Geologic Resources Inventory Scoping Summary
Fort Pulaski National Monument, Georgia

Prepared by John Graham
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Geologic Resources Division
National Park Service
US Department of the Interior

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 the park units of the Southeast Coast Network (SECN) during the week of April 20–24, 2009 at Jacksonville, Florida. These units included Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Monument (CUIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), and Timucuan Ecological and Historic Preserve (TIMU). Fort Pulaski National Monument was discussed on April 20. Bruce Heise (NPS GRD) facilitated the meeting, presented an overview of the GRI program, and led the discussion regarding geologic processes and features at each NPS unit. Stephanie O'Meara (CSU) led the discussion of map coverage relevant to each unit. Randy Parkinson (RWParkinson Consulting) presented an overview of coastal regional geology and barrier island geomorphology. Participants at the meeting included NPS staff from the park, Geologic Resources Division (GRD), and Southeast Coast Network (SECN) and cooperators from the U.S. Geological Survey (USGS), Florida Geologic Survey (FGS), University of West Georgia (UWG), University of Georgia (UGA), Polk Community College (PCC), and Colorado State University (CSU) (see table 2).

This scoping summary highlights the GRI scoping meeting for Fort Pulaski National Monument including the geologic setting, the plan for providing a digital geologic map, a summary of geologic resource management issues, a description of significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

Fort Pulaski National Monument lies approximately 24 km (15 mi) east of Savannah and includes most of Cockspur Island where the fort is located, all of adjoining McQueens Island, Cockspur Island Lighthouse Reservation just east of Cockspur Island, and Daymark Island, a small shell reef north of Cockspur Island. Cockspur Island formed at the mouth of the Savannah River and is separated from McQueens Island to the south by the South Channel of the river. Lazaretto Creek flows between McQueens Island and Tybee Island to the east, and the Buff River to the south and west separates McQueens Island from Wilmington Island, Oatland Island, and the mainland. Approximately 90% of the monument is classified as wetland, and estuarine waters cover over 1,900 ha (4,800 ac) of salt marsh twice a day.

Rising sea level drowned the mouth of the Savannah River and formed an estuarine system behind Tybee Island, Georgia's northernmost barrier island. Tybee Island protects McQueens Island from the open ocean, but Cockspur Island and the smaller island properties of Cockspur Island Lighthouse Reservation and Daymark Island are open to the Atlantic.

The depositional setting of Georgia's coast is related to plate tectonics. Most coastlines may be described as either a "collision" or a "trailing edge" coastline. On the California coast of North America, for example, the North American lithospheric plate is colliding with the Pacific plate. Rapid uplift, young mountain ranges and short rivers characterize these active margins. In contrast, more passive, trailing edge coastlines, such as the eastern U.S. coast, are relatively stable, have a broader continental shelf, and form a "depositional" coast. Barrier islands are frequently found along these depositional coastlines.

Barrier islands are rare along tide-dominated coasts, where tidal range exceeds 4 m (13 ft). Along coastlines such as eastern Florida, where tidal range is small and waves dominate the coastline, barrier islands form long, linear features. A mixed energy environment dominates Georgia's coast where tidal range averages just higher than 1.8 m (6 ft) and wave action associated with seasonal storms and infrequent hurricanes modify the coastline (Henry 2009). Mixed-energy barrier islands tend to be short, wide at one end and narrow at the other. Relatively deep, stable, tidal inlets separate these short barrier islands. Extensive sand shoal systems accumulate at the mouth of tidal inlets, and longshore currents transport the sand to downcurrent recipients.

Georgia tidal marshlands include saltwater wetlands that predominate in the 5- to 8-km-wide (2- to 5-mi-wide) areas between the barrier islands and the mainland and the brackish to freshwater wetlands that extend inland along the estuaries for an additional 16 km (10 mi) or so (Henry 2009). Erosional remnants of Pleistocene and Holocene barrier islands and back barrier deposits are scattered throughout the tidal marshlands.

Material dredged from the Savannah River composes approximately 200 ha (500 ac) of Cockspur and McQueens Islands while unconsolidated alluvial sand and gravel transported by Piedmont rivers that drain the Appalachian Mountains form the rest of these larger islands. The moat that surrounds Fort Pulaski varies in width from 9 m (30 ft) to 15 m (48 ft) and averages 2.4 m (8 ft) deep.

