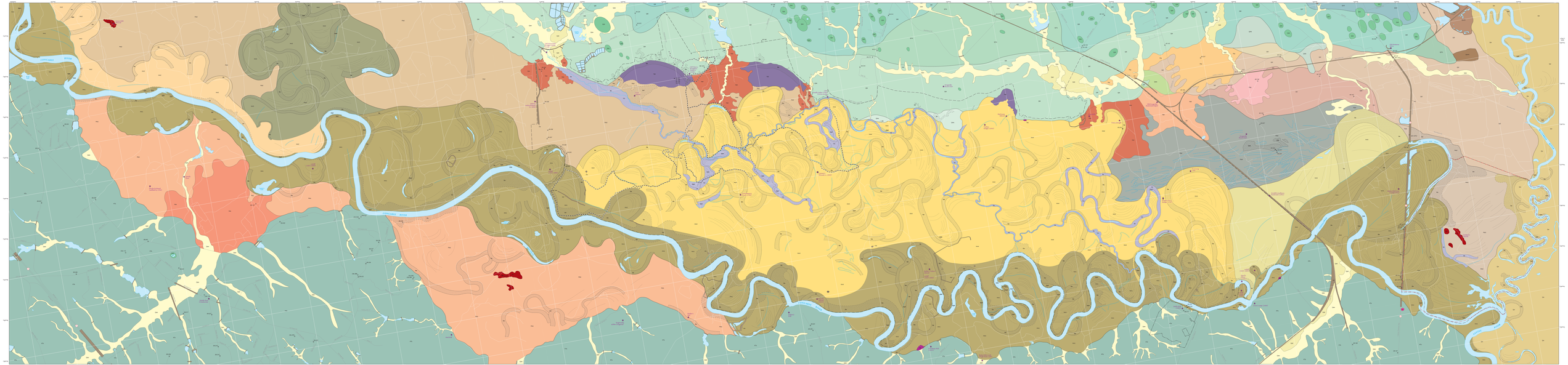
Map Series
MS-2
(Plate 1 of 2)



SCALE
1:12,000

# Geologic and Geomorphic Elements of the Lower Congaree River Floodplain, Central South Carolina
2007

David C. Shelley and Arthur D. Cohen

Department of Natural Resources
South Carolina Geological Survey
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Map Series
MS-27
(Plate 2 of 2)

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# 2007

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1:12,000 Scale
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## INTRODUCTION

The Congaree River Valley is a major geographic feature of central South Carolina (Figure 1). The lower Congaree River Flood plain is home to Congaree National Park, a near 27,000 acre preserve which represents the one of the last, largest, and best-preserved stands of near-virgin Old-Growth Bottomland Hardwood Flood plain Forest remaining on the eastern seaboard. Though today such forests have been largely lost to logging and agriculture, such ecosystems originally covered every river valley from Virginia to northern Florida, across to eastern Texas, and up the Mississippi River Valley as far as Illinois (Mitsch and Gosselink, 2007). The southern border of the Congaree River Flood plain is also home to the South Carolina Department of Natural Resources Congaree Bluffs Heritage Preserve, which protects critical ecosystems along the steep bluffs and adjacent uplands. Much of the rest of the land is managed for timber and hunting, with some agriculture. The adjacent uplands in both Richland County (to the North) and Calhoun County (to the South) are rural.

Preliminary geologic and geomorphic research in the lower Congaree River Flood plain indicates a complex of late Quaternary fluvial terraces, scarps, meander belts and other deposits nested within the Upper Coastal Plain (Figure 1; Sexton, 1999; Cohen and others, 2004; Shelley and others, 2004; Cohen and others, 2005a,b; Meitzen and Shelley, 2005; Shelley and Meitzen, 2005; Cohen and others, 2006; Meitzen, 2006; Shelley, 2006a,b; Shelley and Cohen, 2006; Shelley, 2007a-e). This area was mapped by Shelley (2007a-e) at 1:24,000 scale; given the scale and purpose of those maps, however, the flood plain was simply generalized as Terrace Zero (T0) of the Congaree River Valley Terrace Complex. The purpose of this map is to address this generalization and delineate the major, late Quaternary geologic and geomorphic elements of the lower Congaree River Flood plain.

The current map area (Plate II) forms a 39 km (24 mi) by 9 km (5.6 mi) rectangle that encompasses approximately 350 km2 (135 mi2). This rectangle is rotated 10.13 degrees clockwise and is centered at 3739950N, 518149E, North American Datum of 1927, Universal Transverse Mercator (UTM) Zone 17N. This area mostly covers the Gadsden, Saylor's Lake, and Wateree U.S. Geological Survey (USGS) 7.5-minute quadrangles, but also includes portions of the Fort Motte, Gaston, Lone Star, and Poinsett State Park 7.5-minute quadrangles (Figures 2 and 3). Original colors were picked to accentuate contrasts as needed by the map. Symbology was developed in accordance with USGS guidelines (USGS, 2006).

The flood plain features delineated in Plate II are based upon original field observations and drill hole data supplemented with an array of remote sensing data, previous maps, accounts from local residents, and accounts from other researchers in the area. Copies of drill-hole logs and field notes are on file at the South Carolina Department of Natural Resources Geological Survey (SCGS). Non-flood plain features were adapted from Shelley (2007a-e), Willoughby (2003a,b), and Kite (1984), although slight modifications of the older maps were made to adapt for edge matching and incorporate a few new data points. Supplemental data for the flood plain included 1999 digital ortho-quarter quadrangle aerial photographs (DOQQs), hypsography, Soil Survey Geographic (SSURGO) Database, National Wetlands Inventory (NWI), and other data accessed through the South Carolina Department of Natural Resources GIS (geographic information system) data clearinghouse (http://www.dnr.sc.gov/gis.html; last accessed November, 2006). Within Congaree National Park, several excellent supplemental data sets include Cely (2001) and limited LIDAR data (MD Atlantic Technologies, 2002a). Although Richland County's Internet map server technically provides 2-foot lidar contours across the whole area (MD Atlantic Technologies, 2001b), aerial photographs were generally used as a base layer outside the park because current LIDAR access is prohibitively cumbersome and frustrating to comprehensively trace features. Contacts with local landowners, hunt club members, Congaree National Park staff, and researchers in the park were also useful in directing field work and providing details regarding flooding regime and characteristics of remote areas. All data was imported and projected into an ArcGIS database for analysis and map drafting.

