply to National Park Service minerals and geologic resources. The table does not include laws of general application (e.g., Endangered Species Act, Clean Water Act, Wilderness Act, National Environmental Policy Act, or National Historic Preservation Act). The table does include the NPS Organic Act when it serves as the main authority for protection of a particular resource or when other, more specific laws are not available. Information is current as of August 2016. Contact the NPS Geologic Resources Division for detailed guidance.

Resource	Resource-specific Laws	Resource-specific Regulations	2006 Management Policies
Paleontology	**National Parks Omnibus Management Act of 1998, 16 USC § 5937** protects the confidentiality of the nature and specific location of paleontological resources and objects. **Paleontological Resources Preservation Act of 2009, 16 USC § 470aaa et seq.** provides for the management and protection of paleontological resources on federal lands.	**36 CFR § 2.1(a)(1)(iii)** prohibits destroying, injuring, defacing, removing, digging or disturbing paleontological specimens or parts thereof. **Prohibition in 36 CFR § 13.35** applies even in Alaska parks, where the surface collection of other geologic resources is permitted. DOI regulations in association with 2009 PRPA are being finalized (July 2017).	**Section 4.8.2** requires NPS to protect geologic features from adverse effects of human activity. **Section 4.8.2.1** emphasizes Inventory and Monitoring, encourages scientific research, directs parks to maintain confidentiality of paleontological information, and allows parks to buy fossils only in accordance with certain criteria.
Rocks and Minerals	**NPS Organic Act, 16 USC § 1 et seq.** directs the NPS to conserve all resources in parks (including rock and mineral resources), unless otherwise authorized by law.	**36 CFR § 2.1** prohibits possessing, destroying, disturbing mineral resources… in park units. **Exception: 36 CFR § 13.35** allows some surface collection of rocks and minerals in some Alaska parks (not Klondike Gold Rush, Sitka, Denali, Glacier Bay, or Katmai) by non-disturbing methods (e.g., no pickaxes), which can be stopped by superintendent if collection causes significant adverse effects on park resources and visitor enjoyment.	**Section 4.8.2** requires NPS to protect geologic features from adverse effects of human activity.
Park Use of Sand and Gravel	**Materials Act of 1947, 30 USC § 601** does not authorize the NPS to dispose of mineral materials outside of park units.	None applicable.	**Section 9.1.3.3** clarifies that only the NPS or its agent can extract park-owned common variety minerals (e.g., sand and gravel), and: -only for park administrative uses; -after compliance with NEPA and other federal, state, and local laws, and a finding of non-impairment; -after finding the use is park's most reasonable alternative based on environment and economics; -parks should use existing pits and create new pits only in accordance with park-wide borrow management plan; -spoil areas must comply with Part 6 standards; and -NPS must evaluate use of external quarries. Any deviation from this policy requires a written waiver from the Secretary, Assistant Secretary, or Director.

Resource	Resource-specific Laws	Resource-specific Regulations	2006 Management Policies
Upland and Fluvial Processes	**Rivers and Harbors Appropriation Act of 1899, 33 USC § 403** prohibits the construction of any obstruction on the waters of the United States not authorized by Congress or approved by the USACE. **Clean Water Act 33 USC § 1342** requires a permit from the USACE prior to any discharge of dredged or fill material into navigable waters (waters of the US [including streams]). **Executive Order 11988** requires federal agencies to avoid adverse impacts to floodplains. (see also **D.O. 77-2**) **Executive Order 11990** requires plans for potentially affected wetlands (including riparian wetlands). (see also **D.O. 77-1**)	None applicable.	**Section 4.1** requires NPS to manage natural resources to preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities; maintain all components and processes of naturally evolving park ecosystems. **Section 4.1.5** directs the NPS to re-establish natural functions and processes in human-disturbed components of natural systems in parks, unless directed otherwise by Congress. **Section 4.4.2.4** directs the NPS to allow natural recovery of landscapes disturbed by natural phenomena, unless manipulation of the landscape is necessary to protect park development or human safety. **Section 4.6.4** directs the NPS to (1) manage for the preservation of floodplain values; [and] (2) minimize potentially hazardous conditions associated with flooding. **Section 4.6.6** directs the NPS to manage watersheds as complete hydrologic systems and minimize human-caused disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams. **Section 4.8.1** directs the NPS to allow natural geologic processes to proceed unimpeded. Geologic processes…include… erosion and sedimentation…processes. **Section 4.8.2** directs the NPS to protect geologic features from the unacceptable impacts of human activity while allowing natural processes to continue.

