# GLE Environmental Report

# Chapter 3 – Description of the Affected Environment

## Revision 0

## December 2008

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# 3. Description of the Affected Environment

This chapter describes the baseline conditions of the affected environment at and around the Wilmington Site and includes discussions of land use (**Section 3.1**); transportation (**Section 3.2**); geology and soils (**Section 3.3**); water resources (**Section 3.4**); ecology (**Section 3.5**); meteorology, climatology, and air quality (**Section 3.6**); noise (**Section 3.7**); historical and cultural resources (**Section 3.8**); visual/scenic resources (**Section 3.9**); socioeconomic (**Section 3.10**); public and occupational health (**Section 3.11**); and waste management (**Section 3.12**).

# GLE Environmental Report

# Section 3.1 – Land Use

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# 3.1 Land Use

The Wilmington Site is located in an unincorporated area in northwest New Hanover County about 6.5 miles (10.5 kilometers [km]) north of Wilmington, NC. The Wilmington, NC, Metropolitan Statistical Area (MSA; henceforth referred to as the Wilmington MSA) is the region of study for the land use section of this report. The Office of Management and Budget (OMB) defines and periodically updates the boundaries of MSAs to facilitate and coordinate data collection and distribution activities across many federal agencies. The OMB defines the Wilmington MSA to consist of Brunswick, New Hanover, and Pender counties.

## 3.1.1 Regional Setting

New Hanover County is the largest of the three counties in the Wilmington MSA in terms of population and includes the city of Wilmington. Development in New Hanover County is more intense than in neighboring Pender and Brunswick counties, due in part to the presence of Wilmington, the Port of Wilmington, and numerous popular beach destinations (**Figure 3.1-1**). The rate of population growth (percent increase) in all three counties exceeded that of the state as a whole between 2000 and 2005, and continued growth is anticipated for the foreseeable future.

The regional setting descriptions for each of these three counties are presented in this and the following sections. Greater emphasis on describing the characteristics of New Hanover County relative to the characteristics of Brunswick and Pender counties is a function of the location of the Wilmington Site (New Hanover County), as well as the lower population density and degree of development found in the two more rural counties of the Wilmington MSA. Descriptions of the transportation corridors in the counties are presented in **Section 3.2**, *Transportation*. A detailed description of the land use setting in the off-site areas in the vicinity of the Wilmington Site is presented in **Section 3.1.6**.

### 3.1.1.1 New Hanover County

New Hanover County is located in the southeastern corner of the state and is one of the fastest-growing counties in North Carolina. The North Carolina State Demographer's Office estimates that the population of New Hanover County increased by 14.8% over 6 years, from 160,327 persons in April 2000 to 184,116 persons in July 2006 (NC OSBM, 2006a). During this period, the estimated rate of population growth for the state as a whole was 10.11%. **Figure 3.1-2** shows the population trends for New Hanover County relative to the other two counties within the Wilmington MSA, and **Figure 3.1-3** shows the population trends for the state of North Carolina as a whole.

The county seat and largest municipality in New Hanover County is Wilmington. As of July 2005, Wilmington was the eighth-largest municipality in North Carolina, with an estimated population of 97,135 (NC OSBM, 2006b). The 2000 Decennial Census reports the population of the city as 55,530 and 75,838 persons for 1990 and 2000, respectively (U.S. Census Bureau, 2000). Large annexations in 1995 and 1998 increased the land area of the city, as well as contributed to the observed population growth (City of Wilmington and New Hanover County, 2006).

There are three smaller municipalities (Carolina Beach and Kure Beach to the south and Wrightsville Beach to the east; see **Figure 3.1-1**) and several unincorporated areas within New Hanover County. **Figure 3.1-4** shows the location of the unincorporated areas, or Census Designated Places (CDPs), with a population of 5,000 or more in the 2000 Decennial Census (U.S. Census Bureau, 2000).

The U.S. Geological Survey (USGS) National Land Cover Database (NLCD) is a nationwide spatial dataset derived from satellite imagery and depicting land cover at a 98-feet (ft; 30-meter [m]) spatial resolution using a standardized classification system (USGS, 2001). The most-recent NLCD data are for

the year 2001. USGS land cover data for the three counties in the Wilmington MSA were obtained from the NLCD (**Table 3.1-1**). The dominant land cover classes in New Hanover County (as of 2001) were Woody Wetlands (20% of total land area), Low-Intensity Developed (17% of total land area), and Evergreen Forest (15% of total land area) (USGS, 2001).

#### 3.1.1.2 Brunswick County

Located west of New Hanover County and Wilmington, Brunswick County is a relatively large county for North Carolina, with an area of 856.51 square miles ($mi^2$; 2,218 square kilometers [$km^2$]) and 47 miles (76 km) of coastline (Brunswick County, 2006). Largely rural, the county contains 19 incorporated municipalities and several unincorporated communities. **Figure 3.1-5** shows the location and boundaries of all CDPs in Brunswick County with a population greater than 1,000 persons in the 2000 Decennial Census (U.S. Census Bureau, 2000). The county seat of Brunswick County is Bolivia, which has a total of 148 residents. As a result of its coastal features and proximity to the Wilmington area, Brunswick County has experienced significant population growth. Between 2000 and 2003, Brunswick County ranked fourth in the state for total population growth (11.9%) and for net in-migration (11.3%) (Brunswick County, 2006). Seasonal housing accounts for an increasing portion of the total amount of housing available within the county (Brunswick County, 2006). The total population for Brunswick County was 73,141 in 2000 and 94,964 in 2006 (NC OSBM, 2006a).

In Brunswick County, the dominant land cover classes (as of 2001) were Evergreen Forest (33% of total land area), Woody Wetlands (28% of total land area), and Grassland/Herbaceous (11% of total land area). **Table 3.1-1** contains total acreages by USGS and cover class for Brunswick County. These figures are derived from the 2001 NLCD (USGS, 2001).

#### 3.1.1.3 Pender County

Pender County is located northeast of New Hanover County and Wilmington. Between the 1990 and 2000 Decennial censuses, the county's population grew by 42%. The total population for Pender County was 41,082 persons in 2000 and 48,724 persons in 2006 (NC OSBM, 2006a). Much of the development in Pender County has occurred along the U.S. Interstate Highway 40 (I-40) corridor between the town of Burgaw and the New Hanover County border, as well as in the southeastern corner of the county near Topsail Beach (U.S. Route 17 [US 17] corridor). **Figure 3.1-6** shows the 3 CDPs in Pender County with populations greater than 500 people.

Burgaw is the county seat of Pender County and had an estimated population of 3,621 in July 2005 (NC OSBM, 2006b). Single-family, owner-occupied housing dominates the local housing stock. Between 1990 and 2000, the percentage of rental housing fell from 29% to 22%, and in 2000, approximately 59% of residents lived in single-family units, whereas another 35% of residents lived in manufactured housing (Pender County, 2006).

In Pender County, the dominant land cover classes (as of 2001) were Woody Wetlands (40% of total land area), Evergreen Forest (24% of total land area), and Cultivated Crops (11% of total land area). **Table 3.1-1** contains total acreages by USGS and cover class for Pender County. These figures are derived from the 2001 NLCD (USGS, 2001).

### 3.1.2 Land Use Plans and Staged Plans

In North Carolina, land use planning is mandated for all coastal counties by the State's Coastal Area Management Act (CAMA), which was passed in 1974 by the North Carolina General Assembly. Municipalities in the regulated coastal counties have the option of preparing their own CAMA land use plans or relying on their county government-prepared land use plan to meet this requirement. Land use planning provides a venue for engaging the public and formulating a vision for future development, as

well as establishing a framework that reduces uncertainty for developers, residents, elected officials, and local managers. The CAMA land use plans are considered staged plans, which typically refer to phased development or implementation of a project or policy.

To comply with the CAMA, each county in the Wilmington MSA has prepared a land use plan for the unincorporated area in the county and for the municipalities not electing to prepare their own plan for the area within their jurisdiction. The majority of the municipalities located within the Wilmington MSA chose the option of preparing their own land use plans (Beatley et al., 1994). New Hanover County and the City of Wilmington prepared a joint land use plan (City of Wilmington and New Hanover County, 2006). In addition to mandating land use planning, CAMA also requires that county land use plans address such issues as intergovernmental coordination, economic and community development, resource protection, and natural hazards mitigation (Beatley et al., 1994). Each CAMA land use plan is reviewed by the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Coastal Management (NC DCM), and approval/certification is required for all 20 coastal counties in North Carolina. The CAMA requires that counties (and participating municipalities) produce a land classification map in which all lands within their applicable jurisdictions are assigned to general land use classes, such as urban, transition, community, rural, resource protection, and conservation. The actual names of these classes tend to vary, and the examples listed represent the coarse classifications used for the New Hanover County land use plan.

The CAMA also created the North Carolina Coastal Resources Commission (NC CRC), which sets policies for the State's Coastal Management Program, certifies land use plans for coastal jurisdictions, and designates Areas of Environmental Concern (AECs). Proposed development within an AEC requires a CAMA permit unless it falls within one of the exempt areas specified in Section 103(5)(b) of the CAMA. The GLE Study Area is not located within a designated AEC; therefore, a CAMA permit is not required for construction of the Proposed GLE Facility. The CAMA is further discussed in **Section 3.4.2.9.3**, *Coastal Zone Management Act* (*Federal and State Regulations)*.

#### 3.1.2.1 New Hanover County

The New Hanover County and City of Wilmington governments work closely together on land planning within the county and prepare a joint CAMA land use plan. The most recent update to the Wilmington-New Hanover County CAMA land use plan was certified in 2006 (City of Wilmington and New Hanover County, 2006; **Figure 3.1-7**). This plan includes a land classification map that indicates the locations of specific land category designations within New Hanover County that have been selected to help guide planners and government officials with implementing the land use policies and strategies defined by the plan (see **Figure 3.1-7**). The land categories are urban, transition, community, rural, conservation, and resource protection (which has four subcategories: aquifer resource protection, wetland resource protection, watershed resource protection, and natural heritage resource protection). Locations within New Hanover County indicated on the land classification map as not in the planning area are excluded because either an area is within the jurisdiction of a municipality with an individual CAMA land use plan or an area is federal or State-owned land. The following municipalities located in New Hanover County currently have individual CAMA land use plans that have been certified: Carolina Beach, Kure Beach, and Wrightsville Beach (NC DCM, 2007a). Each of these municipalities received certification of their original CAMA plans from the NC CRC during the 1990s and make periodic revisions. Carolina Beach's plan update is currently under review by the NC CRC; Kure Beach's plan update was certified in 2006; and Wrightsville Beach's plan update was certified in 2005.

The applicability of the land classification map categories shown in **Figure 3.1-7** to the Wilmington Site is discussed in **Section 3.1.6**.

The City of Wilmington has made significant efforts to encourage and promote redevelopment of the downtown and waterfront districts. In 1997, the city completed *Wilmington Vision 2020: A Waterfront Downtown*, which provides guidelines for encouraging and managing revitalization of the downtown and surrounding neighborhoods (City of Wilmington, 2004a). Infill development and a focus on underutilized properties is one of the primary planning strategies for the future in many communities without large reserves of developable land. According to *Choices: The Wilmington Future Land Use Plan, 2004–2025* (City of Wilmington, 2004b), Wilmington is approximately 90% developed and full build-out is anticipated by the end of the 2025 planning period. Population density is increasing, and "new construction has shown a greater trend towards multi-family development, and several U.S. Census Block Groups (CBGs) are showing noticeable increases in renter-occupied dwellings" (City of Wilmington, 2004b).

**Figure 3.1-8** shows the anticipated future land use for Wilmington (the Wilmington Site is located approximately 4.5 miles [7 km] north of the field of view). Key features depicted in the map include a significant amount of mixed use, residential, and industrial development in the area south of Wilmington International Airport and north of Martin Luther King, Jr. Parkway.

Residential land use is the dominant land use within Wilmington, with a distinct trend towards more golf-course–based residential community developments. Between 1999 and 2004, a total of 4,696 permits for new dwelling units were issued in Wilmington. During this period, the numbers of single-family and multi-family units permitted were almost identical at 2,351 and 2,345, respectively (City of Wilmington and New Hanover County, 2006).

In the unincorporated areas and beach communities of New Hanover County, residential land use also is dominant. During the 1990s and early 2000s, the availability of water and sewer infrastructure in the unincorporated areas of the county and the accessibility afforded by I-40 and other major highways in the area stimulated rapid development. Between 1999 and 2004, a total of 8,949 new dwelling units were permitted in the unincorporated areas of New Hanover County. During this period, the number of single-family units permitted far exceeded multi-family units at 7,267 and 1,682, respectively (City of Wilmington and New Hanover County, 2006). **Table 3.1-2** details existing land use in the unincorporated regions of New Hanover County, as well as in the municipal jurisdictions of Wilmington, Carolina Beach, Kure Beach, and Wrightsville Beach.

In the fall of 2007, the New Hanover County Planning Department began a planning initiative for the Castle Hayne community (northwest New Hanover County), which, when completed, will culminate in a Castle Hayne Community Plan to guide future growth in this sector of the county (New Hanover County Planning Department, 2008). The outer zone of the Castle Hayne Planning Initiative study area includes the Wilmington Site. Aside from this current planning process, there are no other known staged plans that would influence the Wilmington Site or its immediate vicinity.

#### 3.1.2.2 Brunswick County

The *Brunswick County Core Land Use Plan* (Brunswick County, 2006) is under review by the NC DCM. The plan identifies key issues related to development in Brunswick County, including sprawling (scattered) development, stormwater impacts, and emergency preparedness (evacuation), primarily related to hurricanes and flooding. According to the NC DCM, the following municipalities located in Brunswick County currently have individual CAMA land use plans that have been certified or are under review: Bald Head Island (draft stage), Calabash (certified 1995), Caswell Beach (certified 1999), Holden Beach (certified 1998), Shallotte (certified 1994), Southport (certified 1999), Sunset Beach (certified 1998), and Varnamtown (sketch certified 1995) (NC DCM, 2007a). It should be noted that many of these municipalities are currently in the process of updating existing CAMA land use plans, including Calabash, Shallotte, Southport, and Varnamtown (NC DCM, 2007b).

Brunswick County has not reached full capacity in terms of developed land area. At the time of the *2004 Brunswick County Core Land Use Plan* (Brunswick County, 2006), commercial and industrial uses comprised a very small proportion of the county's land area, with agricultural uses maintaining an important role in the local economy and land use patterns. Estimates from **Table 3.1-3** show that approximately three quarters of the county are considered undeveloped. The second-most dominant use is low-density residential/agricultural, which is characterized by farmland and sparse rural development (Brunswick County, 2006).

The Brunswick County plan (Brunswick County, 2006) identifies the US 17 corridor—which connects the town of Carolina Shores near the North Carolina–South Carolina border in the southern corner of the county with Shallotte, Bolivia, and the northeast portion of the county—as a major concentration of recent development. Other areas of active development include the north-south corridors along N.C. Route 87 (NC 87; this corridor runs from Oak Island to Northwest) and N.C. Highway 133 (NC 133; this corridor runs from Oak Island to Belville), which pass through land more suited for development (Brunswick County, 2006). (The locations of the US 17, NC 87, and NC 133 corridors within Brunswick County are shown in **Figure 3.2-3** in **Section 3.2**, *Transportation*.) Within the municipal areas in Brunswick County, residential uses are dominant. Future development is expected to occur eastward from the town of Carolina Shores and around the towns of Southport, Oak Island, and Boiling Spring Lakes (**Figure 3.1-9;** Brunswick County, 2006).

#### 3.1.2.3 Pender County

The *Pender County CAMA Land Use Plan, 2005 Update* (Pender County, 2006) is under review by the NC DCM. The Pender County future land use map (**Figure 3.1-10**) has five classifications: 1) conservation, 2) urban growth area, 3) transition area, 4) rural clusters, and 5) rural area. For a detailed description of these classifications, see the *Pender County CAMA Land Use Plan Update* (Pender County, 2006). In addition to the Pender County land use plan, several municipalities located in Pender County currently have CAMA land use plans (of their own) that have been certified or are under review. Surf City's original CAMA plan was certified in 1993, and Topsail Beach's CAMA plan was certified in 1992. Surf City's most recent CAMA plan update was certified in 2004, and Topsail Beach's was certified in 2005 (NC DCM, 2007a).

Pender County is approximately 55% forested, and 10% of the total land area is devoted to agricultural uses; however, among developed uses, residential uses are dominant (Pender County, 2006). **Table 3.1-4** details existing land use in unincorporated areas of Pender County in 2005. The majority of recent development in the county has occurred along the US 17 corridor, which runs southeast to northwest near the towns of Topsail Beach and Surf City (Pender County, 2006).

### 3.1.3 Special Land Use Classifications

There are no special land use classifications within the Wilmington MSA for American Indian reservations (U.S. Census Bureau, 2000). Also, no national parks or federally designated wilderness areas are located within the three-county MSA (National Atlas of the United States, 2005). There are also no federally designated wild and scenic rivers within the Wilmington MSA (Interagency Wild and Scenic Rivers Coordinating Council, 2007). Within the Wilmington MSA, there are several State parks, a national battlefield, two national historical landmarks, and other special land use classifications. The designated special land use classifications within each county in the Wilmington MSA are described below and shown for each county, respectively, in **Figure 3.1-11** (New Hanover County), **Figure 3.1-12** (Brunswick County), and **Figure 3.1-13** (Pender County). Environmentally Sensitive Areas are discussed in **Section 3.5.6**, *Environmentally Sensitive Areas*.

### 3.1.3.1 New Hanover County

#### *3.1.3.1.1 Environmental Conservation Areas*

There are two National Estuarine Research Reserves (NERRs) located within New Hanover County (see **Figure 3.1-11**). Zeke's Island NERR is 22 miles (35 km) south of Wilmington and can be accessed via private boat, and Masonboro Island's NERR is approximately 5 miles (8 km) southeast of Wilmington and is an undeveloped barrier island with pristine ecological systems.

As of 2002, the North Carolina Coastal Land Trust owned land parcels (Northchase Bottomlands and Cape Fear Royal Tracts) that were partially or completely within 5 miles (8 km) of the Wilmington Site. Within the Wilmington MSA, this organization either owns title to or holds land use easements on a total of 9,400 acres (3,800 hectares [ha]) of land.

The Sutton Lake Game Land area is located west of Wrightsboro between U.S. Route 421 (US 421) and the Cape Fear River. It consists of 3,325 acres (1,346 ha) owned by Progress Energy Carolinas, New Hanover County, and Brunswick County. A significant portion of this game land area (2,607 acres [1055 ha]) is located within 5 miles (8 km) of the Wilmington Site (North Carolina Wildlife Resources Commission, 2003). In addition, a portion of the Cape Fear River Trail (paddling) is located within 5 miles (8 km) of the Site and passes the western border of the Site. This paddling trail (for boats, canoes, kayaks) begins in Cumberland County near Fayetteville and follows the Cape Fear River southeast through New Hanover County to the communities of Caswell Beach and Oak Island in southern Brunswick County (North Carolina Division of Parks and Recreation, 2001).

The Cape Fear River Wetlands Game Land is located north of the Wilmington Site and extends into Pender County. This game land covers 1,752 acres (709 ha) in New Hanover County and is owned and maintained by the North Carolina Department of Wildlife Resources (The Nature Conservancy, 2007a). The Pender County portion of the Cape Fear River Wetlands Game Land is discussed in **Section 3.1.3.3**.

Other environmental conservation areas are located outside of a 5-mile (8-km) radius from the Site. Also located in the southern portion of New Hanover County are the Telfairs Creek and Lords Creek wetland preserves (Conservation Biology Institute, 2005). Airlie Gardens (67 acres [27 ha]) was purchased by New Hanover County in 1999 and is now open to the public; the gardens preserve a variety of local flora, fauna, and historic structures (Airlie Gardens, 2007).

#### *3.1.3.1.2 Military Installations*

The U.S. Coast Guard maintains a Long-Range Aids to Navigation (LORAN) station in Carolina Beach, NC (U.S. Coast Guard, 2007). Other lands owned by the U.S. Department of Defense (DoD) are discussed in **Section 3.1.3.2.2**.

#### *3.1.3.1.3 Parks and Recreation Areas*

New Hanover County is home to several State parks and recreational areas. Fort Fisher State Recreation Area is located in southern New Hanover County between the Cape Fear River and Atlantic Ocean. The Fort Fisher State Recreation Area is composed of 287 acres (116 ha) and offers a variety of activities, including swimming, fishing, and hiking. The 420-acre (170-ha) Carolina Beach State Park was established in 1969 and offers swimming, camping, boating, and other activities. No State parks are located within 5 miles (8 km) of the Wilmington Site.

There are 18 parks, 3 trails, and 3 gardens maintained by New Hanover County. Four of these parks are located within a 5-mile (8-km) radius of the Wilmington Site (New Hanover County Parks Department, 2007). **Figure 3.1-15** shows the location of these county parks with respect to the 5-mile (8-km)

Wilmington Site radius. Riverside Park covers 11 acres (4.5 ha) and is located on the Northeast Cape Fear River. The park includes two fishing piers, picnic tables, a gazebo, and a large community building with a 150-person capacity. Castle Hayne Park is 50 acres (20 ha) and offers multiple ball fields, playground equipment, and picnic shelters. Cape Fear Optimist Park consists of seven softball fields, and Trask Middle School Park has two softball fields and four soccer fields on its 7 acres (3 ha) (New Hanover County Parks Department, 2007).

#### *3.1.3.1.4 Historic Sites*

Two historic sites are located in New Hanover County. Within the Fort Fisher State Recreation Area is the Fort Fisher North Carolina Historic Site. This site is the remains of a Confederate Civil War fort that has been preserved by the State of North Carolina. The site has also been designated a National Historic Landmark by the U.S. Department of the Interior (DOI) (NPS, 2007a). The *USS North Carolina* battleship, permanently moored on the west bank of the Cape Fear River on the Wilmington waterfront, is also designated a National Historic Landmark by the DOI (NPS, 2007b). This World War II battleship is maintained by a private foundation and is a popular tourist attraction in Wilmington. Neither historic site is located within 5 miles (8 km) of the Wilmington Site.

#### *3.1.3.1.5 Prime and Unique Farmland*

The Farmland Protection Policy Act (FPPA; 7 USC 4201) defines prime farmland as

> "land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion, as determined by the Secretary [of Agriculture]. Prime farmland includes land that possesses the above characteristics, but is being used currently to produce live stock and timber. It does not include land already in or committed to urban development or water storage."

The U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS) has designated several soil types in New Hanover County as prime farmland, including the Craven, Norfolk, Onslow, and Wrightsboro soil types (see **Section 3.3.4**, *Soils*, for information about the soil types on the Wilmington Site). Prime farmland consists of USDA-designated soil types, is 10 acres (4 ha) or greater in size, and is undeveloped. Most of the prime farmland in New Hanover County is located in the Castle Hayne area and the northwest part of New Hanover County (City of Wilmington and New Hanover County, 2006); however, the county has very little acreage used for agricultural purposes. Of the 140,556 total acres (56,881 ha) in the county, 5,803 acres (2,348 ha) were under cultivation and 534 acres (216 ha) were used for pasture (USGS, 2001). In addition, only 77 farms were active in the entire county at the time of the last USDA survey (USDA, 2002). The area in the immediate vicinity of the Wilmington Site has commercial, industrial, and residential land uses, as well as forest land to the north of the Site. According to data from New Hanover County, there is no agricultural land use within a 5-mile (8 km) radius of the Wilmington Site (City of Wilmington and New Hanover County, 2006).

The FPPA (7 USC 4201) defines unique farmland as

> "land other than prime farmland that is used for the production of specific high value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods. Examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables."

The USDA NRCS has designated several soil types (e.g., Leon sand, Lynn Haven fine sand, Murville fine sand) in New Hanover County as farmland of unique importance (see **Section 3.3.4**, *Soils,* for information about the soil types on the Wilmington Site). These soil types cover 9.1%, 3.8%, and 11.5% of the county, respectively (NRCS, 2006). In North Carolina, the crop used to designate unique farmland is blueberries (NRCS, 2008). There is no significant blueberry acreage in New Hanover County (Wells, 2008).

### 3.1.3.2 Brunswick County

#### *3.1.3.2.1 Environmental Conservation Areas*

According to the North Carolina Wildlife Resources Commission (2006), two gameland areas are located in Brunswick County (see **Figure 3.1-12**). The Nature Conservancy owns the 15,430-acre (6,244-ha) Green Swamp Preserve Game Land located east of Bolivia between US 17 and N.C. Route 211 (NC 211). This area is a black bear sanctuary and provides deer- and turkey-hunting opportunities. The 1,139-acre (461-ha) Brunswick County Game Land is located north of Boiling Springs Lakes and is owned by International Paper, Inc. The 3,328-acre (1,347-ha) Waccamaw River Preserve was purchased by The Nature Conservancy in 2001 and subsequently transferred to the North Carolina Wildlife Resources Commission (The Nature Conservancy, 2007b).

Numerous smaller conservation and recreation areas are located throughout Brunswick County, including Bald Head Woods Coastal Reserve, Bald Head Island State Natural Area, Oak Island Marshes Preserve, Indigo Plantation Marsh Preserve, Myrtle Head Savanna Preserve, Pleasant Oaks Plantation, part of the Cape Fear Royal Tracts, and the Taylor Easement.

In addition, approximately 282,728 acres (114,446 ha) of wetlands with varying characteristics and management needs are located within Brunswick County (Brunswick County, 2006).

#### *3.1.3.2.2 Military Installations*

The Military Ocean Terminal Sunny Point (MOTSU) in Southport, NC, is the largest ammunition port in the nation and is the U.S. Army's primary East Coast deepwater port (U.S. Army SDDC, 2007). The MOTSU is located approximately 20 miles (32 km) south of the Wilmington Site. A separate 652-acre (264-ha) site in Leland, NC, is used by the MOTSU as a railcar holding yard. An additional 2,115 acres (855.9 ha) on the east bank of the Cape Fear River in New Hanover County are included as part of the MOTSU as an explosive safety buffer zone (see **Figure 3.1-11**).

The other military installation in Brunswick County is Eagle Island, which is located in the Cape Fear River (see **Figure 3.1-12**). This area is maintained as a security zone by the U.S. Coast Guard in association with the Port of Wilmington (U.S. Coast Guard, 2003).

#### *3.1.3.2.3 Parks and Recreation Areas*

Brunswick County contains several local parks, but does not have any parks of regional significance (Brunswick County, 2006). Although not technically classified as a park, the Bald Head Island State Natural Area, located in the southeastern corner of Brunswick County (see **Figure 3.1-12**), is managed by the North Carolina Division of Parks and Recreation and is an important site for loggerhead sea turtles (NOAA, 2007).

#### *3.1.3.2.4 Historic Sites*

Brunswick County has several sites that are listed in the National Register of Historic Places (NRHP; NPS, 2008). Among the most significant (as determined by drafters of Brunswick County, 2006) are the

Brunswick County Courthouse, Brunswick Town Historic District, Orton Plantation, St. Philips Church Ruins, and the T.B. McClintic Tripp's Marina. The Brunswick County Courthouse is located in Southport and was added to the NRHP in 1979. The Brunswick Town Historic District, located north of Southport, was added to the registry in 1978 and is significant as an example of a colonial village (NC DCR, 2008a). Orton Plantation is located on the Cape Fear River near the junction of NC 1530 and NC 1529 and was added to the registry in 1973 (Orton Plantation, 2008). Added to the NRHP in 1970, the St. Philips Church Ruins is located near Orton Plantation and was constructed in 1768 (NC DCR, 2008b). Tripp's Marina near Shallotte Point is the home of the tugboat *T.B. McClintic*, which was used by the U.S. Public Health Service in the 1930s for quarantine purposes. Tripp's Marina was added to the NRHP in 1994 (Bath Iron Works, 2008).

#### *3.1.3.2.5 Prime and Unique Farmlands*

Approximately 14% of Brunswick County's total acreage meets the prime farmland designation requirements. This farmland is located primarily in the south-central, western, and northeastern parts of the county (Brunswick County, 2006).

The USDA NRCS has designated the Leon fine sand soil type in Brunswick County as farmland of unique importance (see **Section 3.3.4**, *Soils*, for information about the soil types on the Wilmington Site). This soil type covers 8.7% of the county (NRCS, 2006). In North Carolina, the crop used to designate unique farmland is blueberries (NRCS, 2008). Most of the county's blueberry production is scattered in small plantings and covers approximately 18 acres (7 ha) of land (Hight, 2008).

### 3.1.3.3 Pender County

#### *3.1.3.3.1 Environmental Conservation Areas*

The North Carolina Wildlife Resources Commission owns the 5,281-acre (2,137-ha) Cape Fear River Wetlands Game Land, which consists of several non-contiguous tracts in Pender County to the north and west of the Wilmington Site (see **Figure 3.1-13**). The first of these tracts is located east of St. Helena along the Northeast Cape Fear River and is approximately 850 acres (340 ha). The second of these tracts is located near the Rocky Point area of south-central Pender County on the border with New Hanover within a few miles of the Wilmington Site. This portion of the Cape Fear River Wetlands Game Land is approximately 1,870 acres (757 ha). There are also tracts located in the southwestern portion of the county along the Black River in the Canetuck Township and a portion that extends into New Hanover County, as discussed in **Section 3.1.3.1.1**.

Located between US 17 and N.C. Route 53 (NC 53) is the 64,743-acre (26,201-ha) Holly Shelter Game Land, which is also owned by the North Carolina Wildlife Resources Commission. Adjacent to the Holly Shelter Game Land is the Southwest Ridge Preserve, a 950-acre (380-ha) area that provides habitat for rare and endangered plant and animal species (The Nature Conservancy, 2007c). The 24,483-acre (9,908-ha) Angola Bay Game Land (also owned by the North Carolina Wildlife Resources Commission) spans the border of Duplin and Pender counties, with the majority of the acreage located in northern Pender County.

Numerous smaller conservation and recreation areas are located throughout Pender County, including the Angola Creek Flatwoods Preserve, Sandy Run Preserve, O'Berry Tract, Patterson Tract, Neck Savanna Preserve, Pender Tract, Haws Run Mitigation Site, Castle Bay Tract, Five Eagle Partners Tract Easement, Prigden Tract, Bear Garden Tract, Angola Bay Tract, U.S. Fish and Wildlife Service (FWS) Permanent Easement, and Black River Cypress Forest Preserve.

The Black River flows through Pender County to join the Cape Fear River and is classified as an Outstanding Resource Water (ORW) by the North Carolina Division of Water Quality (NC DWQ). The ORW designation is applied to "unique and special waters of exceptional state or national recreational or ecological significance" and carries special management strategies to ensure the maintenance of existing uses (North Carolina Office of Administrative Hearings, 2007).

##### *3.1.3.3.2 Military Installations*

There are no military installations in Pender County.

##### *3.1.3.3.3 Parks and Recreation Areas*

Pender County maintains an access point to the Northeast Cape Fear River located off of Whitestocking Road, and the Town of Burgaw maintains the Ross Harrell Memorial Park. Aside from these facilities, the other known public recreation areas within Pender County are the Holly Shelter and Angola Bay game lands and other areas discussed above (NC CGIA, 2002b).

##### *3.1.3.3.4 Historic Sites*

The Moores Creek National Battlefield is located off N.C. Highway 210 (NC 210) in southwestern Pender County. This park is administered by the National Park Service (NPS) and commemorates a Revolutionary War victory over the British.

##### *3.1.3.3.5 Prime and Unique Farmland*

The soil survey for Pender County lists 18 soil types that occur in the county and are designated prime farmland. These soil types cover a total of 236,200 acres (95,590 ha) or close to half of Pender County's total 563,820 acres (228,170 ha) (NRCS, 2006; USGS, 2001). Only about one-fourth of this land is under cultivation. At the time of the latest USGS survey, Pender County had 61,977 acres (25,081 ha) of cultivated crops and 2,294 acres (928.3 ha) in pasture land. In this largely rural county, the majority of the land is either in woody wetlands (224,349 acres [90,790.8 ha]) or evergreen forest (131,508 acres [53,219.4 ha]; USGS, 2001).

The USDA NRCS has designated the Leon fine sand soil type in Pender County as farmland of unique importance (see **Section 3.3.4** *Soils*, for information about the soil types on the Wilmington Site). This soil type covers 5.4% of the county (NRCS, 2006). In North Carolina, the crop used to designate unique farmland is blueberries (NRCS, 2008). Pender County is the second leading producer of blueberries in North Carolina. In 2006, 625 acres (253 ha) of land located primarily near Burgaw, Currie, and Atkinson were dedicated to producing blueberries (Glen, 2008).

### 3.1.4 Mineral Resources

A regional discussion of the mineral resources of eastern North Carolina is presented in **Section 3.3.1.5**, *Economic Mineral Resources* (*Regional Geology*). The following is a discussion of the mineral resources of the Wilmington MSA. **Figure 3.1-14** shows the locations of active mining and mineral processing operations in the MSA.

#### 3.1.4.1 New Hanover County

In New Hanover County, active mining operations include a sand-and-gravel mining and processing facility (southwest of the Wilmington Site) owned by Riverfront Co., LLC, and a crushed-stone mining and processing facility (northeast of the Wilmington Site) operated by Martin Marietta Materials (USGS, 2005a). The facility owned by Riverfront Co., LLC, is located within 5 miles (8 km) of the Wilmington Site.

Data available from the USGS Minerals Resource Data System (MRDS) indicate that eight additional sand-and-gravel operations and one additional crushed-stone mining and processing operation located within New Hanover County. Of these additional sites, three of the sand-and-gravel operations are located within a 5-mile (8-km) radius of the Wilmington Site. There are also known occurrences of titanium in New Hanover County near the communities of Silver Lake and Seagate (USGS, 2005b).

#### 3.1.4.2 Brunswick County

As of 2003, there was a sand-and-gravel mining and processing facility, owned by the James C. Hewitt Trucking Company, located along N.C. Route 130 (NC 130) near the town of Shallotte (USGS, 2005a). Data available from the USGS MRDS indicate the existence of eight additional sand-and-gravel mining and processing operations within Brunswick County (USGS, 2005b). These sites are primarily concentrated in the western half of the county.

#### 3.1.4.3 Pender County

In Pender County, Martin Marietta Materials operates a crushed-stone mining and processing facility on SR 1636 near I-40, as of 2003 (USGS, 2005a). Data available from the USGS MRDS indicate the existence of seven additional sand-and-gravel mining and processing operations and a single calcium mine (near Maple Hill community) within Pender County (USGS, 2005b). These sites are primarily concentrated in the western half of the county.

### 3.1.5 Agriculture and Commercial Fisheries

This section discusses agriculture and commercial fisheries in the Wilmington MSA. A description of commercial and sport fisheries specific to the river systems in the vicinity of the Wilmington Site is presented in **Section 3.5.5.2** of this Report (*Commercial and Sport Fisheries [Aquatic Resources]*).

#### 3.1.5.1 New Hanover County

##### *3.1.5.1.1 Agricultural Products*

Agriculture plays a larger role in the economies of Pender and Brunswick counties than in New Hanover County (**Tables 3.1-5 and 3.1-6**). The main crops grown in New Hanover County are corn and soybeans. Based on data from 2006, the county ranked 66th and 77th among the 100 North Carolina counties in the production of these two crops, respectively (North Carolina Agricultural Statistics Division, 2007). The amount of livestock raised within the county was not large enough to warrant inclusion in the 2007 agricultural statistics report, and New Hanover County ranked 98th in total receipts from livestock, dairy, and poultry (North Carolina Agricultural Statistics Division, 2007).

##### *3.1.5.1.2 Commercial Fish and Invertebrate Catch*

In New Hanover County, commercial seafood landings have followed a declining trend. In 1995, an estimated 2,218,614 pounds (1,006,346 kilograms [kg]; valued at $3,218,877) of seafood was landed by commercial fishers in the county (NC DMF, 2006). As detailed in **Table 3.1-7**, this figure had fallen to 1,727,795 pounds (783,715 kg; valued at $2,347,701) by 2006 (NC DMF, 2007).

#### 3.1.5.2 Brunswick County

##### *3.1.5.2.1 Agricultural Products*

In Brunswick County, the primary crops are peanuts, corn, and tobacco, with an estimated total production of 500,000 pounds (227,000 kg), 725,000 bushels, and 1,555,000 pounds (705,000 kg) in 2006, respectively (North Carolina Agricultural Statistics Division, 2007). The area is also a leading

producer of pigs and hogs. Of the 100 counties in the state of North Carolina, Brunswick County ranked 23rd in the production of pigs and hogs, 30th in the production of peanuts, 35th in the production of corn, and 41st in the production of tobacco in 2006 (North Carolina Agricultural Statistics Division, 2007).

#### *3.1.5.2.2 Commercial Fish and Invertebrate Catch*

Fisheries are also an important component of Brunswick County's economy. The total amount and value of commercial seafood landings has witnessed a decline (see **Table 3.1-7**), from 3,738,490 pounds (1,695,750 kg; valued at $5,344,867) in 1995 to 2,287,119 pounds (1,037,420 kg; valued at $3,864,565) in 2006 (NC DMF, 2007). The primary centers of commercial fishing activity in Brunswick County are located in Shallotte and Southport.

### 3.1.5.3 Pender County

#### *3.1.5.3.1 Agricultural Products*

Corn, wheat, cotton, and soybeans are all key crops within Pender County. Approximately 1,450,000 bushels of corn; 234,000 bushels of wheat; 9,600 bales of cotton; and 353,000 bushels of soybeans were produced in 2006 for a statewide ranking of 22nd, 27th, 33rd, and 42nd, respectively (North Carolina Agricultural Statistics Division, 2007). Pender County ranked 12th statewide in turkey production and 10th in hogs and pigs raised in 2006 (North Carolina Agricultural Statistics Division, 2007).

#### *3.1.5.3.2 Commercial Fish and Invertebrate Catch*

Commercial seafood landings in Pender County are small compared to those of Brunswick and New Hanover counties. However, although the trend in its neighboring counties has been towards decline, the amount and value of the commercial seafood harvest in Pender County has remained relatively constant. In 1995, and estimated 684,080 pounds (310,290 kg) were landed, with a value of $801,007 (NC DMF, 2006). In 2006, the estimated commercial landings were 634,126 pounds (287,635 kg) valued at $753,301 (NC DMF, 2007). The primary center of commercial fishing activity in Pender County is Hampstead, which is an unincorporated area north of Wilmington on US 17.

## 3.1.6 Land Use in the Vicinity of the Wilmington Site

The Wilmington Site is the 1,621-acre (656-ha) parcel owned by General Electric Company (GE) west of NC 133 (also locally called Castle Hayne Road in New Hanover County, and previously, designated as U.S. Highway 117 [US 117]; see 5-mile [8-km] radius of Wilmington Site in **Figure 3.1-15**). The property is currently zoned I-2, which is described in the New Hanover County zoning code as intended for heavy industrial uses. No portion of the property is currently used for agricultural purposes.

Immediately north of the Wilmington Site is a large parcel, approximately 4,069 acres (1,647 ha) owned by Hilton Properties and appraised at $841,200 in 2006. The current zoning designation for this property is rural agricultural, which is designed for low-density residential development with an emphasis on farming and open-space preservation. This parcel is locally known as the Sledge Forest and is currently used for timber management and as a private hunting area. Access to the Sledge Forest is provided via a private, unpaved road that intersects NC 133 (Castle Hayne Road) and closely follows the northern property line of the Wilmington Site.

The Northeast Cape Fear River borders the Wilmington Site to the west, and industrial land uses are dominant on the opposite (west) side of the river. The BASF Corporation and Elementis Chromium manufacturing facilities and the L.V. Sutton Steam Electric Plant (a 763 megawatt coal-fired electric utility power plant operated by Progress Energy) are examples of industrial operations located in this area between the Northeast Cape Fear River and the main branch of the Cape Fear River.

In the eastern and southern vicinities of the Wilmington Site, residential uses are dominant due to the presence of the communities of Wrightsboro (south), Skippers Corner (east), and Castle Hayne (northeast). Located adjacent to the Wilmington Site's eastern boundary across NC 133 (Castle Hayne Road) are the North Carolina State University Horticultural Crops Research Station, a truck parking lot, and a small recreational park for use by Wilmington Site employees and owned by GE. Further north along NC 133 (Castle Hayne Road), between Hermitage Road and McDougald Drive, are three water-supply wells that GE pumps to meet the potable water demands of the existing Wilmington Site facilities. Also along this stretch of NC 133 (Castle Hayne Road) are four mobile homes located on the opposite side of the street from the Site.

Three public secondary schools are located within 5 miles (8 km) of the Wilmington Site: Wrightsboro Elementary School, Emma B. Trask Middle School, and Emsley A. Laney High School (North Carolina Department of Public Instruction, 2003). Trask Middle School also serves as an emergency shelter for New Hanover County. Wilmington International Airport (discussed in **Section 3.2**, *Transportation*) is located approximately 5 miles (8 km) south-southeast from the Site. The New Hanover County Landfill is located approximately 4 miles (6 km) southwest of the Site.