The geological features outlined within the flood plain, which for descriptive purposes approximately coincides with the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) flood zone, are here collectively termed the Congaree River flood plain complex. Although a correlation of units is proposed in Figure 4, the following map explanations are organized by type and not chronologically. The units discussed here stop short of formal allostratigraphic nomenclature due to the difficulty of acquiring subsurface information over such a large area; a lack of contrasting, detailed type sections; a near complete lack of absolute dates; and problems with pinning down "bounding discontinuities" over such a large area (e.g. Miall, 1996). Further dating and fieldwork should help refine the age and character of these units as well as the nature and positions of their boundaries, thus permitting elevation of these units to formal allostratigraphic status.

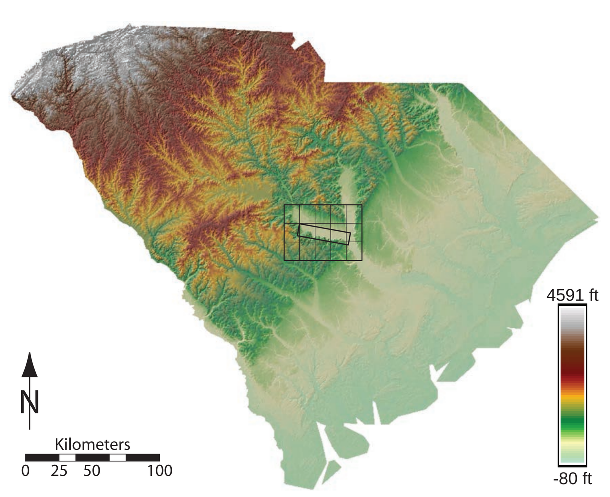


Figure 1. 1:3,000,000 DEM of South Carolina showing the Congaree River Valley and Map Location.

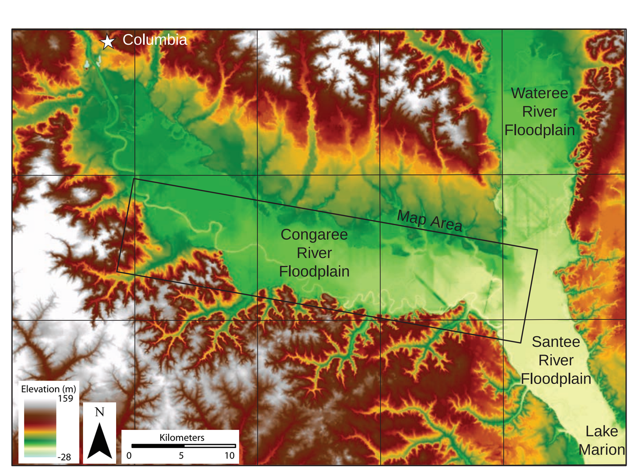


Figure 2. Ten foot DEM of the map area and surrounding region. See Figures 1 for location and Figure 3 for Quadrangle names.

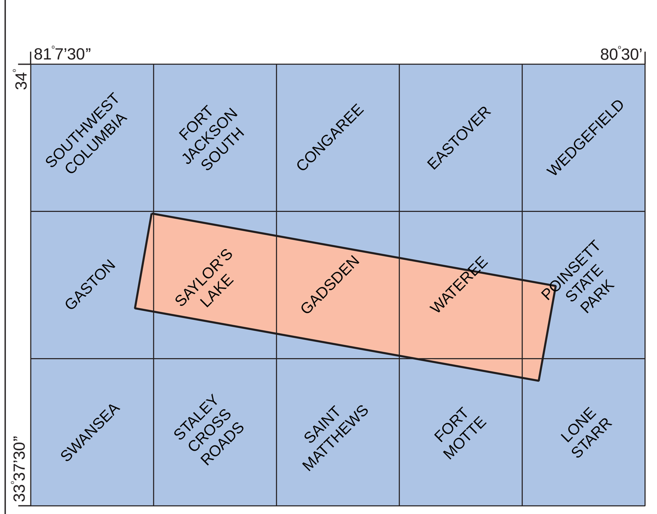


Figure 3. Blow up of map area (Figure 2) showing USGS 7.5 minute Quadrangle names.