Regional Geology and Barrier Island Geomorphology (Randy Parkinson)

Fort Pulaski National Monument, Fort Frederica National Monument, and Cumberland Island National Seashore are part of Georgia's Coastal Plain, one of five major northeast-southwest trending geologic zones that define the landscape in the southeastern United States. From northwest to southeast, these geologic zones include the Appalachian Plateau, Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain provinces. The Coastal Plain is a broad and gently sloping landscape that consists of nearly horizontal sedimentary layers that were deposited, eroded, and modified over the past 100 million years and continues to be modified even today. Barrier islands, tidal creeks, and extensive marshlands mark the eastern edge of the province. To the west, the "Fall Line" represents the boundary between the Coastal Plain and Piedmont provinces. The Fall Line, identified on

topographic maps by a series of waterfalls, marks an abrupt change in elevation between the low-lying plains and the rolling topography and foothills of the Piedmont. The Piedmont and the other elevated provinces formed from tectonic events spanning 250 million to 1 billion years ago. The provinces continue to undergo erosion and supply sediment via rivers and streams to the Coastal Plain and its barrier islands.

Linear features identified on the Coastal Plain represent previous coastlines and barrier islands associated with major fluctuations of sea level over the past 400,000 years. Sea level fell during periods of glacial advance and rose during interglacial periods when glaciers melted. Sea level began to rise about 20,000 years ago and rose rapidly until about 6,000 years ago when the present barrier islands along the eastern seaboard formed. The rapid rise in sea level drowned previously existing barrier islands. About 3,000 years ago, coastal features stabilized so that although sea level continues to rise and the coastline continues to retreat landward, the barrier islands, wetlands, lagoons, and other coastal features have maintained their geomorphic integrity.

To form, barrier islands require an abundant sediment supply, moderate to high wave energy, micro- to meso-tidal ranges of less than 4 m (13 ft), rising sea level, and a broad continental shelf. Barrier island morphology is controlled by both tidal range and wave height. Wave dominated barrier islands, such as those along the east coast of Florida, are long and straight. Short, crenulated barrier islands along Florida's panhandle and southwest coast are tide dominated. The short barrier islands along the Georgia coast result from a mixed wave and tidal energy.

Three conceptual models have been proposed for the origin of barrier islands: 1) dune drowning, 2) spit elongation, and 3) shoal emergence. Dune drowning occurs with a relative rise in sea level, which may inundate a mainland ridge of coastal dunes, thus forming a lagoon between the most seaward dune ridge and the mainland. Stable sea-level conditions and/or an abundant sand supply are conducive to the development of barrier islands by spit elongation. In the spit elongation model, longshore currents transport sand along the coast, and the sand is deposited on the flanks of headlands or at the downdrift ends of existing barrier islands. As these relatively thin spits of sand elongate, they form barriers that block embayments and form lagoons. Eventually, tidal inlets may separate the spits from the headland, forming a barrier island. Shoal emergence results when erosion and redistribution of sediment on the sea floor promotes the upward growth of a submerged sand bar. Shoal emergence is aided by a relative fall in sea level and a local surplus of sand that can maintain the barrier above the ocean's surface.

Barrier islands can be subdivided into a back barrier region, dune system, and beach (fig. 1). A lagoon or estuary separates the barrier island from the mainland. Flood-tidal deltas form on the incoming tide while the outgoing tide produces ebb-tidal deltas. During storms, washover fans distribute sediment into the back barrier and push the barrier island landward.

Sea level rise is a major driving force with regards to barrier island sustainability. With relative sea level rise (transgression), barrier islands migrate landward. Vertical cross-sections through present barrier island systems show this landward migration over time. Buried beneath today's beaches, for example, are yesterday's lagoon and mainland environments. Currently, the margins of North America are being subjected to coastal erosion. Understanding barrier island morphology and its

dynamic association with sea level rise, tides, and wave energy may be used to project future coastline patterns.

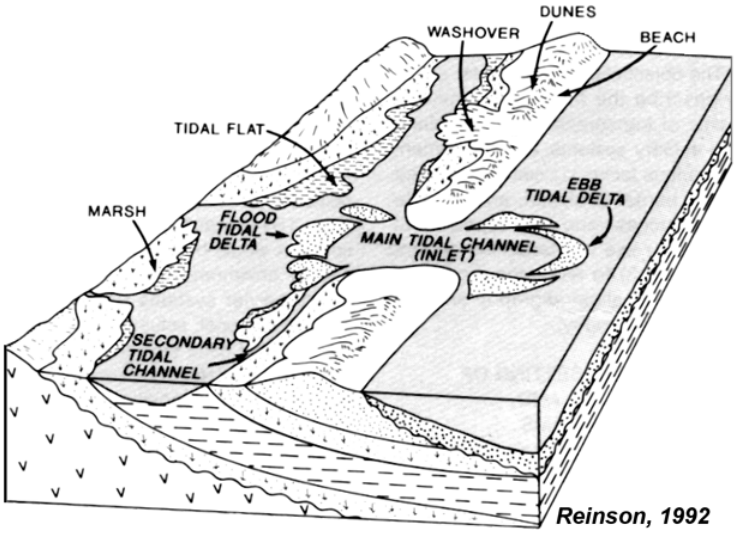

Figure 1. Common coastal environments associated with barrier islands. Schematic is from Reinson (1992).