According to the U.S. Census Bureau's 2000 Decennial Census, a total of 321 Census blocks fall within a 5-mile (8-km) radius of the Wilmington Site (**Figure 3.1-16**). The majority of these Census blocks (261) is within New Hanover County and contains 12,997 persons and 4,953 households. A total of 57 Pender County Census blocks are within the 5-mile (8-km) radius, with a combined population of 3,305 persons and 1,274 households. An examination of Census block data from 2000 reveals a total of three Census blocks in Brunswick County with some portion of their total area inside the 5-mile (8-km) radius. The total population of these three Census blocks is 36 persons in 17 households (NC CGIA, 2002a). It should be noted that all blocks with any portion of their area inside the 5-mile (8-km) radius were included in this population count.

The Wilmington Site is located in an unincorporated area of New Hanover County. Portions of the Wilmington Site are located within a designated Conservation Area or Resource Protection Area, as shown on the most recent land classification map update for the Wilmington–New Hanover County CAMA land use plan (**Figure 3.1-7**). The existing Wilmington Site manufacturing facilities (Eastern Site Sector) is located in a designated Aquifer Resources Protection Area. Zoning ordinances reflect the Wilmington–New Hanover County CAMA land use plan goals of protecting groundwater resources by, for example, limiting residential densities in areas where septic systems are used for wastewater treatment. In addition, the plan suggests "prevention of [land] uses that pose risk of spill of hazardous materials, and encouraging development practices that promote sustained recharge" (City of Wilmington and New Hanover County, 2006). Development of the Wilmington Site by GE predates the CAMA land use plan initially prepared by the City of Wilmington and New Hanover County in 1976. Nevertheless, GE/Global Nuclear Fuel–Americas (GNF-A) actively manage the groundwater resource beneath the active manufacturing portion of the Site by inducing hydraulic control of the aquifer through production of process water (see **Section 3.4.1.2**, *Preexisting Groundwater Impacts*), thus isolating this portion of the aquifer from deeper and surrounding aquifers.

The undeveloped South-Central, Western, Northwestern, and North-Central Site sectors are located outside the Aquifer Resources Protection Area shown in **Figure 3.1-7**. The North-Central Site Sector, including the GLE Study Area, is located in a designated Wetland Resource Protection Area on the current land classification map. The purpose of this land category designation for implementing the City of Wilmington and New Hanover County CAMA land use plan is to protect the loss of wetlands from development (City of Wilmington and New Hanover County, 2006). Field surveys discussed in **Section 3.4.4.1**, *Aquifers and Confining Layers,* found that this area does not contain large areas of wetlands. Based on aerial photographs of New Hanover County, the majority of the naturally occurring wetlands

were drained prior to 1963. As discussed in **Section 3.5.3.2**, *Natural Communities (Biotic Communities)*, currently most of this area is Pine Forest, Pine Plantation, and Pine-Hardwood Forest biotic communities. The Western Site Sector adjacent to the Northeast Cape Fear River is located in an area designated on the land classification map as both a Conservation Area and a Natural Heritage Protection Area. The purpose of the Conservation Area designation for implementing the City of Wilmington and New Hanover County CAMA land use plan is to provide for management and protection of significant or limited natural resources while protecting the rights of the property owner (City of Wilmington and New Hanover County, 2006). Natural Heritage Protection Areas are areas identified by the North Carolina Natural Heritage Program to have unique habitats that need special protection. As discussed in **Section 3.5.6.1**, *Regionally Sensitive Areas*, the Northeast Cape Fear River floodplain natural area includes the Swamp Forest biotic community on the Wilmington Site. GE, GNF-A, and GE-Hitachi Nuclear Energy (GEH) neither conduct, nor have plans to conduct, any activities in this area.

#### 3.1.6.1 New Hanover County Land Parcels within 5 Miles (8 km) of the Wilmington Site

There are 7,190 parcels inside the 5-mile (8-km) radius of the Wilmington Site that fall within the jurisdiction of New Hanover County. Based on the land use dataset (not parcels) available for New Hanover County, 37,274 acres (15,084 ha) of land fall within a 5-mile (8-km) radius of the Wilmington Site, and the acreages by land use class are presented in **Table 3.1-8**. A total of 261 Census blocks within the 5-mile (8-km) radius fall within New Hanover County, with 12,997 persons in 4,953 households, according to the 2000 Decennial Census. It should be noted that all Census blocks with any portion of their areas inside the 5-mile (8-km) radius were included in this sample; therefore, the entire population of all Census blocks may not fall within the 5-mile (8-km) radius. The Census block that contains the Wilmington Site had a population of zero and no households at the time of 2000 Decennial Census. However, a total of five CDPs and Wilmington have some portion of their area inside the 5-mile (8-km) radius (NC CGIA, 2002a). The Castle Hayne, Skippers Corner, and Wrightsboro communities are the most likely candidates for evaluating the potential land use impacts, which will be discussed in **Section 4.1** of this Report (*Land Use Impacts*).

#### 3.1.6.2 Brunswick County Land Parcels within 5 Miles (8 km) of the Wilmington Site

Three parcels located within Brunswick County are also partially located within the 5-mile (8-km) radius of the Wilmington Site. A spatial dataset created by the USGS in cooperation with the U.S. Environmental Protection Agency (EPA) and published as part of the *ESRI® Data & Maps* series indicates that the portion of Brunswick County that falls within the 5-mile (8-km) radius is entirely within the vicinity of Dollisons Swamp (USGS, 2005c).

An examination of Census block data from 2000 shows a total of three Census blocks in Brunswick County with some portion of their total area inside the 5-mile (8-km) radius (NC CGIA, 2002a). The total population of these three Census blocks was 36 persons in 17 households; however, because these data are presented by Census blocks, it could not be determined if these people or households reside in the portion of the Census block that lies within the 5-mile (8-km) radius. Just outside the 5-mile (8-km) radius southwest of the Wilmington Site is Navassa, with a population in 2000 of 479 persons (U.S. Census, 2000). It should be noted that all of the Brunswick County land within the 5-mile (8-km) radius of the Wilmington Site is also within the Federal Emergency Management Agency (FEMA) flood zone designation AE, which corresponds to the 100-year floodplain and carries a mandatory flood insurance purchase requirement.

#### 3.1.6.3 Pender County Land Parcels within 5 Miles of the Wilmington Site

There are 1,348 parcels that are inside a 5-mile (8-km) radius of the Wilmington Site and fall within the jurisdiction of Pender County. The existing land use map for Pender County was created in 2005, and the spatial datasets containing the 2005 land use information are not available. A total of 57 Census blocks

fall within the 5-mile (8-km) radius and the boundaries of Pender County. The combined population of these Census blocks was 3,305 persons and 1,274 households (U.S. Census, 2000).

### 3.1.7 Other Land Use Considerations in the Wilmington MSA

There are no noteworthy facilities, agricultural practices, game harvests, or food processing operations within the three-county Wilmington MSA.

# Tables

**Table 3.1-1. USGS Land Cover by Acreage in the Wilmington MSA**

| USGS Land Cover Class | Total Land Cover (acres) | | | |
|---|---|---|---|---|
| | Brunswick County | New Hanover County | Pender County | Wilmington MSA |
| Open water | 25,406 | 17,464 | 7,639 | 50,509 |
| Developed, open space | 25,929 | 16,773 | 12,888 | 55,590 |
| Developed, low intensity | 15,579 | 20,437 | 4,959 | 40,976 |
| Developed, medium intensity | 2,455 | 6,536 | 716 | 9,708 |
| Developed, high intensity | 484 | 1,749 | 56 | 2,290 |
| Barren land | 2,530 | 2,188 | 1,646 | 6,364 |
| Deciduous forest | 2,863 | 694 | 7,006 | 10,563 |
| Evergreen forest | 181,559 | 18,413 | 131,508 | 331,480 |
| Mixed forest | 6,977 | 1,024 | 13,113 | 21,114 |
| Scrub/shrub | 22,051 | 3,391 | 27,592 | 53,034 |
| Grassland/herbaceous | 60,858 | 9,915 | 57,093 | 127,866 |
| Pasture/hay | 2,550 | 534 | 2,294 | 5,378 |
| Cultivated crops | 45,457 | 5,803 | 61,977 | 113,237 |
| Woody wetlands | 152,961 | 24,514 | 224,349 | 401,825 |
| Emergent herbaceous wetland | 24,553 | 11,121 | 10,984 | 46,658 |
| **Total** | **572,212** | **140,556** | **563,820** | **1,276,592** |

Reference: USGS, 2001.

**Table 3.1-2. New Hanover County Parcel Acreages by Land Use: December 2004**

| Land Use | Unincorporated Portions of New Hanover County | Wilmington | Carolina Beach | Wrightsville Beach | Kure Beach | Total |
|---|---|---|---|---|---|---|
| Agriculture | 3,267 | 64 | 0 | 0 | 0 | 3,332 |
| Undeveloped | 47,293 | 6,769 | 458 | 223 | 118 | 54,862 |
| Other (water, right-of-way, unknown) | 23,549 | 6,748 | 960 | 1,570 | 363 | 33,190 |
| Total developed | 32,160 | 18,631 | 653 | 415 | 246 | 52,105 |
| ▪ Office & institutional | 5,891 | 2,368 | 24 | 44 | 6 | 8,333 |
| ▪ Commercial | 696 | 1,044 | 54 | 18 | 12 | 1,824 |
| ▪ Transportation, utilities, and communications | 4,081 | 775 | 6 | 29 | 1 | 4,892 |
| ▪ Industrial | 4,141 | 665 | 3 | 1 | 0 | 4,810 |
| ▪ Recreation | 1,548 | 2,594 | 103 | 84 | 15 | 4,343 |
| ▪ Residential total | 15,803 | 11,185 | 463 | 239 | 212 | 27,903 |
| – Single family | 13,746 | 9,783 | 409 | 193 | 201 | 24,332 |
| – Multi-family | 585 | 1,084 | 33 | 46 | 5 | 1,754 |
| – Mobile home | 1,472 | 318 | 21 | 0 | 6 | 1,817 |
| **Total** | **106,269** | **32,212** | **2,071** | **2,208** | **727** | **143,489** |

Reference: City of Wilmington and New Hanover County, 2006.

**Table 3.1-3. Brunswick County Parcel Acreages by Land Use: 2005**

| Land Use | Small Municipalities and Unincorporated Portions of Brunswick County | St. James | Belville | Boiling Springs Lakes | Carolina Shores | Northwest | Total |
|---|---|---|---|---|---|---|---|
| Low-density residential/ agricultural | 96,787 | 4 | 58 | 149 | 272 | 932 | 98,202 |
| Other residential total | 8,189 | 354 | 90 | 591 | 593 | 131 | 9,948 |
| ▪ Single family | 7,899 | 335 | 88 | 591 | 582 | 131 | 9,626 |
| ▪ Multi-family | 125 | 19 | 2 | 0 | 11 | 0 | 157 |
| ▪ Mobile home | 165 | 0 | 0 | 0 | <1 | 0 | 165 |
| Commercial | 614 | 0 | 11 | 38 | 52 | 37 | 752 |
| Industrial | 1,647 | 0 | 13 | 0 | 22 | <1 | 1,682 |
| Office & institutional | 2,378 | 10 | 42 | 87 | 49 | 4 | 2,570 |
| Recreational | 220 | 828 | 0 | 157 | 164 | 0 | 1,369 |
| Vacant | 348,890 | 3,255 | 359 | 12,551 | 1,579 | 2,654 | 369,288 |
| **Total** | **458,725** | **4,451** | **573** | **13,573** | **2,731** | **3,758** | **483,811** |

Reference: Brunswick County, 2006.

Note: Water, right-of-way, and unknown uses not included in the above table. Also, addition errors were found in source document's original table and were corrected in this table.

**Table 3.1-4. Pender County (Unincorporated Areas) Parcel Acreages by Land Use: 2005**

| **Land Use** | **Acreage** |
|---|---|
| Total developed | 19,570 |
| ▪ Residential | 15,627 |
| ▪ Commercial/business | 850 |
| ▪ Industrial | 1,144 |
| ▪ Transportation, utilities, and communication | 708 |
| ▪ Institutional | 1,241 |
| Agriculture – Animal operations | 1,633 |
| Agriculture – Crops | 53,387 |
| Forestry | 289,596 |
| Conservation | 102,405 |
| Other | 64,144 |
| **Total** | 530,735 |

Reference: Pender County, 2006.

Note: Water, right-of-way, and unknown uses not included in the above table.

**Table 3.1-5. Agriculture Information by County: 2002**

| Measure | County | | |
|---|---|---|---|
| | Brunswick County | New Hanover County | Pender County |
| Number of farms | 271 | 77 | 296 |
| Total land in farms (acres) | 41,077 | a | 62,714 |
| Average farm size (acres) | 152 | a | 212 |
| Harvested cropland (acres) | 20,344 | 1,676 | 33,369 |
| Average age of farmers | 54 | 59 | 54 |

[a] Data not publicly available.

Reference: USDA, 2002.

**Table 3.1-6. Agricultural Cash Receipts by County: 2005**

| County | Livestock, Dairy, Poultry | Crops | Government Payments | Total |
|---|---|---|---|---|
| Brunswick | $17,751,000 | $16,659,000 | $7,205,000 | $41,615,000 |
| New Hanover | $366,000 | $7,377,000 | $240,000 | $7,983,000 |
| Pender | $82,883,000 | $26,493,000 | $8,291,000 | $117,667,000 |

Reference: North Carolina Agricultural Statistics Division, 2007.

**Table 3.1-7. Annual Seafood Landings by County of Landing**

| Year | Brunswick County | | New Hanover County | | Pender County | |
|---|---|---|---|---|---|---|
| | Weight (lb) | Value | Weight (lb) | Value | Weight (lb) | Value |
| 1994 | 2,997,521 | $4,516,008 | 2,365,785 | $3,074,113 | 637,684 | $737,368 |
| 1995 | 3,738,490 | $5,344,867 | 2,218,614 | $3,218,877 | 684,080 | $801,007 |
| 1996 | 2,800,290 | $4,611,186 | 1,810,350 | $2,660,917 | 556,813 | $678,102 |
| 1997 | 2,808,839 | $4,645,993 | 2,235,758 | $3,196,392 | 586,129 | $754,334 |
| 1998 | 3,007,355 | $4,852,645 | 2,042,606 | $2,899,081 | 535,039 | $769,660 |
| 1999 | 2,964,543 | $5,291,259 | 2,072,789 | $2,899,173 | 650,859 | $803,497 |
| 2000 | 2,615,751 | $4,300,641 | 1,746,549 | $2,513,563 | 576,616 | $853,691 |
| 2001 | 2,425,920 | $3,700,127 | 1,660,434 | $2,393,864 | 540,053 | $793,438 |
| 2002 | 2,193,874 | $3,310,866 | 1,781,515 | $2,587,660 | 538,639 | $720,585 |
| 2003 | 2,249,320 | $3,459,964 | 1,810,440 | $2,644,431 | 612,465 | $759,589 |
| 2004 | 2,392,437 | $3,774,564 | 1,658,837 | $2,103,007 | 649,825 | $762,131 |
| 2005 | 2,021,137 | $3,382,216 | 1,317,862 | $1,847,024 | 708,731 | $714,499 |
| 2006 | 2,287,119 | $3,864,565 | 1,727,795 | $2,347,701 | 634,126 | $753,301 |

Reference: NC DMF, 2006, 2007.

**Table 3.1-8. Land Use in New Hanover County within 5-Mile (8-Km) Radius* of the Wilmington Site**

| Land Use Class | Total Acres |
|---|---|
| Undeveloped | 15,722 |
| Residential – Single family | 4,262 |
| Residential – Mobile home | 412 |
| Residential – Multi-family | 63 |
| Industrial | 3,559 |
| Utilities and transportation | 3,416 |
| Resource industry | 2,812 |
| Office and institutional | 2,141 |
| Commercial | 318 |
| Recreational | 117 |
| Unclassified | 4,451 |
| **Total** | **37,273** |

Reference: City of Wilmington and New Hanover County, 2006.

* The 5-mile (8-kilometer [km]) radius also includes land within Pender and Brunswick counties; however, this table only presents a breakdown of the land uses within the New Hanover County portion of the 5-mile (8-km) radius.

# Figures

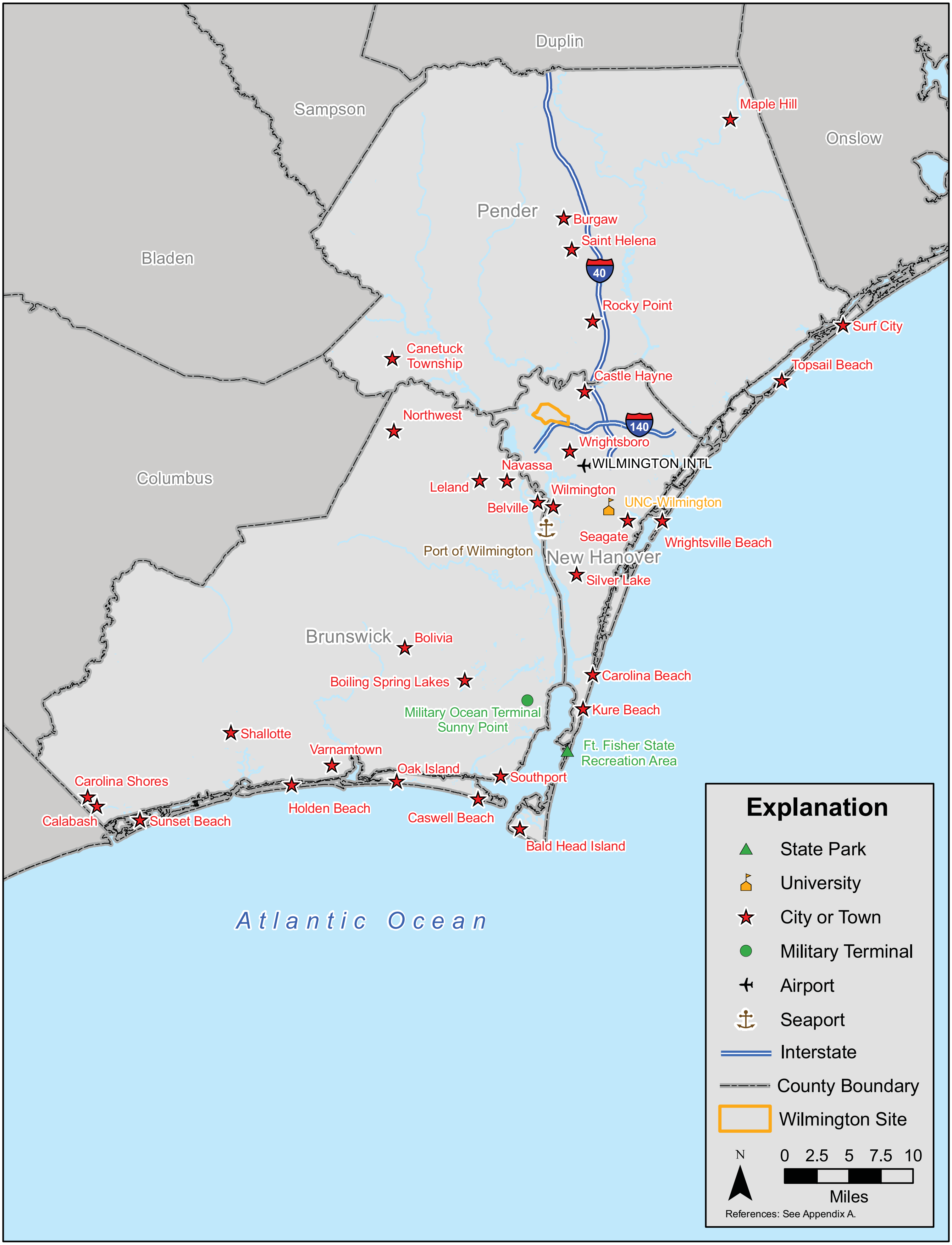



**Figure 3.1-1. Key feature map of three-county Wilmington MSA.**

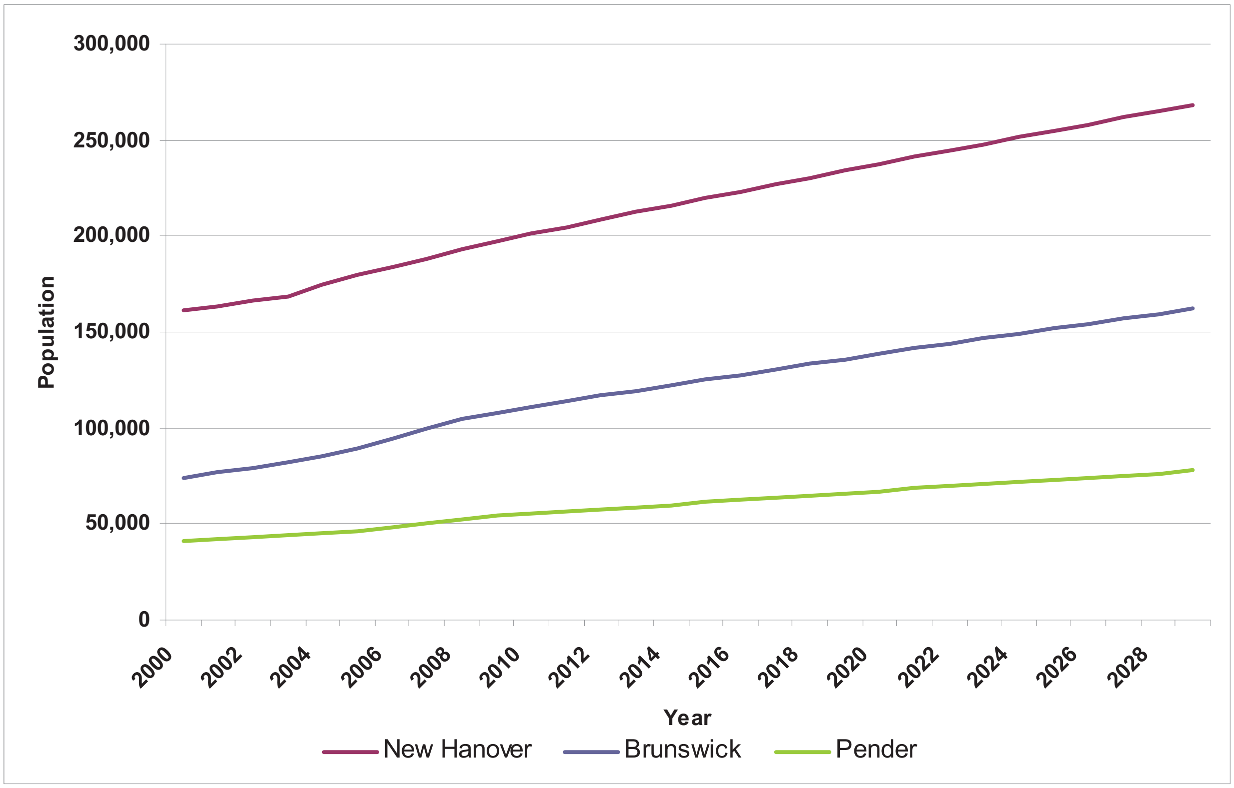



**Figure 3.1-2. Population in the Wilmington MSA: Census counts and state projections.**

Reference: U.S. Census Bureau, 2000e; NC OSBM, 2006a.

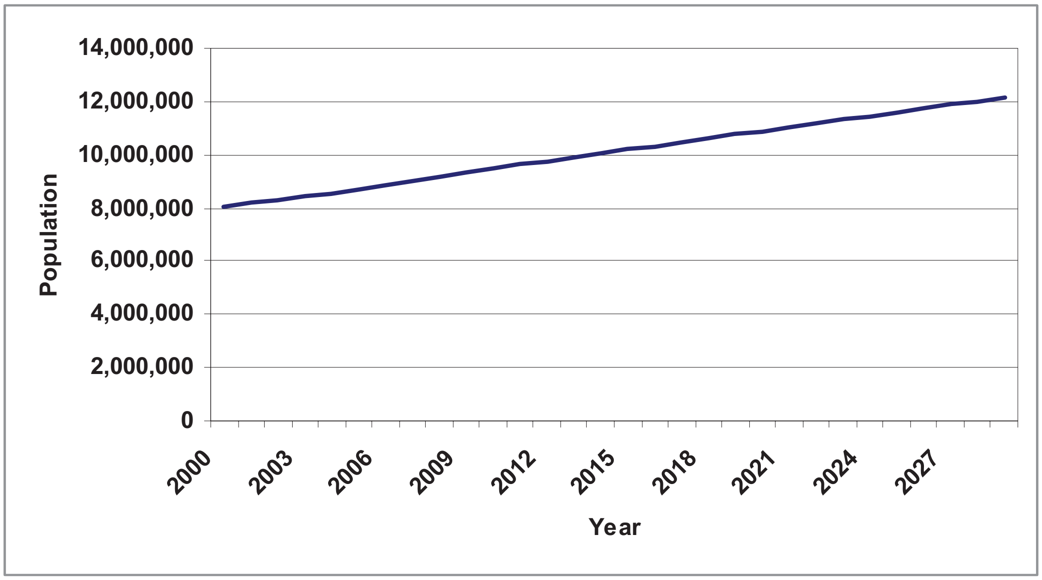



**Figure 3.1-3. Population in North Carolina: Census counts and state projections.**

Reference: U.S. Census Bureau, 2000e; NC OSBM, 2006a.

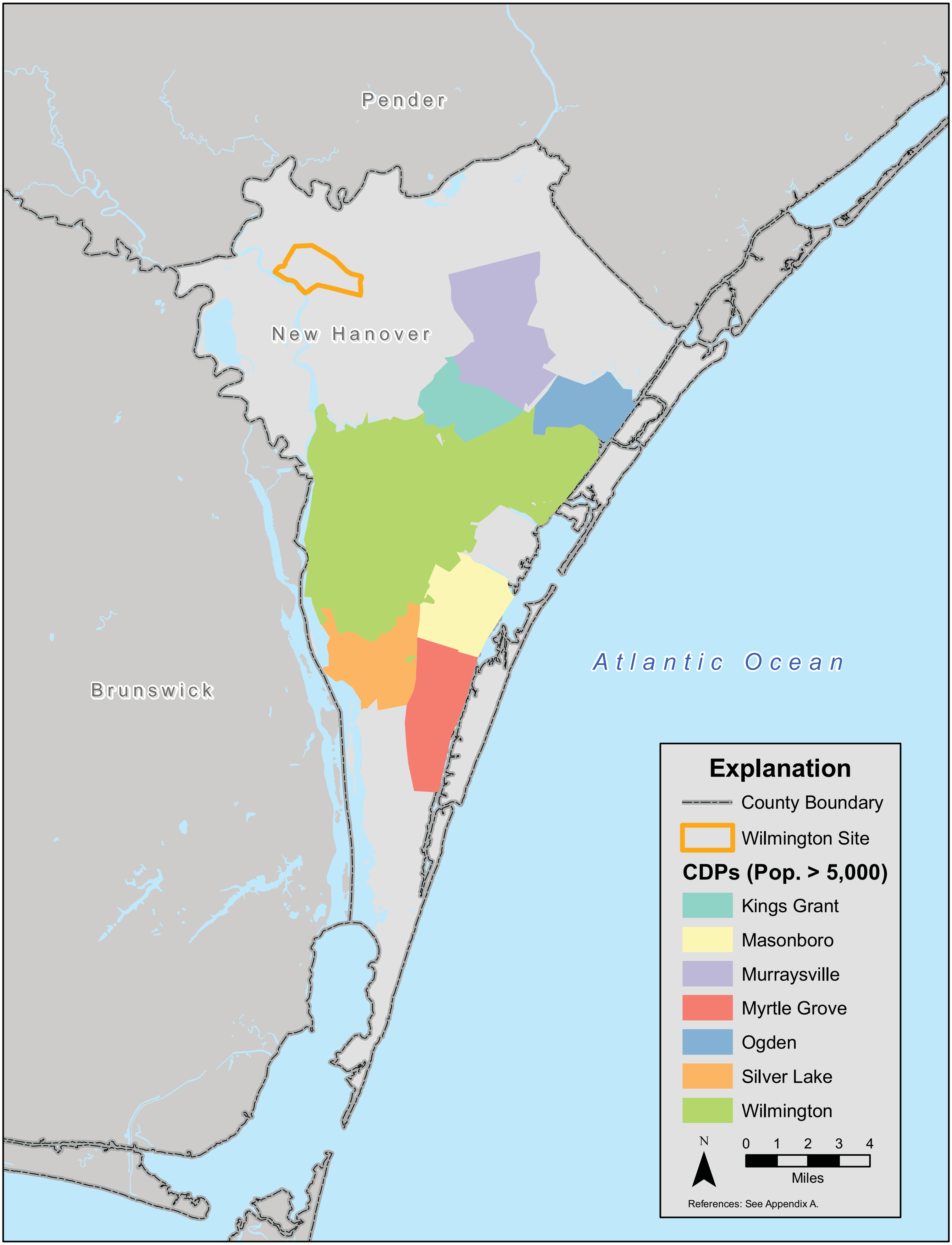



**Figure 3.1-4. Census designated places: New Hanover County, NC.**


**Figure 3.1-5. Census designated places: Brunswick County, NC.**

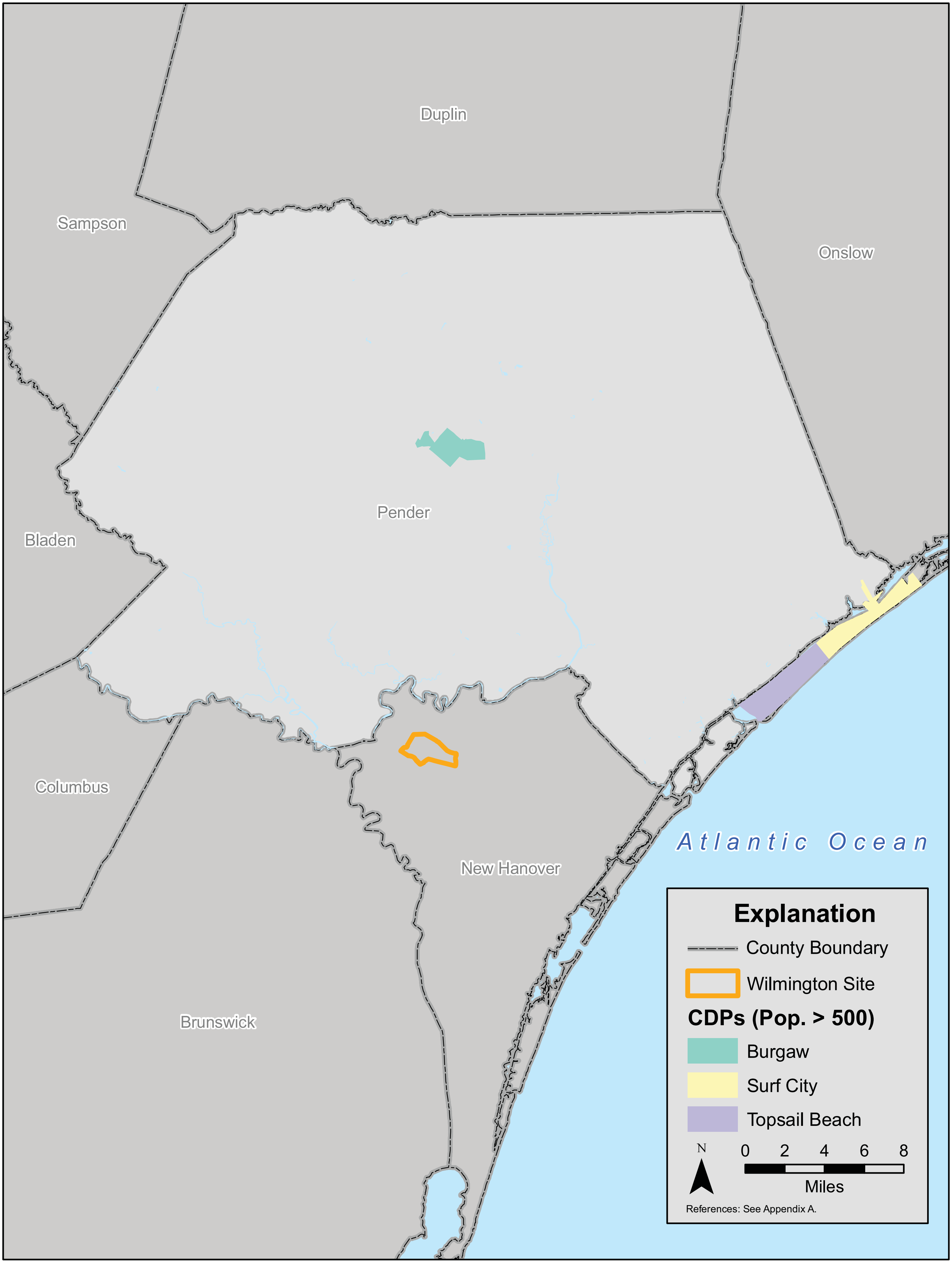



**Figure 3.1-6. Census designated places: Pender County, NC.**

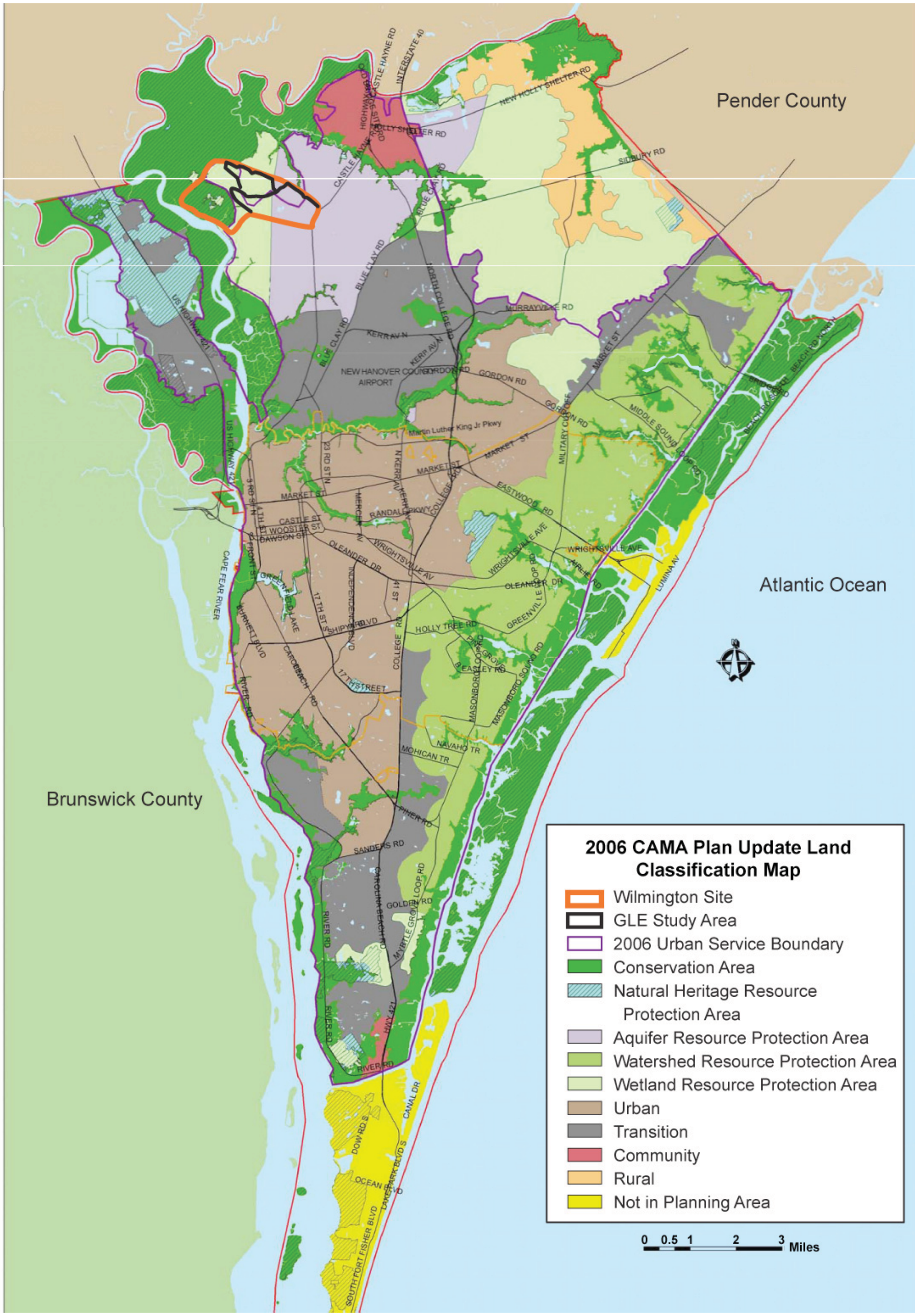



**Figure 3.1-7. CAMA land classification map: City of Wilmington and New Hanover County, NC.**

Reference: City of Wilmington and New Hanover County, 2006.

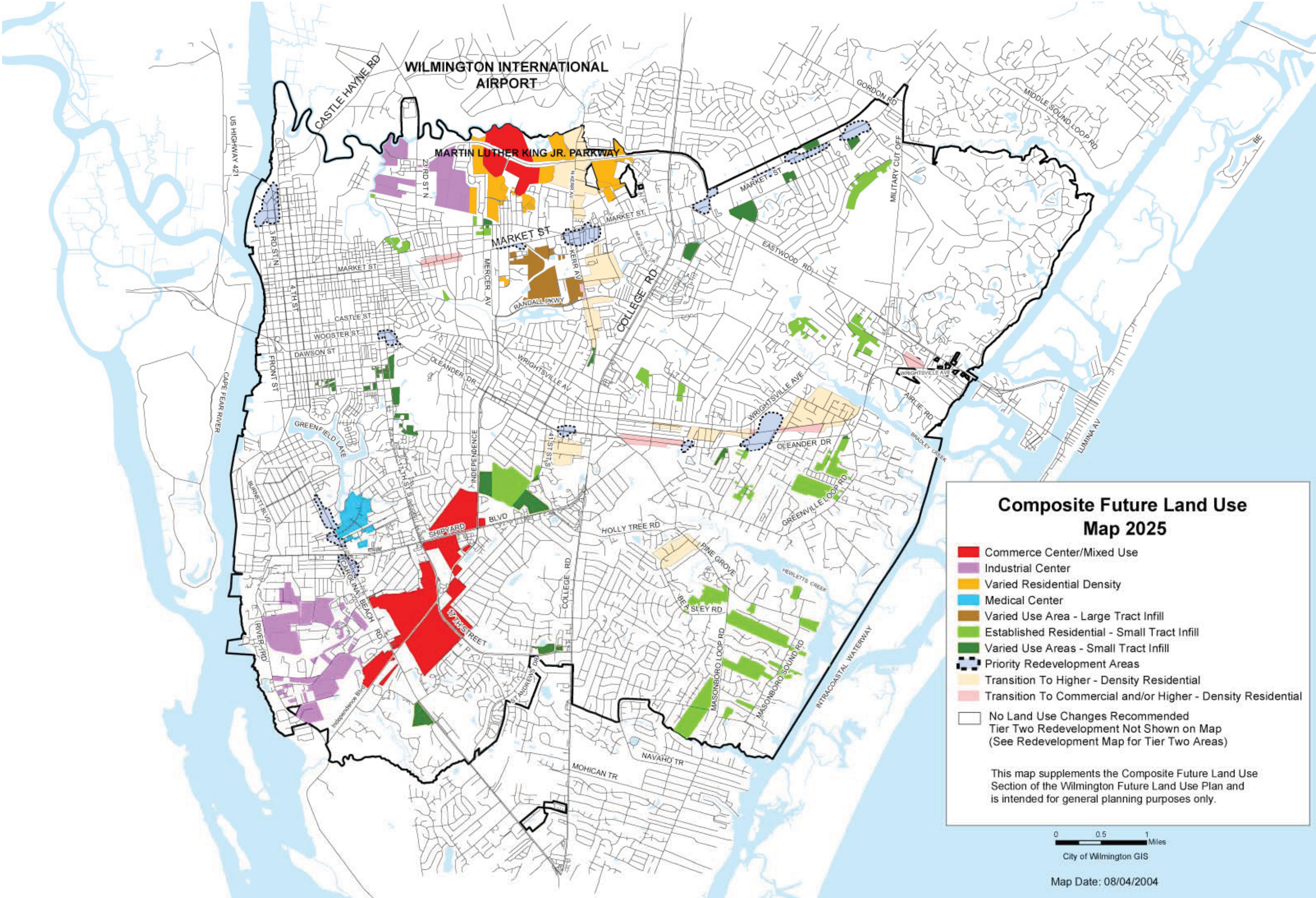



**Figure 3.1-8. Composite future land use map: City of Wilmington.**

Reference: City of Wilmington, 2004b.