Resource	Resource-specific Laws	Resource-specific Regulations	2006 Management Policies
Soils	**Soil and Water Resources Conservation Act, 16 USC §§ 2011–2009** provides for the collection and analysis of soil and related resource data and the appraisal of the status, condition, and trends for these resources. **Farmland Protection Policy Act, 7 USC § 4201 et. seq**. requires NPS to identify and take into account the adverse effects of Federal programs on the preservation of farmland; consider alternative actions, and assure that such Federal programs are compatible with State, unit of local government, and private programs and policies to protect farmland. NPS actions are subject to the FPPA if they may irreversibly convert farmland (directly or indirectly) to nonagricultural use and are completed by a Federal agency or with assistance from a Federal agency. Applicable projects require coordination with the Department of Agriculture's Natural Resources Conservation Service (NRCS).	**7 CFR Parts 610 and 611** are the US Department of Agriculture regulations for the Natural Resources Conservation Service. Part 610 governs the NRCS technical assistance program, soil erosion predictions, and the conservation of private grazing land. Part 611 governs soil surveys and cartographic operations. The NRCS works with the NPS through cooperative arrangements.	**Section 4.8.2.4** requires NPS to -prevent unnatural erosion, removal, and contamination; -conduct soil surveys; -minimize unavoidable excavation; and -develop/follow written prescriptions (instructions).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 432/139243, July 2017