Geologic Mapping for Fort Pulaski National Monument

During the scoping meeting, Stephanie O'Meara (Colorado State University) briefly displayed some of the main features of a GRI digital geologic-GIS map, which includes source map 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-GIS map model using ESRI ArcGIS software. Final digital geologic-GIS map products include GIS data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and an ESRI ArcGIS ArcMap document file that displays the map, and provides a tool to access the PDF help document directly from an ArcMap document. Final data products are posted at http://science.nature.nps.gov/nrdata/. 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, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 2). 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). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Table 1. GRI Mapping Plan for Fort Pulaski National Monument

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Tybee Island North	Near the park boundary	New detailed geomorphic mapping of and adjacent to park	digital	Specify mapping product similar to the geomorphic map produced for CANA by Parkinson, R.W and Schaub, R., 2007	Await digital data from new mapping and convert to the NPS GRI data model if necessary
Fort Pulaski	Intersects the park boundary				
Savannah	Intersects the park boundary				
Tybee Island South	Near the park boundary				
Wassaw Sound	Intersects the park boundary				

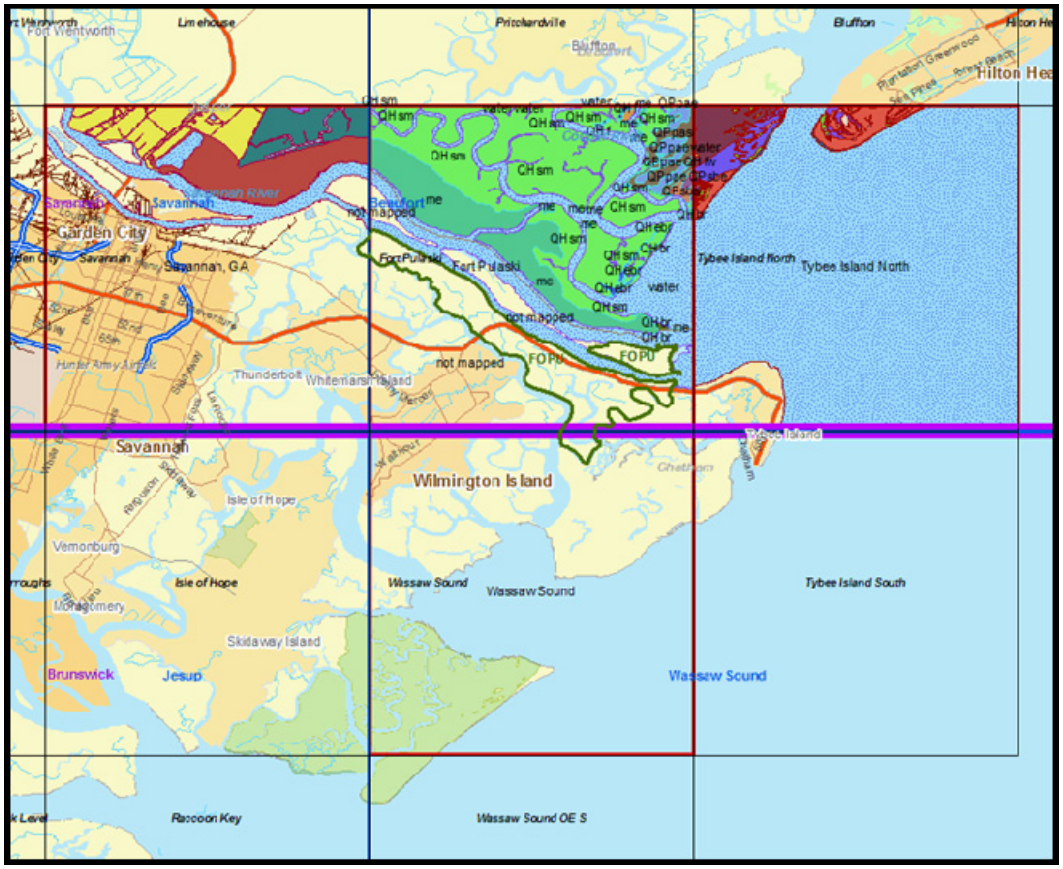

Figure 2. Area of interest for Fort Pulaski National Monument (FOPU). The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national preserve and memorial boundaries. The Tybee Island South 7.5-minute quadrangle, south of Tybee Island North and east of Wassaw Sound, was added to the area of interest at the scoping meeting by Randy Wester (NPS-FUPO).