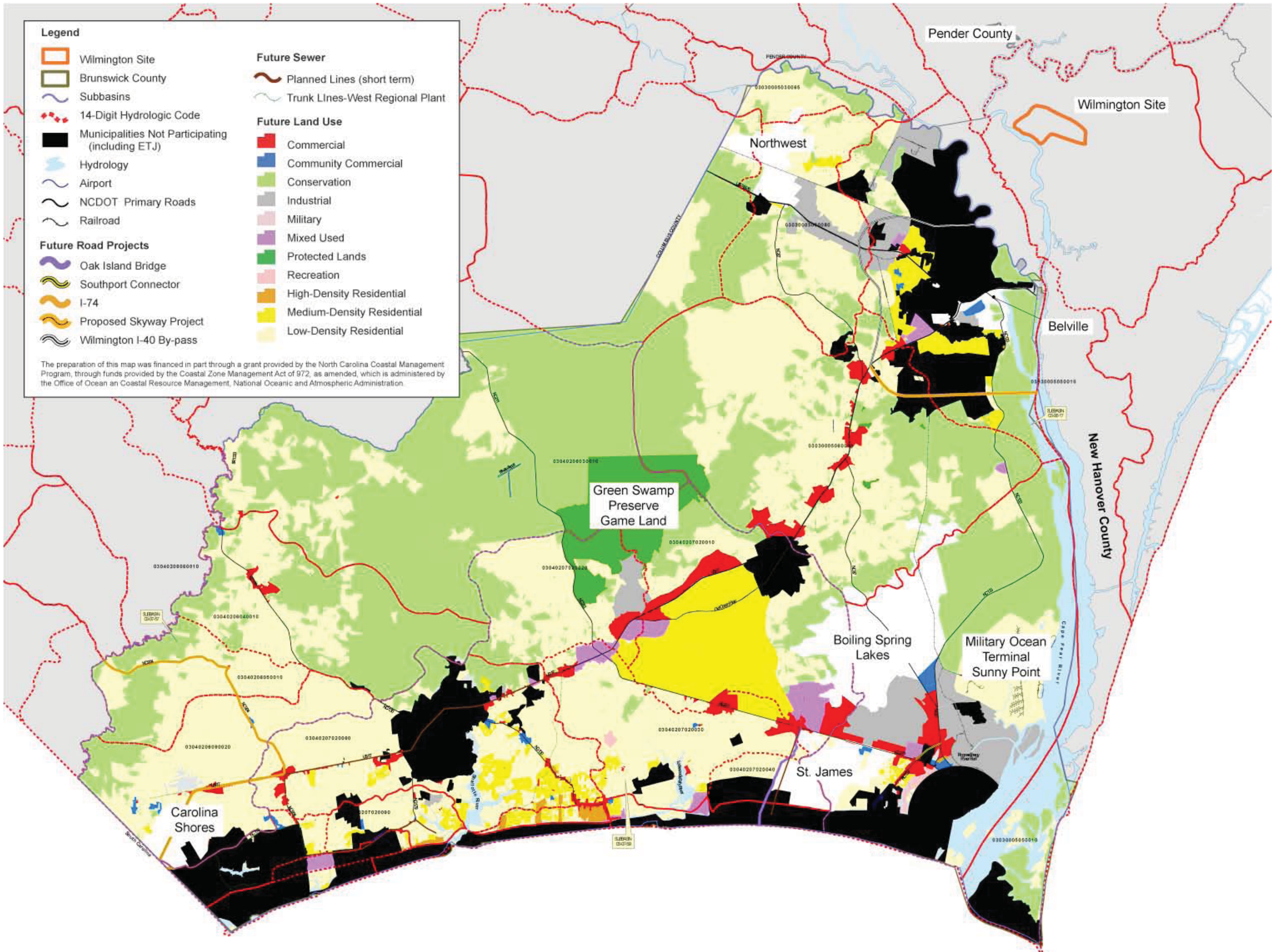



**Figure 3.1-9. CAMA future land use map: Brunswick County, NC.**

Reference: Brunswick County, 2006.

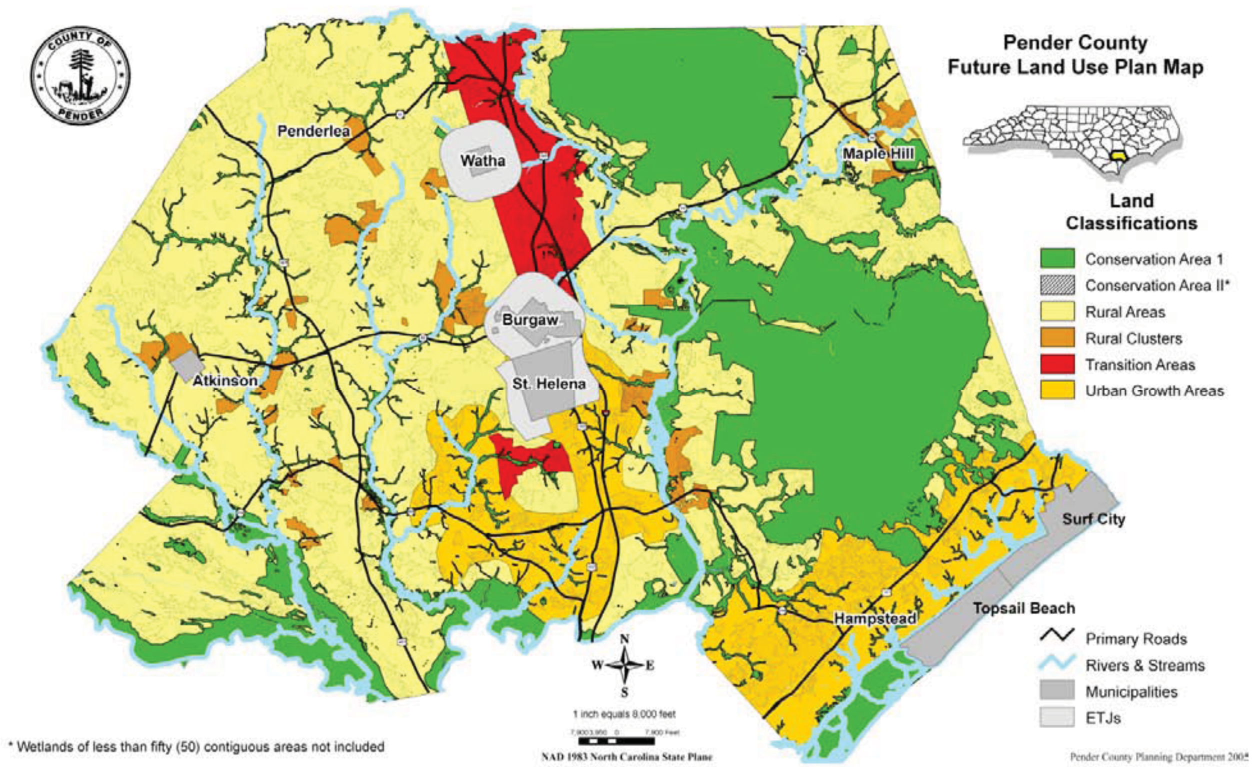



**Figure 3.1-10. CAMA future land use plan map: Pender County, NC.**

Reference: Pender County, 2006.

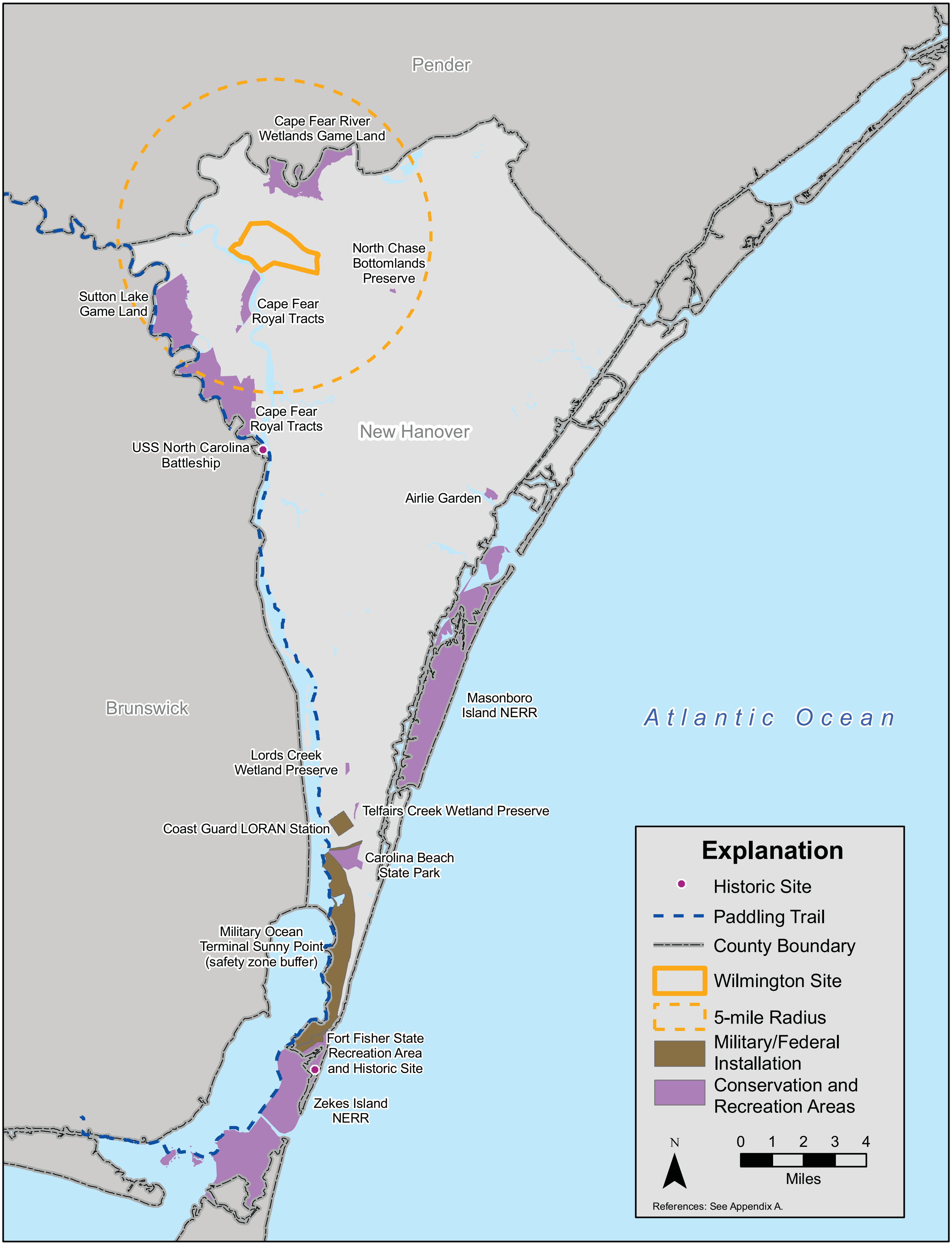



**Figure 3.1-11. Special land use areas: New Hanover County, NC.**


**Figure 3.1-12. Special land use areas: Brunswick County, NC.**

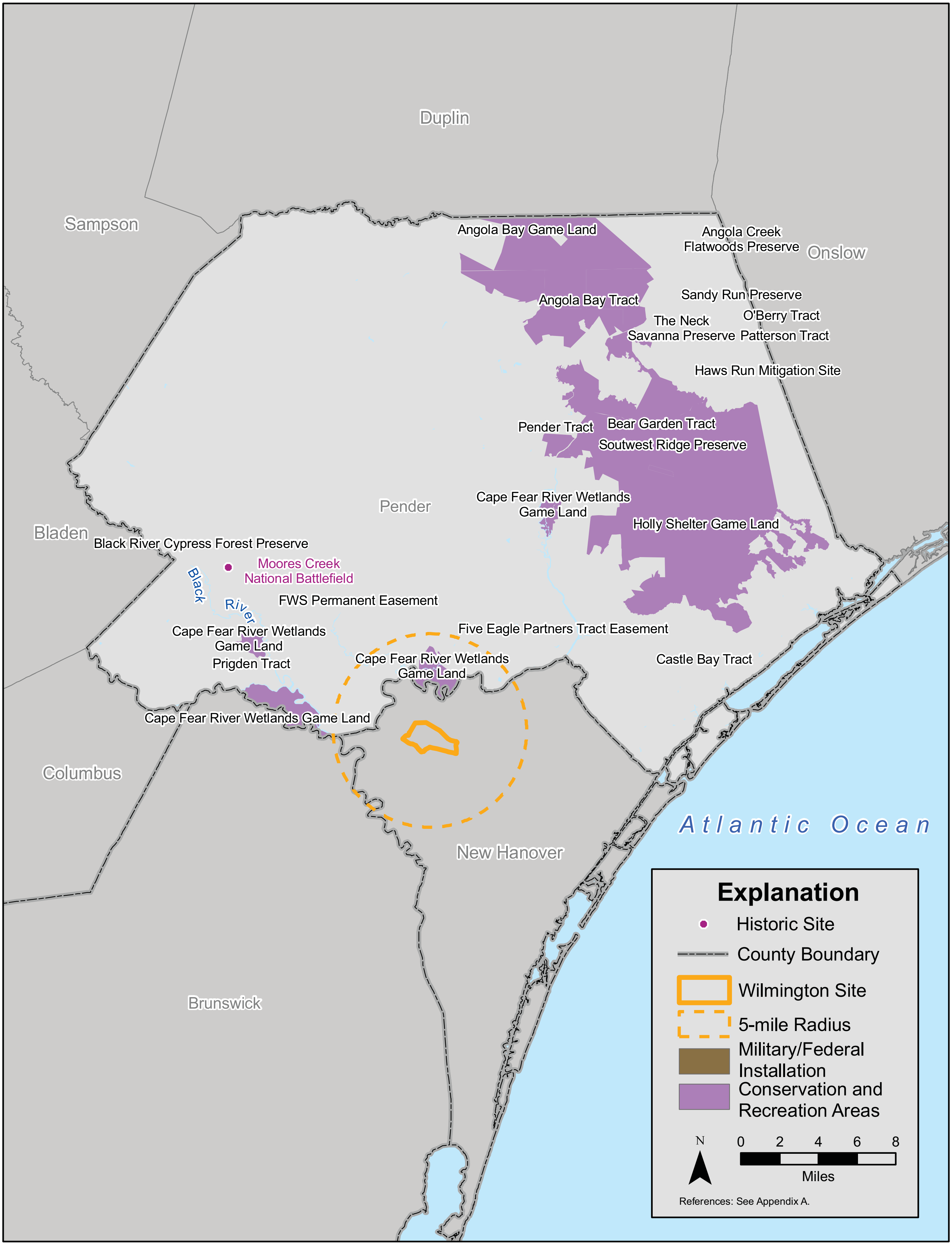
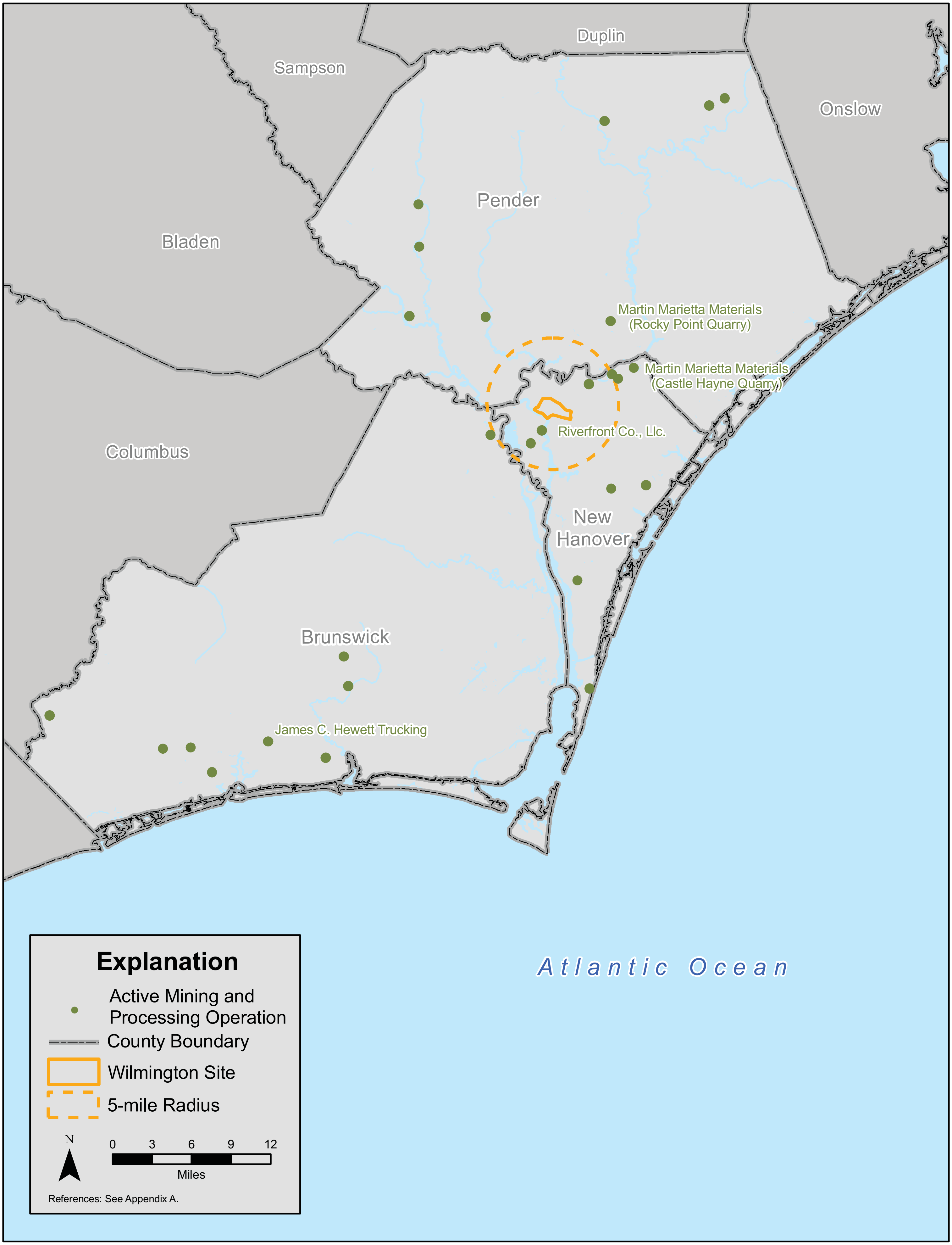



**Figure 3.1-13. Special land use areas: Pender County, NC.**




**3.1-14. Mining and mineral processing operations: Wilmington MSA.**

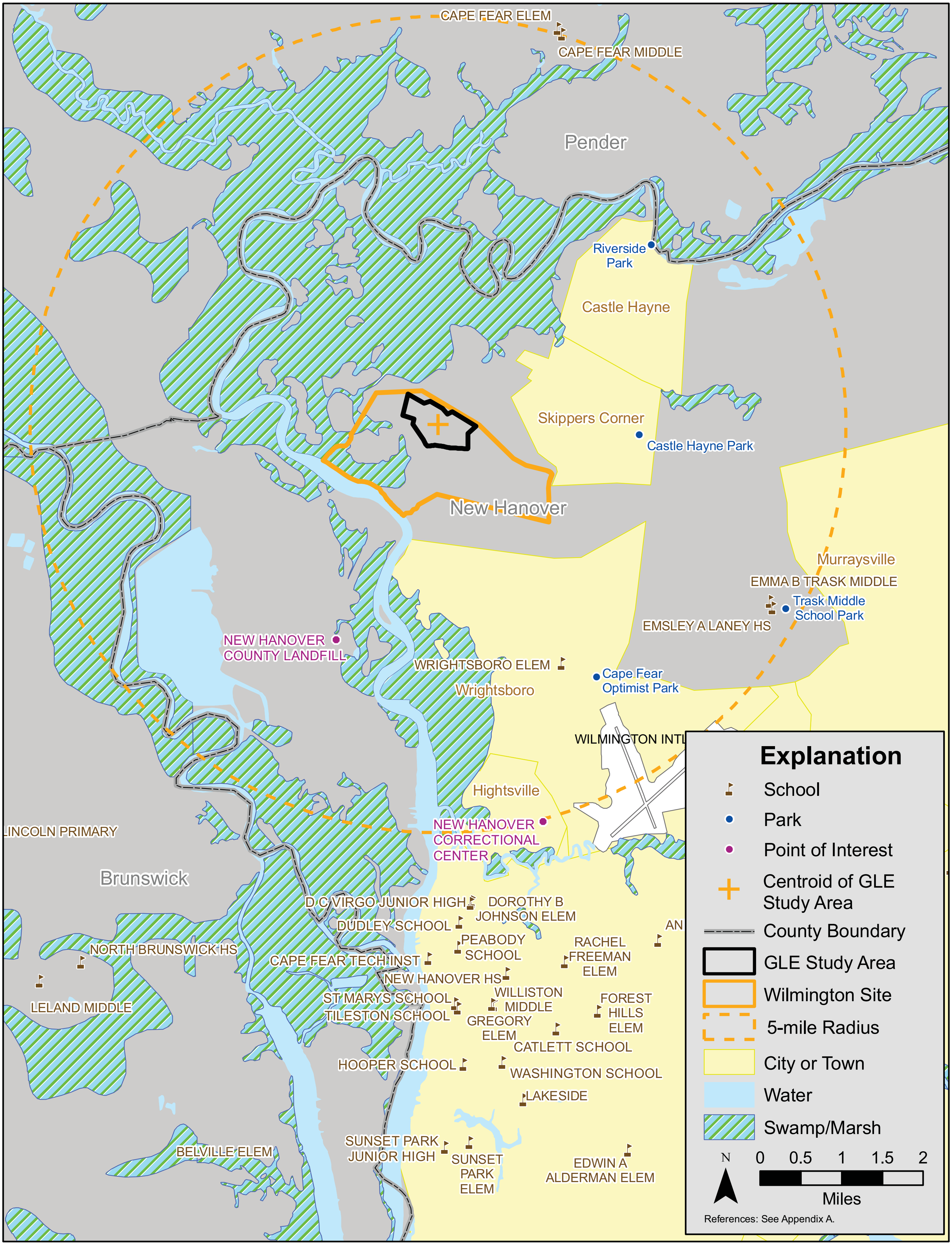



**Figure 3.1-15. Noted features within 5-mile radius of the Wilmington Site.**

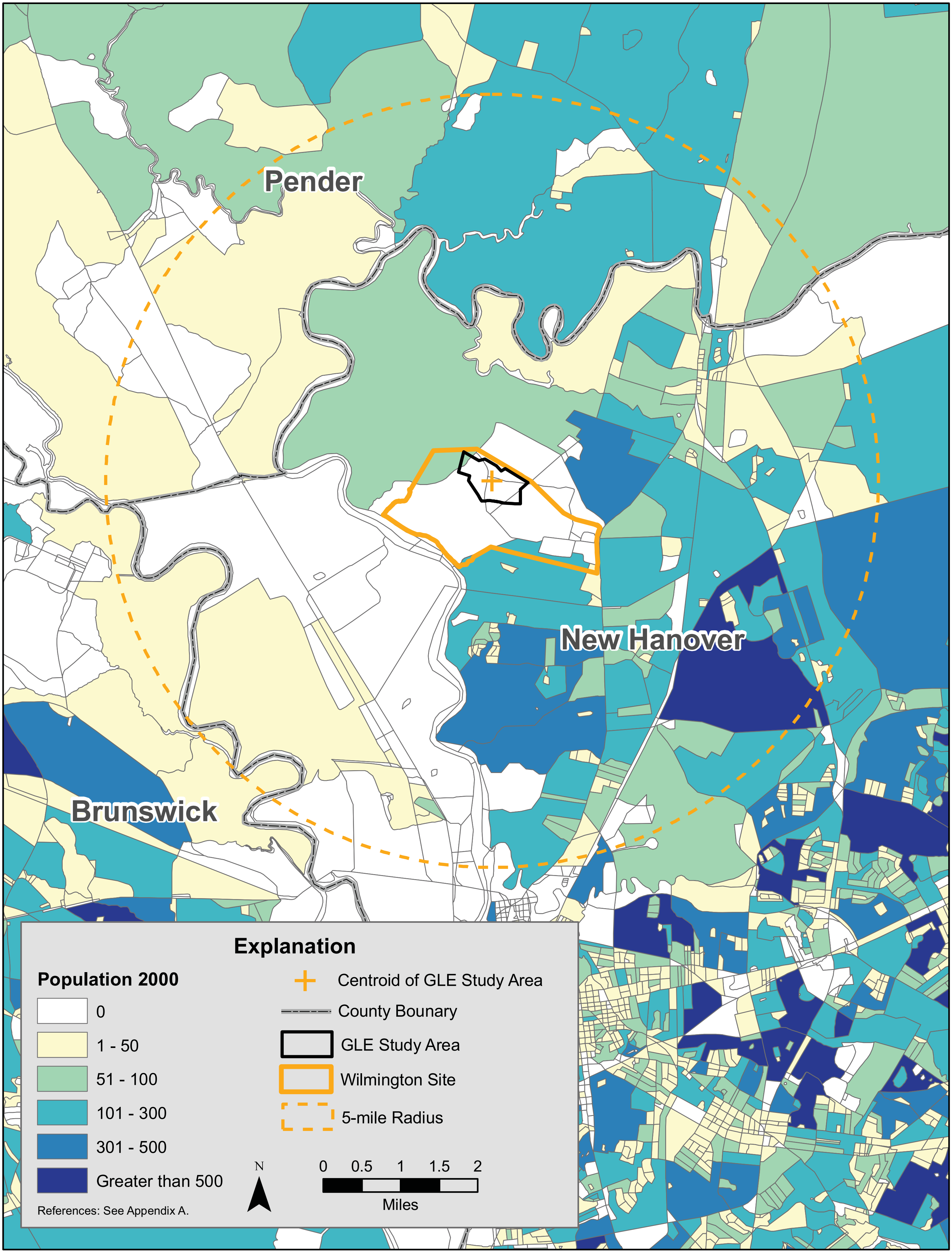



**Figure 3.1-16. Population by U.S. Census block within 5-mile (8-km) radius of the Wilmington Site.**

# GLE Environmental Report
# Section 3.2 – Transportation

## Revision 0
## December 2008

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## 3.2 Transportation

The Wilmington MSA is served by major transportation modes, including interstate highways, railways, and an international seaport and airport. Wilmington is the eastern terminus of I-40 and the location of a major east coast deep-water seaport. Railways are an important component of the transportation infrastructure within the Wilmington MSA because of the presence of the Port of Wilmington and the large quantities of cargo that are shipped through the port. Scheduled commercial airline service is provided to the region through the Wilmington International Airport. The Cape Fear Public Transportation Authority provides public bus service to residents of Wilmington and New Hanover County.

### 3.2.1 Regional Transportation Corridors

#### 3.2.1.1 Roads and Highways

The highway corridors within the three-county Wilmington MSA include the east-west I-40 that passes through Pender County and terminates in Wilmington. The interchange of I-40 with U.S. Interstate Highway 95 (I-95), a main north-south highway corridor along the length of the eastern United States from Florida to Maine, is located outside the Wilmington MSA at an interstate highway distance of approximately 100 miles (161 km) from the Wilmington Site. Another important highway corridor in the Wilmington MSA is US 17. This north-south highway passes through all three counties, essentially paralleling the North Carolina coastline, and has been identified by the North Carolina Department of Transportation (NC DOT) as a strategic corridor, based on its function as a primary coastal highway route linking North Carolina with both South Carolina and Virginia. **Table 3.2-1** provides total mileage of state-maintained primary and secondary roads within each of the three counties in the Wilmington MSA (NC DOT, 2007).

##### *3.2.1.1.1 New Hanover County*

The major transportation features within New Hanover County are shown in **Figure 3.2-1**. I-40 is the primary highway corridor, not only in New Hanover County, but also in the Wilmington MSA, linking the area to the I-95 interchange and to the major cities in central and western North Carolina (e.g., Raleigh, Durham, Greensboro, Winston-Salem, Charlotte, Asheville). Other main thoroughfares of importance within the Wilmington MSA are US 421, which runs from Kure Beach to northwest Pender County; the partially completed U.S. Interstate Highway 140 (I-140); and NC 133 (also locally known as Castle Hayne Road in New Hanover County) and US 117, which link the western (e.g., Hightsville, Wrightsboro, Wilmington) portions of New Hanover County with St. Helena and Burgaw in Pender County.

The highest-profile highway project in the Wilmington MSA is construction of I-140. When completed, this 27-mile (43-km) interstate (often locally called the Wilmington Outer Loop) will provide a link between I-40 and US 17 and U.S. Route 74-76 (US 74-76). The section linking US 17 on the northeastern side of New Hanover County with US 421 has already been completed, and the section of the highway from US 421 to US 74-76 in Brunswick County has received funding and is scheduled for construction in 2011 (Gannon, 2007a). The final portion of I-140 from US 74-76 to US 17 south of Wilmington has not yet been funded (Gannon, 2007a). Designed to improve traffic flow in and around Wilmington, the project is also intended to facilitate economic development by “improving access to the Port of Wilmington, Sunny Point Military Installation, and the beaches of southeastern North Carolina” (Office of the Governor, 2003). To date, the completed western sections of I-140 that are open to traffic connect I-40 with interchanges at NC 133 (Castle Hayne Road) and with US 421. A second completed section of I-140 begins at I-40 and connects with US 17 North near Porters Neck in eastern Wilmington. When the

I-140 extension is completed, the flow of traffic through the northeast portion of New Hanover County is expected to increase. In addition to providing access to the beach communities in southern Brunswick County from I-40, this section of I-140 will pass near the towns of Navassa, Leland, and Belville, with key interchanges at US 74-76 (in Brunswick County), US 17 (in Brunswick County), and Independence Boulevard (in Wilmington).

The City of Wilmington has identified four highway corridors in the city that are of particular importance (Carolina Beach Road, College Road, Market Street, and Oleander Drive [**Figure 3.2-2**]), and in coordination with the NC DOT, has created Small Area Plans to manage the areas along these corridors (City of Wilmington, 2004a).

- **Carolina Beach Road (US 421)** serves approximately 35,000 vehicles per day and is an important north-south corridor linking the southern beaches of New Hanover County with the port and downtown Wilmington (City of Wilmington, 2004b).
- **College Road (N.C. Route 132 [NC 132])** is characterized by strip development and high-volume traffic. It is the primary north-south roadway through New Hanover County and serves as a gateway for the many visitors to Wilmington who enter via I-40.
- **Market Street (US 17)** links the three counties of the Wilmington MSA, serves as an access point for downtown Wilmington, and connects with College Road (and I-40) and Eastwood Road (Wrightsville Beach).
- **Oleander Drive (U.S. Route 76 [US 76])** serves approximately 45,000 vehicles per day and is important as an east-west route for local commuters and as a regional shopping destination (City of Wilmington, 2004c).

The Level of Service (LOS) is the most common measure of highway capacity and relative congestion. Roads are evaluated and assigned one of six grades ranging from A to F. An LOS rating of D or better is considered acceptable for highways (City of Wilmington, 2004a). LOS estimates exist for heavily traveled streets in Wilmington, but are unavailable for less-traveled roads in outlying areas. The Martin Luther King, Jr. Parkway, shown in **Figure 3.2-2**, opened to traffic in 2005 and has contributed to a decrease in downtown traffic congestion. The I-140/US 17 bypass is expected to further reduce traffic congestion in the Market Street area of Wilmington (City of Wilmington and New Hanover County, 2006).

Future road construction in New Hanover County on the eastern side of I-40 includes plans to extend I-140 to Scotts Hill in Pender County. On the western side of I-40, I-140 will eventually pass into Brunswick County, where it will connect with US 74-76 (interchange) near Leland and merge with US 17 South near Town Creek. There also are plans to extend I-40 south to Martin Luther King, Jr. Parkway and to construct an interchange to alleviate traffic congestion (WMPO, 2005). NC 133 (Castle Hayne Road) has also been listed for a widening project (two lanes to four lanes) for the segment between Martin Luther King, Jr. Parkway and I-140 (WMPO, 2005). There are no listed plans to widen the section of NC 133 north of I-140.

#### *3.2.1.1.2 Brunswick County*

As shown in **Figure 3.2-3**, the main highway corridors in Brunswick County include NC 211, US 17, and US 74-76 (Brunswick County, 2006). Brunswick County is bisected in a southwest to northeast direction by US 17. US 74-76 connects Northwest with Leland and Belville and is slated for integration with the I-140/US 17 bypass loop that is currently under construction. Much of the recent development in Brunswick County has occurred in the south and along the coast in the beach communities. NC 211, NC 87, and NC 133 (also locally known as River Road in Brunswick County) connect the south-central beaches (e.g., Holden Beach, Varnamtown) and southeastern beaches (e.g., Oak Island, Southport) with

the communities located in the northeast area of the county (e.g., Boiling Springs Lakes, Leland). In the southwest area of the county, N.C. Route 179 (NC 179) serves as the primary route between Shallotte and the southwestern beaches (e.g., Ocean Isle Beach, Sunset Beach).

##### *3.2.1.1.3 Pender County*

The primary north-south highway corridor in Pender County is I-40 (**Figure 3.2-4**), linking Wilmington in neighboring New Hanover County with the I-95 highway corridor near Benson, NC, in Johnston County. Another important highway corridor in Pender County is the US 17 corridor along the southeastern coast. This corridor provides access from Wilmington to the beach communities of Topsail Beach and Surf City, as well as to Marine Corps Base Camp Lejeune in neighboring Onslow County. There are also lower-volume highways in Pender County, such as US 117, which parallels I-40 through the central portion of the county, and US 421, which provides north-south access in the western portion of the county. Atkinson in western Pender County is connected to the county seat of Burgaw and the center of the county by NC 53, which continues to the Angola Bay Game Land in the northeast (see **Figure 3.1-13**).

#### 3.2.1.2 Waterways

The U.S. Army Corps of Engineers (USACE) maintains the navigability of the Cape Fear River and Intracoastal Waterway, which benefit the local economies of Brunswick and New Hanover counties, as well as Wilmington. Both of these waterways support commercial and recreational navigation in and around the Wilmington MSA.

The Port of Wilmington is a major deep-water port on the east coast, with facilities to handle containerized, bulk, and breakbulk cargoes. **Table 3.2-2** provides information on the volume and weight of materials handled by the port by year since 1997. Located on the east bank of the Cape Fear River near downtown Wilmington, the port has daily CSX Corporation train service and access to I-40. During fiscal year (FY) 2006, the top five imports, in terms of tonnage, passing through the port were forest products, chemicals, cement, general merchandise, and coal (NC SPA, 2007). Wood pulp, forest products, general merchandise, food, and chemicals were the top five exports, in terms of tonnage, during the same period. China, Colombia, Germany, Italy, and Korea were the largest trading partners, in terms of tonnage, passing through the port during FY2006 (NC SPA, 2007).

The North Carolina State Ports Authority (NC SPA) purchased land in Brunswick County near Southport and adjacent to the MOTSU as the future site of the North Carolina International Port (NC SPA, 2006); however, federal budget cutbacks have affected USACE activities and have cast some degree of uncertainty over the future of this project (Scott, 2007).

#### 3.2.1.3 Railways

Freight service to the region is provided by CSX Corporation. As shown in **Figure 3.2-5**, the Port of Wilmington and MOTSU are the primary foci of the rail network. Bulk transfer terminals are located in Wilmington and Leland, and three major corridors lead out of the Wilmington MSA: northwest bound (Charlotte, NC), north bound (Washington, D.C.), and northeast bound (New Bern, NC). There currently is no passenger train service to the Wilmington MSA. A study conducted in 2005 recommended the establishment of passenger rail service from Raleigh to Wilmington through Fayetteville and Goldsboro, as funding becomes available (NC DOT, 2005a).

#### 3.2.1.4 Airports

The locations of the primary commercial airport and several small municipal airport facilities in the three-county MSA are shown in **Figure 3.2-6**. There are five small airports and two heliports located in

Brunswick County. Of these, Brunswick County, Bear Pen, and Odell Williamson airports are public airports (FAA, 2007). Pender County has a total of five small airports, one of which (Henderson Field) is publicly owned (FAA, 2007). In New Hanover County, Pilots Ridge is a small, private airport located near the town of Carolina Beach (FAA, 2007). The other airport facility located in New Hanover County is the Wilmington International Airport.

The Wilmington International Airport has direct, scheduled commercial airline flights to New York, Philadelphia, Atlanta, and Charlotte. International travel to and from the airport currently is limited to either corporate or personal aircraft (Gannon, 2007b). Eight gates and two commercial carriers (Delta, U.S. Airways) are in operation at the airport, and there are six flight paths to and from the airport (WMPO, 2005). Connection/destination airports included in these routes are William B. Hartsfield International Airport (ATL), Charlotte Douglas International Airport (CLT), Cincinnati/Northern Kentucky International Airport (CVG), Ronald Reagan Washington National Airport (DCA), La Guardia Airport (LGA), and Philadelphia International Airport (PHL). The exact flight paths associated with these routes are not publicly available.

### 3.2.2 Wilmington Site Transportation Access

#### 3.2.2.1 Existing Transportation Routes and Traffic Patterns

The southeastern corner of the Wilmington Site borders on the interchange of I-140 with NC 133 (Castle Hayne Road). The existing manufacturing operations at the Site receive materials and supplies by truck shipments. These materials include enriched uranium as input to the nuclear power plant fuel-fabrication operations. Likewise, products manufactured at the Site, including the nuclear fuel bundle components, are shipped from the Site by trucks. Current access to and from the Site by these trucks and all other vehicle traffic is from NC 133. Northbound NC 133 from the I-140 interchange bordering the Site initially is a four-lane road that continues for approximately one-half mile (0.8 km) before narrowing to two lanes. The Wilmington Metropolitan Planning Organization (WMPO) designates NC 133 as an urban principal arterial south of I-140 and as an urban minor arterial north of the I-140 interchange.

**Figure 3.2-7** shows the most-recent NC DOT Traffic Survey average annual daily traffic (AADT) counts (year 2005) for highways and roads located within 5 miles (8 km) of the Wilmington Site (NC DOT, 2005b). The AADT value represents the total number of vehicles expected to travel along a given segment of road on an average day and is an indicator of traffic volume. The segment of I-140 from I-40 to NC 133 (Castle Hayne Road) opened to traffic in August 2005; however, no NC DOT AADT data for I-140 are available to reflect the change in traffic volumes and patterns in Wilmington and the surrounding region as a result of this opening.

The most common route now used for trucks, most visitor vehicles, and many employee vehicles to the Wilmington Site from I-40 is to continue to the interchange with I-140 (I-40 Exit 416) and then travel westbound on I-140 to the NC 133 (Castle Hayne Road) exit (I-140 Exit 18). Alternatively, vehicles traveling from locations outside the region on I-40 can access the Wilmington Site by exiting directly off I-40 at the Holly Shelter Road exit and traveling south on NC 133. The Site can be accessed from the downtown district of Wilmington and the port area by traveling north on NC 133 (Castle Hayne Road). **Table 3.2-3** presents the NC DOT AADT counts for NC 133 (Castle Hayne Road) access routes to and from the Wilmington Site. In 2005, the AADT for NC 133 north of the Wilmington Site (near Sondey Road) was 14,000 vehicles, and the count for the section of NC 133 south of the Site (near Kerr Avenue) was 19,000 vehicles. Currently, approximately 2,800 workers commute to and from the Wilmington Site. The daily trips of these workers to and from the Wilmington Site is accounted for in the AADT estimates. Also included in these estimates are the existing truck and ancillary traffic associated with the existing manufacturing and services operations at the Wilmington Site.

Access onto the Wilmington Site from NC 133 (Castle Hayne Road) is through one of two gate entrances. The South Gate entrance is located directly across NC 133 from the off-ramp of westbound I-140. The second Site entrance, the North Gate entrance, is located approximately one-quarter of a mile (0.4 km) north on NC 133 (Castle Hayne Road). Truck deliveries to the Wilmington Site are directed to enter through the North Gate entrance. Steady traffic flows were observed during the July 24, 2007, Site visit at 10:30 a.m., 1:30 p.m., and 4:30 p.m. Traffic in the vicinity of the Site parcel peaked during the 3:00 p.m. shift change, when large numbers of vehicles were observed exiting and entering the Site (see **Figure 3.2-8**).

Once on the Site, workers and visitors park their vehicles in one of several designated parking lots. Trucks move to the appropriate loading/unloading areas over a network of service roads between the Wilmington Site's manufacturing and services operations. Several unpaved service roads provide access to selected areas in the undeveloped portion of the Wilmington Site.

#### 3.2.2.2 Proposed Routes for Transportation Corridors to and from the Wilmington Site

The existing local roadway routes used for transportation access to and from the existing manufacturing and services operations at the Wilmington Site by employees and truck shipments will continue to be used for the Proposed GLE Facility. **Figure 3.2-9** shows the proposed routes of transportation corridors to and from the Wilmington Site that predominately will be used for shipment of materials required for construction and operation of the Proposed GLE Facility**.** To access the Site from I-40, drivers would likely exit at the junction with I-140 and proceed to the NC 133 (Castle Hayne Road) interchange. On a national basis, some new originations and destinations for radioactive material shipments to and from the Wilmington Site will be added to the current mix of shipping locations, and some of the existing locations will no longer be needed. The proposed radioactive material shipping originations and destinations for the Wilmington Site with the Proposed GLE Facility are listed and discussed in **Section 4.2** of this Report (*Transportation Impacts*).