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

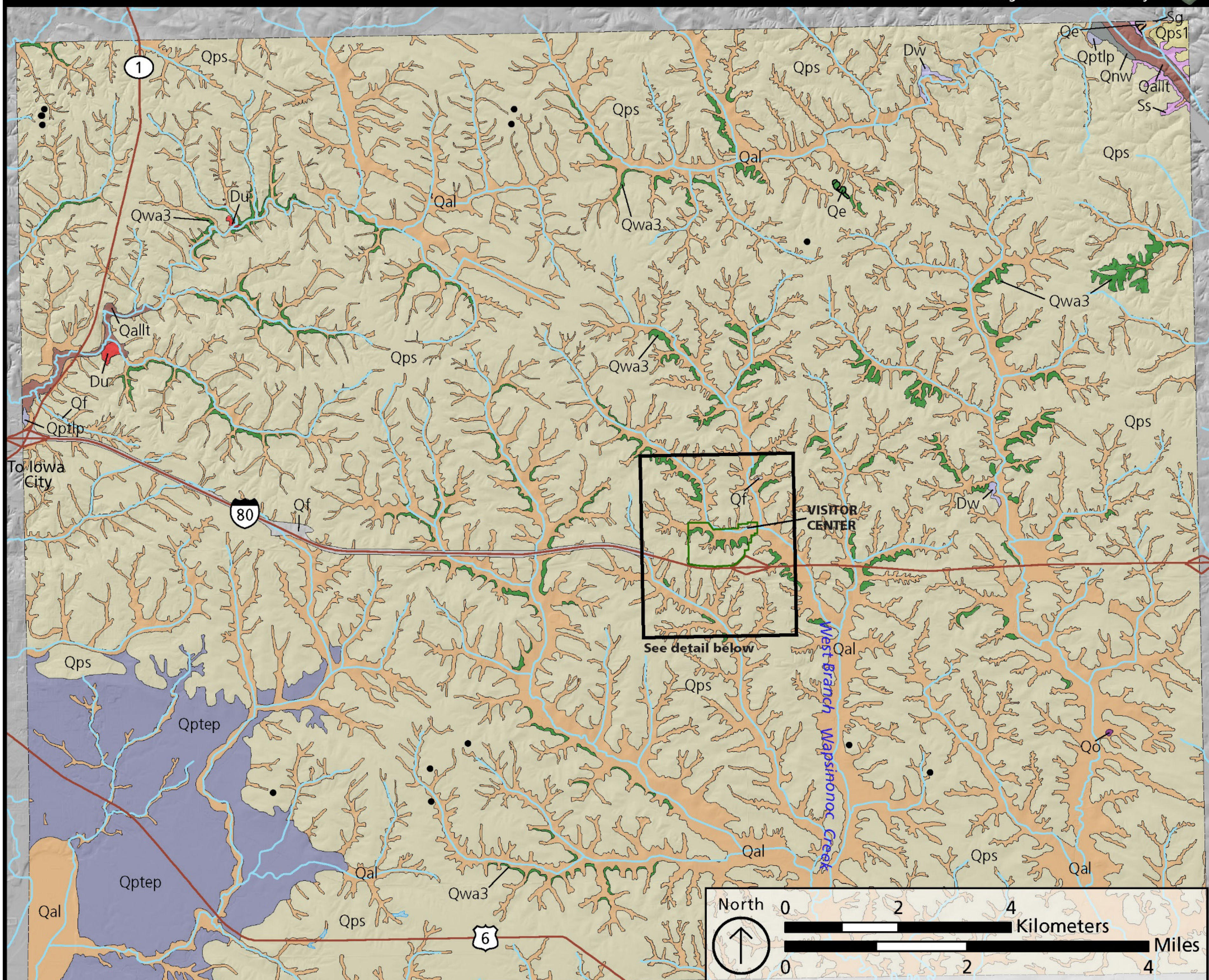
EXPERIENCE YOUR AMERICA™

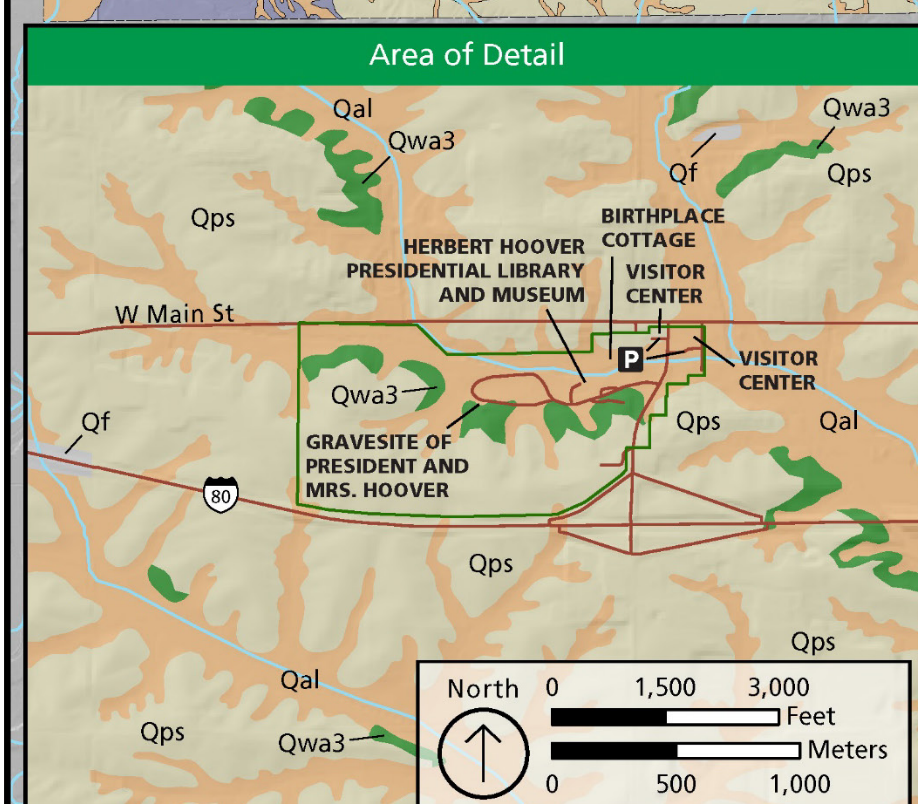
Surficial Geologic Map of Herbert Hoover National Historic Site

Iowa

National Park Service
U.S. Department of the Interior

Geologic Resources Inventory





This map displays geologic map data compiled by the National Park Service Geologic Resources Inventory. It is not a substitute for site specific investigations.

Source Maps

Krieg, J.J., S.A. Tassier-Surine, D.J. Quade, E.A. Bettis III, J.A. Artz, and J.D. Giglierano. 2004. Surficial geologic materials of the Iowa City East 7.5' Quadrangle, Johnson County, Iowa (scale 1:24,000). Open File Map OFM-04-5. Iowa Geological Survey, Iowa City, Iowa.