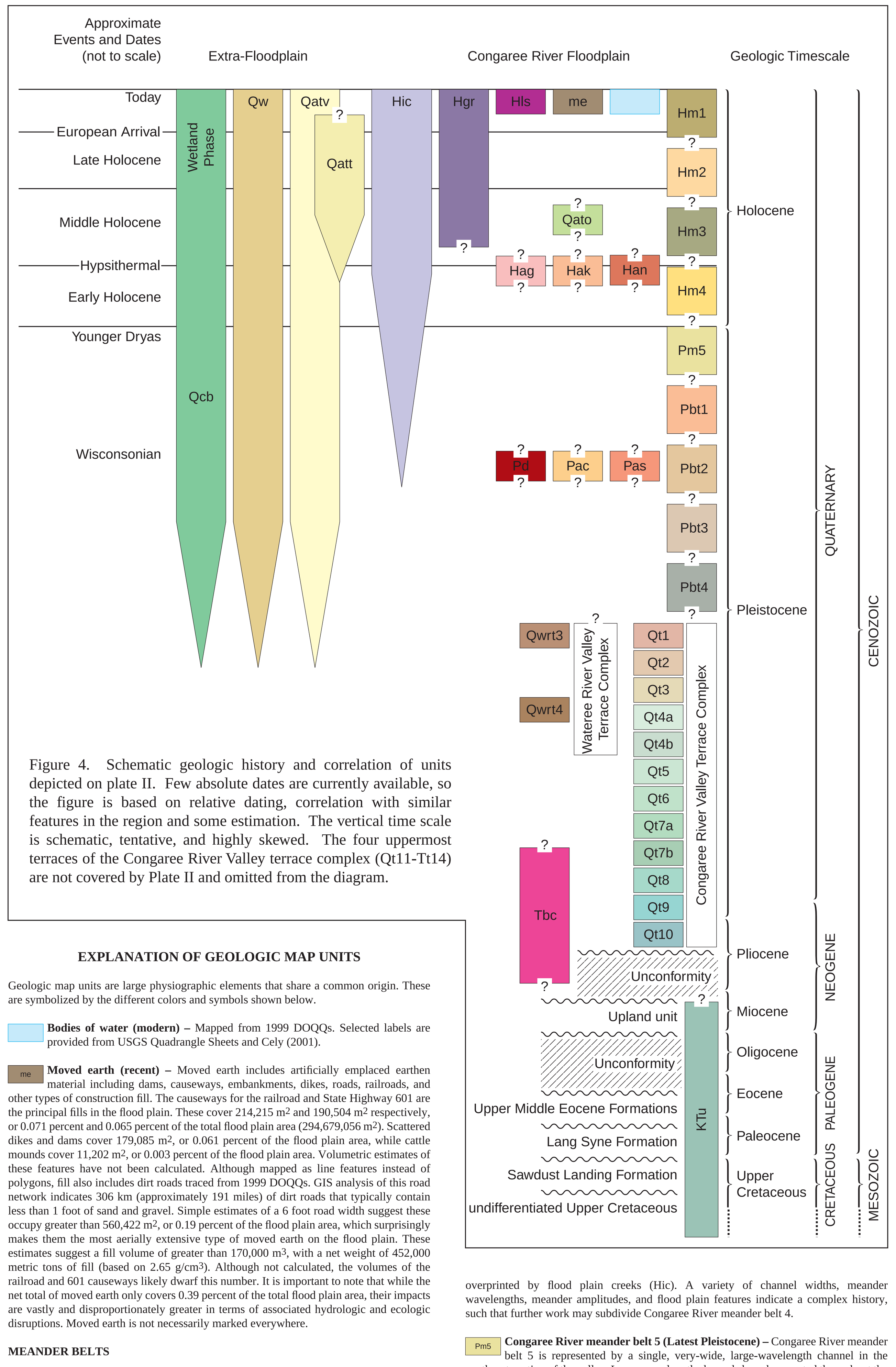


Figure 4. Schematic geologic history and correlation of units depicted on plate II. Few absolute dates are currently available, so the figure is based on relative dating, correlation with similar features in the region and some estimation. The vertical time scale is schematic, tentative, and highly skewed. The four uppermost terraces of the Congaree River Valley terrace complex (Qt11-Tt14) are not covered by Plate II and omitted from the diagram.

## EXPLANATION OF GEOLOGIC MAP UNITS

Geologic map units are large physiographic elements that share a common origin. These are symbolized by the different colors and symbols shown below.

**Bodies of water (modern) –** Mapped from 1999 DOQQs. Selected labels are provided from USGS Quadrangle Sheets and Cely (2001).

me **Moved earth (recent) –** Moved earth includes artificially emplaced earthen material including dams, causeways, embankments, dikes, roads, railroads, and other types of construction fill. The causeways for the railroad and State Highway 601 are the principal fills in the flood plain. These cover 214,215 $m^2$ and 190,504 $m^2$ respectively, or 0.071 percent and 0.065 percent of the total flood plain area (294,679,056 $m^2$). Scattered dikes and dams cover 179,085 $m^2$, or 0.061 percent of the flood plain area, while cattle mounds cover 11,202 $m^2$, or 0.003 percent of the flood plain area. Volumetric estimates of these features have not been calculated. Although mapped as line features instead of polygons, fill also includes dirt roads traced from 1999 DOQQs. GIS analysis of this road network indicates 306 km (approximately 191 miles) of dirt roads that typically contain less than 1 foot of sand and gravel. Simple estimates of a 6 foot road width suggest these occupy greater than 560,422 $m^2$, or 0.19 percent of the flood plain area, which surprisingly makes them the most aerially extensive type of moved earth on the flood plain. These estimates suggest a fill volume of greater than 170,000 $m^3$, with a net weight of 452,000 metric tons of fill (based on 2.65 g/$cm^3$). Although not calculated, the volumes of the railroad and 601 causeways likely dwarf this number. It is important to note that while the net total of moved earth only covers 0.39 percent of the total flood plain area, their impacts are vastly and disproportionately greater in terms of associated hydrologic and ecologic disruptions. Moved earth is not necessarily marked everywhere.

### MEANDER BELTS

Meander belts are irregular, sinuous zones formed by the Congaree River during specific historic to prehistoric intervals when hydrology, sediment supply, climate, valley gradient, and other geomorphic variables were relatively stable. Abandoned channels, scroll complexes, and other riverine features such as levees and point bars are both abundant and distinct. Unlike the bottomland terraces (see below), they have not been exposed long enough to allow for homogenization of topography. Migrating meander belts have largely destroyed earlier deposits in much of the Congaree River Valley (e.g. Suacier, 1994a). Because of the diversity of depositional environments and abundant erosional surfaces, these systems are hard to generalize (e.g. Saucier, 1994a).

Hm1 **Modern Congaree River meander belt (1825-Present) –** The modern Congaree River meander belt includes the active channel as well as several abandoned channels and scroll complexes. This meander belt dates at least to Mills (1825), and six historically documented cutoffs on Plate II are labeled for reference (Shelley and Meitzen, 2005). In the lower valley, an old flood plain surface is exposed beneath this meander belt during low water. Several *in situ* cypress stumps are present on this surface, and a new radiocarbon date (University of Georgia Center for Applied Isotope Studies Lab, sample #01792) from the outermost fresh wood on one of these stumps yielded a minimum age of 1660 +/- 40 years. This is likely a minimum age, because the stump margins were significantly degraded. Based on aerial photographic evidence of recent channel movement (e.g. Sexton, 1999), Hm1 is extended down into the uppermost reaches of the Santee River.

Although not shown, it should be noted that top stratum of vertically accumulating flood plain silt and clay associated with this meander belt covers much of the rest of the flood plain, especially the topographically low areas such as Congaree River meander belt 4 (Hm4). These areas, called back swamps, flood basins and rim swamps, are generally characterized by poorly to well-drained black silt and clay that forms a complex, cumulate soil horizon (e.g. Saucier, 1994a; Asland and Autin, 1998). Laminations, burrows, sand stringers, organic matter, mottles, concretions, stains, and slickensides are common. Planform drainage is irregular. A series of holes along the western Boundary Road in Congaree National Park indicate that the top stratum is locally characterized by 4 to 8 feet of mottled brown, dark gray brown to olive brown clay with varying amounts of silt. Further sampling is needed in the Congaree River Flood plain to understand the age and distribution of this layer.

Hm2 **Congaree River meander belt 2 (Holocene to pre-1825) –** Congaree River meander belt 2 reflects a few abandoned channels in the northwest part of the map that are separated from the modern channel by high cut banks as well as a distinct flood plain scar. This meander belt and contact has not been evaluated in the field. It may be equivalent to bottomland terrace 1 (Pbt1), although there is a strong difference between the two in the degree of definition preserved.