#### 3.2.2.3 Future Potential Transportation Corridor Routes

The joint CAMA land use plan (City of Wilmington and New Hanover County, 2006) includes goals to continue to support the extension of U.S. Interstate Highway 20 (I-20) from Florence, SC, to Wilmington, NC, and the construction of a new U.S. Interstate Highway 74 (I-74) from Charlotte, NC, to Wilmington, NC. These two projects were proposed in 2003 as part of a transportation plan for southeastern North Carolina designed to stimulate economic activity by improving access. The existing I-20 in South Carolina would be extended northeast from Florence, SC, to Wilmington (Office of the Governor, 2003). The NC DOT has undertaken a series of feasibility studies regarding the proposed I-74 route, which would begin in Whiteville, NC, in neighboring Columbus County and continue through Brunswick County to the South Carolina state line.

### 3.2.3 Land Use Restrictions on Transportation Corridors

The Wilmington Site is currently zoned I-2 for Heavy Industrial uses. Neighboring land uses include low-density residential, industrial, and resource management/extraction uses. There are no known restrictions on the types of materials that may be transported along the routes and corridors that will be used to access the Proposed GLE Facility. The types of hazardous and radioactive materials that will be transported to and from the Proposed GLE Facility are similar to the types of materials that are currently transported to the existing GNF-A Facility operations at the Wilmington Site.

# Tables

**Table 3.2-1. State-Maintained Primary- and Secondary-Road Mileage by County in the Wilmington MSA**

| County | 2006 Total Public Highway Mileage (miles) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Non-Municipal | | | Municipal | | | Total | | |
| | Paved | Unpaved | Total | Paved | Unpaved | Total | Paved | Unpaved | Total |
| **Primary Roads** | | | | | | | | | |
| Brunswick | 182 | 0 | 182 | 31 | 0 | 31 | 213 | 0 | 213 |
| New Hanover | 48 | 0 | 48 | 47 | 0 | 47 | 95 | 0 | 95 |
| Pender | 190 | 0 | 190 | 20 | 0 | 20 | 210 | 0 | 210 |
| **Secondary Roads** | | | | | | | | | |
| Brunswick | 484 | 40 | 524 | 80 | 1 | 81 | 564 | 41 | 605 |
| New Hanover | 315 | 1 | 316 | 43 | 0 | 43 | 358 | 1 | 359 |
| Pender | 466 | 38 | 504 | 22 | 1 | 23 | 488 | 39 | 527 |

Reference: NC DOT, 2007.

**Table 3.2-2. Port of Wilmington Tonnage and Trade Statistics**

| Year | Cargo Tonnage (tons) | | | | Cargo Volume (TEU)[a] |
|---|---|---|---|---|---|
| | Container | Breakbulk | Bulk | Total | |
| 1997 | 827,725 | 772,609 | 630,698 | 2,231,032 | 113,368 |
| 1998 | 675,283 | 691,479 | 790,771 | 2,157,533 | 105,997 |
| 1999 | 731,944 | 694,950 | 929,855 | 2,356,749 | 113,185 |
| 2000 | 798,139 | 633,651 | 794,918 | 2,226,708 | 100,546 |
| 2001 | 844,052 | 600,014 | 768,376 | 2,212,442 | 96,380 |
| 2002 | 1,001,728 | 628,800 | 490,929 | 2,121,457 | 91,784 |
| 2003 | 976,082 | 613,923 | 630,799 | 2,220,804 | 99,677 |
| 2004 | 1,054,214 | 624,170 | 648,381 | 2,326,765 | 96,077 |
| 2005 | 1,271,417 | 781,046 | 951,601 | 3,004,064 | 133,723 |
| 2006 | 1,235,331 | 955,370 | 1,270,589 | 3,461,290 | 166,625 |

[a] TEU (i.e., Twenty-foot Equivalent Unit) is a standard form of measurement for cargo volume used in the shipping industry. One TEU is equal to a 20-foot (6-m) section of a shipping container.

Reference: NC SPA, 2007.

**Table 3.2-3. NC DOT Annual Average Daily Traffic (AADT) Counts for NC 133 (Castle Hayne Road) Access Routes to and from the Wilmington Site**

| Traffic Count Station Location | 2005 Average Annual Daily Traffic |
|---|---|
| **Wilmington Site Access Route to and from U.S. Interstate Highway 40 (I-40) [a]** | |
| I-40 west of Holly Shelter Rd Exit (Exit 414) | 25,000 |
| I-40 east of Holly Shelter Rd Exit (Exit 414) | 26,000 |
| Holly Shelter Rd between I-40 (Exit 414) and Castle Hayne Rd | 12,000 |
| Castle Hayne Rd south of junction with North College Rd (U.S. Route 117 ) | 13,000 |
| Castle Hayne Rd north of the Wilmington Site near intersection with Sondey Rd | 14,000 |
| **Wilmington Site Access Route to and from Downtown Wilmington** | |
| Castle Hayne Rd south of Wilmington Site near intersection with N. Kerr Ave. | 19,000 |

Reference: NC DOT, 2005a.

[a] The segment of U.S. Interstate Highway (I-140) from I-40 to NC 133 (Castle Hayne Road) opened to traffic in August 2005. At the time this Report was prepared, no N.C. Department of Transportation annual average daily traffic (AADT) data were available for I-140 to reflect change in traffic volumes and patterns in Wilmington and the surrounding region as a result of vehicles being able to travel on the I-140 segments now open. Traffic to the Wilmington Site from I-40 is now likely to continue to I-140 (I-40, Exit 416) and travel westbound on I-140 to the NC 133 (Castle Hayne Road) exit.

# Figures

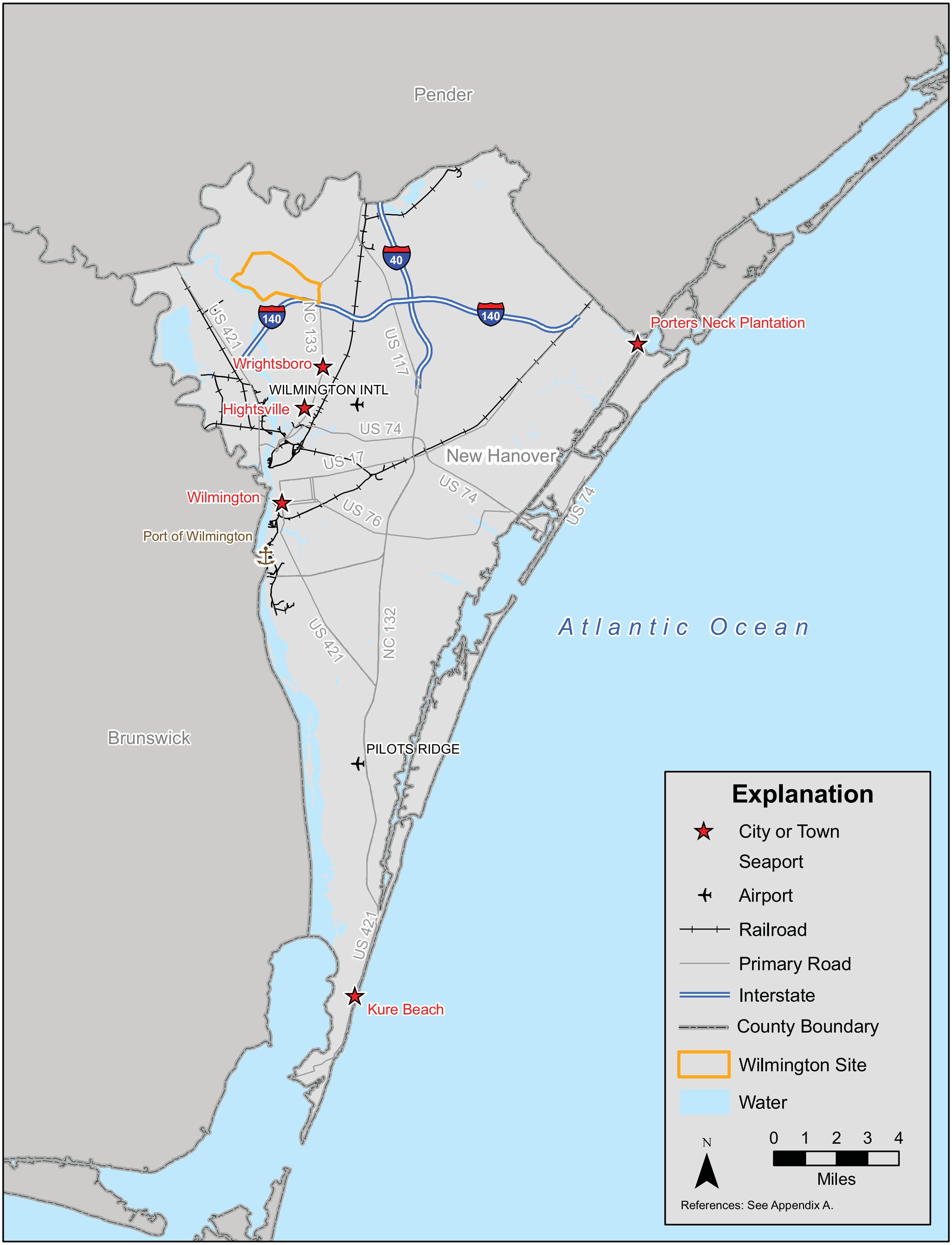


**Figure 3.2-1. Major transportation features in New Hanover County, NC.**

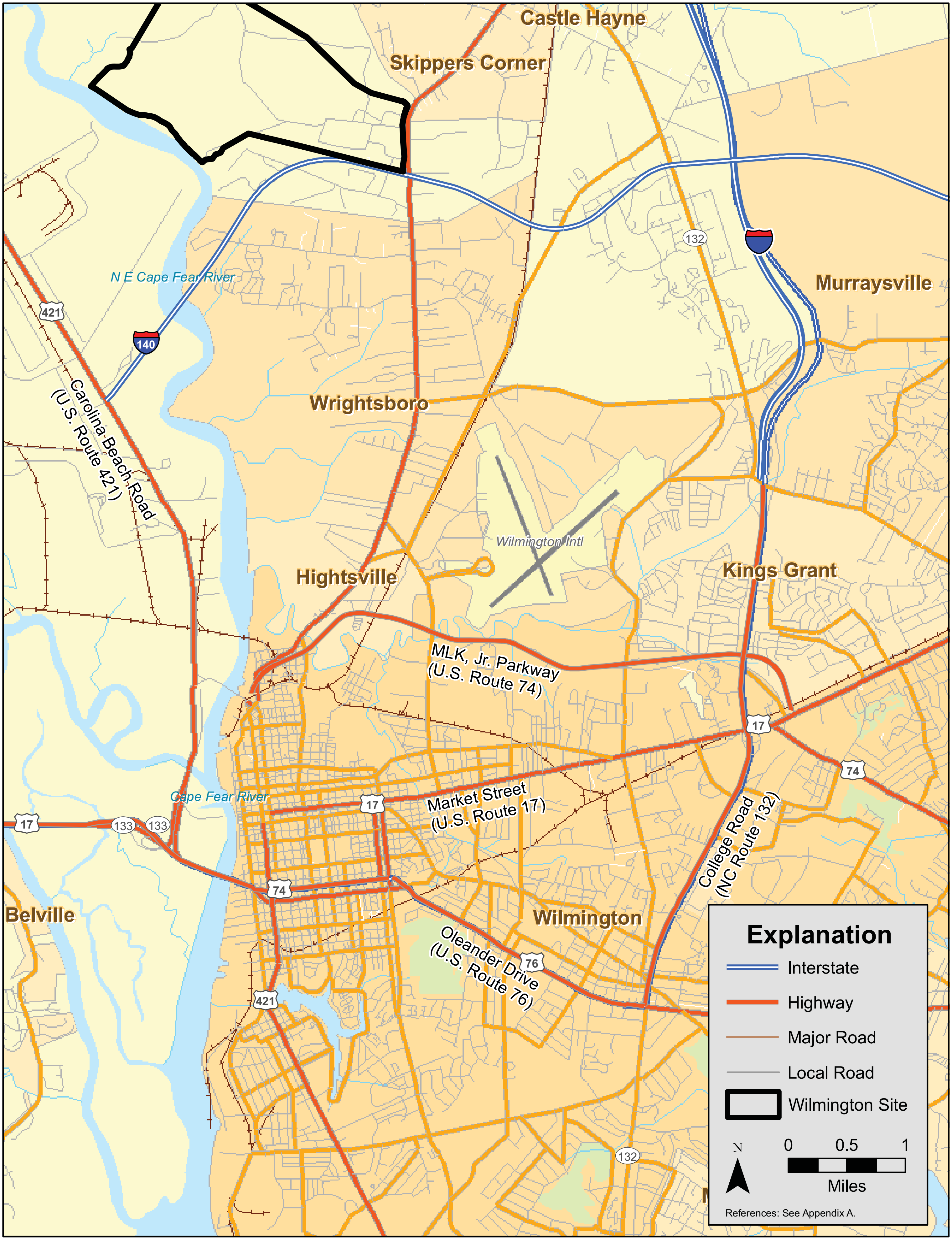


**Figure 3.2-2. Major thoroughfares and features: Wilmington, NC.**


**Figure 3.2-3. Major transportation features in Brunswick County, NC.**

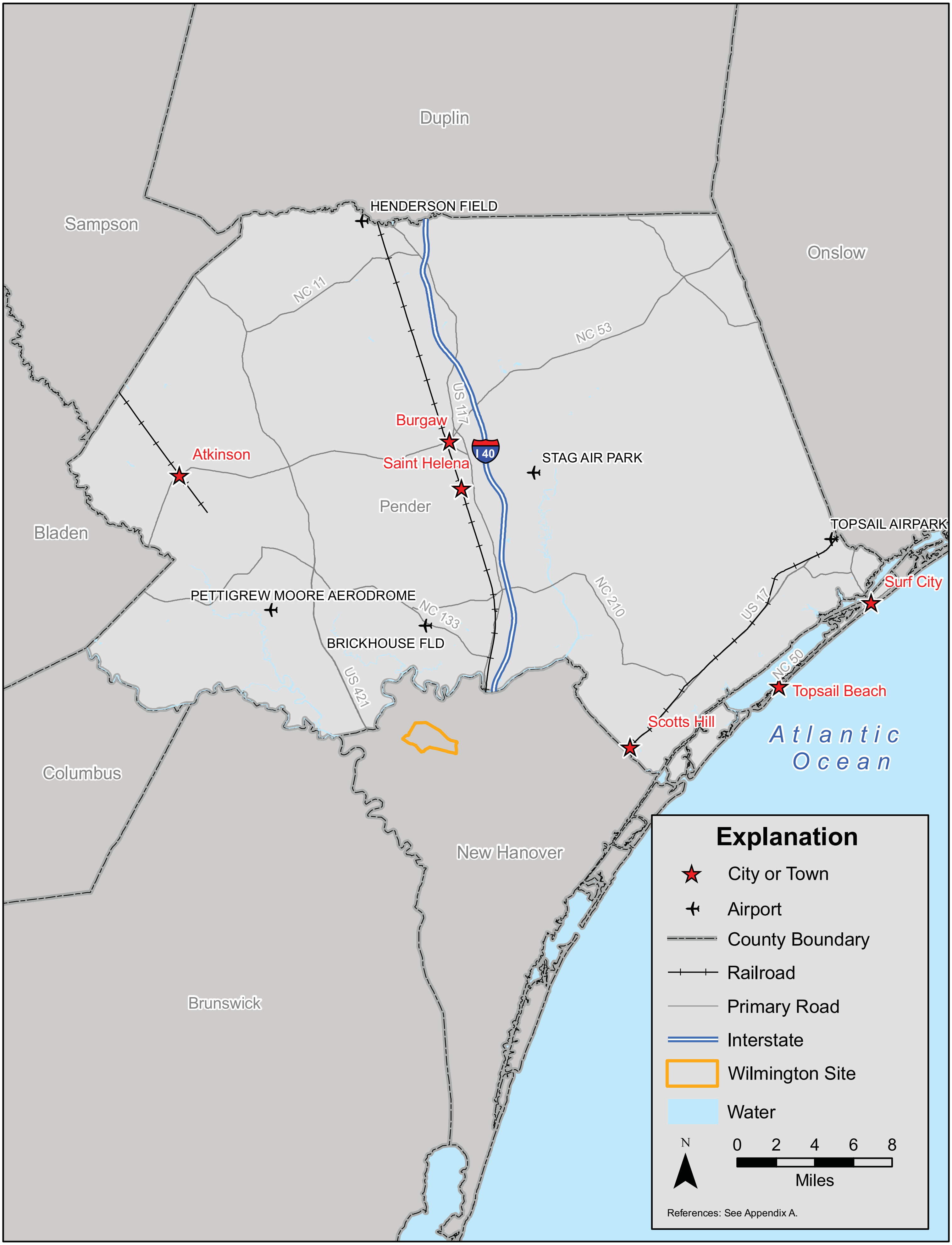


**Figure 3.2-4. Major transportation features in Pender County, NC.**

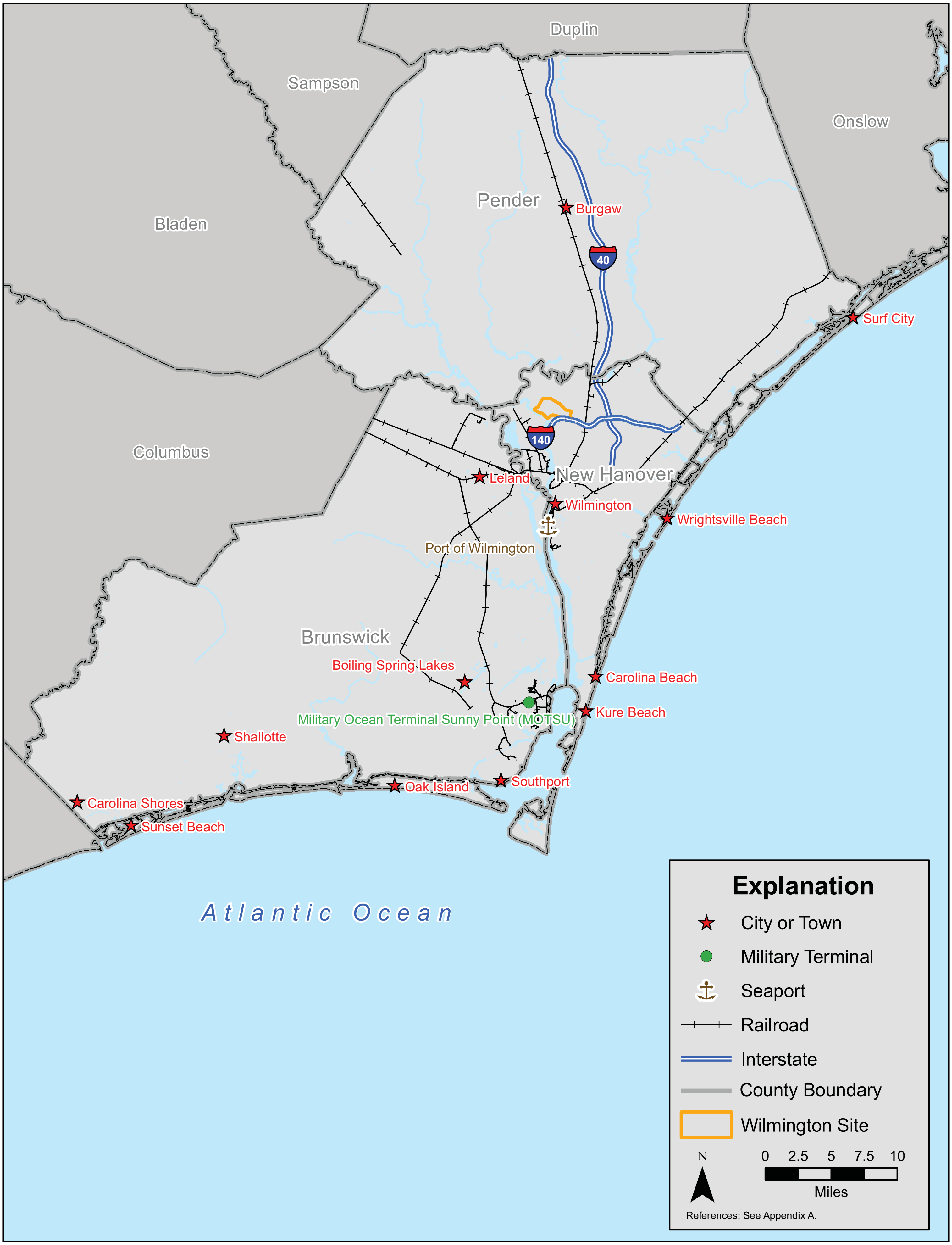


**Figure 3.2-5. Rail network in the Wilmington MSA.**


**Figure 3.2-6. Airports and landing facilities in the Wilmington MSA.**

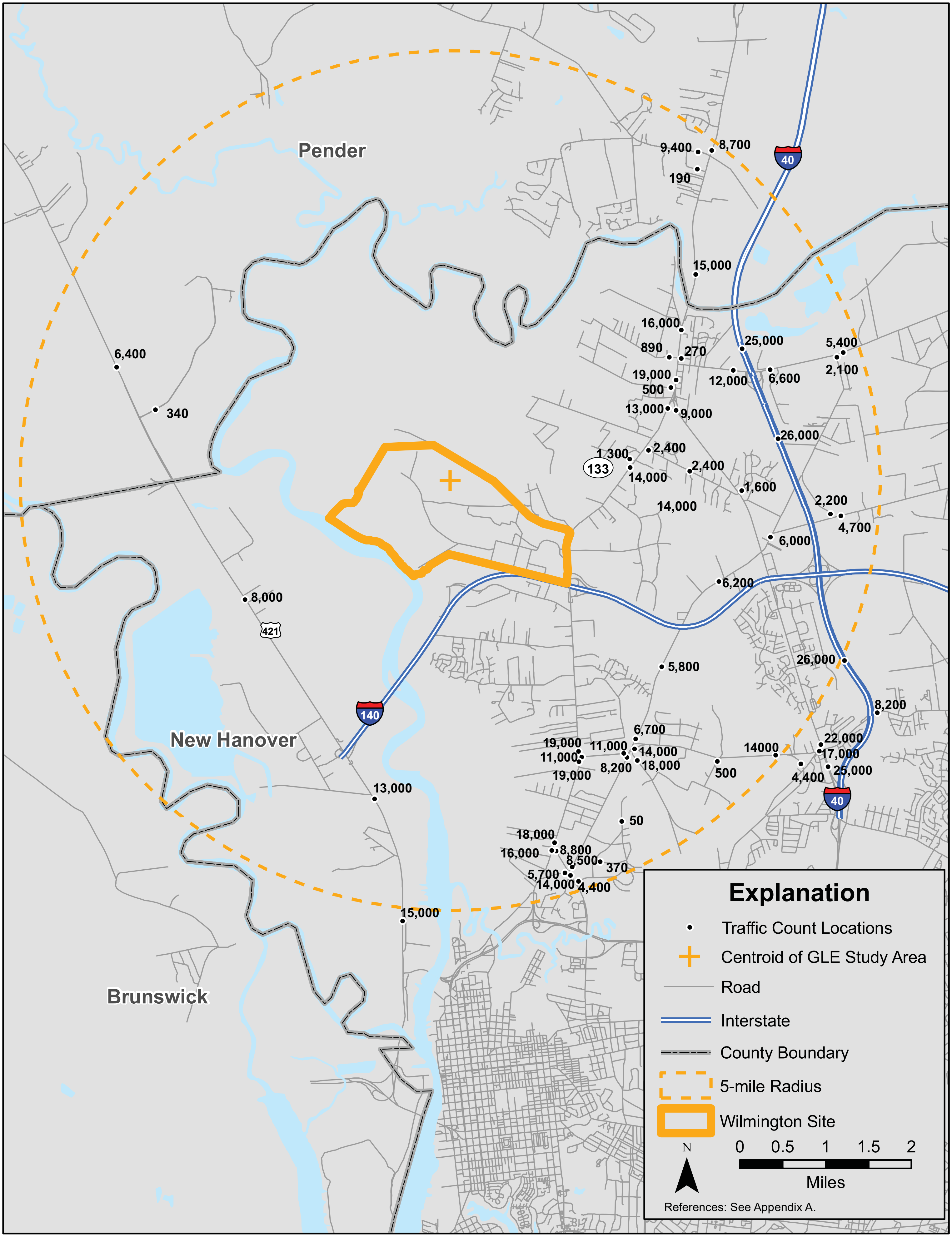


**Figure 3.2-7. NC DOT annual average daily traffic (AADT) counts for roadways within a 5-mile (8-km) radius of the Wilmington Site.**

**Figure 3.2-8. Afternoon shift change, Wilmington Site South Gate and NC 133 (Castle Hayne Road), July 24, 2007.**

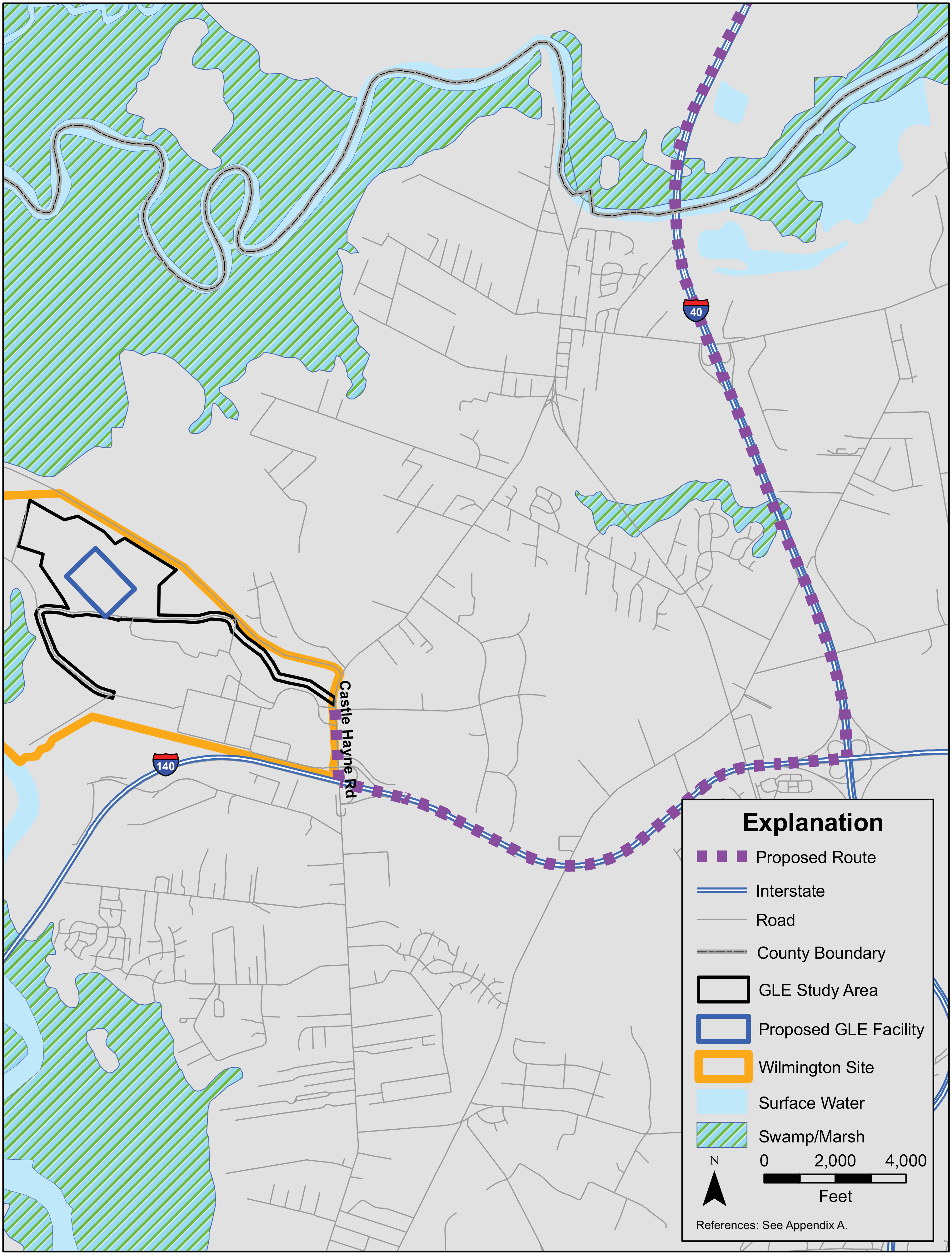


**Figure 3.2-9. Proposed routes of transportation corridors to and from the Wilmington Site.**

# GLE Environmental Report
# Section 3.3 – Geology and Soils

## Revision 0
## December 2008

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# 3.3 Geology and Soils

This section of the Report describes the geology in the region surrounding the Wilmington Site (**Section 3.3.1**), in the vicinity of the Site (**Section 3.3.2**), and at the Site (**Section 3.3.3**). This section also provides general information pertaining to regional soil patterns and the characteristics of soils of the Site (**Section 3.3.4**), as well as the geotechnical properties of the soils in the GLE Study Area (without the roads) (**Section 3.3.5**). In addition to providing technical background information about the regional and site-specific geologic setting, this section also provides information pertaining to the seismology of the region and in the vicinity of the Wilmington Site (**Section 3.3.6**). The potential impacts on the Proposed Action related to the geology of the GLE Study Area and surrounding region, as well as the potential impacts of the Proposed Action on the Site geological setting, are described in **Section 4.3** of this Report (*Soils and Geological Impacts*).

## 3.3.1 Regional Geology

The southeastern United States, where the Wilmington Site is located, is on the passive margin of the North American continent (**Figure 3.3-1**). Passive continental margins, such as those along the Atlantic Coast, develop along coastlines that are not tectonically active (Withjack and Schlische, 2007).

The Atlantic Coastal Plain physiographic province is a broad, relatively low-relief terrace that stretches along the Atlantic Ocean and Gulf of Mexico of the United States (Fenneman, 1938; Fenneman and Johnson, 1946). The Atlantic Coastal Plain physiographic province is subdivided into several smaller physiographic provinces. The Mid-Atlantic Coastal Plain physiographic province is the subdivision of the Atlantic Coastal Plain physiographic province located in North Carolina (**Figure 3.3-2**). The Mid-Atlantic Coastal Plain physiographic province extends from northern New Jersey to the North Carolina-South Carolina border. In North Carolina, the Mid-Atlantic Coastal Plain physiographic province is subdivided into the Inner Coastal Plain province and the Outer Coastal Plain province (**Figure 3.3-3**) (Ator et al., 2005).

In general, the geology of the Mid-Atlantic Coastal Plain physiographic province, where the Wilmington Site is located, can be characterized as a wedge of unconsolidated sediments composed of alternating layers of sand, silt, marl, and other clays. Limestone is also present in the North Carolina portion of this province. These sedimentary deposits rest on crystalline basement rock. The sequence of sediments and rock gradually dip and increase in thickness eastwardly toward the Atlantic Ocean.

### 3.3.1.1 Physiography

The physiography of the Inner and Outer Coastal Plain physiographic provinces exhibit the effects of both ancient and recent fluvial erosion and deposition, as well as a regional geologic history of ancient shoreline migrations, climatic change, and tectonic uplift. The characteristic topography of terraces, low rolling hills, and flat plains that is typical of landforms found in other areas of the larger Mid-Atlantic Coastal Plain physiographic province is also present in North Carolina's Coastal Plain provinces. The Inner and Outer Coastal Plain physiographic provinces, combined, extend 90 to 150 miles (145 to 240 km) from the Atlantic Coast inland to the Fall Zone.

The area along the North Carolina and South Carolina border has a high number of Carolina Bays, which are recognized as geologically and ecologically unique areas. Carolina Bays are circular, typically elliptical, depressions in the ground that are oriented along their long axis from the northwest to the southeast. They are also characterized by an elevated rim of fine sand surrounding the perimeter. These physiographic features are a prominent part of the landscape of the Atlantic Coastal Plain physiographic province (Winner and Coble, 1996).

#### *3.3.1.1.1 The Fall Zone*

The Fall Zone represents the transition from the more resistant rocks of the Piedmont physiographic province to the more easily eroded unconsolidated alluvial and marine sedimentary formations of the Inner and Outer Coastal Plain physiographic provinces (Soller and Mills, 1991; Winner and Coble, 1996). Within this zone, the rivers in North Carolina that cross from the Piedmont province into the Coastal Plain provinces change gradient, and alluvial erosion is accelerated. In most of the Atlantic Coastal Plain physiographic province, this transitional area between the Piedmont and Coastal Plain physiographic provinces is only a few miles wide and is commonly referred to as the Fall Line (**Figure 3.3-4**). The influence of ancient large-scale tectonics on the underlying basement rocks has resulted in geologic structures that have stretched this boundary into a wide transitional zone unique to North Carolina. The Fall Zone in North Carolina is almost 100-miles (160-km) wide in the central range of the Piedmont physiographic province.

Most of the geographic area of North Carolina drains into the Atlantic Ocean, and the river systems that traverse North Carolina’s Inner and Outer Coastal Plain physiographic provinces characterize the present physiography of the region. There are several major, eastwardly flowing river systems that drain the Piedmont physiographic province of North Carolina and shape the land across the extent of North Carolina’s Inner and Outer Coastal Plain physiographic provinces. Influenced by deep geologic structures, a few rivers in the southern part of the region cross into South Carolina’s Atlantic Coastal Plain physiographic province. The principal North Carolina rivers that drain into the Atlantic Ocean are the Roanoke, Tar, Neuse, and Cape Fear rivers. The Roanoke River rises in the Allegheny Mountains west of Roanoke, VA, and flows in a southeasterly direction through Virginia and North Carolina for a distance of 400 miles (640 km), 150 miles (240 km) of which are in North Carolina. The Tar, Neuse, and Cape Fear rivers rise in the Piedmont physiographic province in North Carolina and flow in a general southeasterly direction to the Atlantic Ocean. Other dominant features of the North Carolina Inner and Outer Coastal Plain physiographic provinces are wetlands that are present throughout the region (**Figure 3.3-5**). A more detailed discussion of surface waters and wetlands of the Wilmington Site are presented in **Section 3.4.2**, *Surface Waters,* and **Section 3.4.4**, *Wetlands*.

#### *3.3.1.1.2 The Inner Coastal Plain Physiographic Province*

The elevation of the Inner Coastal Plain physiographic province, where the Wilmington Site is located, generally ranges between 600 ft (180 m) above mean sea level (msl) to 25 ft (8 m) msl, with the highest elevations located in the southwest (Reid, 2007). The low ridge of the Fall Line defines the western boundary of the Inner Coastal Plain physiographic province and the eastern boundary of the higher Piedmont province. Most of the Inner Coastal Plain province is characterized by stepped, planar, and eastward-dipping slopes.

The Inner Coastal Plain physiographic province transitions northward and eastward from an elevated area in the southwest to flat to gently rolling topography that is dissected by some of North Carolina’s major rivers. The province is characterized by broad, flat topography and inter-riverine swamps. Ancient terrace deposits, marking past shorelines of ancient seas, form north-south trending low ridges that are still visible in some areas. The Inner Coastal Plain physiographic province is characterized by fertile soils and is an important area of agricultural production supporting the majority of North Carolina’s farming industry.

On the eastern edge of the Inner Coastal Plain physiographic province is a low, sandy ridge called the Suffolk Scarp (Zullo and Harris, 1979). The Suffolk Scarp marks the position of an ancient shoreline and forms the boundary between the Inner Coastal Plain and Outer Coastal Plain physiographic provinces.

#### 3.3.1.1.2.1 The Sandhills Region

The Sandhills region is a subset of the Inner Coastal Plain physiographic province. This region is located in the southwestern portion of the province and includes areas of moderately higher elevation where the topography is marked by low, gently rolling hills and valleys. The Sandhills region extends southward into South Carolina. The elevation of this relatively narrow region of rolling hills is 450 to 600 ft (135 to 180 m) msl in North Carolina. The region is underlain by fluvial sands, and the soils are sandy and well drained. These generally organically poor sandy formations, which are usually underlain by clays, are non-marine in origin (i.e., alluvial and colluvial sediments) and are typically thought to have originated as ancient alluvial fans created by rivers flowing from the Piedmont physiographic province into the ocean in the geologic past when the ocean covered most of North Carolina's Coastal Plain physiographic provinces (Ator et al., 2005). Drainage patterns in the Sandhills are generally dendritic and highly dissected, and rivers can be incised 50 ft (15 m) or more, often with steep banks and well-developed floodplains.

#### *3.3.1.1.3 The Outer Coastal Plain Physiographic Province*

The Outer Coastal Plain physiographic province extends to North Carolina's coast and includes the barrier islands along its shore. This province is divided into two regions: the Tidewater region and the Outer Banks region. River systems in the Inner Coastal Plain physiographic province transition eastward and flow across the Suffolk Scarp and into the gradual sloping lowlands of the Tidewater region.

#### 3.3.1.1.3.1 Tidewater Region

The Tidewater region extends from the Suffolk Scarp to the intercoastal waterways that separate North Carolina's barrier islands from the mainland. This mostly flat-lying region has gradual slopes that dip slightly seaward at elevations averaging approximately 25 ft (7 m) msl (Diemer and Bobyarchick, 2005). Land elevation is close to sea level along the region's eastern boundary. The low-lying swampy lands and the rivers throughout the region are heavily influenced by oceanic tides. The sands in the region are deeply cut by the major rivers draining the Piedmont and Inner Coastal Plain physiographic provinces (Soller and Mills, 1991). Fluvial flood deposits are present near streams; however, away from rivers and their tributaries, the surficial deposits in the Tidewater region are mostly marine sediments.

The Tidewater region is characteristically poorly drained due to the presence of shallow clays and other clayey soils common to the Mid-Atlantic Coastal Plain physiographic province. As a result, this region contains numerous and various types of wetland areas, including the Great Dismal Swamp, which is a marshy region of southeastern Virginia and northeastern North Carolina. There are seven sounds in the Tidewater region: Pamlico, Albemarle, Currituck, Croatan, Roanoke, Core, and Bogue sounds. The mouths of the major streams and rivers in the region empty into sounds or the ocean. Sinkholes are encountered in specific areas of the Tidewater region underlain by limestone. These sinkholes often fill with water and support local ecological communities.

#### 3.3.1.1.3.2 Outer Banks Region

The Outer Banks region consists of a string of barrier islands separated from the mainland by sounds or inlets. The largest islands are Bodie, Hatteras, Ocracoke, Portsmouth, and the Core Banks. Three capes are part of the region: Cape Hatteras, Cape Lookout, and Cape Fear. Erosion and deposition at the surface of the Outer Banks region is primarily influenced by ocean winds and storms.

### 3.3.1.2 Stratigraphy

In general, the stratigraphy of the Mid-Atlantic Coastal Plain physiographic province includes sand and clay formations of Upper Cretaceous through Pleistocene ages that overlie crystalline basement rocks of pre-Mesozoic age. Limestone formations also occur in the stratigraphic sequence of North Carolina's

Coastal Plain provinces. Thick deposits of marine sediments have accumulated in ancient shelf seas as the periodic advance and retreat of the shoreline occurred over the Coastal Plain provinces of North Carolina. In topographic lows and along modern drainage areas, these mostly marine formations are overlain by fluvial sediments and surficial sands of late-Pliocene to Quaternary age (Horton and Zullo, 1991). **Figure 3.3-6** provides the stratigraphic formations and correlates geologic ages (e.g., eras, periods, epochs) to numerical time periods. As shown in a generalized and vertically exaggerated regional cross-section, these sedimentary formations are absent west of the Fall Zone, whereas to the east, they dip slightly and thicken to form a wedge (**Figure 3.3-7**).

The chronostratigraphic record in eastern North Carolina is not continuous due to periods of intense erosion. Periodic uplift, fluvial erosion, and the sequential retreat of the shoreline due to eustatic sea-level change has either fully or partially removed formations from the stratigraphic sequence of the Coastal Plain provinces in North Carolina (Stuckey and Conrad, 1958; Horton and Zullo, 1991). For example, Quaternary-age sediments overlie formations of Cretaceous age at the Wilmington Site. In turn, the Cretaceous-age formations are underlain by a pre-Mesozoic-age crystalline basement rock complex.

In general, older formations are exposed at the surface inland toward the Fall Zone, and subsequently, younger formations crop out at the surface to the east. The sedimentary formations are thin along their western, up-dip extents. The older formations dip below the overlying younger formations towards the coast (see **Figure 3.3-7**). The following sections describe the specific and detailed stratigraphy of the North Carolina Inner and Outer Coastal Plain physiographic provinces (Beyer, 1991).

#### *3.3.1.2.1 Fluvial Terraces and Younger Deposits*

Late Pliocene- to Quaternary-aged fluvial terrace and upland erosional formations consist of gravel, clayey sand, sand, and minor iron-oxide cemented sandstone. The Pleistocene formations generally consist of surficial deposits found near the coastline in the Inner and Outer Coastal Plain physiographic provinces. Younger deposits are also found as fluvial terrace deposits along rivers and tributaries in the Inner and Outer Coastal Plain physiographic provinces (Brown et al., 1985). These deposits are listed on **Figure 3.3-6** as “Coextensive Surficial Sediments.” The water-bearing properties of these deposits are discussed in **Section 3.4.1.1.1.1**, *Surficial Aquifer (Aquifers and Confining Layers)*.