Available map coverage for FOPU and within the Georgia portions of its quadrangles of interest is at a very small scale and of limited use by park managers. A possible alternative would be any coverage of this area similar to the 1981 C. T. Swann map, *Geology as applied to land-use management on Cumberland Island, Georgia*, published by the Department of Natural Resources, Environmental Protection Division, Georgia Geological Survey. C. J. Jackson (UGA, PCC) has agreed to research and determine if any such map exists. If so, it would be evaluated to determine its adequacy.

If no other map is available, a detailed geomorphic map of FOPU would require new mapping that leverages from recent LIDAR data. USGS Coastal Geologist Jim Flocks agreed to investigate what LIDAR coverage might be already available. Depending on the level of GRI funding, a solicitation for bids for a new map of the park could be announced in 2010 on the Federal Business Opportunities website, FedBizOpps.gov. Standards for the map product will be detailed in the solicitation but would likely include delivering a product similar to the detailed geomorphic mapping produced in the GRI Geology-GIS Geodatabase Data Model format for the GRI at Canaveral National Seashore.

The GRI also will evaluate the usefulness of the following published South Carolina Geological Survey (SCGS) geologic maps for those portions of the Tybee Island North, Fort Pulaski and Savannah 7.5-minute quadrangles that are within South Carolina.

- Doar, W.R., III. 2002. *Geologic map of the Tybee Island North 7.5-minute quadrangle*. Scale 1:24,000. Geologic Quadrangle Map GQM-4. Columbia, SC: South Carolina Geological Survey. (GRI Source Map ID 75102).
- Doar, W.R., III. 2002. *Geologic map of the Fort Pulaski 7.5-minute quadrangle*. Scale 1:24,000. Geologic Quadrangle Map GQM-5. Columbia, SC: South Carolina Geological Survey. (GRI Source Map ID 75098).
- Doar, W.R., III. 2002. *Geologic map of the Savannah 7.5-minute quadrangle*. Scale 1:24,000. Geologic Quadrangle Map GQM-3. Columbia, SC: South Carolina Geological Survey. (GRI Source Map ID 75101).

Geologic Resource Management Issues

The principal geologic resource management issue discussed during the scoping session involved shoreline erosion along the northern boundary of the monument due to substantial dredging of the Savannah River's main channel.

Shoreline Alteration

Shoaling and sedimentation in the Savannah River requires frequent dredging to keep the channel open for navigation. Dredge spoil accretion, ships' wake, and tidal action produce relatively rapid changes to the shoreline (Alexander 2008; Howell and Alexander 2004; Howell et al. 2005). Both erosion and the migration of an oyster-shell bank are altering Cockspur Island's northern shoreline. In addition to natural resources, cultural resources, including the North Pier and Battery Hambright, are being threatened by erosion.

Shoreline erosion and accretion processes are not well understood with regards to Cockspur Island. Storms may erode one area and accrete sediments to another. Recently, a gap has opened between Cockspur Island and Long Island, located upstream from Cockspur Island. The impact of upstream dams on the Savannah River on downstream sedimentation and shoreline accretion is also unknown. Erosion of the shoreline around the small island that contains the Cockspur Island Lighthouse Reservation may also be a management concern.

Other geologic resource management issues

Contamination due to increased dredging. Contaminants previously sequestered in the sediments become reintroduced into the water column during the annual dredging process. Sediments dredged from the channel are dumped on land. Contamination remains a threat from numerous industrial sources upstream on the Savannah River in the vicinity of Savannah, including wastewater treatment plants, chemical producers, a natural gas processing facility, and a paper mill. The Savannah River Site, a nuclear weapons production facility notorious for contamination of the Savannah River, lies farther upstream. However, deeper dredging activity to accommodate larger ship traffic digs into Miocene sediments, which present minimal potential for contamination.

Impacts from the highway and a raised hiking trail. The hiking trail parallels the highway for about 10 km (6 mi). The highway and hiking trail, converted from an old railroad bed, may divert runoff and increase erosion.

Saltwater intrusion. Rising sea level and increased groundwater pumping may allow saltwater to intrude into freshwater aquifers. Many US Geological Survey reports address groundwater issues along the Georgia coast.