Hm3 **Congaree River meander belt 3 (Holocene to pre-1825) –** Congaree River meander belt 3 is represented by a highly continuous, sinuous abandoned channel complex that is currently occupied by Mill Creek in the northwest part of the map area. Channel features appear distinct and fresh. The preservation of long channel segments suggests that this meanderbelt may have been abandoned by avulsion in the geologically recent past. Significant base-flows, abundant black water, and organic deposits adjacent to Mill Creek suggest a groundwater table connection.

Hm4 **Congaree River meander belt 4 (Holocene to pre-1825) –** Congaree River meander belt 4 represents a large array of highly fragmented meander scars and associated features that dominate the north-central part of the lower Congaree River Flood plain. This area is the primary refuge of old-growth bottomland hardwood flood plain forest preserved in Congaree National Park. This meander belt has been largely overprinted by flood plain creeks (Hic). A variety of channel widths, meander wavelengths, meander amplitudes, and flood plain features indicate a complex history, such that further work may subdivide Congaree River meander belt 4.

Pm5 **Congaree River meander belt 5 (Latest Pleistocene) –** Congaree River meander belt 5 is represented by a single, very-wide, large-wavelength channel in the southeast portion of the valley. Large-wavelength channels have been noted throughout the Atlantic and Gulf Coastal Plains, where they have historically been referred to as the "Deweyville" terrace or complex (e.g. Gagliano and Thom, 1967; Saucier, 1994a). Leigh (2006) demonstrated that these channels are terminal Pleistocene in age in the Carolinas and Georgia, and were established 17 to 14 ka in response to an increase in both precipitation and vegetation cover. This discharge and river regime may have been responsible for significant incision and enlargement of valleys in the Southeast (Riggs and others, 2000). Meanderbelt 5 may correlate locally with bottomland terraces upstream that have been topographically homogenized.

### BOTTOMLAND TERRACES

Bottomland terraces are distinct surfaces within the flood plain that lack abundant meander scars. Although these surfaces likely originated as meander belts or meander belt mosaics, the effects of age, scouring, creek migration, and flood plain deposition have obscured and homogenized all but a few robust, isolated features. One bottomland terrace includes areas associated with braided, as opposed to meandering, river deposits. Many of these terraces, or at least portions of them, are topographically elevated "second bottoms" that flood only during high water.

Pbt1 **Bottomland terrace 1 (Pleistocene) –** Bottomland terrace 1 occurs in two deeply recessed portions of the southern bluffs south of the Modern Congaree River meander belt. The relative elevation and stability of this terrace is indicated by the steep banks along the modern river, well-developed modern levees (MD Atlantic Technologies, 2002a), housing development along Banks Lane in Calhoun County, and a history of colonial settlements in the Devil's Orchard area as early as 1760. The age of this terrace is constrained by the presence of Muller's Barn Ridge dune complex (Pd), and the Sandy Run alluvial fan complex (Pas). Although this unit generally appears to have fewer distinct features than the bulk of Congaree River meander belt 2 (Hm2), elevation models suggest the two could be correlated.

Pbt2 **Bottomland terrace 2 (Pleistocene) –** Bottomland terrace 2 includes areas in the northern part of the map area with little surface topography and relatively deranged drainage. The minimum age of this terrace is constrained by the presence of Green Hill Mound dune complex (Pd).

Pbt3 **Bottomland terrace 3 (Pleistocene) –** Bottomland terrace 3 is found in the lowermost portions of the valley near the confluence of the Congaree and Wateree Rivers. The minimum age of this terrace is constrained by the presence of Solomon Island dune complex (Pd). Bottomland terrace 3 is topographically lower than the modern Congaree and Wateree meander belts that flank it, indicating a post-Pleistocene reduction in valley gradient.

Pbt4 **Bottomland terrace 4 (Pleistocene) –** Bottomland terrace 4 is a Pleistocene braided river terrace. Field observations and remote sensing data indicate diverse features including braid bars and relict braided channels expressed as modern sloughs. Bottomland terrace 4 is correlated with other braided terraces from Georgia to North Carolina; these latter terraces largely cluster from 30 to 17 ka, but some date back as old as 68 ka (Leigh and others, 2004). This braiding reflects the river response to a very different Pleistocene landscape and climate characterized by significant discharge variability, bed load size and abundance, gradient, bank stability, and vegetation (Saucier, 1994a; Miall, 1996; Leigh and others, 2004). Leigh and others (2004) suggests that it has actually been the most common river patter during the Quaternary in the Southeast. The braided-meandering transition during the terminal Pleistocene is closely associated with the Congaree River meander belt 5 (Leigh and others, 2004).

### ALLUVIAL FANS

Alluvial fans are lobate cones of sediment deposited where tributary streams open up as they converge with larger valleys. Groups of fans consistently associated with a specific scarp or surface are referred to as a complex, while coalesced, laterally-merged fans are known referred to as aprons. Fans are subtle at best in the Congaree River Valley, and have not been recognized here in the past. They have been mentioned elsewhere in the South Atlantic Coastal Plain (e.g. Stevenson, 1982; Brooks and Sassaman, 1990), but not studied in significant detail in the region. They have been studied in the Mississippi River Valley (Saucier, 1994a,b). Fans contain a range of stream and overbank facies at a local scale, but these are too complicated to generalize at the present scale of observation (e.g. Saucier, 1994a,b). In the current map area, alluvial fans have generally been traced to the distal edge of their surface expression as visible on the LIDAR data (MD Atlantic Technologies, 2002b). Unpublished GPR and coring data, however, indicate that they locally extend further into the subsurface, where they are onlapped by vertically accumulating silt and clay. Two of the alluvial fans are technically upland deposits, but included here for organizational purposes.

Han **North Rim alluvial fan complex (Holocene) –** This fan complex includes the remains of several dissected fans resting within the modern flood plain. Coring data indicate these fans are up to 8 to 12 feet thick, but they have been largely buried (onlapped) by vertically accumulating flood plain fines. A fan associated with Dry Branch, located southeast of the Harry Hampton Visitors Center at Congaree National Park, is truncated by the meander scar associated with Weston Lake, and another fan associated with Toms Creek is also cut by a meander scar from Holocene meander belt 4 as well. This is suggests at least a middle Holocene age. Such an age would be consistent with regional shifts towards wetter climate, organic sediment accumulation, and vegetation shifts (e.g. Gaiser and others, 2001). These fans tend to be the primary source of coarse sediment along the northern flood plain margin. This complex may be correlative with the Kingville and Griffin's Creek alluvial fans (Pac and Hag) to the east, but more work is needed to date these features.