Although many of these formations are considered to be undifferentiated, two Plio-Pleistocene formations in the Mid-Atlantic Coastal Plain physiographic province are named the Waccamaw Formation and the James City Formation. These formations generally consist of bluish-gray, lime-rich clays and sands, but the predominant lithology and texture are variable across the region and with depth below the land surface. These sediments represent mostly nearshore depositional environments similar to today’s coastal sounds, where the depth of the water approximates 20 ft (6 m), but near Aurora, the sediments of the James City Formation suggest a more open continental-shelf environment. The variability of the deposits is predominantly associated with changes in sediment load and fauna due to rainfall and salinity patterns (Beyer, 1991).

#### *3.3.1.2.2 Upper Tertiary Formations*

The formations that were deposited during the Upper Tertiary period (Pliocene and Miocene epochs) in the northern portion of the Coastal Plain provinces of North Carolina include the Chowan River and the Yorktown, Eastover, and Pungo River formations; those formations deposited in the southern Coastal Plain provinces of North Carolina include the Bear Bluff and Duplin formations.

##### 3.3.1.2.2.1 Chowan River and Bear Bluff Formations

Pliocene- to Pleistocene-aged Chowan River and Bear Bluff formations were deposited onto the undivided Yorktown and Duplin formations (see **Section 3.3.1.2.2.2**) and are sporadically distributed.

These formations consist of a series of irregular deposits of fossiliferous sand, with silt and bluish-gray to tan, loosely consolidated clay that grades into unconsolidated medium- to coarse-grained sands with cross-bedding and common rhythmic bands of clayey sand.

Throughout geologic time, rivers cut deep channels into the North Carolina Coastal Plain physiographic provinces. River channels as deep as 50 ft (15 m) were carved into the surface of the Yorktown and Duplin formations. The channels filled in with deposits that are now the Chowan River Formation.

Along the northern border of North Carolina, deposits accumulated in shallow water along the coast. Sediments from the Black Creek Formation (see **Section 3.3.1.2.4.2**) were eroded by longshore currents and waves and redeposited as the Bear Bluff Formation.

#### 3.3.1.2.2.2 Yorktown Formation and Duplin Formation

In the southern part of the Coastal Plain physiographic provinces in North Carolina, Miocene-aged deposits (Eastover and Pungo River formations; see **Sections 3.3.1.2.2.3 and 3.3.1.2.2.4**, respectively) are not present; therefore, Oligocene formations (River Bend and Belgrade formations; see **Section 3.3.1.2.3.1**) are unconformably overlain by the Pliocene-aged Yorktown Formation and Duplin Formation, located north and south of the Neuse River, respectively (see **Figure 3.3-6**). The Yorktown Formation is a unit of fossiliferous clay with varying amounts of fine-grained, bluish-gray sand with shell lenses. The Duplin Formation is a series of shelly, medium-to-coarse-grained sand, sandy marl, and bluish-gray limestone. These two undivided formations are collectively known as the Yorktown Formation. Deposition of these formations initially began in a shallow, warm, advancing Miocene sea and continued in the brackish waters of a sound. These formations are well known for the numbers and variety of fossils present.

#### 3.3.1.2.2.3 Eastover Formation

The Eastover Formation was deposited during shoreline advancement over the modern-day North Carolina Inner and Outer Coastal Plain physiographic provinces during the Upper Tertiary period. The formation is principally calcareous sand. The tropical climate allowed for abundant development of marine communities and includes significant shell beds.

#### 3.3.1.2.2.4 Pungo River Formation

The Pungo River Formation is a phosphate deposit formed in nutrient-rich sediments deposited in shallow troughs of a fault basin near Beaufort and Washington, NC, and intermixed with clays and volcanic ash deposited when the Upper Tertiary seas retreated (see **Sections 3.3.1.2.4.1 and 3.3.1.2.4.2**, respectively).

### *3.3.1.2.3 Lower Tertiary Formations*

The Lower Tertiary formations that are present in the North Carolina Coastal Plain physiographic provinces are the Belgrade Formation, River Bend Formation, Castle Hayne Formation, and Beaufort Formation. During the early Tertiary period, the Upper Cretaceous-age Peedee and Black Creek formations were uplifted by regional geologic structures (see **Section 3.3.1.3**). These formations were subsequently eroded and redeposited to form the Lower Tertiary-aged sedimentary deposits described below.

#### 3.3.1.2.3.1 Belgrade and River Bend Formations

The Belgrade and River Bend formations were deposited during the Oligocene epoch. The Belgrade Formation is subdivided into the Haywood Landing Member and the Pollocksville Member. The Haywood Landing Member, consisting of shell mounds of giant oysters in a tan to orange sand matrix, grades upward into the Pollocksville Member, a layer of gray to brown fossiliferous clayey sand (Lautier,

1998; Feldmann et al., 1998; Harrelson and Fine, 2006). The River Bend Formation underlies the younger Belgrade Formation and consists of layers of calcarenite limestone overlain by and intercalated with indurated, sandy, molluscan-mold limestone. The Belgrade and River Bend formations were deposited during advances and retreats of the shoreline, as reflected in the lithology of the deposits. Initially, the lithologies reflect deepening seas (Pollocksville Member), then quiet shelf deposition (Belgrade Formation), and finally, recessive shallow seas (Haywood Landing Member).

#### 3.3.1.2.3.2 Castle Hayne Formation

The Castle Hayne Formation, Upper Eocene in age, contains very sandy, molluscan-mold limestone that grades into locally dolomitized, bryozoan-echinoid skeletal limestone with commonly present solution cavities. Locally, a thin, micritic, phosphate-pebble basal conglomerate is present. The Castle Hayne Formation was deposited during an episode of sea-level rise when the Upper Eocene shoreline migrated into the area of the current Piedmont physiographic province. The Eocene climate was sub-tropical, and shallow seas encouraged the development of numerous invertebrates. The shell and calcareous mud was deposited in this formation over an extensive period. A small deposit of volcanic ash (bentonite) also occurs in the formation. After the Eocene seas retreated and then again advanced to the present location of New Bern, NC, wave action eroded part of the Castle Hayne Formation, reworked the sediments, and deposited a series of sand beds, known as the New Bern Member of the Castle Hayne Formation. This formation is in contact with the Peedee Formation (see **Section 3.3.1.2.4.1**) in the area north of the Cape Fear Arch (see **Section 3.3.1.3**). The water-bearing properties of the Castle Hayne Formation are discussed in **Section 3.4.1.1.1.2**, *Castle Hayne Aquifer (Regional Aquifers and Confining Layers)*.

#### 3.3.1.2.3.3 Beaufort Formation

The Lower Paleocene-aged Beaufort Formation is the oldest of the Tertiary formations in the Inner and Outer physiographic provinces and is only sporadically present north of the uplifted region known as the Cape Fear Arch (see **Section 3.3.1.3.2**). In North Carolina, the Beaufort Formation reaches a maximum thickness of 15 ft (5 m). The formation is more prevalent in other areas of the Atlantic Coastal Plain physiographic province such as in South Carolina, south of the Cape Fear Arch (Horton and Zullo, 1991). The formation consists of sand and glauconitic and fossiliferous silty clay, as well as siliceous mudstone with thin lenses of sandstone containing some basal phosphatic pebble conglomerate. Volcanic ash is also present, suggesting tectonic activity during the early Tertiary period. The formation is thought to have been deposited on the flat continental shelf bottom in shallow water during the episodes of uplift and erosion that occurred during the Lower Paleocene epoch (Beyer, 1990).

### *3.3.1.2.4 Upper Cretaceous Formations*

The similarity of Upper Cretaceous formations in the Atlantic Coastal Plain physiographic province has complicated the correlation of these formations across the entire province, from the Gulf States to Virginia. The latest studies (Winner and Coble, 1996; Horton and Zullo, 1991; Ator et al., 2005) agree to four Upper Cretaceous formations in the Mid-Atlantic Coastal Plain physiographic province. The youngest of the Upper Cretaceous formations in the North Carolina Inner and Outer Coastal Plain physiographic provinces is the Peedee Formation, which is underlain by the progressively older formations of the Black Creek Formation, Middendorf Formation, and Cape Fear Formation. The contact between the oldest Cretaceous formations and the basement rock is exposed in the westernmost areas of the Coastal Plain provinces near the Fall Line (Horton and Zullo, 1991). The four Upper Cretaceous formations are described in the following sections, from youngest to oldest age. Of these formations, only the Middendorf Formation is absent beneath the Wilmington Site (see **Figure 3.3-6**).

#### 3.3.1.2.4.1 Peedee Formation

The Peedee Formation is the youngest of the Upper Cretaceous formations and consists of glauconitic and phosphoritic silty, fine- to very fine-grained quartz sand with trace amounts of shell and pyrite. Clayey sand and greenish-gray to olive black, massive, locally fossiliferous and calcareous clay are also present (Brown et al., 1985). The uppermost part of the Peedee Formation includes a discontinuous unit referred to as the Rocky Point Member, which is present in southeastern Brunswick and north-central New Hanover counties. The Rocky Point Member consists of a moldic limestone grading down into calcareous sandstone (Lautier, 1998). The water-bearing properties of the Peedee Formation are discussed in **Sections 3.4.1.1.1.3**, *Peedee Aquifer[Regional Aquifers and Confining Layers]*; **3.4.1.1.2.3**, *Wilmington Site Groundwater Remediation*; **and 3.4.5**, *Water Use.*

#### 3.3.1.2.4.2 Black Creek Formation

The Black Creek Formation is widespread and consists of alternating beds of fine-grained micaceous "salt and pepper" sands thinly laminated with gray-to-black lignitic clays. These deposits are indicative of lagoon to marine sediments (Harrelson and Fine, 2006; Lautier, 2006). The formation also includes fossiliferous clayey-sand lenses with shell, glauconite, and organic material. In the lower section of the Black Creek Formation, the presence of a kaolinitic clay and cross-bedded sand, silty-clay, coarse channel sands, and thinly laminated beds of sand and clay demonstrate a non-marine fluviodeltaic sequence (Beyer, 1991; Harrelson and Fine, 2006). The water-bearing properties of the Black Creek Formation are discussed in **Section 3.4.1.1.1.4**, *Black Creek Aquifer (Regional Aquifers and Confining Layers)*.

#### 3.3.1.2.4.3 Middendorf Formation

The Middendorf Formation contains sand, sandstone, and mudstone. The sediments are typically mottled gray to pale gray with an orange cast. The beds are laterally discontinuous, and cross bedding is common. These deposits were formed because subsidence near the edge of the continent caused the shorelines to advance during the Upper Cretaceous period, causing deltaic sands to be deposited over the Cape Fear Formation (**Section 3.3.1.2.4.4**). During this geologic period, meandering streams and rivers traversed back and forth over a low, flat delta, depositing the sand and mud of the Middendorf Formation.

#### 3.3.1.2.4.4 Cape Fear Formation

The Cape Fear Formation is the oldest of the Upper Cretaceous sedimentary formations in North Carolina's Inner and Outer Coastal Plain physiographic provinces. In North Carolina, the Cape Fear Formation often contains beds of quartz and feldspar sands, clay and silt, and iron-oxide minerals. Lower sections of the formation consist of red to yellow-brown clays and silts and thin interbedded sands (Beyer, 1991). The formation also consists of sandstone and sandy mudstone, is yellowish gray to bluish gray, and can be mottled red to yellowish orange in places. The formation is indurated and graded and exhibits laterally continuous bedding with faint cross bedding (Ator et al., 2005). The cross-bedding structure is indicative of the formation's origin as fluvial deposits on deltas and shallow estuaries in shallow shelf seas during the Cretaceous period. The water-bearing properties of the Cape Fear Formation are discussed in **Section 3.4.1.1.1.5**, *Black Creek Aquifer (Regional Aquifers and Confining Layers)*, and **Section 3.4.1.1.1.6**, *Lower Cape Fear Aquifer (Regional Aquifers and Confining Layers).*

### 3.3.1.3 Structure

This section describes the distribution, position, shape, and internal structures of the geologic formations of the Mid-Atlantic Coastal Plain physiographic province. Geological structures include folds, fractures, joints, faults, and other effects of tectonic processes that occurred in geologic time. The wedge of sedimentary formations that overlies pre-Mesozoic crystalline basement rock in the Mid-Atlantic Coastal Plain province east of the Fall Line establishes the setting for the framework of the region. Structural

features in the crystalline basement rock have shaped the sediment wedge and surface features in the region.

#### *3.3.1.3.1 Geometry of Formations in the Mid-Atlantic Coastal Plain Physiographic Province*

In the Mid-Atlantic Coastal Plain physiographic province, the thickness of the sedimentary formations overlying the crystalline basement rock increases eastward, and the steepness of the slope of these formations dramatically increases toward the continental shelf (**Figure 3.3-7 and Figure 3.3-8**). The combination of increased thickness and slope toward the coast forms a massive wedge that thickens to over 30,000 ft (9,100 m) on the continental shelf (Siple, 1957). In North Carolina, the sedimentary formations thicken from zero at the Mid-Atlantic Coastal Plain physiographic province's western extent at the Fall Line to over 1,100 ft (330 m) in the vicinity of the Wilmington Site (Stuckey and Conrad, 1958). The thickness of the wedge in North Carolina is less than surrounding states; for example, the wedge thickens to approximately 3,500 ft (1,100 m) at the coast of South Carolina (Siple, 1957). As described in **Section 3.3.1.2**, the western edges of older formations are exposed at the surface toward the Fall Line. **Figure 3.3-9** is a geologic map that shows the formation outcrop patterns in the North Carolina Coastal Plain.

#### *3.3.1.3.2 Tectonic Features of the Crystalline Basement Rock Complex*

A series of arches and embayment areas are present on the bedrock surface of the deep crystalline basement rock complex along the Mid-Atlantic Coastal Plain physiographic province (Winner and Coble, 1996) (**Figure 3.3-10**). From north to south, the depositional basins in this province are as follows (Ator et al., 2005):

- Raritan Embayment in northern New Jersey
- Salisbury Embayment in Maryland, Delaware, and Virginia
- Albemarle Embayment in northeastern North Carolina.

These basins are separated by the following:

- South New Jersey Arch
- Norfolk Arch
- Neuse and Cape Fear arches.

The Cape Fear Arch trends in a northwest-southeast direction in North Carolina and is the most prominent of the arches listed above. In general, the arch extends from beyond the Outer Banks inland along the full length of the approximately 200-mile (320-km) Cape Fear River drainage basin. The arch then extends further west into the Blue Ridge Mountains, where it elevates North Carolina's peaks to topographic levels that exceed those of the same mountain range in neighboring states (Rogers, 1999).

The Neuse Arch is a smaller-scale feature on the northern flank of the Cape Fear Arch. The Neuse Arch also trends in a northwest-southeast direction and parallels the New and Neuse rivers. These geologic structures are believed to be associated with large-scale tectonic features in the crystalline basement and may have vertical offsets of about 1,000 ft (305 m) relative to the adjacent basin (Ator et al., 2005). The Cape Fear Arch and the Neuse Arch combine to raise North Carolina's southern Coastal Plain to elevations higher than those in adjacent states to the north and south.

##### 3.3.1.3.2.1 Investigations of the Cape Fear Arch

Several researchers in the 1970s concluded that two arch structures, the Cape Fear Arch and Neuse Arch, were caused by regional episodic crustal uplift since the Cretaceous period (Harris et al., 1979; Zullo and

Harris, 1979; Prowell and Obermeier, 1991). Both arches are inferred to exist in the pre-Mesozoic crystalline basement rock and are expressed at the surface as broad deformations in the overlying, younger sedimentary formations. The arch structures have been active at least since the early Cretaceous period (135 million years ago) and remain active into the present day (Zullo and Harris, 1979).

The escarpments created during high stands in sea level and their relationships to flood terraces deposited by the Cape Fear River suggest a history of uplift in the region (Zullo and Harris, 1979). The effects of this tectonic activity are expressed in the topography and stratigraphic relationship within both the marine and fluvial sediments in the area. Multiple investigators have provided evidence of continual tectonic activity by demonstrating a relationship between uplift, Cape Fear River flood terrace deposition, erosional escarpments (Harris et al., 1979; Soller and Mills, 1991), and offsets in sedimentary deposits (Zullo and Harris, 1979). This evidence consistently shows the cyclical and episodic uplift of the tectonic block between the Cape Fear and Neuse arches.

Determining the rate of uplift along the Cape Fear Arch since the Cretaceous period has been attempted by numerous investigators. General approximations determined from the stratigraphic record have suggested various rates of uplift through the Cenozoic era; however, uplift rates appear to have increased uniformly in the past 3 million years. Blackwelder (1981) estimated an average rate of 1.3 cm per 1000 years for the uplift that has occurred since the Pliocene epoch (beginning 5.3 million years ago). Other investigators have noted that uplift rates in the Holocene epoch (10,000 years ago to the present) have varied along the axis of the Cape Fear Arch, with greater uplift in the northwest and relatively lower amounts in the southeast (Markewich, 1985; Soller, 1988).

Inaccuracies have been realized in modern attempts to quantify rates of uplift along the Cape Fear Arch using the data collected between 1900 and 1976, as well as efforts to measure the rates of crustal movements in other zones along the east coast of the United States. An evaluation (Brown, 1978) of measurement errors and discrepancies between the methods used to create profiles along the east coast of the United States (i.e., geodetic surveys and tide gauge measurement) revealed that the crustal movements observed during the period of study cannot be attributed to any of the measurement errors or measurement anomalies identified. Therefore, there is some movement occurring in this area; however, modern rates of uplift (see **Section 3.3.6.6**) along the Cape Fear and Neuse arches, as reported in current literature, can only be considered as rough estimates.

#### 3.3.1.3.2.2 Physiographic Control

The orientation and thickness of the Mid-Atlantic Coastal Plain physiographic province sedimentary sequence has been controlled by the undulating surface of the crystalline basement rock complex deformed by the stresses that are creating the Cape Fear Arch. In the geologic past, the trough areas in this complex have served as sedimentary basins where more sediment accumulated than along the arched areas, and during certain periods, the Cape Fear Arch has stood as a peninsula when rising seas submerged the surrounding areas (Beyer, 1991). As a result, formation thicknesses are less on the crest of the arches than on the flanks (**Figure 3.3-11**). The geometry of the younger overlying sedimentary formations has been affected by this deformation. Thinner and younger sediments along the crest of the arch have eroded more quickly, exposing older, underlying formations in juxtaposition to younger strata on the flanks.

The area along the Cape Fear Arch has been slightly uplifted, possibly several times during its geologic history, relative to the rest of the Mid-Atlantic Coastal Plain physiographic province. The resulting higher topography of this part of the Inner and Outer Coastal Plain physiographic provinces and the adjoining Piedmont physiographic province has been the controlling influence on the orientation of river systems and on the physiographic development in eastern North Carolina. In this elevated area of the Coastal Plain physiographic provinces, there are currently few streams and rivers; however, the river systems that are

present have cut deeply into the sediments and flow within well-defined channels with high banks (Ator et al., 2005). Locally, the rivers on either flank of the arch have migrated to the opposite sides of their channels and cut deep bluffs that overlook the flood plains. In contrast, riverine systems flowing along low, flat areas bordering the flanks of the arch, where the marine sediments are thicker and the basement rock is deeper, typically do not have the well-defined channel flow or flood plain areas of the rivers located near the arch, but rather are typically associated with better-developed swamps, estuaries, and sounds.

#### 3.3.1.3.2.3 Faults and Seismic Events

As described below and in detail in **Section 3.3.6**, there are no active Quaternary faults (i.e., surface displacements that occurred within the past 2 million years) mapped in the in the vicinity of the Wilmington Site. The vast majority of seismic activity in North Carolina is concentrated in the western mountainous regions, where sutures and faults are predominantly associated with North American collisional tectonics. There are clusters of events scattered throughout South Carolina and a few isolated occurrences of singular events along the coasts of North and South Carolina.

Linear features have been identified in the crystalline basement rock complex from geophysical exploration in the region. Recent studies include gravity-anomaly and side-penetrating radar investigations. There is no empirical evidence of offset or displacement in the surficial geology associated with these deep linear features to suggest recent seismic activity. The seismic record shows only a few low-magnitude earthquakes outside of the Charleston, SC, region and the Appalachian Mountains. The seismic hazard in the Inner and Outer Coastal Plain physiographic provinces of North Carolina is not considered to be significant because only a few earthquakes are scattered in these provinces and those within 43.5 miles (70 km) of the Wilmington Site were of magnitude 3.5M or less and would not have caused significant damage (see **Section 3.3.6**).

#### 3.3.1.3.2.4 USGS Investigation of Seismic Features in the Eastern United States

The USGS is conducting a nationwide assessment to identify all published and unpublished information pertaining to inactive Quaternary faults, liquefaction features, and deformation (i.e., fault-related folds) in the tectonically stable central and eastern United States (see **Appendix D**, *Information on the USGS Assessment of the Cape Fear Arch Tectonic Feature*). This work is funded largely by the National Earthquake Hazard Reduction Program (NEHRP) through the USGS. The following common geological criteria are used in the USGS determination: paleoseismological, stratigraphic, sedimentological, structural, and geomorphological information (Crone and Wheeler, 2000).

The USGS has identified the Cape Fear Arch as a possible tectonic structure for that assessment. The category applied to the arch is Class C, i.e., geologic evidence is insufficient to demonstrate 1) the existence of tectonic fault, or 2) quaternary slip or deformation associated with the feature. The following is an excerpt from Crone and Wheeler (2000) and provides the rationales that are used to assign the Cape Fear Arch to Class C:

> "Lack of evidence for Quaternary faulting. Harris and others (1979) and Zullo and others (1979) collected earlier suggestions for the existence of three faults longer than 60 miles (100 km) on the arch and its northeastern limb. However, Soller (1988, p. 49–50) suggested an alternative explanation of the evidence for one of the faults, and Prowell and Obermeier (1991) noted that much evidence favors regional warping, but none requires faulting. Harris (1996) omitted two of the earlier faults and referred to the third as a hinge."

Additional information about this assessment from the USGS report (Crone and Wheeler, 2000) is provided in **Appendix D**. Additional research on the region's seismicity and faults is discussed in **Section 3.3.6**.

### 3.3.1.4 Subsidence/Sinkholes

Subsidence takes place in any given geographic region due to one or more of the following processes: tectonic displacement along active faults, sediment loading on the land and continental shelf, cooling of the crust (Prowell and Obermeier, 1991), overpumping of an aquifer, and/or underground mining. Evidence of subsidence has been displayed in the relationship between formation thickness, escarpments, and fluvial deposits (Zullo and Harris, 1979; Prowell and Obermeier, 1991). Subsidence from natural processes takes place over long periods on the geologic time scale, but induced subsidence can occur more rapidly depending on conditions in a particular area.

In northeastern North Carolina, the land is subsiding at about 0.8 inches/year (2centimeters [cm]/year), independent of sea-level rise, whereas in southeastern North Carolina, the land is rising at about the same rate (Rogers, 1999). This subsidence and uplift are being caused by the regional tectonism discussed in **Section 3.3.1.3**.

The State of North Carolina implemented a Capacity Use Area program to reduce groundwater withdrawals from endangered aquifers (see **Section 3.4.5**, *Water Use*) and has established two areas in the Mid-Atlantic Coastal Plain physiographic province to control the rate of groundwater withdrawal in this region. Reducing groundwater withdrawals can also minimize induced subsidence. Large pumping centers do exist in the region, but the hydrogeologic settings of those pumping areas are somewhat different from the setting of the Wilmington Site. State agencies are monitoring conditions in southeastern North Carolina, but currently do not have plans to implement regional controls on water withdrawal in New Hanover County. However, there are concerns about potential saltwater encroachment for the Peedee and Castle Hayne aquifers (Wilson, 2007).

Mining does occur in North Carolina's Mid-Atlantic Coastal Plain physiographic province (see **Section 3.3.1.5**).The mining operations in eastern North Carolina use open-pit mining techniques as opposed to underground mining; therefore, the potential for collapsing mine structures causing local subsidence does not exist.

Sinkholes typically occur due to the natural dissolution of carbonate-bearing rock, such as limestone (i.e., karst terrain) by rainwater and shallow groundwater. Areas in the Mid-Atlantic Coastal Plain physiographic province of North Carolina with carbonate-bearing rock are well characterized and occur predominantly in the counties of Brunswick, New Hanover, Pender, Onslow, Jones, Lenoir, Craven, and Beaufort. Ground collapse and subsidence from karst sinkholes is a geologic hazard that is present in the North Carolina Coastal Plain (NCGS, 2007). Sinkholes can be a contributing factor in the rapid introduction of surface contaminants to groundwater. Ground-disturbing activity and changes in surface water and groundwater-flow patterns can also lead to the formation of sinkholes.

Many of the Cretaceous to Cenozoic sedimentary formations in the Mid-Atlantic Coastal Plain physiographic province are limestone or carbonate-cemented sandstone. Carbonate-bearing formations susceptible to sinkhole development in North Carolina's Mid-Atlantic Coastal Plain physiographic province include the Castle Hayne Formation, Waccamaw Formation, Belgrade Formation, and River Bend Formation (NCGS, 2007). A geologic map of the Mid-Atlantic Coastal Plain shows the general area where these formations are exposed at the ground surface (**Figure 3.3-12**). Most of the sinkholes in the region have occurred in the Castle Hayne limestone. As shown in **Figure 3.3-12** and further discussed in **Section 3.3.2.5**, the Wilmington Site is not underlain by the Castle Hayne Formation or the other geologic formations known to be susceptible to sinkhole development.

Many theories exist to explain the processes that form Carolina Bays, which are described in **Section 3.1.1.1**, *New Hanover County (Regional Setting)* (Howard, 1997). Although they appear from the surface to be similar to sinkholes formed in karst environments, the North Carolina Geological Survey (NCGS) (2007) states the following:

> "[Carolina Bays] are not sinkholes. While their origin is not determined, Carolina Bays are very different from a sinkhole in that they can be much larger, but more shallow and do not overlie underground caverns."

Therefore, the presence of Carolina Bays does not imply the presence of dissolution features in a karst environment.

### 3.3.1.5 Economic Mineral Resources

Surface mining is common in the Mid-Atlantic Coastal Plain physiographic province of North Carolina (**Figure 3.3-13**). Economic mineral resources in the region are limited to sand and gravel, clay, limestone, phosphate, and peat. Other minerals have been discovered in the province, but currently are not mined. Mining and mineral processing operations in the Wilmington MSA are discussed in **Section 3.1.4** of this Report (*Mineral Resources*).

Industrial sand is mined in the Sandhills region for making container glass, flat glass, and ferrosilicon. This sand is also used for filtration, sandblasting, and construction purposes. Limestone is mined in several areas, including New Hanover County (Castle Hayne Formation), for production of agricultural lime and cement products. Phosphate is the most prominent economic mineral available in the Mid-Atlantic Coastal Plain physiographic province (Feiss et al., 1991). It is an important fertilizer component and is mined in the northern part of the North Carolina Mid-Atlantic Coastal Plain physiographic province in Beaufort County near Aurora (from the Pungo River Formation).

Fuel-grade peat deposits cover about 677,000 acres (274,000 ha) in the Mid-Atlantic Coastal Plain province of North Carolina. These deposits are primarily mined as a fuel due to their wood content, but are not highly valued for agricultural uses (except for agricultural products, such as a low-grade soil conditioner and potting soil). Other uses of peat include feed stock for synthetic compounds, a waste-treatment material, and a filter material (NCGS, 2007). Reserves of moisture-free peat deposits occur in swamps or pocosins, Carolina Bays, and river flood plains. Most of the peat occurs at the surface with no overburden. The peat generally ranges from 1- to 15-ft (0.3- to 5-m) thick and is reported to average 4.5-ft (1.4-m) thick (NCGS, 2007). The largest deposits of peat are in the Albemarle-Pamlico peninsula and the Dismal Swamp; however, many environmental factors must be addressed before these sensitive areas could be mined for peat.

Deposits of heavy minerals, including ilmenite, rutile, and zircon, have been discovered in the upper portion of the Mid-Atlantic Coastal Plain physiographic province of North Carolina. Deposits of these heavy minerals are located in Wilson, Nash, and Halifax counties, areas near Roanoke Rapids, and in the Aurelian Springs and Bailey areas of North Carolina. These mineral resources have not yet been economically developed in these areas.

### 3.3.1.6 Potential Geologic or Other Natural Hazards

Several other types of potential geologic or other natural hazards considered in the vicinity of the Wilmington Site include the following:

- **Volcanic activity.** There is no current volcanic activity in the region or vicinity of the Site and none is expected; therefore, volcanic activity was not evaluated as a potential hazard.

- **Possible threat by tsunami.** FEMA defines the geographic threshold for concern for a tsunami as 1 mile (1.6 km) inland from the coast and 25 ft (8 m) msl. The Wilmington Site is about 11 miles (18 km) from the coastline and is above 25 ft (8 m) msl; therefore, there is no threat to the Site from direct effects of a potential tsunami, and tsunamis were not evaluated as a potential hazard.
- **Possibility of landslide.** Landslides occur on steep slopes when soils move down slope by gravity under certain conditions. The topography is mostly flat in the vicinity of the Site and in the GLE Study Area; therefore, landslides were not evaluated as a potential hazard.
- **Presence of radon or methane gas.** The Mid-Atlantic Coastal Plain physiographic province counties in North Carolina are in a Low Potential zone for the presence of radon gas (**Figure 3.3-14**). Soil samples collected at the Wilmington Site typically do not have high amounts of natural organic material present, and there are no municipal landfills on or in the immediate vicinity of the Site (see **Section 3.4.1**, *Groundwater*); therefore, radon gas and methane gas buildup beneath the Wilmington Site was not evaluated as a potential hazard.

### 3.3.2 Geology in the Vicinity of the Site

For the purposes of this section, the vicinity assessed generally includes New Hanover County, Brunswick County, and portions of neighboring counties. The Wilmington Site is located in the northwestern corner of New Hanover County within the drainage basin of the Northeast Cape Fear River, a major tributary to the Cape Fear River (**Figure 3.3-15**). The Northeast Cape Fear River is the most prominent physiographic feature in the vicinity of the Site. Wetlands and surface waters in the vicinity of the Site are discussed further in **Section 3.4**, *Water Resources,* and **Section 4.4**, *Water Resources Impacts*.

Many of the formations common to North Carolina's Mid-Atlantic Coastal Plain physiographic province, including some that were previously discussed (**Section 3.3.1.2**), are not present in the vicinity of the Wilmington Site (Ator et al., 2005; Fine and Cunningham, 2001). Most of the stratigraphic units in the Mid-Atlantic Coastal Plain physiographic province represent specific oceanic and fluvial paleo-environments, along with associated transitional environments, such as deltas and shorelines. Therefore, the absence of a geologic unit (i.e., a formation or member) may be attributed to the limited extent of a depositional environment. Long periods of fluvial erosion or the wave action of migrating shorelines may also have removed formations completely or left irregular, broken geographic boundaries before the deposition of younger sediments (Beyer, 1991).

#### 3.3.2.1 Local Physiography

New Hanover County is located partially in North Carolina's Inner Coastal Plain physiographic province and partially in the Outer Coastal Plain physiographic province (Winner and Coble, 1996), and the southeastern corner of the county forms part of the Cape Fear peninsula, the southernmost cape on the coast of North Carolina. Cape Fear is located approximately 30 miles (50 km) downstream from the Wilmington Site. In general, the physiography and geologic setting in the vicinity of the Site is characteristic of the Inner and Outer Coastal Plain physiographic provinces described previously (see **Section 3.3.1.1**). The topography in the vicinity of the Wilmington Site is generally consistent with the low relief that is characteristic of the surrounding Mid-Atlantic Coastal Plain physiographic province. Elevations in the vicinity of the Site are also consistent with the nearby areas of the surrounding Inner Coastal Plain province, where elevations can reach approximately 40 ft (12 m) msl.

The riverine systems of the Inner and Outer Coastal Plain physiographic provinces are characterized by broad floodplains containing relatively small, active river channels. These active rivers and streams are not large enough to have the hydraulic capacity or available sediment load to build their existing floodplain areas. These floodplain areas were likely formed by ancient riverine systems that were more

extensive than the existing rivers now occupying the area. These ancient riverine systems drained Appalachian Mountains that were taller than those of today, and as a result, the river gradients were steeper in transition from the mountainous regions to the Mid-Atlantic Coastal Plain physiographic province. Higher relief and steeper gradients created more erosion and, therefore, more sediment for the larger rivers to carry. The greater flows and available sediment loads allowed the steep, young rivers to shape the low plains more extensively.

Periods of global sea-level change may have also contributed to the broad reaches of the ancient floodplains along the riverine systems of the Inner and Outer Coastal Plain physiographic provinces. These changes in sea level are evidenced by the series of fluvial terrace deposits that overlie and are intermixed with marine sediments in the vicinity of the Wilmington Site (Soller and Mills, 1991). This relationship between the ancient floodplains and the smaller, modern river channels flowing through them describes the Northeast Cape Fear River and Cape Fear River drainage basins, in general. As is discussed in **Section 3.4.3**, *Floodplains*, flooding has a negligible effect on the stages of these rivers in the vicinity of the Site because the ancient floodplains provide a natural buffering capacity when these rivers are faced with overflows from tributaries.

### 3.3.2.2 Local Stratigraphic Relationships

Aside from Quaternary surficial deposits, only Upper Cretaceous-aged sediments are encountered above the crystalline basement rock complex in the vicinity of the Wilmington Site (**Figure 3.3-16**). The Upper Cretaceous formations include (from shallowest to deepest and youngest to oldest) the Peedee Formation, Black Creek Formation, and Cape Fear Formation. The younger Tertiary formations that are part of the regional stratigraphy are missing from the chronostratigraphic record in the vicinity of the Site (**Figure 3.3-17**). The elevation of crystalline basement rock complex in the vicinity of the Site is estimated to be approximately 1,100 ft (340 m) below ground surface (bgs) (see **Figures 3.3-8 and 3.3-16**).

#### *3.3.2.2.1 Surficial Deposits*

Like many areas in the Mid-Atlantic Coastal Plain physiographic province, the surficial deposits in the vicinity of the Site are considered “undifferentiated,” in that multiple types of deposits exist within a relatively small area without having been mapped in detail. The surficial deposits from the recent Quaternary period (i.e., Holocene Series) may include beach, sand dune, tidal marsh, swamp, and alluvial-valley swamp deposits. Older Quaternary-age sediments (i.e., Pleistocene Series) have been correlated to the Tabb, Wando, Shirley, Socastee, and Waccamaw formations. These formations are common in much of the Mid-Atlantic Coastal Plain province, including the Site vicinity (see **Figure 3.3-17**).

#### *3.3.2.2.2 Peedee Formation*

The Peedee Formation consists primarily of gray, gray-green, or light brown, silty fine to very fine grained glauconitic and phosphoritic sand with trace quantities of oyster shells and pyrite (Lautier, 1998). The sands contain sporadic iron-oxide stringers and nodules, and apparent increases in sand and lime and decreases in clay are found toward the top of the formation (Stuckey and Conrad, 1958).

#### *3.3.2.2.3 Black Creek Formation*

The Peedee Formation lies conformably over the Black Creek Formation in the vicinity of the Site. Based on data obtained from fully penetrating boreholes reaching the basement rock, the depths to the top and base of the Black Creek Formation are estimated to be approximately 350 to 650 ft (140 to 230 m) bgs, respectively. This would suggest an approximate thickness of 300 ft (90 m) in the vicinity of the Wilmington Site (Winner and Coble, 1996).

##### *3.3.2.2.4 Cape Fear Formation*

The Cape Fear Formation is divided into upper and lower hydrologic units (see **Section 3.4**, *Water Resources*). These sediments were deposited in shallow seas and in deltaic and estuarine environments and are characterized as interbedded clays and clayey sand to sandy clay deposits. The depth to the top of the clay that is part of this formation and separates the Upper Cape Fear Formation and the Black Creek Formation occurs at an estimated 650 ft (140 m) bgs in the vicinity of the Wilmington Site. The base of the Cape Fear Formation is estimated to be around 1,050 ft (320 m) bgs, and the thickness of the entire Cape Fear Formation is approximately 400 ft (120 m) (Winner and Coble, 1996; Fine and Cunningham, 2001).

##### *3.3.2.2.5 Basement Rocks*

The Lower Cape Fear Formation rests unconformably upon the pre-Mesozoic crystalline basement rocks at an estimated depth of 1,100 ft (340 m) bgs in the vicinity of the Site (see **Figures 3.3-8 and 3.3-17**; Winner and Coble, 1996).

#### 3.3.2.3 Structural Geology

The stratigraphy and structure in the vicinity of the Wilmington Site is consistent with the regional setting of the Mid-Atlantic Coastal Plain physiographic province and is largely controlled by the presence of the prominent Cape Fear Arch (Figure **3.3-18**; see also **Figure 3.3-12**), which trends roughly parallel with the Cape Fear River. Uplift along the Cape Fear Arch has caused anticlinal deformation of the sedimentary formations. The formations dip slightly to the northeast relative to the regional stratigraphic dip to the east. The thickness of each formation decreases in the vicinity of the axis of the Cape Fear Arch and increases northward towards the synclinal embayments of the Mid-Atlantic Coastal Plain physiographic province. The Site is located on the northeast flank of the Cape Fear Arch, where younger geologic formations that are part of the regional stratigraphy are missing from the chronostratigraphic record, as previously described (see **Section 3.3.2.2**).

#### 3.3.2.4 Karst Conditions

Areas of North Carolina's Mid-Atlantic Coastal Plain physiographic province where carbonate-bearing formations and karst topography are present were discussed for the region in **Section 3.3.1.4.** The region's primary carbonate-bearing formation that is characteristically karstic is the Castle Hayne Formation. The Castle Hayne Formation thins to zero thickness just to the east of the Wilmington Site and, based on boring records, is not present beneath the Site; therefore, no sinkholes are known or expected to be present at the Site.

### 3.3.3 Site-Specific Geology

The geology within specific areas of the Wilmington Site has been extensively studied during on-site investigations over the past 40 years. Investigations for most of these studies have been restricted to relatively shallow depths, usually less than 100 ft (30 m) bgs. Most of these past subsurface investigations are concentrated in the Eastern and Northwestern site sectors. A preliminary geotechnical investigation was performed in the GLE Study Area in 2007 (see also **Section 3.3.5** and **Section 4.3**, *Soils and Geological Impacts*, of this Report) to supplement the limited data specific to the subsurface conditions in the North-Central Site Sector. A summary of the recorded observations and the lithologic descriptions of formation samples collected during past on-site investigations are presented below.

#### 3.3.3.1 Topography and Physiography

Generally flat topography characterizes most of the Wilmington Site's physiography; however, the GLE Study Area is positioned on a topographic high compared to the adjacent land in that area of the Site. The

ground surface begins to gently roll into small low hills in the Northwestern Site Sector, suggesting the presence of possible sand dune or remnant terrace deposits from shoreline migration in the recent geologic past. The Northeast Cape Fear River and its floodplain are the most prominent physiographic features bordering the Western and Northwestern site sectors. High bluffs and extensive estuarine areas along this reach of the river help protect the overall Site, including the GLE Study Area, from flooding events. The area west of the river channel scar, which is clearly visible in aerial images (**Figure 3.3-19**), marks an ancient flow boundary of the Northeast Cape Fear River. The abandoned part of the channel is today an estuarine area of low topographic relief bordering the current river's edge. This alluvial plain has been designated as the Western Site Sector.

### 3.3.3.2 Stratigraphy

Undifferentiated Quaternary surficial deposits overlie the Upper Cretaceous-aged Peedee Formation at the Wilmington Site (see **Figure 3.3-6**). In the following discussion, the Peedee Formation at the Site will be discussed in two parts. The Peedee Clay is a marine clay layer that occurs over much of the Site area and, where present, is typically mapped as the top bed of the Peedee Formation. The Peedee Sands occur beneath the entire Site. The stratigraphic relationship between the surficial deposits (**Section 3.3.3.2.1**), Peedee Clay (**Section 3.3.3.2.2**), and Peedee Sands (**Section 3.3.3.2.3**), demonstrated schematically in **Figure 3.3-20** based on available Site data, is the topic of this discussion. The stratigraphic descriptions are derived from numerous borings that have been drilled over the past 40 years since the Site was first developed by GE in the late 1960s. Area-specific subsurface data is limited or unavailable for the Western and South-Central site sectors. Driller's logs are available for only two observation wells drilled in the South-Central Site Sector during the early 1970s as part of a water resource evaluation.

#### *3.3.3.2.1 Surficial Deposits*

Surficial sedimentary deposits at the Wilmington Site are interpreted to be mostly a result of deposition in the geologic past associated with the ancient Northeast Cape Fear River system. These surficial deposits overlie the Peedee Formation at the Site and are largely undifferentiated and unconsolidated alluvial sands, clayey sands, and clays. Some of these deposits are previously deposited marine sediments that were reworked and redeposited by alluvial processes.