Quade, D.J., S. Tassier-Surine, J.D. Giglierano, and E.A. Bettis III. 2008. Surficial geologic map of Cedar County (scale 1:100,000). Open File Map OFM-08-8. Iowa Geological Survey, Iowa City, Iowa.

Tassier-Surine, S.A., J.J. Krieg, D.J. Quade, E.A. Bettis III, J.A. Artz, and J.D. Giglierano. 2004. Surficial geologic materials of Johnson County, Iowa (scale 1:100,000). Open File Map OFM-04-3. Iowa Geological Survey, Iowa City, Iowa.

Poster Layout
Chase Winters and Georgia Hybels (Colorado State University)

Poster Date
August 2017

GRI Data Date
June 2012

Source Map Date
2004 and 2008

Source Scale: 1:24,000 and 1:100,000

According to US National Map accuracy standards, features are within 12 m (40 ft) (1:24,000 scale data) or 50 m (166 ft) (1:100,000 scale data) of their true location.

All Geologic Resources Inventory geologic map data and publications are available at http://go.nps.gov/gripubs.

NPS Boundary

Infrastructure

- Road
- River/stream

Mine Point Features

- Drill hole

Contacts

- Known or certain
- Map boundary

Eolian Sand Deposits

- Qe - Sand dunes and sand sheets (Peoria Formation, sand facies; Quaternary)

Surficial Units

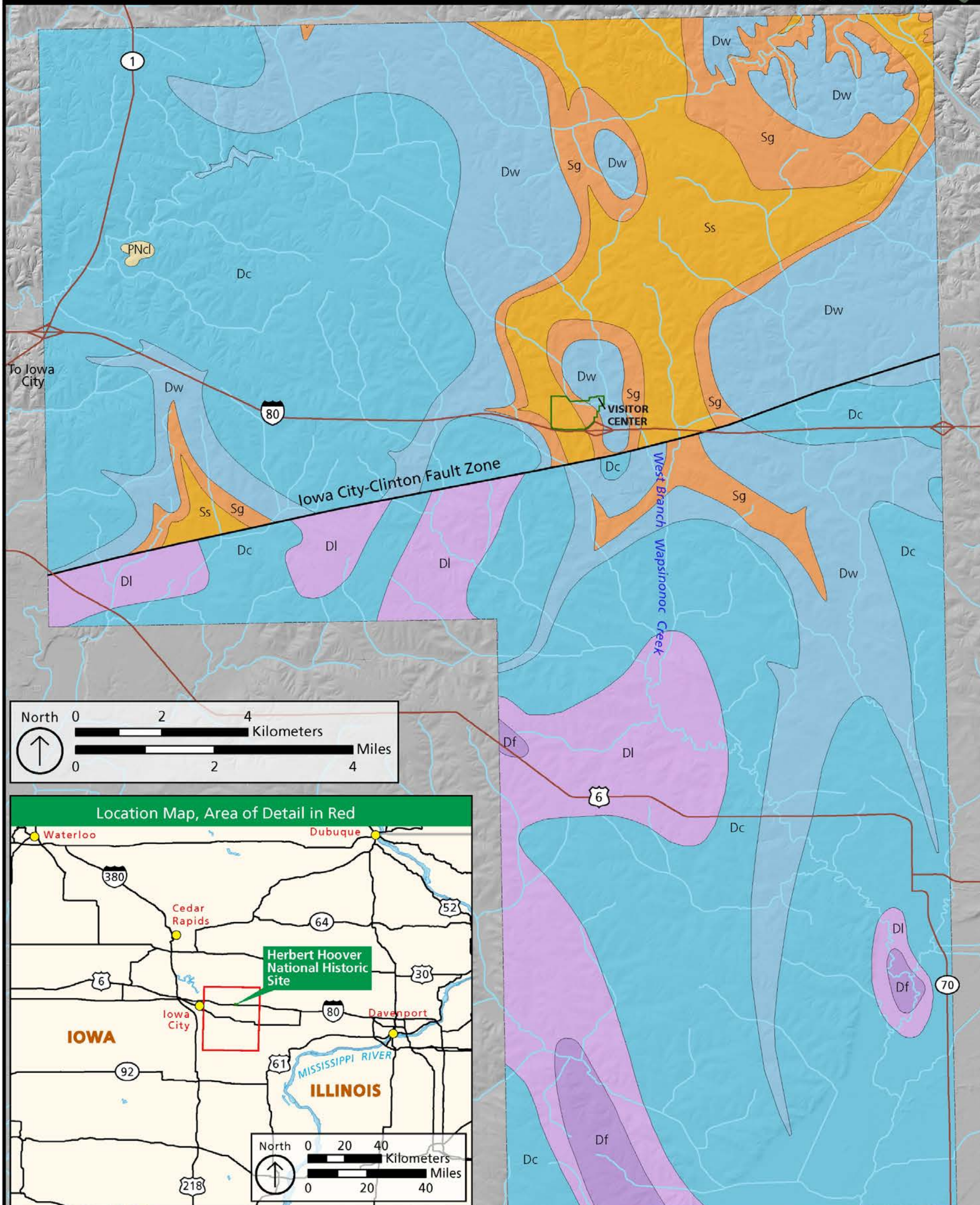
- Water
- Qf — Fill (Quaternary)
- Qo — DeForest Formation, Woden Member (Quaternary)
- Qal — DeForest Formation, alluvium undifferentiated (Quaternary)
- Qallt — DeForest Formation, Camp Creek and Roberts Creek Members, low terrace/modern channel belt (Quaternary)
- Qnw — Noah Creek Formation, sand and gravel (Quaternary)
- Qptlp — Peoria Formation, silt and/or sand facies, late phase high terrace (Quaternary)
- Qptep — Peoria Formation, silt and/or sand facies, early phase high terrace (Quaternary)
- Qps — Peoria Formation, silt facies, loess (Quaternary)
- Qps1 — Peoria Formation, silt facies, loess and intercalated eolian sand (Quaternary)
- Qwa3 — Wolf Creek or Alburnett formations (Quaternary)
  glacial till
- Du — Fractured carbonate bedrock (Devonian)
- Dw — Wapsipinicon Group (Devonian)
  vuggy (Otis Formation) and laminated (Pinicon Ridge Formation) dolomites
- Sg — Gower Formation (Silurian)
  fossiliferous dolomite
- Ss — Scotch Grove Formation (Silurian)
  cherty fossiliferous dolomite