Hak **Kingville alluvial fan (Holocene) –** The Kingville alluvial fan complex is found on top of Pleistocene bottomland terrace 4 (Pbt4) in the vicinity of the old Kingville railroad station at the railroad intersection. Interpretation of this fan complex and Old Mckenzie Creek (Qato) is complicated by less than 4 feet of historical sedimentation (not just moved earth) associated with the railroad, especially inside the v-shaped notch to the north of the railroad intersection. There are, however, distinct lobes out onto Pleistocene bottomland terrace 4 (Pbt4) that are not associated with the railroad. The Kingville alluvial fan appears to merge to the west with the North Rim alluvial fan complex associated with Tom's Creek, but correlation is unknown at this time.

Hag **Griffins Creek alluvial fan (Holocene) –** An isolated feature deposited by Griffins Creek on top of Terrace 1 of the Congaree River Valley terrace complex (Qt1). This fan is technically an upland deposit but included here for reference. The age of this fan is only speculative at this point, and the only definite constraints are that it is younger than both Qt1 and the Chimney alluvial fan (Pac).

Pas **Sandy Run alluvial fan (Plesitocene?) –** This enormous fan is associated with Sandy Run, a large tributary draining the southern bluffs. Drill hole log 09-247 indicates at least 17-feet of deposits consisting of multiple sequences of buff tan to brown silty clay to very coarse sand. The Sandy Run drainage basin contains deeply incised, Upper Coastal Plain sediments that include very loose, sandy Eocene sediments that represent a convenient source for the fan.

Pac **Chimney alluvial apron (Late Pleistocene) –** The Chimney alluvial apron is a series of two fans that are coalesced on top of Terrace 2 of the Congaree River Valley terrace complex (Qt2). The dominant fan in this complex is associated with Griffins Creek. The Southeast corner of this fan toes out near a railroad intersection locally named "Chimney." Scattered alluvial surfaces are found to the west, near McKenzie Creek, at the same elevation. These are interpreted as another fan simultaneously deposited by that system. This fan is technically an upland deposit but included here for reference.

### ADDITIONAL FLOOD PLAIN ELEMENTS

Although the meander belts, bottomland terraces, and alluvial fans represent the principal building blocks of the Congaree River flood plain, there are a host of other deposits as well.

Hic **Flood plain creeks (Pleistocene to Holocene) –** The flood plain is covered with a complex, dynamic network of permanent creeks that connect the tributary valleys (Qatv) with the main river. These systems, which are very abundant in Congaree River menader belt 4 (Hm4), are characterized by significant, mappable, sinuous channels with widths, meander amplitudes, and meander wavelengths that are significantly smaller than river-related features (MD Atlantic Technologies 2002a). In these areas the creek activity has effectively dominated and erased the underlying features, although their courses are likely controlled by underlying abandoned channel geometries and an effective discharge associated with large flood events. While these creek networks are generally too numerous, complex and distracting to display at the present scale, a few of the most dramatic, dominant, and unavoidable ones are shown for reference. Further high-resolution mapping is also needed to detail relationships definable geomorphic features, including channels and ridge-scroll topography, in these systems (see Explanation of Geomorphic Map Units and Explanation of Map Symbols).

Hgr **Groundwater rim swamps (Holocene) –** Ground water rim swamps are large, arcuate embayments in the northern flood plain margin that contain several feet of peat and muck (Shelley and others, 2004, Cohen and others, 2005a,b). This sediment, which is a mixture of organic sediments and clay, is regionally referred to as Dorovan Muck (e.g. Lawrence, 1978). These swamps are hydrologically dominated by groundwater seepage from the adjacent bluffs and concentrated in the hollow shape of the scarp (e.g. Knighton, 1998; Cohen and others, 2004; Shelley and others, 2004). These surficial deposits are likely middle Holocene to recent in age, and underlain by terminal Pleistocene ox-bow deposits capped by a paleosol (Cohen and others, 2004; Shelley and others, 2004). A pollen diagram indicates a number of significant climatic and hydrologic changes over the last 21,000 years (Cohen and others, 2004). These areas show extreme biological diversity, act as important filters for water moving into the flood plain, and may be good modern analogs for certain ancient fluvial coal deposits (Brinson, 1995; Cohen and others, 2005a,b).

Hls **Landslide deposits (Holocene to Recent) –** The modern south bluffs are actively retreating southward due to mass wasting (Shelley and Cohen, 2006). Although the vast majority of these landslide events and deposits are too small to map at the present scale, LIDAR data indicate at least two measurable cones at the base of the bluffs. One small cone is located along the north bluffs, though this may reflect more of a washout than a true landslide.

Pd **Dune complexes (Late Pleistocene) –** Three sand dune complexes, known as Muller's Barn Ridge, Green Hill Mound, and Solomon Island, are recognized within the Congaree River Flood plain (Michie, 1980). These deposits consist of large, vegetated mounds of sand that locally rise more than 30-feet above the flood plain. The sediments are light olive brown (2.5Y5/6) to light yellowish brown (2.5Y7/6) to pale brownish orange (10YR7/8), loose, well-sorted quartz sand with locally abundant heavy minerals and virtually no interstitial clay. These features are correlated with sand dunes on the coastal plain of Georgia, some of which were significantly active 15,000 to 30,000 years ago (Ivester and others, 2001; Ivester and Leigh, 2003).

Qw **Wateree River Flood plain, undifferentiated (Late Pleistocene to recent) –** The deposits of the Wateree River Flood plain have not been studied or subdivided in the present study, but they are likely similar in complexity, age, character, and distribution to those within the Congaree River Flood plain (e.g. Sexton, 1999). In the southeastern corner of the map especially, the eastern portion of the Santee River Valley appears to contain abundant braided deposits that are likely correlative with Pleistocene bottomland terrace 4 (Pbt4; Sexton, 1999).

### UPLAND DEPOSITS

The geologic and geomorphic elements that are adjacent to (but outside of) the flood plain are critical to understanding the long-term geologic context and evolution of the Congaree River system. Note that two of the alluvial fans are also technically upland deposits.

Qatv **Quaternary alluvium, tributary valleys (Pleistocene to recent) –** Tributaries occupy small stream valleys containing saturated, variably brown, red, and black sand, peat, and clay that have been mapped from a combination of LIDAR (MD Atlantic Technologies, 2002a,b) and DOQQs. Nystrom (1992) reported several Late Pleistocene (Wisconsonian) dates for similar tributaries in the Savannah River Valley, and these minimum ages are assumed to apply in the Congaree River Valley as well. The perennial to ephemeral streams that occupy these valleys are too complex, distracting, and dynamic to show at the present scale.