Based on available Site boring logs, the surficial sands are thickest in the Eastern Site Sector and generally thin to the west. The surficial sands in the GLE Study Area are significantly thinner than those in the Eastern Site Sector (**Figure 3.3-21**).

##### 3.3.3.2.1.1 Eastern Site Sector

In the Eastern Site Sector, lithologic descriptions for surficial sediments somewhat vary and include sandy clays, clayey sands, and coarse-to-medium sands. Some surficial deposits consist of medium- to fine-grained quartz sands and sandy clay. Boring records indicate the presence of loamy surface silts that occur above interbedded near-surface clays, as well as silty iron-oxide stringer beds in some places. In addition, medium-to-fine silty sands overlie thin, sandy clay beds, and fine-to-very fine quartz sands overlie the marine clay layer (Peedee Clay), as described in **Section 3.3.3.2.2**.

Remnant deposits of peat, stumps, and other woody materials have been encountered during on-site investigations in samples from boreholes generally located near existing drainages in the Eastern Site Sector. These sporadic occurrences of minor peat layers are typically interbedded with alluvial clay layers. This stratigraphic relationship suggests that these sediments originated in a low-lying swamp or a regional fluvial environment in the geologic past. Coarse sand and gravel deposits, interpreted to be channel deposits of ancient streams, are also commonly encountered in boreholes at the base of the surficial unit. The surficial deposits also include some remnant terrace and barrier beach deposits, as well as sand dunes of the geologic past.

The surficial deposits can reach a thickness of approximately 20 ft (6 m) in the Eastern Site Sector.

#### 3.3.3.2.1.2 South-Central Site Sector

Boring records in this sector of the Wilmington Site indicate that light-colored, fine-to-medium sands occur to a depth of approximately 45 ft (14 m) bgs.

#### 3.3.3.2.1.3 Western Site Sector

The surficial sediments in the Western Site Sector are assumed to be riverine. The shallow alluvial sediments would likely overlie the eroded surface of the Peedee Sands in this sector.

#### 3.3.3.2.1.4 Northwestern Site Sector

The Northwestern Site Sector has undergone a more dramatic erosional and depositional history in the geologic past than others sectors as a result of its proximity to the Northeast Cape Fear River. Dune sands from the relatively recent geologic past are present in the Northwestern Site Sector and adjacent property. The stratigraphy in this sector reflects this erosional/depositional history in a series of cyclical deposits characterized by a well-defined series of fine sand layers interbedded with sporadic, thin, gray clay stringers. Iron-oxide stringers and iron-oxide nodules are also found in these shallow sediments. The deeper surficial sediments consists of fine to very-fine silty sands that grade downward into glauconitic, micaceous, and heavy mineral sands, clayey sands, and occasional phosphatic material.

#### 3.3.3.2.1.5 North-Central Site Sector

The sedimentary sequence in the North-Central Site Sector is comprised of 10 to 30 ft (3 to 9 m) of thin layers of silty fine sands, silty fine clayey sands, fine sandy silts, and fine sandy clays that overlie the Peedee Formation (as defined on the basis of geotechnical and geophysical properties described in **Section 3.3.5**). Data shown in **Figure 3.3-21** indicate that surficial sands are present in the North-Central Site Sector with an apparent average thickness of less than 5 ft (1.5 m). Thicker surficial sand deposits are present in the vicinity of the boring at LF-2 (approximately 10 ft [3 m] thick). Surficial sediments in the uppermost 4 to 10 ft (1 to 3 m) of this sector range from dark brown and black sand with some organic material to gray and tan fine- to medium-grained sand with minimal gravel. Beneath these sands, a dark gray, very silty and clayey fine sand is present in some locations. A series of well records (see **Figure 3.3-21**) with accompanying gamma-ray data indicate that the presence of these clayey sands is at an elevation that is generally consistent with the Peedee Clay layer in the Eastern Site Sector (see **Section 3.3.3.2.2**). Significant color differences in the silty and clayey sands in the North-Central Site Sector suggest separate origins for these deposits (probably alluvial) than those of the marine Peedee Clay layer in the Eastern Site Sector (Alexander and Wallace, 1980). Underlying these units is about 15 to 20 ft (4.5 to 6 m) of olive-gray to tan, fine- to medium-fine-grained sand that grades into the Peedee Sands.

### *3.3.3.2.2 Peedee Clay*

At the base of the surficial deposits in many locations on the Wilmington Site lies a substantial marine clay layer that is considered to be part of the Peedee Formation. The Peedee Clay layer is encountered at a typical depth range of 20 to 30 ft (6 to 9 m) bgs (see **Figure 3.3-16**). Hydraulically, the Peedee Clay forms an important semi-confining unit overlying the Peedee Aquifer, which is the source of process water for the existing Wilmington Site facilities (see **Section 3.4.1**, *Groundwater*, and **Section 3.4.5**, *Water Uses*). The presence of glauconite throughout the Peedee Clay and the absence of reworked sediments more characteristic of shallower alluvial deposits suggest that the Peedee Clay is of marine origin; therefore, this marine clay layer is stratigraphically considered part of the Peedee Formation. The Peedee Clay varies in both thickness and distribution across the Site.

Field observations of samples collected during Site investigations indicate that the consistency of the Peedee Clay is generally firm, but can be softer if located near the ground surface. In general, this clay layer contains more silt than sand and is easily distinguished from other surficial alluvial clays present in some areas of the Site by the uniform presence of glauconite and the Peedee Clay's characteristic gray to dark gray color.

#### 3.3.3.2.2.1 Eastern Site Sector

In the Eastern Site Sector, the Peedee Clay layer is better defined, more contiguous, and clearly separates the surficial sands from the underlying sands of the Peedee Formation (Peedee Sands; see **Section 3.3.3.2.3**). Well and boring logs show the Peedee Clay to be as much as 12-ft (4-m) thick and clearly indicate an abrupt change in lithologic character from surficial sand to marine clay in this area of the Wilmington Site. The texture of the Peedee Clay grades with increasing depth from fine sandy clay to silty clay with increasing glauconite content.

**Figure 3.3-22** shows that the thickest parts of the Peedee Clay layer exist under the existing Wilmington Site facilities in the Eastern Site Sector and thin toward the Central and Western site sectors. Well logs indicate that the Peedee Clay also thins to approximately 4- to 6-ft (1- to 2-m) thick at the eastern boundary of the Site, adjacent to NC 133 (Castle Hayne Road). The few well records from east of NC 133 (Castle Hayne Road) indicate either a lack of the Peedee Clay at a corresponding horizon or a thin clay layer with a thickness around 1 ft (0.5 m). Although these data suggest that the Peedee Clay layer thins to the east of NC 133 (Castle Hayne Road), the limited amount of data east of the Site makes statements about the clay layer in this area less certain than those made about the clay layer in the Eastern Site Sector, where more data are available.

#### 3.3.3.2.2.2 South-Central Site Sector

Based on the available boring records, insufficient data are available to determine if the Peedee Clay is present in the South-Central Site Sector.

#### 3.3.3.2.2.3 Western Site Sector

Based on the relative ground elevations in the Western Site Sector, it is inferred that the Peedee Clay is probably absent in this sector due to erosion by the Northeast Cape Fear River during the recent geologic past.

#### 3.3.3.2.2.4 Northwestern Site Sector

The Peedee Clay is absent in the Northwestern Site Sector. In this sector, surficial deposits are in direct contact with the sands of the Peedee Formation.

#### 3.3.3.2.2.5 North-Central Site Sector

Shallow clay layers are encountered in some of the borings that have been drilled in the North-Central Site Sector; however, the marine Peedee Clay, as noted by its characteristics previously described (see **Section 3.3.3.2.2**), is not present as a continuous layer in the North-Central Site Sector (see **Figure 3.3-21**) as it is in the Eastern Site Sector. The marine Peedee Clay appears to have been eroded in most of the North-Central Site Sector and replaced by reworked sediments characteristic of shallower alluvial deposits.

### *3.3.3.2.3 Peedee Sands*

The Peedee Sands at the Wilmington Site contain significant glauconite, which gives the fine to very fine sands a characteristic greenish color. Cemented laminae (i.e., less than 0.4-inches or 1-cm thick) to

cemented layers (1-ft [0.5-m] thick) also occur at the Site. These cemented zones are similar in texture to calcareous sandstone or sandy limestone and have thin zones of both molds and fossil shell fragments.

#### 3.3.3.2.3.1 Eastern Site Sector

In the Eastern Site Sector, detailed lithologic descriptions indicate that a fine gravel laminae occurs at the top of the Peedee Sands immediately below the Peedee Clay layer, and that gray-green glauconitic sands and silt overlie the top of a sandstone layer are encountered at a depth of about 25 ft (8 m) bgs. Beneath this sandstone layer, gray-green glauconitic, very fine-grained sands, silts, cemented sandstone layers, and shell hash layers occur to a depth of 93 ft (28 m) bgs. Near the northern property line of the Eastern Site Sector, calcareous, fossiliferous cemented sands and unconsolidated fine-to-very fine sands grade with depth to a dark gray, sandy silt that approaches a clayey texture at a depth of approximately 95 ft (29 m) bgs.

The sandstones in this sector contain sporadically distributed shell hash lenses that can be dissolved by groundwater. When dissolution occurs, the surrounding sands are then cemented into lenses and discontinuous layers of sandstone. Where the fossil shells have dissolved, a localized void is created; however, this void does not result in the collapse of the surrounding formation structure. Small voids with vertical extents typically ranging from a few inches to just over a foot have been encountered in some wells on in the Eastern Site Sector. These small voids typically occur at depths of approximately 35 to 100 ft (11 to 30 m) bgs. The voids occur sporadically and do not seem be laterally extensive or continuous within a vertical horizon. Available data and observations generally suggest that these voids occur in a narrow zone along the north side of the Eastern Site Sector, possibly extending to NC 133 (Castle Hayne Road). Examples of these voids are generally expressed in the boring records as circulation losses of drilling fluids to the formation.

Beneath the marine Peedee Clay in other parts of the Eastern Site Sector, interbedded clays and coarse-to-very fine sands grade downward to glauconitic, micaceous, and heavy mineral very fine sands. These deposits grade into beds of shell hash, consolidated and semi-consolidated sandstones, clayey silts, and micaceous fine sands and are underlain by white, chalky clay with fine silty sand. Beneath the Peedee Clay along the southern boundary of the Eastern Site Sector, fine to very fine glauconitic quartz sands, silts, and glauconitic clay stringers with some shell hash are typical. Below these sands, a calcareous sandstone unit occurs at around 34 ft (10 m) bgs.

#### 3.3.3.2.3.2 South-Central Site Sector

At about 45 ft (14 m) bgs in the South-Central Site Sector, the surficial deposits grade to the gray glauconitic sands (“pepper sands”) of the Peedee Sands. These sands contain streaks of clay and some shell hash and extend to a total observed depth of 165 ft (50 m) bgs. Cemented sand zones were noted at a depth of approximately 75 ft (23 m) bgs in the South-Central Site Sector.

#### 3.3.3.2.3.3 Western Site Sector

Subsurface data are not available for the Western Site Sector. The Peedee Sands are inferred to be present beneath this floodplain area based on the Site-specific data and geologic information available in the vicinity of the Site (see **Section 3.3.2.2**).

#### 3.3.3.2.3.4 Northwestern Site Sector

The sedimentary sequence in the Northwestern Site Sector is comprised of calcareous cemented fine sandstones, shell hash, and impure shelly limestone. Increasing concentrations of glauconite occur at depths of around 35 to 70 ft (11 to 21 m) bgs in this sector.

#### 3.3.3.2.3.5 North-Central Site Sector

The Peedee Formation in the North-Central Site Sector is generally encountered at a depth of 10 to 30 ft (3 to 9 m) bgs on the basis of the geotechnical and geophysical properties described in detail in **Section 3.3.5**. The coarse-grained fraction of the Peedee Formation consists of silty fine sands and some cemented calcareous fine sandstones.

### 3.3.4 Soils

Over time, visually and texturally distinct layers, or soil profiles, develop within the upper horizons of the surficial geologic deposits described in **Sections 3.3.1, 3.3.2, and 3.3.3**. In this section, patterns of regional soil associations are discussed, along with site-specific soil series. General characteristics that are typical of the Wilmington Site soils are also discussed, and a summary of general engineering properties, as provided by the USDA, is presented. Specific geotechnical conditions evaluated across the GLE Study Area are discussed in **Section 3.3.5**.

The NCSS is a partnership led by the NRCS of the USDA, in conjunction with state agricultural experiment stations and state and local agencies that provide soil survey information that is necessary for understanding, managing, conserving, and sustaining the nation's limited soil resources (NRCS, 2006a). Soil surveys have been completed on a county level for the United States and its territories through this program. Within North Carolina, the official soil surveys for the counties in the region surrounding the Site include the following:

- New Hanover County, published in 1977
- Pender County, published in 1990
- Brunswick County, published in 1986.

Digital compilations of the soil surveys are available through two national data systems: the U.S. General Soil Map (STATSGO) (NRCS, 2006b) and the Soil Survey Geographic (SSURGO) (NRCS, 2006c) Database. STATSGO was developed by the NCSS and consists of general soil association units digitized from delineations assigned using USGS 1:250,000-scale topographic quadrangles (NRCS, 2006d). The SSURGO Database, also created through the NCSS, contains digitized data at the most detailed level of soil mapping done by the NRCS, levels that duplicate the original soil survey maps (NRCS, 2006c). These soil units were originally assigned by soil scientists using aerial photographs at a scale of 1:15,840 and later validated and registered to 1:24,000 quadrangle orthophotographic base maps (NRCS, 2007). This database of soil units was designed primarily for farm, landowner/user, township, or county natural-resource planning and management. In addition to those applications, the NRCS recommends the SSURGO data for use in developing erosion-control practices, reviewing site-development proposals and land-use potential, making land-use and chemical fate assessments, and identifying potential wetlands and areas where the surficial cover is sand and gravel. Soils information, such as soil type, thickness, and permeability, are available from the attribute database linked to the SSURGO soil unit delineation. Database documentation is available from the NRCS (NRCS, 2006c).

#### 3.3.4.1 Regional Soils

A 5-mile (8-km) radius around the Wilmington Site is considered the region for this discussion, and four major soil associations occur within this region (**Figure 3.3-23**). The descriptions of these major soil associations, presented below, are typical regional characteristics and are not intended to describe specific conditions at the Wilmington Site. Site-specific soil characteristics are presented in **Section 3.3.4.2**. The four major soil associations are the following:

- Meggett-Johnston-Dorovan

- Woodington-Rains-Pantego
- Marvyn-Kenansville-Baymeade
- Seagate-Murville-Leon.

The Meggett-Johnston-Dorovan association is mapped generally across much of the Wilmington Site, as well as the majority of the land in the 5-mile (8-km) Site radius. This soil association typically is very poorly drained and has very little slope (average weighted slope gradient of 1.4), a high flooding frequency due to poor drainage, and moderate permeability. In general, this group of soils has formed on the alluvium in the recent and former flood plain areas.

The Woodington-Rains-Pantego soil association is mapped generally across the eastern portion of Eastern Site Sector and the surrounding region. These soils are poorly drained and also have a low slope where the weighted slope gradient is 1.5. There is a low flooding frequency within these soils, and the depth to the water table is typically around 15 inches (38.1 cm).

The Marvyn-Kenansville-Baymeade and Seagate-Murville-Leon soil associations are present to a lesser extent within 5 miles (8 km) of the Wilmington Site, but these soils are not mapped across any part of the actual Site. The Marvyn-Kenansville-Baymeade association contains well-drained soils with higher slopes (average weighted slope gradient of 3.9). Within these soils, the depth to the water table is greater than 10 ft (3.05 m). Conversely, the Seagate-Murville-Leon association soils are more like the other major soil classes mapped within 5 miles (8 km) of the Site; these are very poorly drained soils with lower slopes (average weighted slope gradient of 1.3). Neither the Marvyn-Kenansville-Baymeade or Seagate-Murville-Leon associations frequently flood.

Three other soil-association groups have limited occurrence within 5 miles (8 km) of the Wilmington Site to the northeast:

- Pamlico-Leon-Kureb (slope gradient of 3.7, does not flood, is excessively drained)
- Stockade-Grifton-Croatan (slope gradient of 1, rarely flood, is very poorly drained)
- Rains-Norfold-Coxville (slope gradient of 1.3, does not flood, is well drained).

### 3.3.4.2 Wilmington Site and GLE Study Area Soils

The soils that are included in the SSURGO database and occur across the Wilmington Site (and specifically within the GLE Study Area) are discussed below. The distributions of these soils are shown in **Figure 3.3-24**. These are general descriptions from the USDA NRCS Soil Survey Division Official Soil Series Descriptions (OSD) database (NRCS, 2004). In some cases, these descriptions do not reflect specific conditions at the Wilmington Site, although they are expected to represent Site conditions on average. The soils identified by the SSURGO database constitute the lowest category (i.e., most detailed) of the national soil classification system; therefore, these data provide the most accurate representation of soils available outside of an on-site characterization. Additional characteristics of each soil type are presented in **Table 3.3-1**. **Appendix E**, *Official Soil Series Descriptions for Soils within the GLE Study Area*, provides the NRCS OSD reports for the soils that exist within the GLE Study Area[1]. These reports contain information on the following attributes for each soil series: location, author's initials, introductory paragraph, taxonomic classification, detailed soil profile description, location of the typical soil profile, range in characteristics, competing series, geographic setting, geographically associated soils, drainage

[1] **Appendix E** provides information directly taken from the USDA NRCS Web site accessed at http://soils.usda.gov/TECHNICAL/CLASSIFICATION/OSD/.

and permeability, use and vegetation, distribution and extent, series established, remarks, and additional data.

Fourteen different soil types (including borrow pits) are found across the Wilmington Site. Eleven of these soil types lie within or cross the boundaries of the GLE Study Area.

#### *3.3.4.2.1 Bayboro Loam*

This very poorly drained soil is found on broad, smooth flats and in slight depressions on the uplands. Permeability is low, and available water capacity is high. The depth to the seasonal high-water table ranges from 0 to 12 inches (0 to 30.5 cm). Many areas are commonly flooded for brief periods.

There is a small area of this soil type in the southeastern corner of the site near NC 133 (Castle Hayne Road), outside of the GLE Study Area in the Eastern Site Sector.

#### *3.3.4.2.2 Baymeade Fine Sand*

This well-drained soil is found on flats, on low ridges that are on the uplands, and in small areas along drainage-ways, all of which are not subject to flooding. Permeability is moderately high, and available water capacity is low. The seasonal high-water table is at a depth of more than 4 ft (1.22 m).

This soil type is located adjacent to the former borrow pits, discussed below, in the center of the Site, mainly in the North-Central and South-Central site sectors, although a small portion of this soil type crosses the border into the Eastern Site Sector. The area of Baymeade Fine Sand in the North-Central Site Sector extends a few hundred feet into the southern boundary of the GLE Study Area. The South Road portion of the GLE Study Area contains a few other small segments of this soil type.

#### *3.3.4.2.3 Borrow Pits*

There are four former borrow pits on the Wilmington Site where the soil was removed and used as fill material. These pits were created in the 1960s during the construction of buildings and roads on the Site. These areas can be managed or reclaimed to provide wildlife habitat. Most borrow pit areas on the Site have been replanted with slash pine (GE, 2006).

Of the four former borrow pits on the Site, three are aligned through the center of the Site along a north-northwest to south-southeast axis through the North-Central and South-Central site sectors, surrounded mostly by Kenansville and Baymeade fine sands. The South Road portion of the GLE Study Area includes parts of these three borrow pits. A fourth borrow pit sits in the Northwestern Site Sector in a region surrounded by Kenansville fine sands.

#### *3.3.4.2.4 Dorovan Series Soils*

These nearly level, very poorly drained soils make up the majority of the land surface in the forested Western Site Sector along the Northeast Cape Fear River. Permeability is very low, and available water capacity is very high. The seasonal high-water table is at or near the surface (i.e., the soil is saturated to the surface most of the time). Runoff is very low, and water is ponded on the surface in depressions. These soils are the only type on the Site to have a high erosion potential; however, the high erosion potential is countered by very low slopes, which are graded 0 to 2% (**Section 3.4.2.10.3**, *Erosion Characteristics and Sediment Transport [Site-Specific Surface Water Characteristics]*).

Dorovan series soils are almost entirely contained in the Western Site Sector, with only a slim band of this soil type extending along the border between the North-Central and South-Central site sectors. All of the Dorovan series soils acreage within the Western Site Sector is used for wildlife habitat, and Unnamed

Tributary #1 to Northeast Cape Fear River passes through the eastern edge of this soil area, and Unnamed Tributary #2 to Northeast Cape Fear River passes through the northern part of this soil area. The South Road portion of the GLE Study Area crosses over a small area of this soil type along Unnamed Tributary #1 to Northeast Cape Fear River, but the existing road spans over this soil.

#### *3.3.4.2.5 Kenansville Fine Sands*

This well-drained soil is found on broad, smooth flats on the uplands of the Wilmington Site. Kenansville soils generally are on the smoother parts of the landscape between the higher, sandier ridges and the lower wet areas. Slope gradients are commonly 0 to 4%, with a full range up to 10%. Permeability is moderately high, and available water capacity is low. The seasonal high-water table is at a depth of more than 6 ft (1.83 m). Runoff from these soils is low.

These soils are present in the western portion of the Site, within the Northwestern and North-Central and South-Central site sectors. The Kenansville fine sands form the boundary between the poorly drained Dorovan series soils in the Western Site Sector and the upland areas in the other site sectors.

#### *3.3.4.2.6 Kureb Sands*

Kureb sands are typically located on long, broad ridges on the uplands. Permeability is high, and available water capacity is very low. The seasonal high-water table is at a depth of more than 6 ft (1.83 m). This soil is very deep and excessively drained. The thickness of the sandy horizons is more than 80 inches (203.2 cm). These characteristics allow for low runoff from this soil type.

This soil type is found only in the Western Site Sector, but is not located in the GLE Study Area. This area of Kureb and Leon sands (see below) is surrounded by Dorovan series soils near the Northeast Cape Fear River.

#### *3.3.4.2.7 Leon Sands*

This nearly level, poorly drained soil is found on rims of depressions, on smooth flats, and in indefinite patterns on the uplands and stream terraces. These sandy soils tend to be very deep. Permeability is high in the surface layers, moderate to moderately high in the subsoils, and very high in the underlying layer. Available water capacity is low. The seasonal high-water table is at or near the surface.

This soil type is located in several areas of the Wilmington Site. An area of Leon sand and Kureb sand, surrounded by the typically wet Donovan soil, is located near the Northeast Cape Fear River in the Western Site Sector and forms an estuarine island with an elevation of 10 to 15 ft (3.05 to 4.57 m) msl. A generally small linear area of Leon Sands is present just inside of the southwestern boundary of the GLE Study Area in the North-Central Site Sector.

#### *3.3.4.2.8 Lynchburg Fine Sandy Loam*

This relatively level soil is somewhat poorly drained, and slope gradients range from 0 to 2%. This soil is very deep, with depths to bedrock normally greater than 80 inches (203.2 cm). Permeability is moderate, and the runoff index is negligible. The seasonal high-water table is at a depth of 6 to 18 inches (15.2 to 45.7 cm).

A small area of this soil lies in the Eastern Site Sector surrounded by Pantego loam and Murville fine sands. The North Road portion of the GLE Study Area crosses over a small area of this soil type.

#### *3.3.4.2.9 Murville Fine Sands*

This soil is formed from wet, sandy marine and fluvial sediments on broad interstream areas of uplands and stream terraces in the Mid-Atlantic Coastal Plain physiographic province. This nearly level (slopes are graded less than 2%), very poorly drained soil is typically found in flat or slightly depressed areas. Permeability is high in the surface layer and moderately high in the subsoil. Available water capacity is low. The seasonal high-water table is at or near the surface. Solum thickness ranges from 30 to 60 inches (76.2 to 152.4 cm). Humus in the A and Bh horizons gives the sandy material a loamy feel and appearance. The soil is strongly to extremely acidic.

This soil type covers a large area in the North-Central Site Sector that is currently managed for timber production (GE, 2006). The Murville Fine Sand series is present in a significant portion of the GLE Study Area. This soil type extends into the Eastern Site Sector, where it surrounds the northwestern edge of the existing Wilmington Site facilities and encompasses a large section of the North Road portion of the GLE Study Area.

#### *3.3.4.2.10 Onslow Loamy Fine Sands*

This nearly level, moderately well-drained, and somewhat poorly drained soil is located on broad smooth flats on the uplands. Slope gradients range from 0 to 3%. Permeability is moderate, and available water capacity is medium. The seasonal high-water table is at a depth of about 18 inches (45.7 cm) bgs for 2 to 4 months in most years.

This soil is concentrated in the central portion of the Wilmington Site between existing developed areas and the higher ground adjacent to the borrow pits on the border of the Eastern, North-Central, and South-Central site sectors. Unnamed Tributary #1 to Northeast Cape Fear River crosses through this soil in a natural channel. A band of this soil, estimated to average about 800-ft (243.8-m) wide, runs along the western border of the GLE Study Area within the North-Central Site Sector, and the South Road portion of the GLE Study Area crosses over a small area of this soil type in the Eastern and South-Central site sectors. Pockets of this soil also lie in the Eastern Site Sector along the northeastern, eastern, and southeastern boundaries of the Wilmington Site along NC 133 (Castle Hayne Road), outside the GLE Study Area.

#### *3.3.4.2.11 Pantego Loam*

This nearly level, very poorly drained soil is found on broad, smooth flats and in slight depressions on the uplands. Slope gradients are generally less than 2%. Permeability is moderate, and the available water capacity is medium. Water will pond on or slowly run off from these soils. The seasonal high-water table is at or near the surface.

This soil type makes up the majority of the northeastern portion of the Eastern Site Sector not covered by buildings and other maintained facilities. Part of the North Road portion of the GLE Study Area crosses over this soil type. A small area of Pantego Loam is also present in the central part of the Site within the Eastern Site Sector and outside the GLE Study Area.

#### *3.3.4.2.12 Seagate Fine Sand*

This nearly level, somewhat poorly drained soil is found on broad, smooth flats on the uplands. Slope gradients are generally less than 2%, but range up to 3%. Permeability is high to a depth of 36 inches (91.4 cm) (the upper sandy horizons) and moderately low at greater depths (loamy horizons). Available water capacity is low. The seasonal high-water table is about 1.5 to 2.5 ft (0.46 to 0.76 m) bgs.

There is a small area of this soil type that occurs only in the southeastern corner of the Eastern Site Sector near NC 133 (Castle Hayne Road), outside the GLE Study Area.

##### *3.3.4.2.13 Woodington Fine Sand Loam*

This nearly level, poorly drained soil is found on broad smooth flats on the uplands. Slope gradients are 2% or less. Permeability is moderately high, and available water capacity is medium. Runoff from these soils is low. A seasonal high-water table is within 10 inches (25.4 cm) of the surface during periods of high rainfall.

A small area of this soil is located in the North-Central Site Sector within Kenansville fine sand. A ribbon enters the GLE Study Area along the southwestern border.

##### *3.3.4.2.14 Wrightsboro Fine Sandy Loam*

This moderately well-drained soil is found on broad, smooth flats on the uplands. Slope gradients range from 0 to 4% and are dominantly less than 2%. Permeability is moderate in the upper subsoil and low in the lower subsoil. Available water capacity is medium, and runoff is low. The seasonal high-water table is about 2 to 3 ft (0.61 to 0.91 m) bgs.

This soil crosses the border of the South-Central and Eastern site sectors between the south-central property line, I-140, and a former borrow pit. The South Road portion of the GLE Study Area crosses a small amount of this soil type at this location within the Eastern Site Sector. A small area also exists along the northern boundary of the Site in the Eastern Site Sector, just west of Unnamed Tributary #1 to Prince George Creek. This area of the soil is crossed by the North Road portion of the GLE Study Area.

#### 3.3.4.3 Ground Stability and Soils within the GLE Study Area

As previously stated, 11 soil types lay within or cross the boundaries of the GLE Study Area. **Table 3.3-2** presents the engineering characteristics (listed in SSURGO) for these soils.

The potential for differential settlement, or the difference in settlement across a foundation, must be considered when preparing Facility and roadway engineering designs. The characteristics presented in **Table 3.3-2** provide general information that can be used to make an initial assessment as to the likelihood that differential settlement will occur within these soils types, followed by site-specific geotechnical investigations, as appropriate. Soils with high clay content, organic matter, liquid limits, and plasticity indices have greater potential for shrink and swell, which are important considerations for differential settlement. Specifically, O'Neill and Poormoayed (1980) defined soils with a liquid limit less than 50 and a plasticity index less than 25 as having low potential for swell. Additionally, sandy soils undergo immediate and simultaneous settlement and consolidation upon porewater drainage. As evidenced by the information in **Table 3.3-2**, no soil types within the approximately 200-acre (81-ha) portion of the Main portion of the GLE Study Area within the North-Central Site Sector where the Proposed GLE Facility will be constructed currently pose any construction concerns based on this analysis. Geotechnical investigations performed within the GLE Study Area to further assess the potential for differential settlement, as well as soil liquefaction, are described in **Section 3.3.5** and **Section 4.3**, *Soils and Geological Impacts*. Further impacts to the GLE Study Area soils themselves will be discussed in **Section 4.3.1** of this Report (*Site Soils*).

### 3.3.5 Geotechnical Conditions

#### 3.3.5.1 General Foundation Considerations

The plant layout for the Proposed Action is described in **Section 2.1.2.1** of this Report (*Impacts from Performing the Proposed Action and Mitigation Measures*). The Proposed GLE Facility would involve construction of an approximately 600,000 $ft^2$ (56,000 $m^2$) 1-story main operations building with a 160-ft (49-m) high tower; several lightly loaded Facility-support buildings; a parking lot; two stormwater detention ponds; $UF_6$ storage areas; and maintained landscaped areas within the North-Central Site Sector (see **Figure 1.2-3**). This primary construction area would occupy approximately 100 acres (40 ha) of the 209-acre (84-ha) main portion of GLE Study Area (**Figure 3.3-25**) and is the focus of this discussion.

A number of geotechnical investigations have been performed at the Wilmington Site to evaluate the largely unconsolidated materials for foundation considerations across the now developed portions of the Site (primarily within the Eastern Site Sector). Two subsurface investigations have been performed in the GLE Study Area, one in 1980 and one in 2007, and these investigations are described below.

#### 3.3.5.2 Initial Subsurface Investigation (1980)

A subsurface investigation was performed in the GLE Study Area in 1980 with the purpose of assessing the hydrogeology in the GLE Study Area for a proposed landfill siting (Alexander and Wallace, 1980). The investigation characterized the hydrogeology based on four standard penetration soil test borings and 10 LF-series wells that were installed in clusters of 2 or 3 (wells within a cluster completed at varying depths) adjacent to the borings (see **Figure 3.3-25**). Three of these borings (LF-1, LF-2, and LF-3) were within the GLE Study Area, and the remaining boring (LF-4) was drilled adjacent to the GLE Study Area. The geotechnical results of the 1980 investigation are incorporated in the findings of the 2007 investigation, as described in the following sections.

#### 3.3.5.3 Preliminary Subsurface Investigation (2007)

A preliminary subsurface investigation of the 209-acre (84-ha) GLE Study Area was conducted in December 2007. This investigation was performed to support a preliminary analysis of foundations under a range of loads and Site response during the design basis earthquake event (further described in **Appendix G**, *Results of Soils Laboratory Testing and Geotechnical Evaluation and Analysis*). The 2007 investigation is considered preliminary because a further evaluation, including a more detailed foundation investigation, would be necessary once the full-scale Proposed GLE Facility design is complete. The methods of this 2007 investigation are outlined in **Section 3.3.5.3.1** of this Report, and the results of this investigation are provided in **Section 3.3.5.3.2**.

##### *3.3.5.3.1 Methodology*

###### 3.3.5.3.1.1 Seismic Refraction Profiling

A total of 3,500 linear ft (1,067 m) of detailed seismic refraction profile data were obtained within the GLE Study Area on December 13 and 14, 2007. The acquisition of the seismic refraction data was along four transect lines (Seismic lines 1 through 4, as shown in **Figure 3.3-25**). The seismic refraction survey method is a means of determining the depths to refracting horizons and the thickness of major seismic discontinuities overlying higher-velocity refracting horizons. The seismic horizons are used to calculate the mechanical properties of the subsurface deposits, as well as for general stratigraphic correlation.

###### 3.3.5.3.1.2 Soil Test Borings

Six widely spaced borings were drilled over the GLE Study Area between December 17 and 19, 2007. The boring locations were initially established in the field using a Trimble® handheld GeoXT™ global

positioning system (i.e., GPS) unit to locate state plane coordinates and were later surveyed more precisely by a registered land surveyor. The borings were advanced to termination depths of 35 to 57 ft (10.7 to 17.4 m) bgs by wash boring methods, and standard penetration tests were performed at selected intervals in each of the borings to evaluate the consistency and density of the subsurface soils. Selected soil samples were tested for grain-size distribution, water content, and Atterberg Limits to assist in soil classification and to provide information required for geotechnical seismic analyses. Once the borings were completed, they were properly abandoned to comply with NCDENR requirements. **Figure 3.3-25** shows the locations of the six soil test borings (G-1 to G-6) along with the locations of the 1980 borings (and associated monitoring wells LF-1 to LF-4) that were re-evaluated as part of the 2007 investigation and assessments.

#### *3.3.5.3.2 Results*

Generalized subsurface profiles prepared from the test boring data are provided in **Figures 3.3-26 and 3.3-27** to graphically illustrate subsurface conditions along an approximate northwest-southeast profile through the center of the GLE Study Area and for a profile generally along much of the perimeter of the GLE Study Area, respectively. More detailed descriptions of the conditions encountered at the individual test boring locations are contained in test boring records (**Appendix F**, *Soil Test Boring Records in GLE Study Area*). The results of the seismic refraction profiling are summarized in **Figures 3.3-28 and 3-3-29** and represent the measured compression wave velocities along the four seismic lines. **Appendix G** provides the results of soils laboratory testing, geotechnical evaluation and analysis, and additional velocity modeling outputs. A summary of the Unified Soil Classification System that is used to describe the lithologic (grain size and texture) and engineering designation of the unconsolidated materials is provided in **Appendix H**, *Summary of Unified Soil Classification System*.

**Table G-3** summarizes the soil test borings, including date drilled, surface elevation, depth of boring bgs, depths of clay layers encountered, and the depth to top of the Peedee Formation (based on visual classification of soil samples, depth to the 6,000 feet per second [fps; 1,829 meters per second (m/s) layer measured in seismic refraction profiling, and the depth to first sample with SPT penetration resistance (N-value) greater than 30 blows per foot [bpf]). The depth to groundwater, the depth to caving measured 24 hours after boring completion, and the depth of observed water losses during drilling are also provided in **Table G-3**.

**Figure 3.3-26** shows that the subsurface profile through the center of the GLE Study Area consists of a topsoil layer varying in thickness from 0 to 3 ft (0 to 0.91 m), with organically stained silty sands often underlying the highly organic topsoil. Underlying the topsoil were loose- to medium-dense silty fine sands with N-values varying from 4 to 28 bpf that extend to a depth of 20 to 34 ft (6.1 to 10.4 m) bgs, where the first N-value greater than 30 bpf was encountered (except for one elevated N-value at 5 ft in boring LF-2). The dense silty sands are interlayered with cemented zones having N-values greater than 100 bpf, which can be penetrated by soil drilling tools and are classified as Partially Weathered Rock (PWR). Borings G-4 and G-6 encountered 0.5- to 4-ft (0.15- to 6.1-m) thick stiff clay layers (N-values of 8 and 9 bpf, respectively) at depths between 8 and 16 ft (2.4 and 4.9 m) bgs, respectively. Borings LF-1 and G-6 encountered loose silty sand layers at depths of 40 to 45 ft (12.2 to 13.7 m) bgs that underlie dense silty sands.

**Figure 3.3-27** shows that subsurface conditions encountered in borings located around the perimeter of the GLE Study Area also generally consist of loose- to medium-dense silty sands extending to depths of 10 to 30 ft (3.0 to 9.1 m) bgs; stiff clay layers in borings G-4 and G-5; and a loose silty sand zone underlying shallower dense sands in LF-3.

**Table G-4** summarizes the results of laboratory tests performed to assist in classification of soil samples collected from the borings, and **Figures G-1**, **G-2**, **and G-3** show the grain-size distributions measured on

soil collected from the six soil test borings. The samples were collected using split-spoon samplers. The soils had 32% to 66% fines passing the #200 (0.075 millimeter [mm]) sieve, with most of the sand portion being fine-sand sized. The Atterberg Limits tests performed on five of the samples with more than 50% fines had liquid limits (LL) varying from 17 to 34 and plasticity indices (PI) varying from 1 to 13. Organic content tests performed on the 0.5- to 2-ft (0.15- to 0.61-m) deep samples from four of the borings measured greater than 6% organics for samples from borings G-5 and G-6 and less than 2% organics for samples from borings G-2 and G-4. In summary, the soils generally consist of silty fine sands with greater than 30% fines and some low-plasticity silt and clay layers.

The seismic-refraction profiling shows general trends along the seismic lines without identifying local loose sand and cemented sand zones. The measured compression wave velocities can also be used to provide a preliminary seismic site classification, although the final design of the Proposed GLE Facility should be based upon measured velocities of shear waves instead of compression waves. The compression wave velocity along the four seismic lines was contoured in **Figures G-8 through G-11** using 2,500 fps (762 m/s), 6,000 fps (1,829 m/s), 8,000 fps (2,438 m/s), and 11,000 fps (3,353 m/s) intervals. The same information also is shown in profile in **Figures 3.3-28 and 3.3-29**, omitting the 8,000 fps (2,438 m/s) contour line. The 6,000 fps (1,829 m/s) contours are used as a general indication of the boundary between soil overburden and underlying stiffer deposits. Along seismic line 1, the depth to the 6,000 fps (1,829 m/s) contour varies from 10 to 20 ft (3.0 to 6.1 m) bgs (see **Figures 3.3-28 and G-8**); along line 2, the depth to the 6,000 fps (1,829 m/s) contour varies from 20 to 40 ft (6.1 to 12.2 m) bgs (see **Figures 3.3-28 and G -9**); along line 3, the depth to the 6,000 fps (1,829 m/s) contour varies from 20 to 30 ft (6.1 to 9.1 m) bgs (see **Figures 3.3-29 and G-10**); and along line 4, the depth to the 6,000 fps (1,829 m/s) contour varies from 20 to 45 ft (6.1 to 13.7 m) bgs (see **Figures 3.3-29 and G-11**). Based upon the preliminary seismic refraction profiling, the thinnest soft-soil overburden appears to be located near the center of the GLE Study Area along seismic line 1 (see **Figure 3.3-25**). **Table G-5** summarizes the depths to each of the compression wave contours for the soil test borings located along the seismic lines. The depth to the 6,000 fps (1,829 m/s) contour varies from 11 ft (3.4 m) bgs in G-6 and LF-2 (central part of the GLE Study Area) to 37 ft (11.3 m) bgs in G-1 (at the north perimeter of the GLE Study Area).

The depths to the top of the Peedee Formation are provided in **Table G-3**, as defined on a geotechnical basis of visual classification of soil samples, the depth to the 6,000 fps (1,829 m/s) contour from seismic refraction profiling, and the depth to the first measured N-value greater than 30 bpf in the six G borings and the four LF borings. The depths to the visual classification of the top of the Peedee Formation and to the 6,000 fps (1,829 m/s) contour are close for borings LF-2 and G-5; the depths to visual classification of the Peedee Formation and to the first N-value greater than 30 bpf are close for borings LF-3, G-3, and G-5; and the depths to the 6,000 fps (1,829 m/s) contour and to the first N-value greater than 30 bpf are close in LF-1, G-1, G-4, and G-5. In summary, there appears to be between 10 and 30 ft (3.0 and 9.1 m) of soils overlying the Peedee Formation, which is characterized as generally dense silty sands with isolated loose and cemented zones.

Groundwater was observed at 10 to 11 ft (3.0 to 3.4 m) bgs in borings G-1, G-2, and G-6 at 24 hours after the completion of boring. Groundwater flow and hydrogeologic setting details are described in **Section 3.4.1**, *Groundwater*.

#### *3.3.5.3.3 Geotechnical Summary*

**Table G-2** summarizes a range of settlements that could be expected based on anticipated equipment loads within the different areas of the approximately 600,000-$ft^2$ (56,000-$m^2$) building. In addition to these equipment loads, there would be loads resulting from the building itself that are anticipated to be relatively light. The final foundation design would be based upon available subsurface information and would use actual loads from buildings, equipment, and any associated structures. The final grades are also

anticipated to be relatively close to existing grades and, therefore, minimize the amount of cut and fill needed. Additional geotechnical information derived from the 2007 subsurface investigation not discussed above is provided in **Appendix G** (including preliminary considerations of shallow and/or deep foundations). Potential geological impacts (including seismic design response spectrum and liquefaction potential) are provided in **Section 4.3.2** of this Report (*Geological Impacts*).