Impacts from climate change. The rate of sea level rise may increase the degree of erosion along the shoreline and determine whether or not the marsh environment can keep pace with the rising water. Salinity in the estuary may change, affecting both the flora and fauna. The submerged aquatic vegetation (SAV) will be impacted by a change in the photic and nonphotic zones, and invasive plant and animal species may become more abundant. Climate change may also lead to an increase in the intensity and frequency of storms.

Features and Processes

The scoping session for Fort Pulaski National Monument provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. Please note that the National Park Service monitoring manual (R. Young and L. Norby, editors. *Geological Monitoring*. Special paper. Geological Society of America, Boulder, CO.) is currently in press and will contain information on monitoring of geologic features and processes found in NPS coastal units. These features at Fort Pulaski National Monument include:

- Fluvial features that result from both the Savannah River and tidal channels along with stream channel morphology,
- Coastal features including shell ridges, a middle-ground shoal, and features resulting from tidal changes and storms,
- A tidal saltwater moat,

- Paleontological resources. Larry West (NPS SECN) suggested consulting the recently published *Paleontological Resource Inventory and Monitoring* report for the SECN to review the paleontological resources in the monument (Tweet et al. 2009). The following information is from that report.

  Although no known fossil specimens exist in the collections database of the Southeast Archeological Center (SEAC), fossils are present in subsurface formations beneath and adjacent to Fort Pulaski National Monument. Fossils also may be found in dredge material and may be associated with cultural resources.

References

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Henry, J. 2009. *Geology of the Georgia coast*. The New Georgia Encyclopedia. http://www.georgiaencyclopedia.org/nge/ArticlePrintable.jsp?id=h-2777.

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Tweet, J. S., V. L. Santucci, and J. P. Kenworthy. 2009. *Paleontological resource inventory and monitoring: Southeast Coast Network*. Natural Resource Technical Report NPS/NRPC/NRTR – 2009/197. Fort Collins, CO: National Park Service, Natural Resource Program Center.

Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Bryant, Richard	NPS TIMU & FOCA	Chief, Resource Management	904-221-7567	richard_bryant@nps.gov
Bush, David	U. of West Georgia	Professor of Geology	678-839-4057	dbush@westga.edu
Byrne, Mike	NPS SECN	Terrestrial Ecologist	912-882-9203	michael_w_byrne@nps.gov
Corbett, Sara	NPS SECN	Botanist	972-882-9139	sara_corbett@nps.gov
Curtis, Tony	NPS SECN	Coastal Ecologist	912-882-9239	tony_curtis@nps.gov
DeVivo, Joe	NPS SECN	Network Coordinator	404-562-3113 x 739	joe_devivo@nps.gov
Flocks, Jim	USGS CCWS	Geologist	727-803-8747 x 3012	jflocks@usgs.gov
Fry, John	NPS CUIS	Chief, Resource Management	912-882-4336 x 262	john_fry@nps.gov
Graham, John	Colorado State U.	Geologist – Report Writer	970-581-4203	rockdoc250@comcast.net
Heise, Bruce	NPS GRD	Geologist - GRI Program Coordinator	303-969-2017	bruce_heise@nps.gov
Jackson, C.J.	University of Georgia/Polk CC	Coastal Geologist	863-258-4226	jackson.cwjr@gmail.com
Means, Harley	Florida Geological Survey	Geologist	850-487-9455 x 112	guy.means@dep.state.fl.us
O'Meara, Stephanie	Colorado State U.	Geologist, GRI Map Team Coordinator	970-225-3584	Stephanie_O'Meara@partner.nps.gov
Parkinson, Randy	RWParkinson Consulting	Coastal Geomorphologist	321-373-0976	rwparkinson@cfl.rr.com
Rich, Andrew	NPS CASA & FOMA	Chief, Resource Management	904-471-0116	andrew_rich@nps.gov
Spear, Denise	NPS FOFR	Cultural Resource Specialist	912-638-3639	denise_spear@nps.gov
Spechler, Rich	USGS WRD	Hydrologist	407-803-5523	spechler@usgs.gov
Stiner, John	NPS CANA	Chief, Resource Management	321-267-1110	john_stiner@nps.gov
West, Larry	NPS SER	IM Coordinator	404-562-3113	larry_west@nps.gov
Wester, Mary Beth	NPS FOFR	Superintendent	912-638-3639	mary_beth_wester@nps.gov
Wester, Randy	NPS FOPU	Acting Superintendent	912-786-5787	randy_wester@nps.gov