Qatt **Quaternary alluvium, tributary valley microterraces (Pleistocene to recent) –** Two-foot contours (MD Atlantic Technologies, Inc., 2002a,b), DOQQs, and USGS topographic maps indicate small, scattered, fragmentary steps between the active, swampy tributary valleys and the true upland terrace surface. Hand augering indicates that at least one of these features contains several feet of wet, loose, reddish brown (2.5Y5/4) to light peach red (2.5Y7/6), medium to very coarse quartz sand with abundant heavy minerals. These deposits are inconsistent with holes in the nearby terrace, and likely reflect older tributary deposits abandoned during Holocene climate changes associated with deposition of the North Rim alluvial fan complex. The presence of some Cretaceous subcrop and local clay pits along tributary valley margins to the north of the current map area (e.g. Kite, 1988, Shelley, 2007a,b) suggests that some of these features higher up in the valley could be erosional benches abandoned during incision rather than constructional terraces.

Qato **Quaternary alluvium, old McKenzie Creek (Pleistocene to Holocene) –** Old McKenzie Creek is a vaguely defined, southeast trending depression just northeast of the Old Kingville railroad depot. It is 4-feet below the elevation of the adjacent Terrace 2 of the Congaree River Valley terrace complex (Qt2), but geometrically it cannot be a younger fluvial terrace than that surface. It is, however, located just below a significant westward curve of McKenzie creek, in line with and adjacent to the Kingville alluvial fan complex (Pac) to the southeast. This feature is presently interpreted as an old course of McKenzie Creek that was the feeder system for the Kingville alluvial fan complex (Hak), but subsequently abandoned due to stream capture from Tom's Creek to the west. Details of this interpretation are difficult to resolve because of earth moving and upto 4-feet of subsequent sedimentation, much of which is conspicuously (historically?) accumulated upstream from the railroad. Incision associated with the formation of tributary valley microterraces (Qatt) could be related to headward knickpoint erosion and stream capture.

Qcb **Carolina bays (Pleistocene) –** Undisturbed Carolina bays are elliptical depressions containing 3-5 feet of variably gray and black sandy clay to clayey quartz sand and often surrounded by an eolian sand rim. Bays commonly have the primary (long) axis oriented north-northwest. Carolina bays are Pleistocene periglacial features formed over time by the action of dominant southwesterly winds on ponded water and dry land under conditions of fluctuating ground water (Kaczorowski, 1977; Soller and Mills, 1991; Brooks and others, 1996). During the Holocene, bays have become important seasonal depressional wetlands (Brooks and others, 1996; Sharitz, 2003). Many bays have been destroyed by plowing, ditching, and filling during land development; these can only be mapped using a combination of DOQQs, LIDAR data (MD Atlantic Technologies, 2002a,b), and observations of artificial drainage networks. Carolina bays are not labeled everywhere.

Qt1, Qt2, Qt3, Qt4a, Qt4b, Qt5, Qt6, Qt7a, Qt7b, Qt8, Qt9, Qt10 **Congaree River Valley terrace complex (Pliocene to Pleistocene) –** The Congaree River Valley terrace complex includes a series of estuarine and fluvial terraces deposited by the ancestral Congaree River and preserved above the modern flood plain. Where intact, terrace deposits form graded sequences of red clay and sandy clay grading downward to massive, white to pink, poorly to moderately sorted, medium to very coarse sand with varying interstitial clay. Gravel lags are often present at or near the base. Multiple sequences are present in some terraces, suggesting multiple phases of deposition and development. Terrace surfaces are fragmentary at best, and have been significantly modified by alluvial, colluvial, eolian, and groundwater processes. The complexity of the modern flood plain suggests that these upland terraces are likely composite features of various meanderbelts, terraces, creeks, and the like. A total 14 terrace surfaces have been identified in the terrace complex (Shelley, 2007 a-f). The modern flood plain is considered terrace 0, and the progressively older terraces have been named in order of age (1 = youngest, 2 = older, etc.), with 'a' and 'b' designations if the relative age cannot be determined by cross cutting relationships. Scarps have been generalized, and are not drawn to reflect local topography; this is especially true with the higher (older) scarps. See Shelley (2007a-f) for a more detailed listing and discussion of terraces.

Qwrt3, Qwrt4 **Wateree River Valley terrace complex (Late Pleistocene) –** A few terraces at the western edge of the Wateree River Valley appear to be unique from the Congaree River Valley terrace complex based on surficial gradient models. Alternatively, they could be eroded and improperly correlated. These terraces have been delineated and tentatively assigned unique identification numbers, but were not subjected to intense study during this project.

Tuc **Buckhead conglomerate (Pliocene to middle Pleistocene) –** A small utility cut on State Highway 601 just south of the Congaree River provides an excellent and unique outcrop of reddish brown, cross-bedded sands and quartz pebble conglomerates with minor clay lenses. This outcrop is here informally termed the Buckhead conglomerate, named for the creek just to the north. Several stacked sets of complexly related cross-beds are present, and suggestive of a braided setting. Trough cross-bed orientations and weak pebble imbrication indicate an eastward transport direction. This outcrop is topographically too low to be correlated with fluvial deposits of the Miocene upland unit of the Upper Coastal Plain (e.g. Shelley, 2007d). Instead, the Buckhead comglomerate is interpreted as a very old Santee River tributary formed at a time when the Congaree River was several kilometers to the north and local drainages flowed eastward into the Santee River Valley. Subsequent southward migration and incision of the Congaree River has resulted in pirating of local drainages by steep, north-flowing tributaries of the Congaree River Valley.

KTu **Upper Coastal Plain, undifferentiated (Late Cretaceous to Eocene) –** The Upper Coastal Plain contains a series of Late Cretaceous to Eocene deposits grading from approximately 200-feet thick in the northwest map area to more than 800-feet thick in the southeast map area (Shelley, unpublished data from SCDNR Hydrology Section files). Many of the Late Cretaceous deposits are undifferentiated. The Maastrichtian Sawdust Landing Formation and the Paleocene Lang Syne Formation are deltaic in origin, while the overlying upper middle Eocene strata include several shallow marine deposits such as the Congaree Formation, Warley Hill Formation, Orangeburg District Bed, and Barnwell Group. The upland unit, a post-middle Miocene conglomerate, locally caps the high hilltops. See Shelley (2007a-e), Willoughby (2003), and Kite (1988) and references therein for more information on the Upper Coastal Plain.