### 3.3.6 Seismology

Seismic potential is assessed by examining the earthquake record as it relates to tectonics and fault activity in the region. Earthquake locations and magnitudes are accessible via catalogs stored by regional and federal agencies and can be accessed on the Internet and through personal exchange of data. Earthquakes are analyzed as points in space (epicenters) and time, are referred to as "events," and are geographically correlated with geologic features, such as faults and other tectonic processes. To assess the seismic potential of the Wilmington Site, this section presents a discussion of the catalog sources, earthquake distribution in space and time, fault maps, and regional tectonics.

#### 3.3.6.1 Overview

Earthquake epicenters in the southeastern United States generally extend in a northeasterly orientation along the axis of the Appalachian Mountain range (**Figure 3.3-30**). In North Carolina, the vast majority of seismic activity is concentrated in the western mountainous regions, where sutures and faults are predominantly associated with North American collisional tectonics. There are clusters of events scattered throughout South Carolina, and a few isolated occurrences of singular events along the coast. A small number of events are recorded along the Mid-Atlantic Coastal Plain physiographic province (**Figure 3.3-30**). In summary, seismicity levels are low outside of the Charleston region and the mountains to the west. In the Wilmington Site region, seismicity levels are relatively low; therefore, the seismic hazard is not significant.

#### 3.3.6.2 Catalog of Seismic Events

**Appendix I**, *Historical Earthquakes Ranked by Distance from the Wilmington Site*, presents a listing of earthquake events located within 200 miles (322 km) of the Wilmington Site. Earthquake event data were extracted from publicly available catalogs. There is considerable overlap in these published catalogs, and the datasets acquired for use in this analysis were those that were the most detailed and current. Using 12,899 events published by the Virginia Tech Seismological Observatory (SEUSSN, 2008), with augmented catalogs extracted from the Advanced National Seismic System (USGS]) for more recent events, 896 unique earthquakes were located within a 200-mile (322-km) radius of the Wilmington Site between 1698 and 2007. The earliest instrumental-based event locations were recorded in 1925, although reliable, spatially diverse networks did not accumulate earthquake locations and magnitudes until the early 1970s.

Prior to 1924, there are no events whose horizontal location error is less than 12.4 miles (20 km), and not until 1965 was the network large enough to provide constraints to locate events with a 2.5-mile (4-km) error. The median horizontal error for events in the 200-mile (322-km) radius is 51.6 miles (83 km), with an inter-quartile distance (spread) of 51 miles (82 km).

Earlier than 1973, there were no estimates of uncertainty for hypocenter depths. After installation of seismic arrays, event depth uncertainty varies from within 0 to 62 miles (0 to 100 km), with a median of 0.9 miles (1.45 km) and an inter-quartile spread of 1.7 miles (2.7 km).

The SEUSSN catalogs include up to three magnitude estimates for a given event; therefore, for the purpose of conservative statistical analysis, the largest of the three magnitudes was extracted and is provided in **Appendix I**. Magnitude estimates improved significantly after the installation of digital

seismic arrays in the early 1970s. **Figure 3.3-31** illustrates how magnitude estimates evolved over 300 years. Event magnitudes listed prior to 1925 are speculative and based on anecdotal accounts of shaking and damage. Of the 896 unique earthquakes, 498 occurred prior to 1925.

### 3.3.6.3 Seismicity

Epicenters for events near the Wilmington Site are displayed in **Figure 3.3-30**. Small clusters are evident, mainly in central South Carolina trending along a southeast-northwest lineament. This trend is located between approximately 125 and 185 miles (200 and 300 km) from the Wilmington Site.

There is a large cluster of events in the Charleston, SC, area, mainly associated with the magnitude 6.9 earthquake event of 1886. Between 1698 and 1975, 507 events were reported in the Charleston region, and from 1975 to the present, 256 events are on record. The 1886 earthquake and its associated aftershocks are the dominant seismic feature of the Mid-Atlantic Coastal Plain physiographic province and account for a significant portion of seismic activity in this part of the United States.

In North Carolina, scattered, low-level seismicity pockets such as the one near Winston-Salem are evident, primarily in the Piedmont physiographic province. About 12 events are spread along the Mid-Atlantic Coastal Plain physiographic province. Within a 43.5-mile (70-km) radius of the Wilmington Site, 8 events are cited in the catalog, dating from years 1871, 1884 (two events), 1927, 1928, 1958, 1968, and 1974 (**Figure 3.3-32**). These events have estimated magnitudes of 3.5 or less and would have been felt by local populations in Wilmington, NC; however, it is unlikely they would have caused significant damage. Since all but one of these events were recorded prior to the installation of reliable seismic networks, the estimates of the epicenter locations are very rough. As further discussed in **Section 3.3.6.6**, the dashed faults on **Figure 3.3-32** are inferred. This means there is no observational evidence for a surface contact that can be mapped by geologists. These faults are inferred from geophysical (i.e., seismic surveys, aeromagnetic, and gravity data) and geological observations of rocks from boreholes (Lawrence and Hoffman, 1993), and there is no empirical evidence that these are capable faults (see also **Sections 3.3.1.3 and 3.3.2.3**).

### 3.3.6.4 Seismicity Rate

With such a long record of earthquake activity, it is possible to estimate an earthquake rate of occurrence (**Figure 3.3-33**). This was achieved after removal of obvious sequences of aftershocks, mainly associated with the 1886 Charleston event, although other cases of smaller aftershock sequences were also excised from the catalog. In accordance with Appendix A to 10 CFR 100 (*Seismic and Geologic Siting Criteria for Nuclear Power Plants*), only events within a 200-mile (322-km) radius were used in this analysis. **Figure 3.3-33A** presents a histogram of a number of events recorded within 25-year intervals. Cumulative sum plots of earthquake events are presented in **Figures 3.3-33B and 3.3-34**. Since the catalog is incomplete prior to the late 19th century, a statistical analysis of early events can not be performed. Following the 1886 Charleston event, there was a rapid increase in the seismicity rate until it leveled off to a background rate of about 2 events per year between 1910 and 1975. After digital seismic networks were installed in 1973, the record appears to be complete down to a threshold of magnitude 3. The recorded rate then rises dramatically to around 12 events per year due to this higher sensitivity of earthquake recording.

**Figure 3.3-33C** is an empirical survivor plot that illustrates the departure of a series of events from randomness. Deviations from a straight line on the log empirical survivor plot suggest more random behavior. The data from the southeastern U.S. catalogs do not show a linear pattern, indicating that there are probably no significant temporal correlations between events in the catalog. This is corroborated by the serial correlation plot (**Figure 3.3-33D**), which indicates no strong temporal correlation between interval times among events in this catalog.

Since the mid 1990s, the USGS has published probability of exceedance maps for ground shaking at 1 and 5 hertz (Hz) for a 50-year time span (USGS, 2007). A spectral acceleration of 1 Hz represents low-frequency ground shaking (appropriate for Rayleigh and Love surface waves), whereas a 5-Hz spectral acceleration represents high-frequency ground shaking related to body waves (P-waves and S-waves). For many cases of interest, the primary controlling earthquake is the postulated event that governs the spectral accelerations in the 5- to 10-Hz range (U.S. DOE, 2002). The maps are developed for peak horizontal ground acceleration or spectral accelerations with 2%, 5%, or 10% probability of being exceeded in 50 years on uniform firm-rock site conditions (Vs30 = 760 m/s). These data present the peak acceleration for earthquakes believed to be likely near a given site. In **Figure 3.3-35**, these data are presented for a peak acceleration at 5 Hz, with 2% probability of exceedance over 50 years (2500-year earthquake). Given this map, the Wilmington Site has a peak acceleration of approximately 0.1 g (0.98 meters per second per second [m/s/s]) at 2% probability for 5 Hz wave over 50 years. This corresponds to a peak acceleration of approximately 0.03g for a 10% probability of exceedance in 50 years (500-year earthquake) that was used in the site-selection process (see **Section 2.2.3.1.3.2** of this Report, *Decision Criteria and General Procedures for Initial Screening [Elimination of Site Alternatives]*).

### 3.3.6.5 Frequency-Magnitude Relationship

The b-value of an earthquake catalogue, defined as the slope of the Gutenberg-Richter frequency-magnitude relationship, log N = a – bM, is typically found to be about 1 in a variety of tectonic situations. Higher b-values indicate more small events relative to the expected number of large events. The b-value for seismicity in the 200-mile (322-km) radius of the Wilmington Site with magnitudes greater than 2.5 and less than 5.0 is estimated to be 2.5, a relatively large number for earthquake distributions (**Figure 3.3-36**). This suggests that there are fewer large events in the southeastern United States than would be expected in a typical tectonically active region.

### 3.3.6.6 Tectonics

Published maps show faults in the North Carolina and South Carolina region trending southwest to northeast, parallel to ancient sutures associated with tectonic construction of North America during continental plate collisions. There are no active Quaternary faults mapped in the region of the Wilmington Site. Several inferred faults in eastern North Carolina are shown in **Figures 3.3-31, 3.3-32, and 3.3-35**, although seismicity associated with these faults is not clear. Uncertainties in the locations of these faults, as well as the locations of the posted earthquakes, are large. These faults are mapped based on basement geology (Lawrence and Hoffman, 1993) (see also **Sections 3.3.1.3 and 3.3.2.3**). The distance from the Wilmington Site to the closest inferred faults is about 6 miles (10 km). The earthquakes located near these faults (**Figure 3.3-28**) are based on subjective observational reporting and thus have large associated errors.

Earthquakes can induce liquefaction, which impacts the strength and stiffness of a soil. Among others, Obermeier and colleagues (1987) reported prehistoric (late Holocene) liquefaction features near Georgetown, SC, approximately 60 miles (100 km) northeast of Charleston, SC (Wheeler, 1998). Talwani and Schaeffer (2001) presented a reanalysis of results of 15 years of paleoliquefaction investigations in the South Carolina Mid-Atlantic Coastal Plain physiographic province. The result of this analysis suggests seven episodes of prehistoric liquefaction in the past 6,000 years. It is uncertain if these liquefaction features extend into the Wilmington area. In order to evaluate potential liquefaction at the Wilmington Site, geotechnical investigations were performed within the GLE Study Area and are described in **Section 3.3.5** and **Appendix G**.

Faults associated with the magnitude 6.9 Charleston event have never been verified and are thus mapped as inferred. This is because thick sediments overlie these regions and earthquake ruptures commonly do not break the surface.

As discussed in **Sections 3.3.1.3 and 3.3.2.4**, the Wilmington Site resides on the northern edge of the Cape Fear Arch, an uplifted region that extends from the continental margin northwest towards the Piedmont physiographic province. Some researchers suggest that this arched structure is still rising at a rate of a few centimeters per year (Soller, 1988). The source of the Cape Fear Arch is unknown, and moderate seismicity may be associated with the uplift, although definite correlation has not been established. The extensive seismicity west of the Cape Fear Arch does not have a corresponding mirrored feature to the east in North Carolina.

# Tables

**Table 3.3-1. Characteristics for Soil Types at the Wilmington Site**

| Map Unit Symbol (Figure 3.3-24) | Soil Type | Additional Description | % of Soil Map Unit | Hydrologic Group | Kf | T Factor | Slope Gradient | % Sand | % Silt | % Clay | Surface Runoff | Farmland Potential[a] | Hazard of erosion (off and on roads or trails) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ba | Bayboro loam | ponded | 80 | D | 0.17 | 5 | 1 | 44.8 | 32.7 | 22.5 | Negligible | I | slight |
| | | drained | 10 | D | 0.17 | 5 | 1 | 44.8 | 32.7 | 22.5 | Very High | | slight |
| Be | Baymeade fine sand | NA | 85 | A | 0.05 | 5 | 3 | 95.4 | 0.6 | 4.0 | Very Low | I | slight |
| Bp | Borrow pits | NA | 100 | B | 0.20 | 5 | 3 | 59.6 | 17.9 | 22.5 | Low | N | slight |
| DO | Dorovan soils | NA | 80 | D | 0.02 | 3 | 1 | NR | NR | 0.0 | Negligible | N | Very severe (organic matter content high) |
| Ke | Kenansville fine sand | NA | 90 | A | 0.05 | 5 | 2 | 94.4 | 0.6 | 5.0 | Very Low | I | slight |
| Kr | Kureb sand | NA | 85 | A | 0.05 | 5 | 3 | 97.0 | 1.5 | 5.0 | Very Low | N | slight |
| Le | Leon sand | NA | 80 | B/D | 0.02 | 5 | 1 | 96.3 | 0.7 | 5.0 | Very High | U | slight |
| Ls | Lynchburg fine sandy loam | NA | 85 | C | 0.24 | 5 | 1 | 68.5 | 21.5 | 5.0 | Very High | Pd | slight |
| Mu | Murville fine sand | undrained | 80 | A/D | 0.02 | 5 | 1 | 94.4 | 0.6 | 5.0 | Negligible | U | slight |
| | | drained | 10 | A/D | 0.02 | 5 | 1 | 94.4 | 0.6 | 5.0 | Very High | | slight |
| On | Onslow loamy fine sand | NA | 90 | B | 0.28 | 5 | 2 | 78.6 | 16.4 | 5.0 | Low | P | slight |
| Pn | Pantego loam | drained | 80 | B/D | 0.17 | 5 | 1 | 46.0 | 44.0 | 5.0 | Very High | Pd | slight |
| | | undrained | 10 | B/D | 0.17 | 5 | 1 | 46.0 | 44.0 | 5.0 | Very High | | slight |
| Se | Seagate fine sand | NA | 85 | B | 0.10 | 5 | 1 | 97.9 | 0.6 | 5.0 | Low | N | slight |
| Wo | Woodington fine sandy loam | drained | 80 | B/D | 0.24 | 5 | 1 | 62.5 | 26.0 | 5.0 | Very High | Pd | slight |
| | | undrained | 10 | B/D | 0.24 | 5 | 1 | 62.5 | 26.0 | 5.0 | Very High | | slight |
| Wr | Wrightsboro fine sandy loam | NA | 90 | C | 0.28 | 4 | 1 | 62.5 | 26.0 | 5.0 | Low | P | slight |

[a] Farmland Potential Abbreviations: I = Farmland of statewide importance; N = Not prime farmland; P = All areas are prime farmland; Pd = Prime farmland if drained; U = Farmland of unique importance (NRCS, 2007).

Reference: NRCS, 2007.

NA = Soil type does not exist in separate ponded or drained stages at the Site.

NR = Not reported in reference.

Note: Erosion factors (as defined by the U.S. Department of Agriculture [USDA] in the Revised Universal Soil Loss Equation documentation) are shown in this table as the K factor (Kw [not shown] and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Values of K (unitless) range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. Values of T range from 1 to 5 tons/acre/year. The T factor accounts for water and wind erosion but is typically not used for construction site erosion. Exceptions include areas where soils are disturbed; impact and preservation of habitat are considered where soils are disturbed or where wind breaks protecting bare soils are altered. See the glossary for specific

Note: Polygons in the digital map data from SSURGO are map unit delineations. Map units are typically made up of one or more named soils. Other miscellaneous land types or areas of water may be included. These entities and their percent compositions make up the map unit components and define the map unit composition. Component attributes must be aggregated to a map unit level for map visualization. This table and the column for Percent of Soil Map Unit reflect this definition and these aggregated attributes.

**Table 3.3-2. Engineering Properties for Soils within the GLE Study Area**

| Soil Type | Depth (in) | USDA texture | Classificication | | Percent passing sieve number | | | | Liquid limit | Plasticity index | Limitations for Building | Clay Content (%) | Moist Bulk Density (g/cc) | Organic Content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unified | AASHTO | 4 (4.70 mm) | 10 (2.0 mm) | 40 (0.42 mm) | 200 (0.074 mm) | | | | | | |
| Baymeade fine sand | 0-2 | Fine sand, sand | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 51-100 | 5-20 | 6-14 | NP | Not limiting | 0-8 | 1 60-1 75 | 0 5-1 0 |
| | 2-30 | Fine sand, sand | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 51-100 | 5-20 | 6-14 | NP | | 0-4 | 1 60-1 75 | 0 5-1 0 |
| | 20-40 | Fine sandy loam, Sandy clay loam, Sandy loam | SC, SC-SM, SM | A-2-4, A-4 | 100 | 100 | 60-100 | 23-49 | 0-24 | 0-10 | | 8-26 | 1 45-1 60 | 0-0 5 |
| | 40-80 | Fine sand, Loamy fine sand, Sand | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 51-100 | 5-30 | 6-14 | NP | | 0-12 | 1 60-1 75 | 0-0 5 |
| Borrow pits, Udorthents, loamy | 0-80 | Fine sandy loam, Loamy sand, Sandy clay loam, Sandy loam | SC-SM, SM | A-2-4, A-4, A-6, A-7-5 | 85-100 | 85-100 | 70-90 | 23-45 | 20-45 | 0-13 | Not limiting | 5-35 | 1 40-1 60 | 0-0 1 |
| Dorovan | 0-5 | Mucky peat, Muck | GP, PT | A-1-a | -- | -- | -- | -- | 0 | NP | Very limited by ponding, subsidence, flooding, and depth to saturated zone | 0 | 0 25-0 40 | 20-80 |
| | 5-85 | Muck | GP, PT | A-1-a | -- | -- | -- | -- | 0 | NP | | 0 | 0 35-0 55 | 20-70 |
| | 85-90 | Loam, Loamy sand, Sand | SC-SM, SM, SP-SM | A-1, A-2-4, A-3, A-4 | 100 | 100 | 5-70 | 5-49 | 7-20 | 0-2 | | 5-20 | 1 40-4 65 | 0 5-5 0 |
| Kenansville, moderately wet | 0-8 | Fine sand, Sand | SM, SW-SM | A-1-b, A-2-4 | 100 | 95-100 | 45-99 | 10-25 | 6-14 | NP | Not limiting | 0-10 | 1 50-1 70 | 0 5-2 0 |
| | 8-24 | Fine sand, Loamy fine sand, Loamy sand, Sand | SM, SW-SM | A-1-b, A-2-4 | 100 | 95-100 | 45-99 | 10-25 | 7-13 | NP | | 0-10 | 1 50-1 70 | 0-1 0 |
| | 24-36 | Fine sandy loam, Sandy clay loam, Sandy loam | SC, SC-SM, SM | A-1-b, A-2-4, A-4, A-6 | 100 | 95-100 | 50-99 | 25-45 | 16-32 | 2-14 | | 5-21 | 1 30-1 50 | 0-0 2 |
| | 36-42 | Fine sandy loam, Loamy sand, Sand, Sandy loam | SC-SM, SM, SW-SM | A-1-b, A-2-4 | 100 | 95-100 | 40-99 | 10-30 | 0-27 | 0-10 | | 3-16 | 1 30-1 50 | 0 |
| | 42-84 | Loamy fine sand, Loamy sand | SM, SP-SM | A-1-b, A-2-4 | 100 | 95-100 | 40-99 | 5-30 | 6-13 | NP | | 1-10 | 1 50-1 70 | 0 |
| Leon sand | 0-3 | Sand | SM | A-2-4 | 100 | 100 | 65-80 | 20-35 | 6-13 | NP | Limited by depth to saturated zone | 1-5 | 1 05-1 45 | 0 5-4 0 |
| | 3-15 | Sand | SM, SP-SM | A-1-b, A-2-4, A-3 | 100 | 100 | 50-80 | 5-35 | 6-13 | NP | | 0-4 | 1 40-1 60 | 0 0-0 5 |
| | 15-30 | Fine sand, Loamy sand, Sand | SM, SP-SM | A-1-b, A-2-4, A-3, A-4 | 100 | 100 | 50-85 | 5-45 | 6-14 | NP | | 2-8 | 1 20-1 60 | 2 0-4 0 |
| | 30-33 | Fine sand, Sand | SM, SP-SM | A-1-b, A-2-4, A-3 | 100 | 100 | 50-80 | 5-35 | 6-14 | NP | | 1-5 | 1 45-1 80 | 0 0-0 5 |
| | 33-66 | Fine sand, sand | SM, SP-SM | A-1-b, A-2-4, A-3 | 100 | 100 | 50-80 | 5-35 | 6-14 | NP | | 1-5 | 1 45-1 80 | 0 0-0 5 |
| | 66-80 | Fine sand, sand | SM, SP-SM | A-1-b, A-2-4, A-3 | 100 | 100 | 50-80 | 5-35 | 6-14 | NP | | 2-8 | 1 50-1 80 | 1 0-3 0 |

**Table 3.3-2. Engineering Properties for Soils within the GLE Study Area**

| Soil Type | Depth (in) | USDA texture | Classificication | | Percent passing sieve number | | | | Liquid limit | Plasticity index | Limitations for Building | Clay Content (%) | Moist Bulk Density (g/cc) | Organic Content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unified | AASHTO | 4 (4.70 mm) | 10 (2.0 mm) | 40 (0.42 mm) | 200 (0.074 mm) | | | | | | |
| Lynchburg | 0-9 | Fine sandy loam, Loam, Sandy loam | ML, SC-SM, SM | A-2, A-2-4, A-4 | 92-100 | 90-100 | 75-100 | 25-55 | 0-30 | 0-4 | Limited by depth to saturated zone | 5-20 | 1 30-1 60 | 0 5-5 0 |
| | 9-14 | Fine sandy loam, Loam, Loamy fine sand, Loamy sand, Sandy loam | SC-SM, SM, SP-SM | A-2, A-2-4, A-4 | 92-100 | 90-100 | 60-100 | 12-40 | 0-25 | 0-7 | | 2-10 | 1 35-1 60 | 0 0-0 5 |
| | 14-65 | Clay loam, Sandy clay loam, Sandy loam | CL, CL-ML, SC, SC-SM | A-2, A-2-4, A-4, A-6 | 92-100 | 90-100 | 70-100 | 25-67 | 16-40 | 4-18 | | 18-35 | 1 30-1 50 | 0 0-0 5 |
| | 65-80 | Clay, Sandy clay, Sandy clay loam | CL, CL-ML, SC, SC-SM | A-2, A-2-4, A-2-6, A-4, A-6 | 95-100 | 92-100 | 70-100 | 25-73 | 15-40 | 0-20 | | 20-50 | 1 25-1 50 | 0 0-0 5 |
| Murville, undrained and drained | 0-8 | Fine sand, Loamy fine sand, Sand | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 85-100 | 5-30 | 6-14 | NP | Limited by depth to saturated zone and ponding on undrained areas | 2-8 | 1 45-1 60 | 2 0-9 0 |
| | 8-45 | Fine sand, Loamy fine sand, Sand | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 85-100 | 5-20 | 6-14 | NP | | 2-8 | 1 60-1 75 | 2 0-8 0 |
| | 45-80 | Fine sand, Loamy sand, Sandy loam | SC-SM,SM, SP-SM | A-2-4, A-3 | 100 | 100 | 80-100 | 3-12 | 6-14 | NP | | 2-8 | 1 60-1 75 | 0 0-2 0 |
| Onslow loamy fine sand | 0-4 | Loamy fine sand, Loamy sand | SC-SM,SM, SP-SM | A-2-4, A-3, A-4 | 100 | 95-100 | 60-100 | 5-38 | 6-14 | NP | Somewhat limited due to depth to saturated zone | 2-8 | 1 60-1 75 | 0 5-2 0 |
| | 4-20 | Fine sandy loam, Loamy fine sand, Loamy sand, Sandy loam | SC-SM,SM, SP-SM | A-2-4, A-3, A-4 | 100 | 95-100 | 60-100 | 5-38 | 6-14 | NP | | 2-6 | 1 60-1 75 | 0 5-2 0 |
| | 20-68 | Clay loam, Fine sandy loam, Sandy clay loam, Sandy loam | CL, ML, SC | A-2, A-4, A-6 | 100 | 95-100 | 60-100 | 30-55 | 20-40 | 0-17 | | 15-35 | 1 30-1 50 | 0 0-0 5 |
| | 68-80 | Clay loam, Sandy clay loam, Sandy loam | CL, ML, SC | A-2, A-4, A-6 | 100 | 95-100 | 60-100 | 30-55 | 20-40 | 0-17 | | 15-35 | 1 30-1 50 | 0 0-0 5 |
| Pantego, undrained and drained | 0-18 | Fine sandy loam, Loam, Sandy loam | ML, SM | A-2-4, A-4 | 100 | 95-100 | 60-95 | 25-75 | 20-35 | 0-10 | Limited due to flooding and depth to saturaed zone | 5-15 | 1 40-1 60 | 4 0-10 |
| | 18-27 | Clay loam, Sandy clay loam, Sandy loam | CL, CL-ML, SC, SC-SM | A-2-4, A-4, A-6 | 100 | 95-100 | 65-100 | 30-80 | 20-40 | 4-16 | | 18-35 | 1 30-1 50 | 0 5-2 0 |
| | 27-80 | Clay loam, Sandy clay, Sandy loam | CL, SC | A-6, A-7-6 | 100 | 95-100 | 80-100 | 36-80 | 25-49 | 11-24 | | 20-40 | 1 30-1 60 | 0 0-0 5 |
| Woodington, undrained and drained | 0-6 | Fine sandy loam, Sandy loam | SM | A-1-b, A-2-4, A-4 | 100 | 95-100 | 50-100 | 20-50 | 15-25 | 0-3 | Somewhat limited due to depth to saturated zone | 5-18 | 1 45-1 65 | 2 0-4 0 |
| | 6-14 | Fine sandy loam, Sandy loam | SM | A-1-b, A-2-4, A-4 | 100 | 95-100 | 50-100 | 20-50 | 15-25 | 0-3 | | 5-10 | 1 45-1 65 | 2 0-4 0 |
| | 14-74 | Fine sandy loam, Sandy loam | SM | A-1-b, A-2-4, A-4 | 100 | 95-100 | 50-100 | 20-50 | 15-25 | 0-3 | | 5-18 | 1 45-1 65 | 0 0-0 5 |
| | 74-85 | Loamy fine sand, Loamy sand, Sandy loam | SM, SP-SM, SW-SM | A-1-b, A-2-4, A-4 | 100 | 95-100 | 50-100 | 10-50 | 10-25 | 0-3 | | 3-18 | 1 45-1 65 | 0 0-0 5 |

**Table 3.3-2. Engineering Properties for Soils within the GLE Study Area**

| Soil Type | Depth (in) | USDA texture | Classificication | | Percent passing sieve number | | | | Liquid limit | Plasticity index | Limitations for Building | Clay Content (%) | Moist Bulk Density (g/cc) | Organic Content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unified | AASHTO | 4 (4.70 mm) | 10 (2.0 mm) | 40 (0.42 mm) | 200 (0.074 mm) | | | | | | |
| Wrightsboro | 0-6 | Fine sandy loam | SM | A-2-4, A-4 | 98-100 | 95-100 | 51-95 | 20-50 | 15-25 | 0-3 | Not limiting | 5-18 | 1 45-1 60 | 0 5-2 0 |
| | 6-24 | Fine sandy loam | SM | A-2-4, A-4 | 98-100 | 95-100 | 51-95 | 20-50 | 15-25 | 0-3 | | 5-18 | 1 45-1 60 | 0 0-0 5 |
| | 24-48 | Clay loam, Loam, Sandy clay loam | CL, SC | A-6, A-7-6 | 98-100 | 95-100 | 60-95 | 40-70 | 30-50 | 11-25 | | 18-35 | 1 35-1 50 | 0 0-0 5 |
| | 48-80 | Clay, Sandy clay | CH | A-7-6 | 98-100 | 95-100 | 85-98 | 75-95 | 50-75 | 25-45 | | 35-60 | 1 25-1 40 | 0 0-0 5 |

Reference: NRCS, 2007

Note: Classification of the soils is determined according to the Unified Soil Classification System (USCS; ASTM, 1998) and the system adopted by the American Association of State Highway and Transportation Officials AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index This

(CH) – Typically inorganic clays with high liquid limits
(CL) – Low compressibility, principally inorganic clays, and may include gravelly clays, sandy clays, silty clays, and lean clays
(ML) – Typically inorganic silts of low plasticity that may include very fine sands, silty or clayey fine sands with slight plasticity
(SC) – Clayey sands and poorly graded sand-clay mixtures
(SM) – Silty sands and poorly graded sand-silt mixtures
(SP) – Poorly graded (uniform) sand
(SW) – Well-graded sands and gravelly sands with little or no fines