Bedrock Geologic Map of Herbert Hoover National Historic Site

Iowa

National Park Service
U.S. Department of the Interior

Geologic Resources Inventory



NPS Boundary

Infrastructure

City

Road

River/stream

Faults

Unknown offset/displacement, known or certain

Contacts

Known or certain

Map boundary

Geologic Units

PNcl	Lower Cherokee Group and Raccoon Creek Group (Pennsylvanian)
Df	Famennian Formations (Devonian)
Dl	Lime Creek Formation and Sweetland Creek Shale (Devonian)
Dc	Cedar Valley Group (Devonian)
Dw	Wapsipinicon Group (Devonian) *vuggy (Otis Formation) and laminated (Pinicon Ridge Formation) dolomites*
Sg	Gower Formation (Silurian) *fossiliferous dolomite*
Ss	Scotch Grove Formation (Silurian) *cherty fossiliferous dolomite*

This map displays geologic map data compiled by the National Park Service Geologic Resources Inventory. It is not a substitute for site specific investigations.

Source Maps

Witzke, B.J., and R.R. Anderson. 2008. Bedrock Geologic Map of Cedar County (scale 1:100,000). Open File Map OFM-08-7. Iowa Geological Survey, Iowa City, Iowa.

Witze, B.J, R.R. Anderson, and J.P. Pope. 2010. Bedrock geologic map of Iowa (scale 1:500,000). Open File Map OFM-2010-01. Iowa Geological Survey, Iowa City, Iowa.

Source Scale: 1:100,00 and 1:500,000

According to US National Map accuracy standards, features are within 50 m (166 ft) (1:100,000 scale data) or 254 m (833 ft) (1:500,000 scale data) of their true location.

Poster Layout
Chase Winters and Georgia Hybels (Colorado State University)

Poster Date
August 2017

GRI Data Date
June 2012

Source Map Date
2008 and 2010

All Geologic Resources Inventory geologic map data and publications are available at http://go.nps.gov/gripubs.