## EXPLANATIONOF GEOMORPHIC MAP UNITS

Geomorphic units, symbolized by textured overlays, reflect distinct physiographic features related to depositional and hydrologic processes within the Congaree River Flood plain

### CHANNEL FEATURES

Several distinct geomorphic features are associated with the processes and depositional environments of meandering channels, including the modern channel.

Ga **Abandoned channels –** Abandoned channels are expressed as curved, low depressions that represent old river segments. Many abandoned channels are associated with extensive ridge scroll complexes, and some are associated with relict levees and point bars. Most are either expressed as sloughs, contain ox-bows, contain axial, meandering creeks known as batture channels (e.g. Shelley and Meitzen, 2005), or a combination thereof. The cut banks, or outer edges, of abandoned channels are often characterized by a small scarp 2 to 4 feet in elevation and represent the best-defined part of the channel. Subsequent deposition and slough development, however, tend to cause flaring of the channel ends and to obscure the inner channel margin. This latter effect may result in apparent narrowing of the actual relict channel. Local flood plain creeks (Hic) may completely overprint and obscure some abandoned channel courses.

In the subsurface, abandoned channel fills can often be simplified into a tripartite fill sequence reflecting three evolutionary stages (e.g. Saucier, 1994a). The lowermost unit is a basal sand, which reflects deposition by the active river. This is overlain by a sequence of clay plug and lacustrine deposits reflecting a sudden drop in energy. Above the clays is a mixture of peat, organic-rich clay, creek sand, and soil from a slough phase of development. The style of fill and associated ecological successions are also complicated by groundwater connections, flooding regime (frequency, magnitude, timing, quality, and duration), and nutrient dynamics (e.g. Amoros and others, 2000; Amoros and Bornette, 2002).

Go **Overbank deposits –** Overbank deposits are characterized by variably red and orange clayey sand associated with subtle, poorly defined, relatively well-drained elevated areas associated with channel margins (e.g. Saucier, 1994a). These environments are well reflected by changes in soil type and vegetation. Overbank deposits are cut by deeply incised guts and crevasse channels, indicating the importance of initial back-flooding in the formation of these environments during floods (Shelley and Meitzen, 2005). Technically these deposits include both levees and small crevasse splays, though distinguishing the two requires detailed facies work beyond the current map resolution. The vast majority of overbank deposits are associated with the active channel, especially well developed where the channel impinges on the steep southern bluffs. In some places, overbank deposits are closely associated with point bars, demonstrating very different channel behavior at different discharges. A few obvious relict levees are delineated adjacent to abandoned channels, especially in Holocene meander belt 4 (Hm4); note that these are not all of the relict levees, because many are so subtle that they do not lend themselves to mapping at the present scale.

Gsb **Sand bar –** Several sand bars are exposed at low water in the Congaree River. Levey (1978, 1979) specifically studied several of these bars in the Upper Congaree River and described distinct sub-environments related to channel flow dynamics.

Gpd **Point bar –** Point bars are those portions of meander curves that are frequently inundated during mid-flow events, characterized by an active surface and colonized by a distinct, disturbance tolerant vegetation assemblage (Meitzen, 2006). The southern bluffs of the Congaree River Flood plain may locally force changes in meander migration resulting in finer point bars (e.g. Saucier, 1994a).

Gri **River island –** Several river islands are present in the Congaree River. The formation and fate of these islands, which have not been intensely studied to date, is likely related to channel cutoff dynamics (Shelley and Meitzen, 2005).

### FLOOD PLAIN FEATURES

Many geomorphic features are associated with flood plain processes that operate somewhat independently of the modern channel.

Gsi **Swamp islands –** Several areas in the northern portion of the flood plain, such as Pine Island, are characterized by orange-brown, anomalously well-drained, soils with abundant fine to medium sand with occasional granules. These areas, which are also colonized by a significantly less-flood-tolerant flora, occur adjacent to flood plain creeks but are not creek levees and cannot be identified with a specific alluvial fan or relict river levee. Rather, they appear to be formed by depression of the groundwater table due to local incision of Cedar Creek and other flood plain creeks. The coarse texture, which allows this groundwater table response, is interpreted to reflect original deposition as a ridge scroll complex in Pleistocene flood plain terrace 2 (Pbt2).

Gbb **Braid bar –** Bottomland terrace 4 (Pbt4) contains several distinct, sandy mounds with slight relief of 4 to 6 feet. The largest of these has historically been mapped as an anomalous occurrence of Persianti very fine sandy loam (Lawrence, 1978). New, original field reconnaissance indicates a moderately poorly sorted, sub-angular to sub-rounded, fine to coarse sand with abundant interstitial clay. The relief and lithology are inconsistent with Pleistocene dunes complexes (Pd) examined in the valley, but they are, along with proximity to braid scars, entirely consistent with a braid bar facies. Braid bars are not mapped everywhere, but often implied by braid scar lines (see Explanation of Map Symbols).

Gn **North Bluff washes –** Several subtle drainages are present along the northern flood plain bluffs, especially near the groundwater rim swamps (Hgr). These features show up on LIDAR imagery as broad, shallow drainages and appear to be best developed in association with compound scarps. These washes could reflect groundwater geomorphology and sapping processes associated with seepage from the scarp (e.g. Schumm and others, 1995). Although ground examination does not indicate significant sedimentation or vegetation changes in many of these, they should eventually incise into the terrace and backfill with Quaternary alluvium over time.

Gc **Creek Channels –** Within the flood plain creek networks there is often a dominant channel zone that is geomorphically distinct from associated point bar and meander scroll complexes. These channels are often deceptively wide and deep, as their effective discharge is associated with large flood events. Some of these, such as Cedar Creek, likely receive a high base flow component from the deep aquifer somewhere near the northern flood plain margin (Patterson and others, 1985). While specific creek channels are generally too numerous, complex and distracting to display at the present scale, Cedar Creek is a large, perennial creek and shown for reference. It is recognized as South Carolina's only stretch of Outstanding National Resource Waters and a popular paddling route in Congaree National Park. These channels are connected to a whole network of smaller channels, locally called guts, within the flood plain (Shelley and Meitzen, 2005).

## EXPLANATION OF MAP SYMBOLS

**Contact –** Identity and existence certain, location accurate (dotted where concealed).

**Contact –** Identity and existence certain, location approximate. In several locations, boundaries cannot be pinned down precisely without significant further fieldwork.

**Fluvial terrace scarp –** Identity and existence certain, location approximate. Hachures point downscarp. These features range from 2 to 15 feet high, with higher relief common along compound scarps.

**Gradational contact –** Identity and existence certain, location inferred. Many geomorphic features, including Holocene Groundwater Rimswamps (Hgr), the Holocene North Rim Alluvial Fan Complex (Han), North Bluff Washes (Gn), and overbank deposits (Go), lack sharp, defined boundaries. Instead these are characterized by gradients related to facies, hydrology, and depositional environments. Similar complications have been noted by other cartographers in fluvial settings (e.g. Saucier, 1994a,b).

**Internal contact –** Identity and existence certain, location inferred. The terminations of many abandoned channels have been modified by subsequent slough and creek development such that they simply fade into the flood plain without sharp truncation by another feature. These terminations are the mappable limit of abandoned channels, though they may actually extend further along the channel trend in the subsurface. See Cely (2001) for slough representations.

**Flood plain scar –** Identity or existence questionable, location accurate. LIDAR (MD Atlantic Technologies, 2002a,b) and DOQQ sources indicate a number of scars, lineaments, and cuts in the flood plain that cannot be directly attributed to a specific channel or tributary. For most scars, hachures point off a small hill or scarp 2-4 feet high. In many places, these appear to be high water features cut by either the main river or flood plain creeks during flood events; in other places, they may reflect antecedent features that have been otherwise modified beyond recognition. In many places, scars represent contacts between units, but they do not necessarily seem associated with distinct fluvial terrace contacts. Scars are not marked everywhere.

**Braid scar –** Identity or existence certain, location accurate. LIDAR (MD Atlantic Technologies, 2002a,b) and DOQQ data indicate a number of discontinuous scars from relict braided channels on bottomland terrace 4 (Pbt4). In many cases, the topography is significant degraded and the entire relict braided channel is not preserved. Hachures point downhill. Braid scars are not marked everywhere.

**Ridge scroll topography –** Location or existence questionable, location accurate. Prominent, curved lineaments are reflected in the topography, hydrology, and vegetation represented by LIDAR (MD Atlantic Technologies, 2002a, b) and DOQQ data. These features are interpreted to reflect extensive ridge scroll complexes throughout the flood plain. Ridge scroll complexes have locally developed drainage systems paralleling trough axes (Meitzen and Shelley, 2005). Delineation of these features is not necessarily restricted to successive swale troughs or scroll crests, but includes prominent lineaments throughout the area. Ridge scroll topography is not marked everywhere.

**Cedar Creek –** Location and existence certain, location accurate. See discussions of flood plain creeks (Hic in Explanation of Geologic Map Units) and creek channels (Explanation of Geomorphic Map Units).

**One Kilometer Grid (UTM Zone 17S, NAD27) –** Location and existence certain, location accurate.

**Congaree National Park (United States National Park Service) –** Location and existence certain, location accurate.

**Congaree Bluffs Heritage Preserve (South Carolina Department of Natural Resources) –** Location and existence certain, location accurate.

**Roads, Upland –** Location and existence certain, location accurate. These labeled, paved road networks provided for reference by the South Carolina Geodetic Survey.

**Roads, Dirt –** Location and existence certain, location accurate. See Moved Earth (me) discussion.

**Boardwalk and trail network at Congaree National Park –** Location and existence certain, location accurate.

40-237 **Hand Auger Hole –** South Carolina Department of Natural Resources Geological Survey (SCGS) hand auger hole locations with log identification numbers. All logs are on file at the SCGS

09-107 **Power Auger Hole –** SCGS power auger hole locations with log identification numbers. All logs are on file at the SCGS.

CAL-083 **Other Well Logs –** South Carolina Department of Natural Resources (SCDNR), Hydrology Section well log locations with identification numbers. All logs are on file at the SCDNR.

601-B2 **Geotechnical data –** Geotechnical data provided by John Lessley, P.E., S&ME, Inc.; Florence and Hutcheson, Inc.; and the South Carolina Department of Transportation. Data often represent holes that are too numerous to accurately display and have been simplified with a site identifier. Logs are on file at SCGS.

★ **Selected cultural and historical features have been labeled for reference –** Many labels are from Cely (2001).

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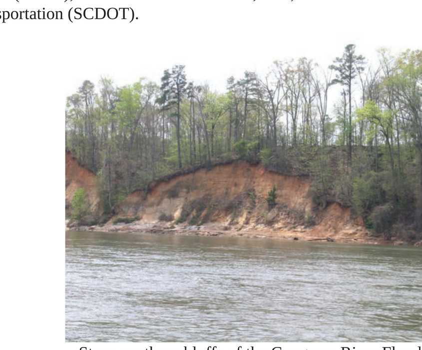
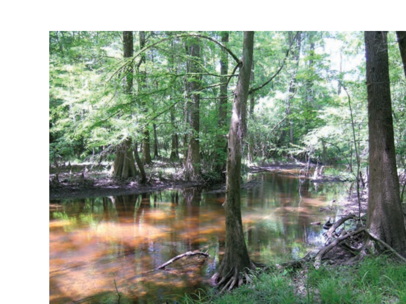
## ATTRIBUTION OF WORK

The United States National Park Service (NPS) provided funding for this project, while the South Carolina Department of Natural Resources (SCGS) provided momentous field, logistical, and technical support. David C. Shelley and Art Cohen mapped the flood plain geology and geomorphology. David C. Shelley and Jennifer Krauser developed the digital cartography. Scott Howard provided extensive editing. Scott Howard and Bill Clendenin provided logistical and management support. David C. Shelley mapped and compiled the upland geology in consultation with Ralph Willoughby and Paul Nystrom. Joe Koch and Gary Taylor drilled original power auger holes with assistance from Ernest Howard III, Quinton Jones, Robert Hurst, Scott Howard, Will Doar III, and David C. Shelley. David C. Shelley, Art Cohen, and Ralph Willoughby drilled and logged hand auger holes with assistance from Scott Howard, Kimberly Meitzen, Quinton Jones, Robert Hurst, Chris Judge, Brian Long, Andy Bruening, and Allison Humphries. Will Doar III provided support for boatwork on the river. Brett Moule provided access to the SCDNR Congaree Bluffs Heritage Preserve. Many holes and field investigations were made possible only through the kind support and permission of local land owners and hunt club managers. Additional subsurface information was provided by Joe Gellici and Roy Newcombe of the SCDNR Hydrology Section; John Lessley, P.E., of S&ME, Inc.; Dr. David Prowell of the USGS (retired); Florence and Hutcheson, Inc.; and the South Carolina Department of Transportation (SCDOT).



Steep southern bluffs of the Congaree River Floodplain.



Upstream (northwest) view of Cedar Creek from Pine Island.

Hand auger equipment at site 40-238.