# Figures

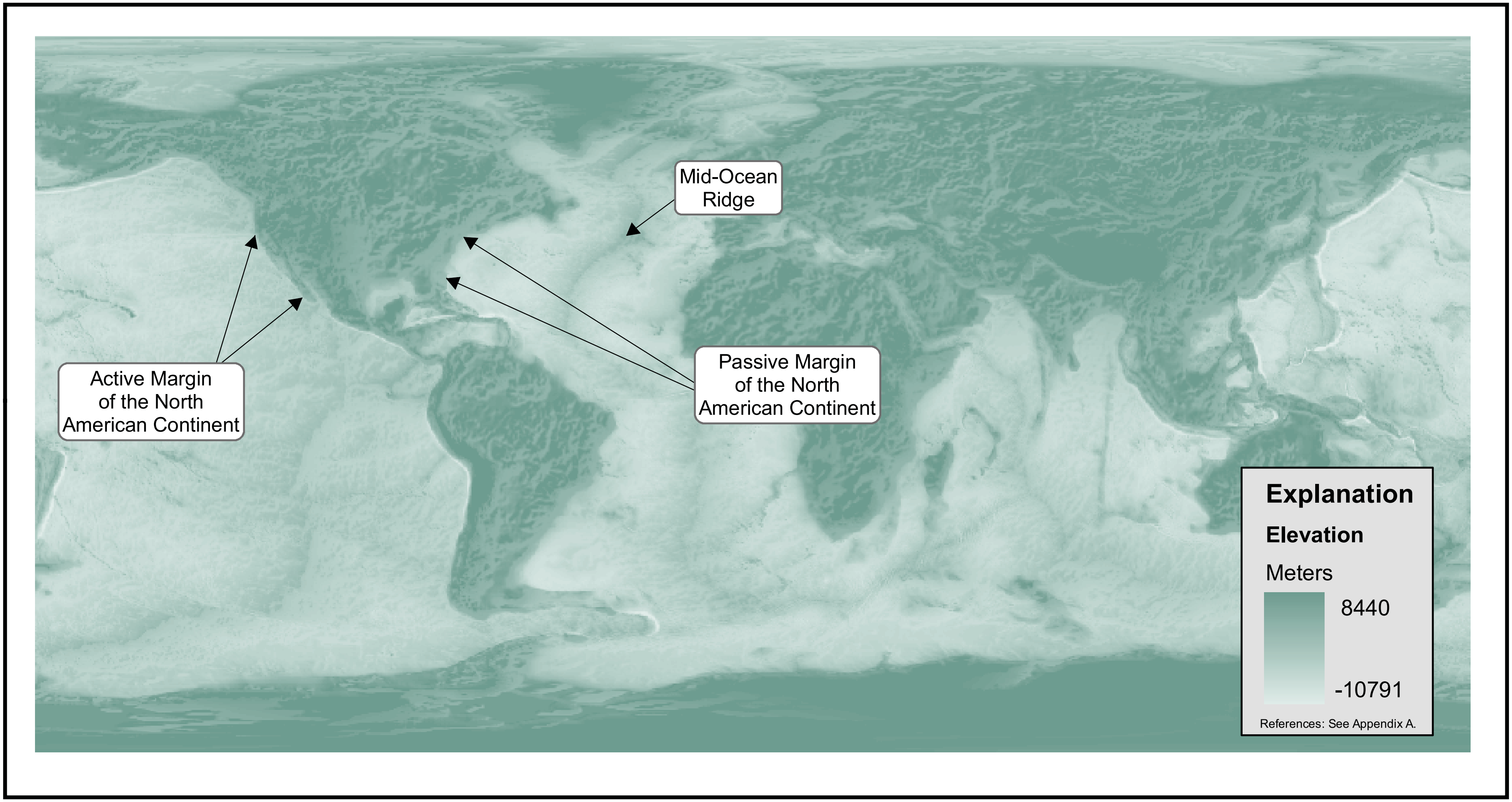



**Figure 3.3-1. World map of tectonic plates indicating the passive margin of the North American continent.**

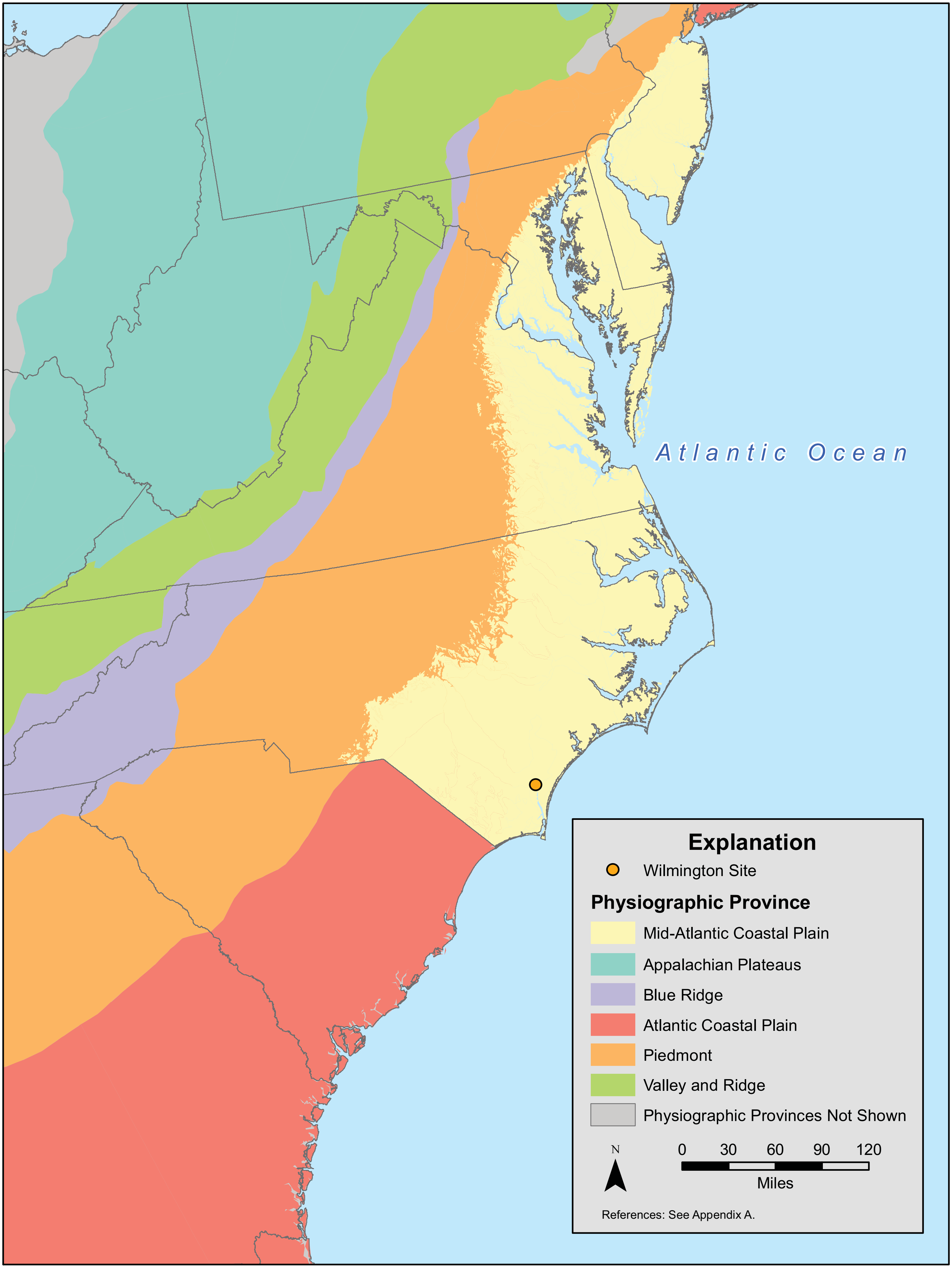



**Figure 3.3-2. Physiographic provinces and the Mid-Atlantic Coastal Plain.**

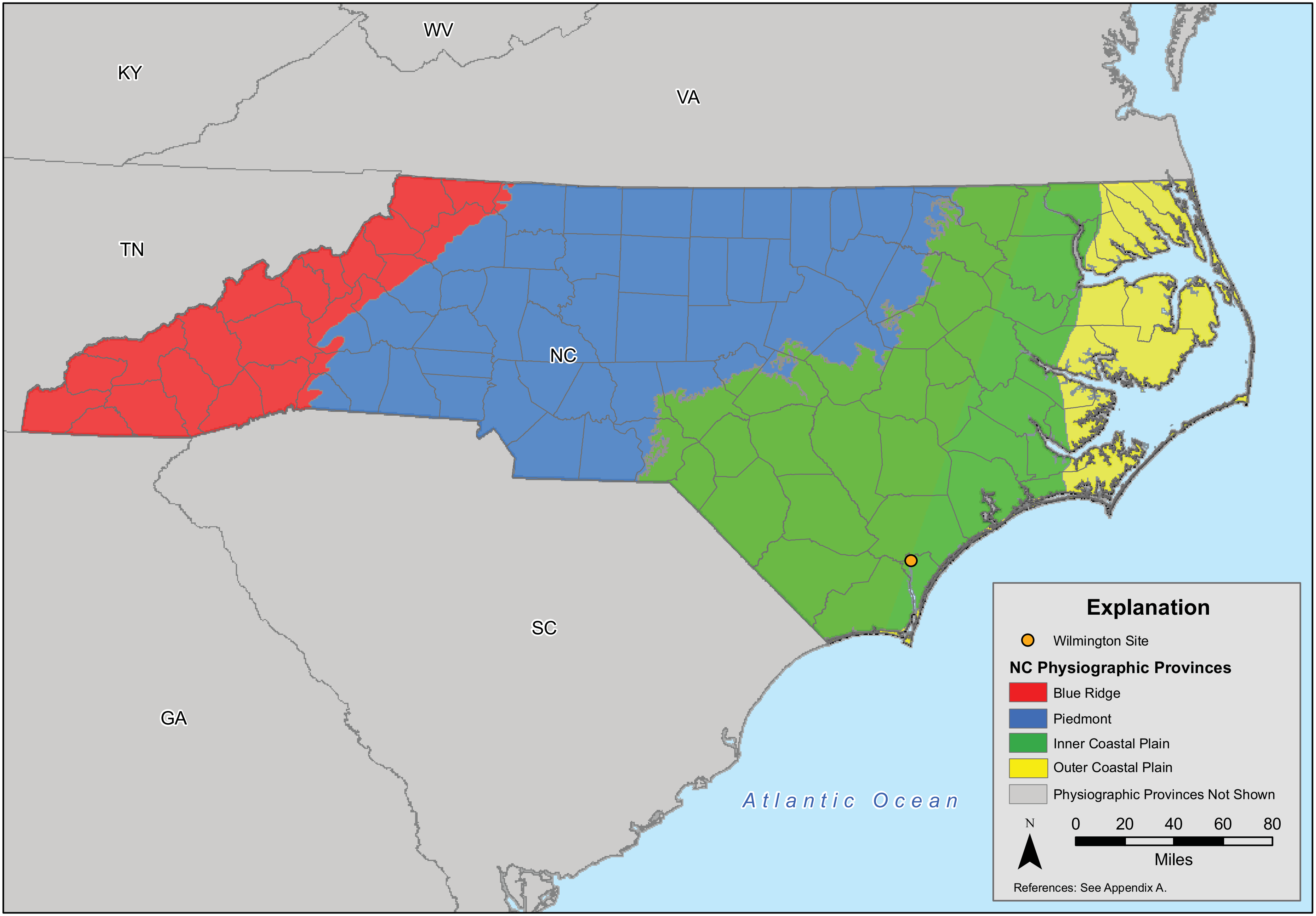



**Figure 3.3-3. Physiographic provinces of North Carolina.**

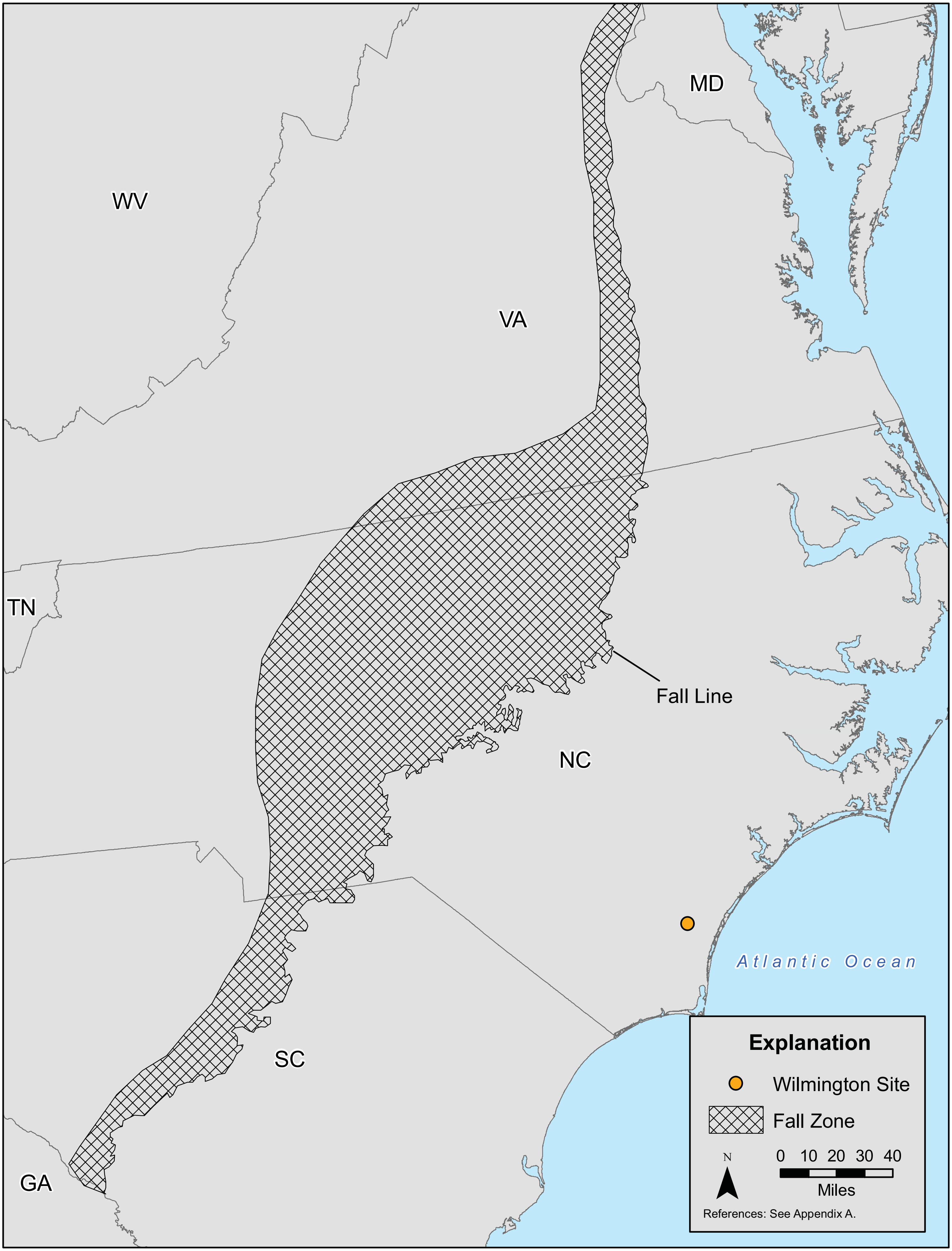



**Figure 3.3-4. Map of the Fall Line and Fall Zone in Virginia, North Carolina, and South Carolina.**

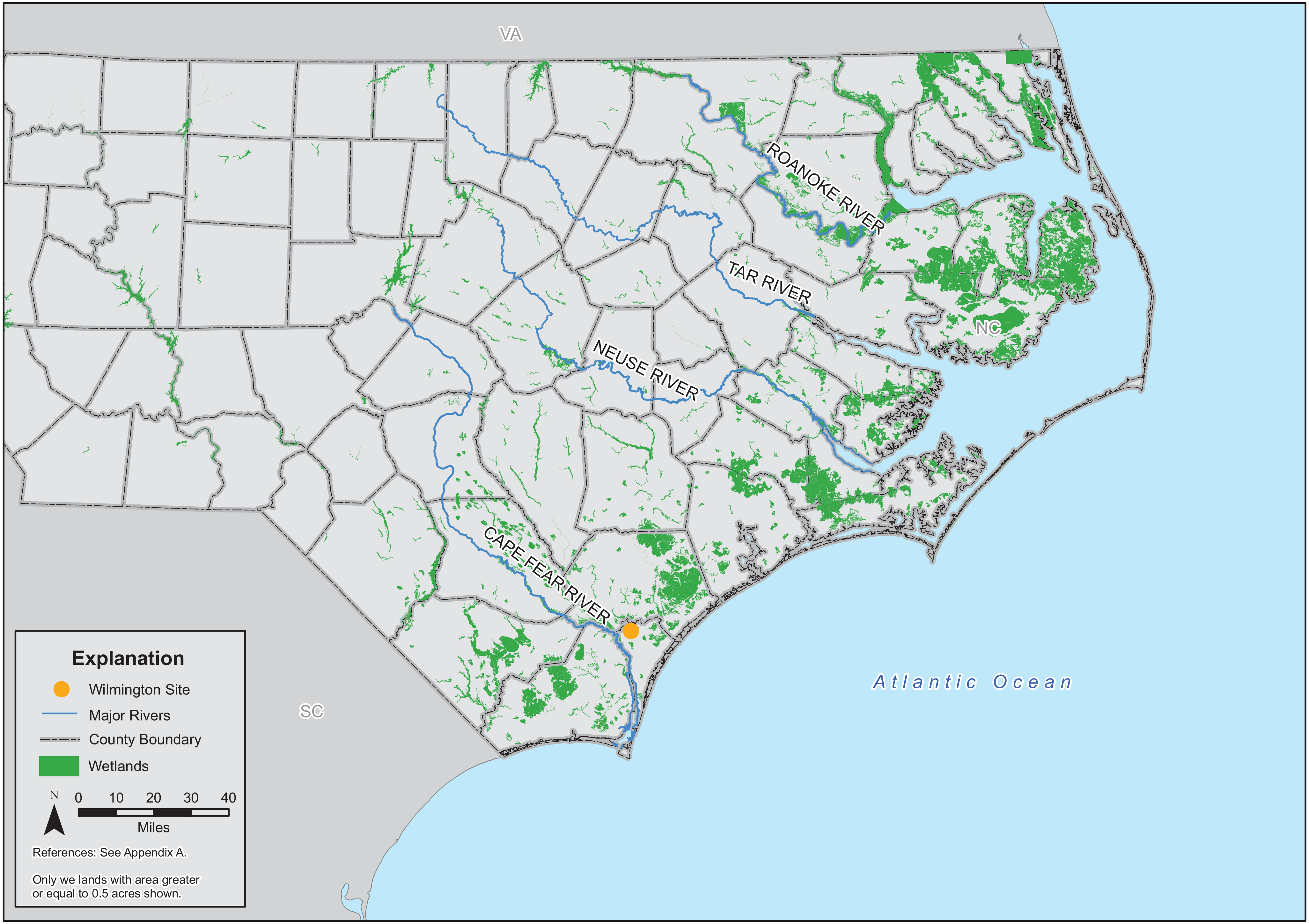



**Figure 3.3-5. Generalized map showing the major rivers and the concentration of wetlands in eastern North Carolina.**

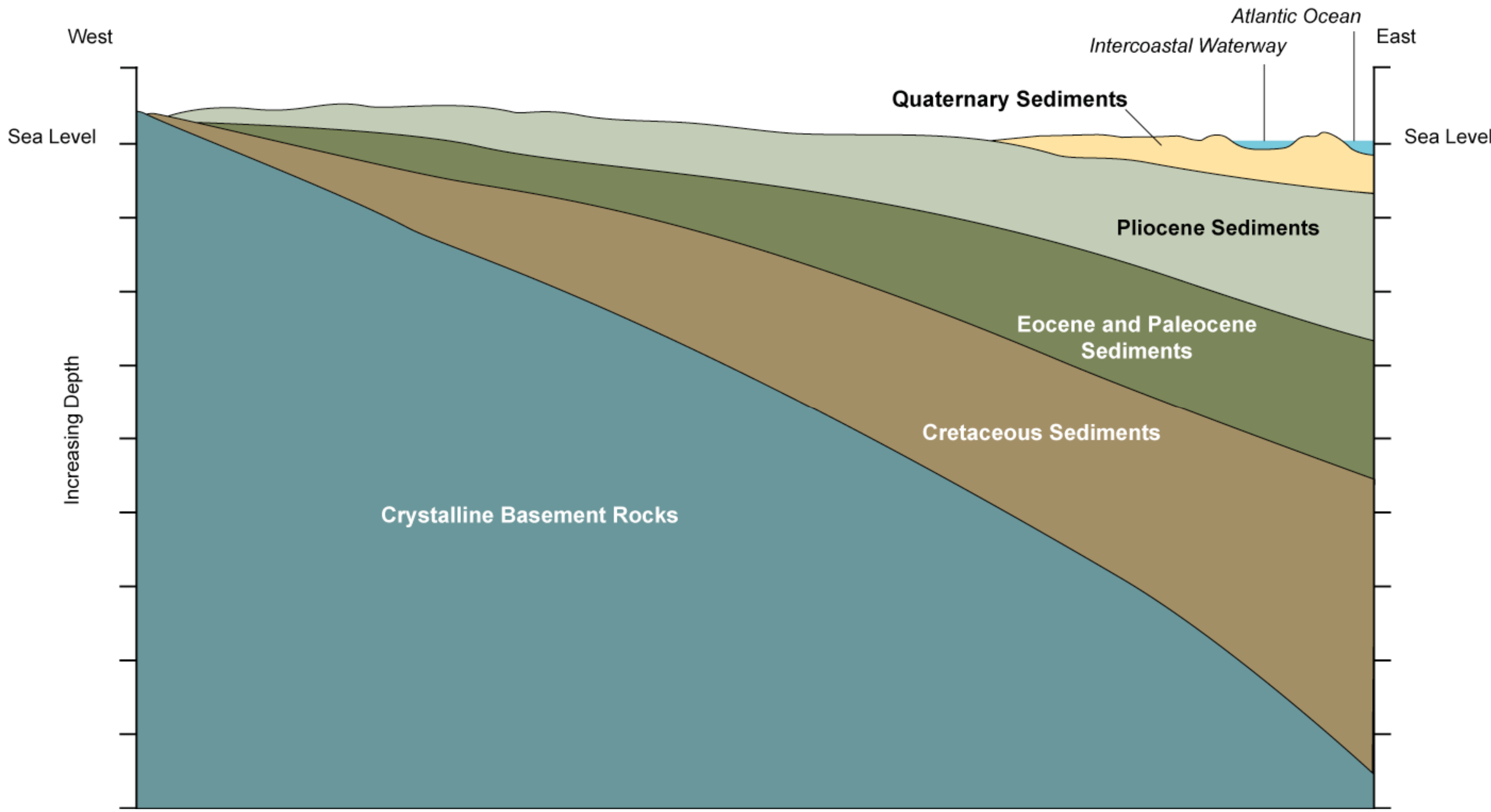
| North NCCP — Formation Name and Relative Location Along the North Carolina Inner and Outer Coastal Plain Physiographic Provinces (NCCP) | | South NCCP | Era | Period | Epoch | Age (Ma*) | Lithological Description |
|---|---|---|---|---|---|---|---|
| Coextensive Surficial Sediments | | | Cenozoic | Quaternary | Holocene | 0.01 | Gravel, clayey sand, sand, and minor iron-oxide cemented sandstone |
| | | | | | Pleistocene | 1.6 | Fossiliferous sand with silt, bluish-gray to tan, loosely consolidated |
| Chowan River | | Bear Bluff | | Tertiary | Pliocene | | Clay that grades into unconsolidated, medium- to coarse-grained sands with cross-bedding and common, rhythmic bands of clayey sand |
| Yorktown | | Duplin | | | | 5.3 | Yorktown Formation: Fossiliferous clay with varying amounts of fine-grained, bluish-gray sand with shell lenses<br>Duplin Formation: A series of shelly, medium-to-coarse-grained sand, sandy marl, and bluish-gray limestone |
| Eastover | | | | | Miocene | | Calcareous sand with significant shell beds |
| Pungo River | | | | | | 23.7 | A phosphate deposit formed in nutrient-rich sediments intermixed with clays and volcanic ashes |
| | Belgrade | | | | Oligocene | | Shell mounds of giant oysters in a tan to orange sand matrix, grading upward into a layer of gray to brown fossiliferous clayey sand |
| | River Bend | | | | | 36.6 | Calcarenite limestone overlain by and intercalated with indurated, sandy, molluscan-mold limestone |
| | Castle Hayne Limestone | | | | Eocene | 54.6 | Very sandy, molluscan-mold limestone that grades into locally dolomitized, bryozoan-echinoid skeletal limestone commonly with solution cavities |
| | Beaufort | | | | Paleocene | 66.4 | Sand and glauconitic and fossiliferous silty clay as well as siliceous mudstone with thin lenses of sandstone with some basal phosphatic pebble conglomerate |
| | Peedee | | Late Mesozoic | Upper Cretaceous | | | Glauconitic and phosphoritic silty, fine- to very fine-grained quartz sand with trace amounts of shell and pyrite Locally, some clayey sand and greenish gray to olive black, massive, locally fossiliferous and calcareous clay |
| | Black Creek | | | | | | Alternating beds of fine-grained micaceous "salt and pepper" sands thinly laminated with gray to black lignitic clays Also has fossiliferous clayey sand lenses with shell, glauconite, and organic material |
| | Middendorf | | | | | | Sand, sandstone, and mudstone Sediments are typically mottled gray to pale gray with an orange cast Beds are laterally discontinuous and cross bedding is common |
| | Cape Fear | | | | | 97.5 | Sandstone and sandy mudstone; yellowish gray to bluish gray, and mottled red to yellowish orange in color in other areas; indurated and graded and exhibits laterally continuous bedding with faint cross-bedding |
| Crystalline Basement | | | Pre-Mesozoic | | | >250 | Schist, gneiss, granite, and metamorphosed volcanic rocks typical of rocks which are exposed in the Piedmont physiographic province of North Carolina |

* Million Years Ago (from Present)

Formation is beneath the Wilmington Site. (shaded yellow: Coextensive Surficial Sediments, Peedee, Black Creek, Cape Fear, Crystalline Basement)

Date: 1/9/08
Reference: Modified from Beyer (1991)

**Figure 3.3-6. Geologic column of the North Carolina Mid-Atlantic Coastal Plain physiographic province.**

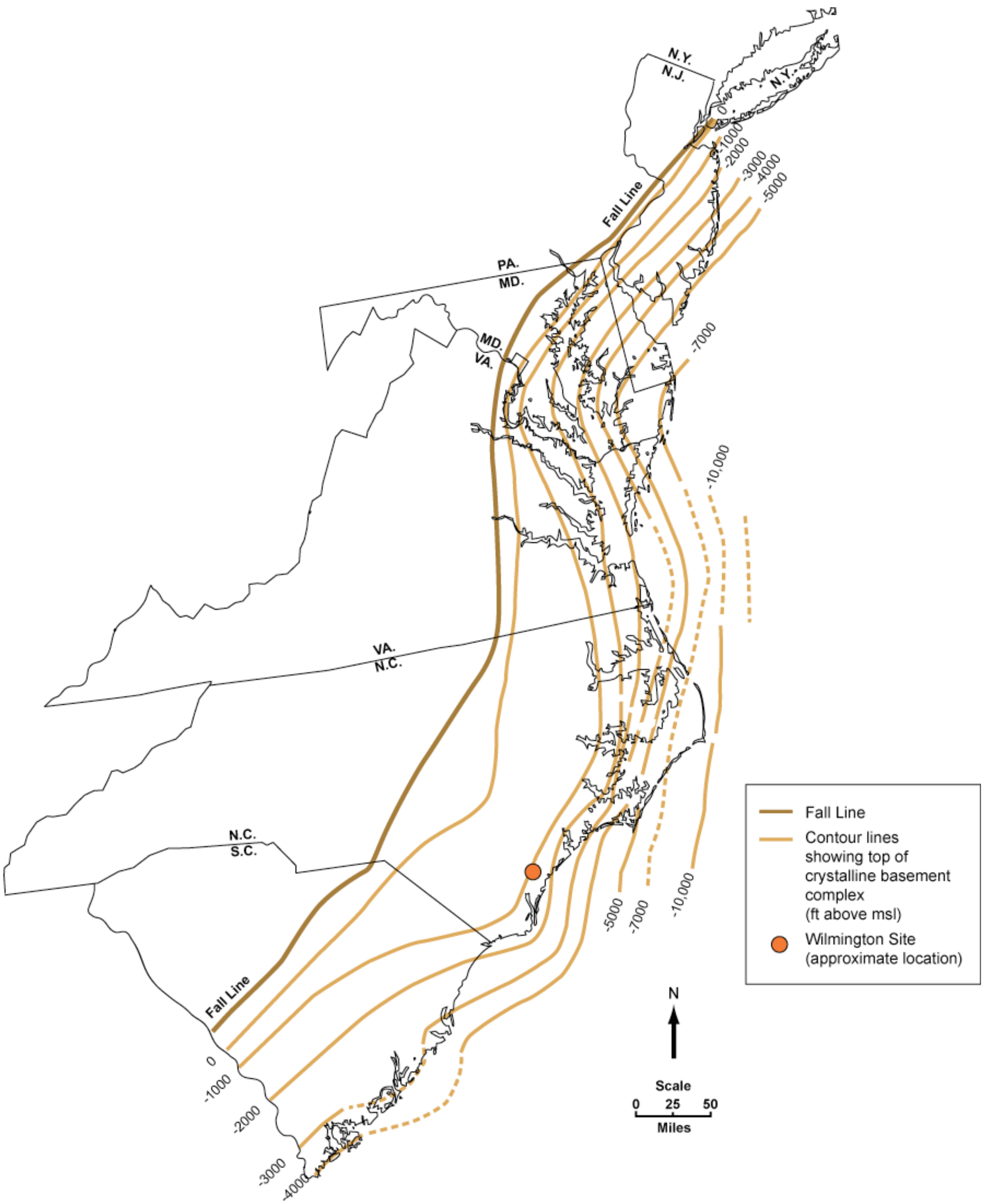



**Vertical Scale greatly exaggerated.**

Note: In the vicinity of the Wilmington Site, Quaternary sediments overlay Upper Cretaceous formations, and the Tertiary sediments are not present (see Figure 3.3-6).

Reference: Based on Ator et al., 2005.

**Figure 3.3-7. Generalized geologic cross-section of the Mid-Atlantic Coastal Plain physiographic province.**




Reference: Based on Richards, 1950.

**Figure 3.3-8. Contour map showing elevation of the top of crystalline basement complex, Mid-Atlantic Coastal Plain physiographic province.**

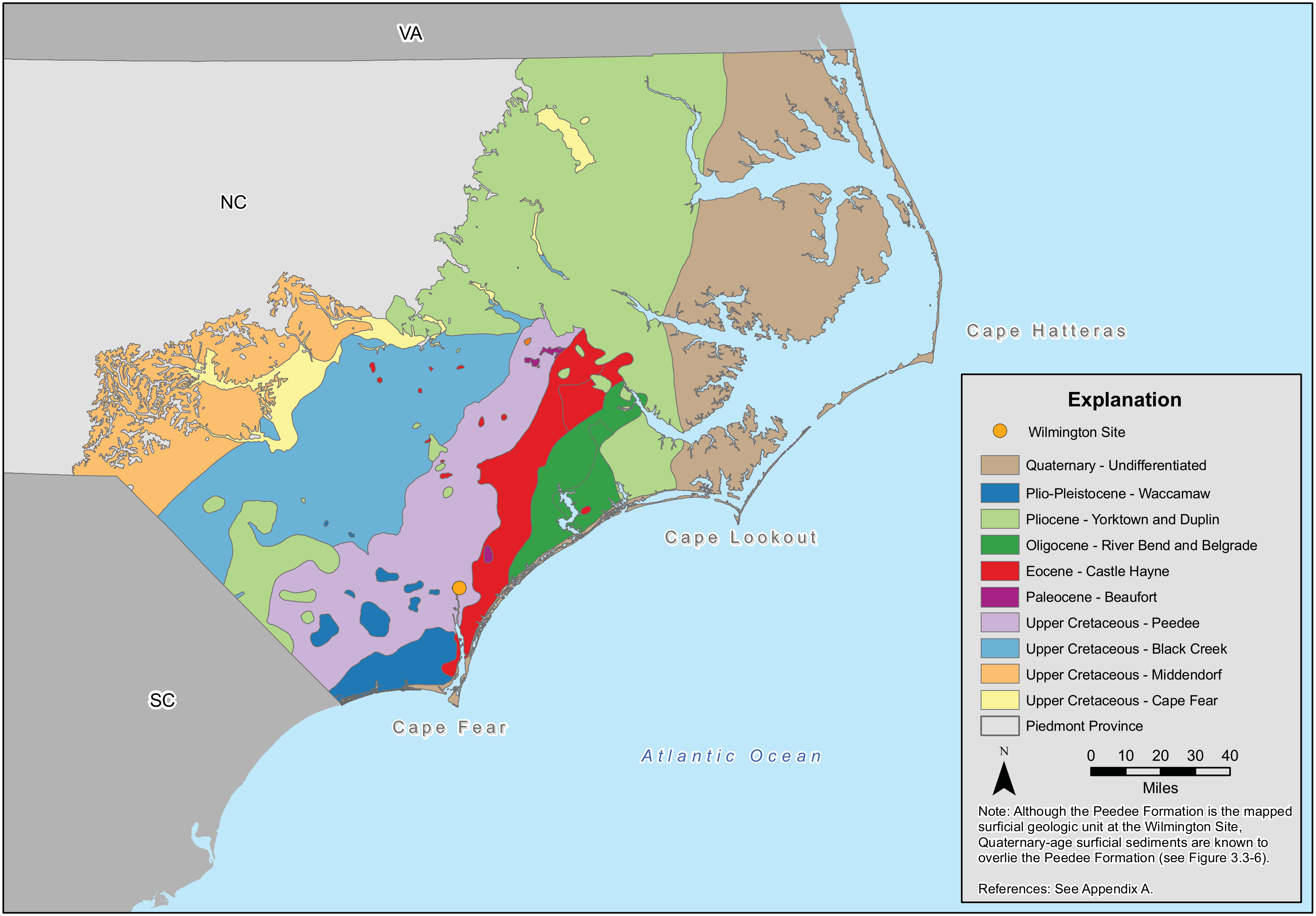
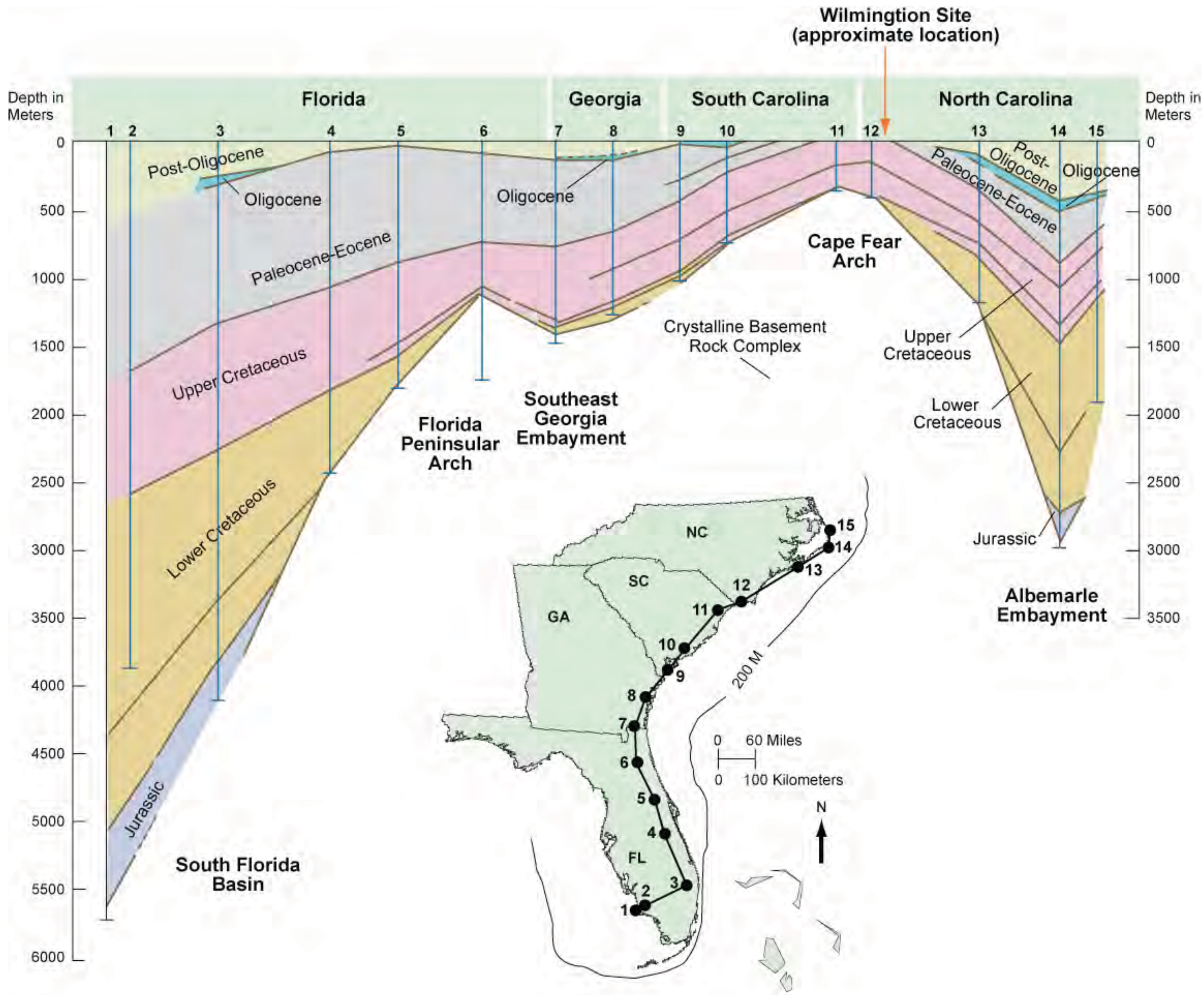



**Figure 3.3-9. Map of regional surficial geology of the Mid-Atlantic Coastal Plain physiographic province in North Carolina.**


**Figure 3.3-10. Structural arches and embayments: Mid-Atlantic Coastal Plain physiographic province.**




Reference: Based on Baldwin et al., 2004.

**Figure 3.3-11. Cross section along margin of Mid-Atlantic Coastal Plain physiographic province showing Cape Fear Arch.**

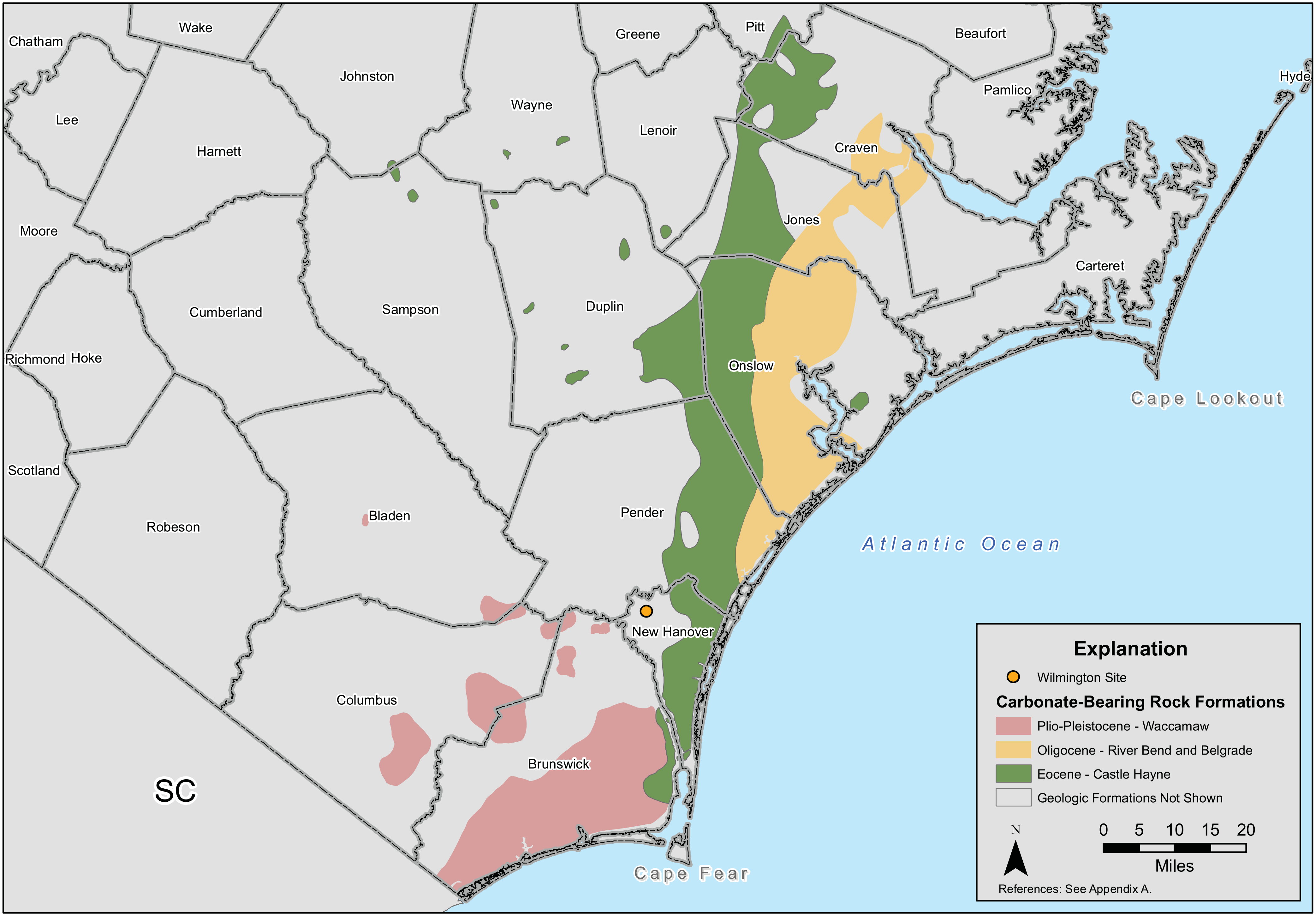



**Figure 3.3-12. Location of carbonate-bearing rock in the North Carolina Mid-Atlantic Coastal Plain physiographic province.**

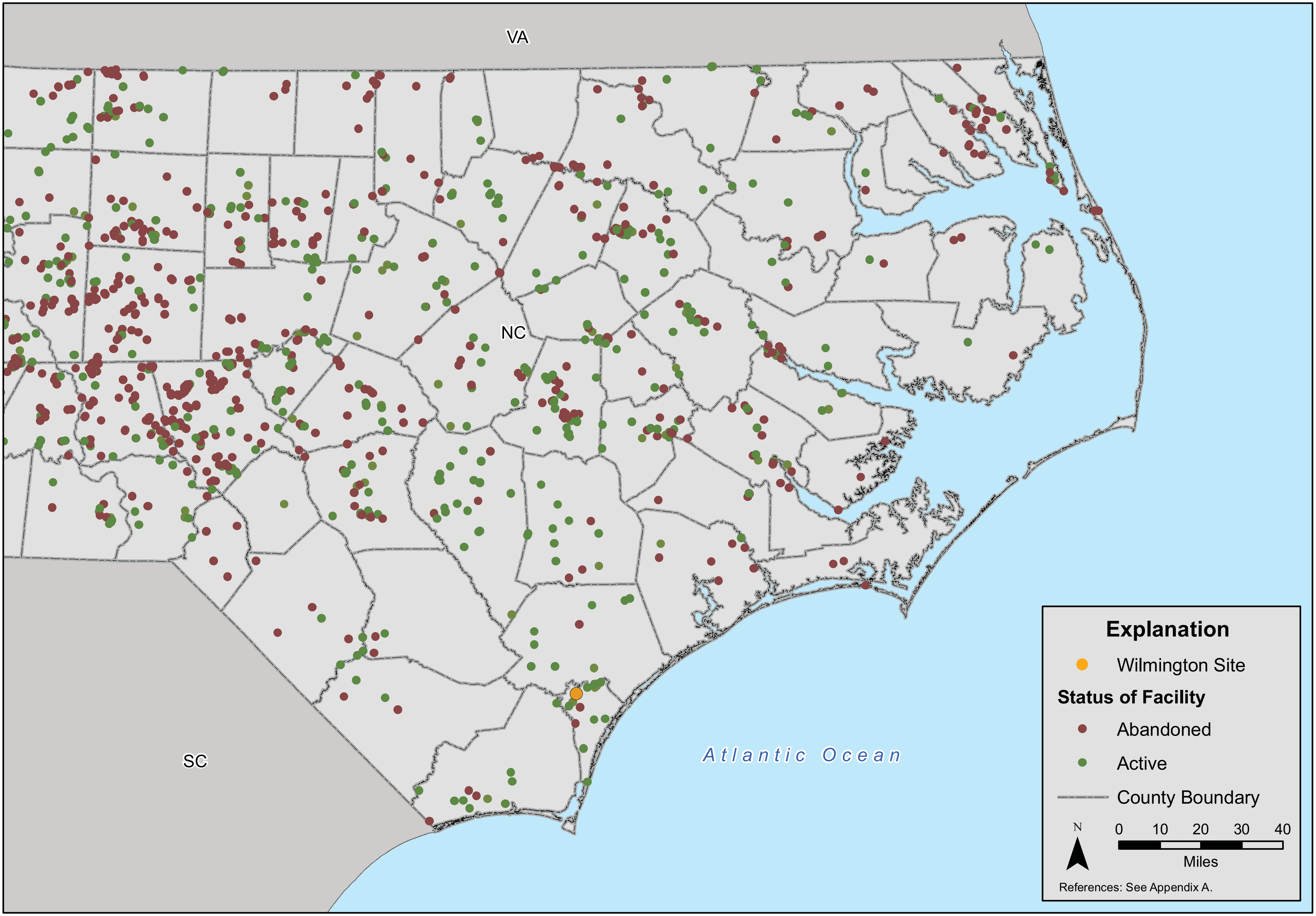



**Figure 3.3-13. Locations of active and abandoned mines and mineral-processing plants in eastern North Carolina.**

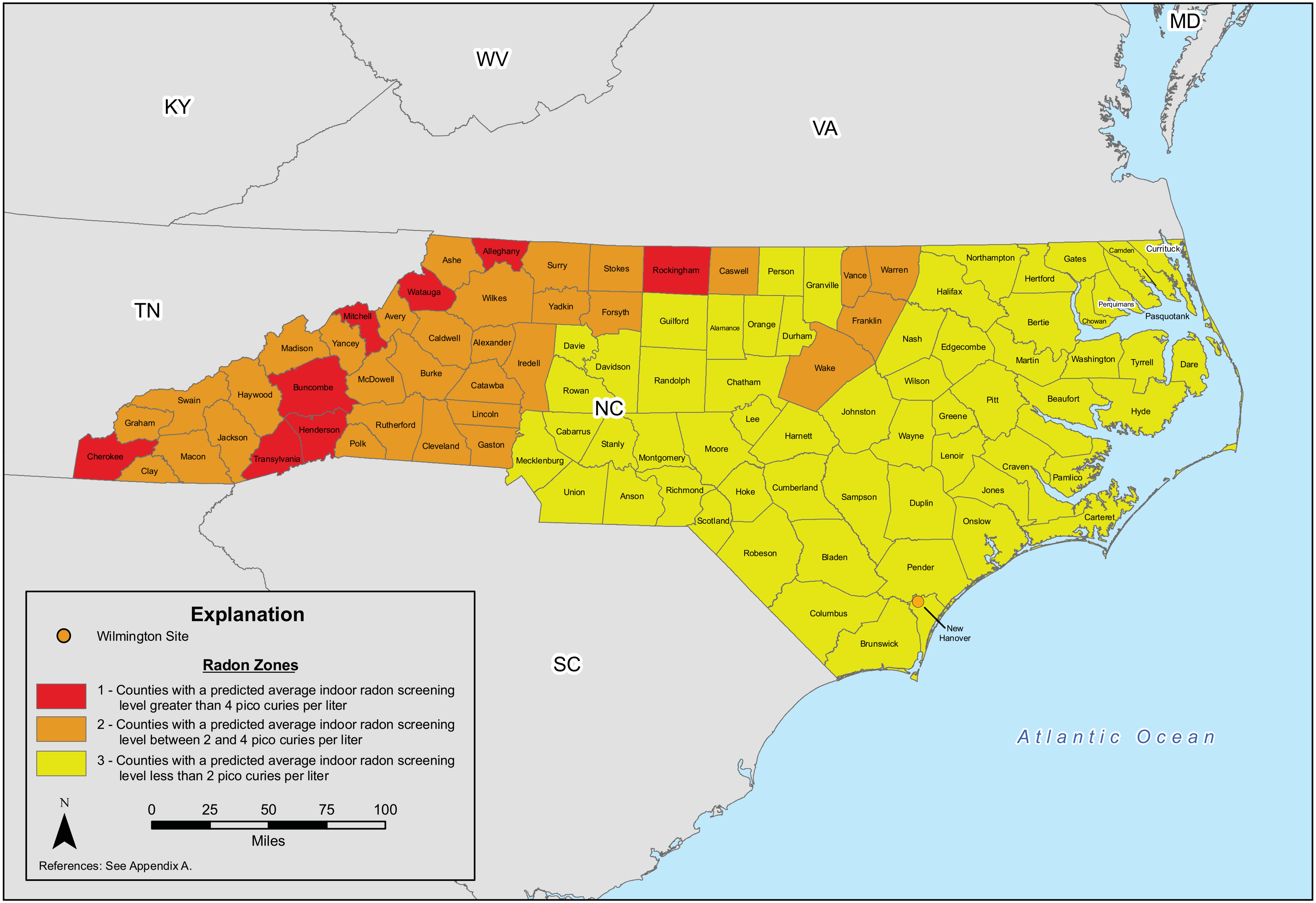



**Figure 3.3-14. Radon potential for each county in North Carolina.**

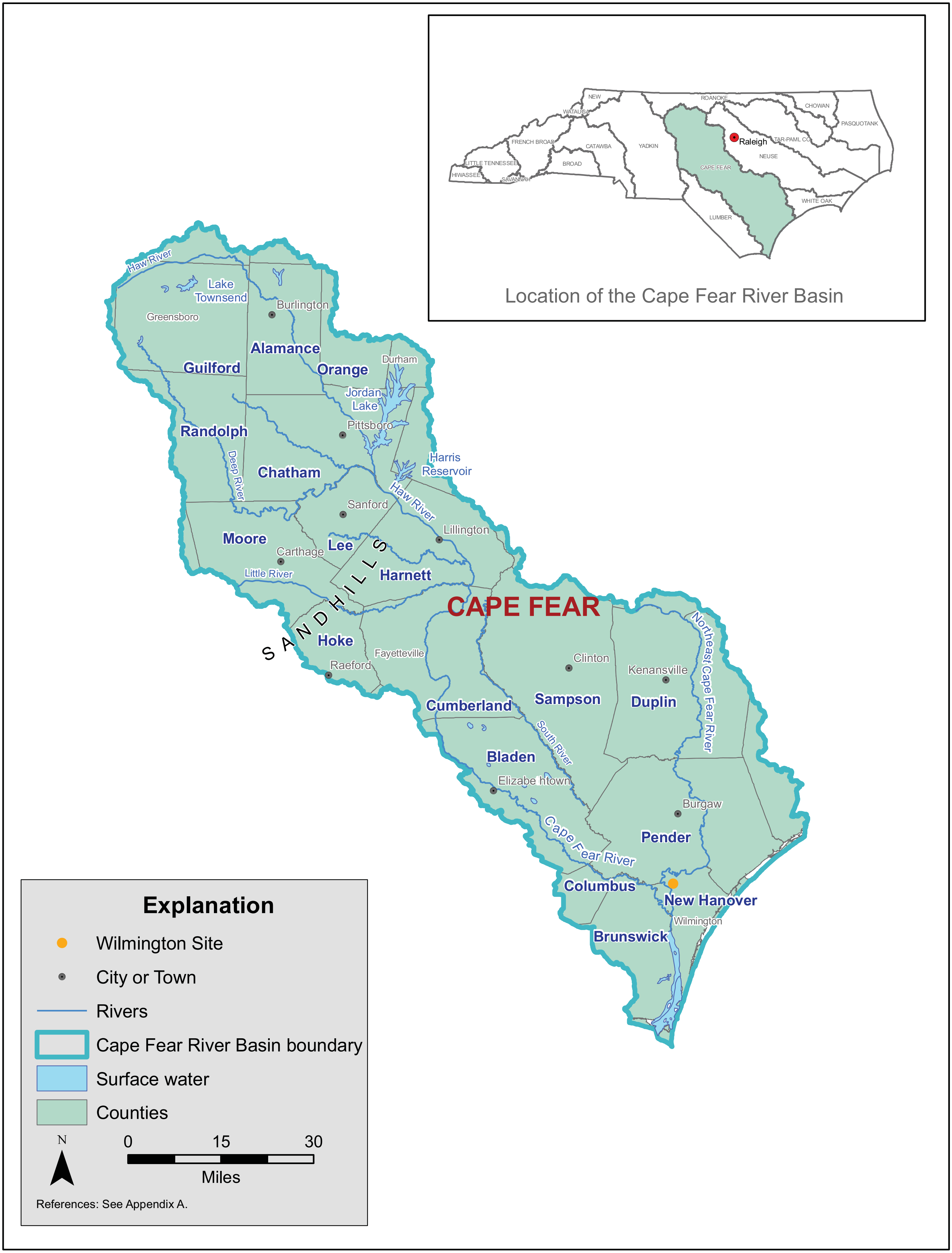
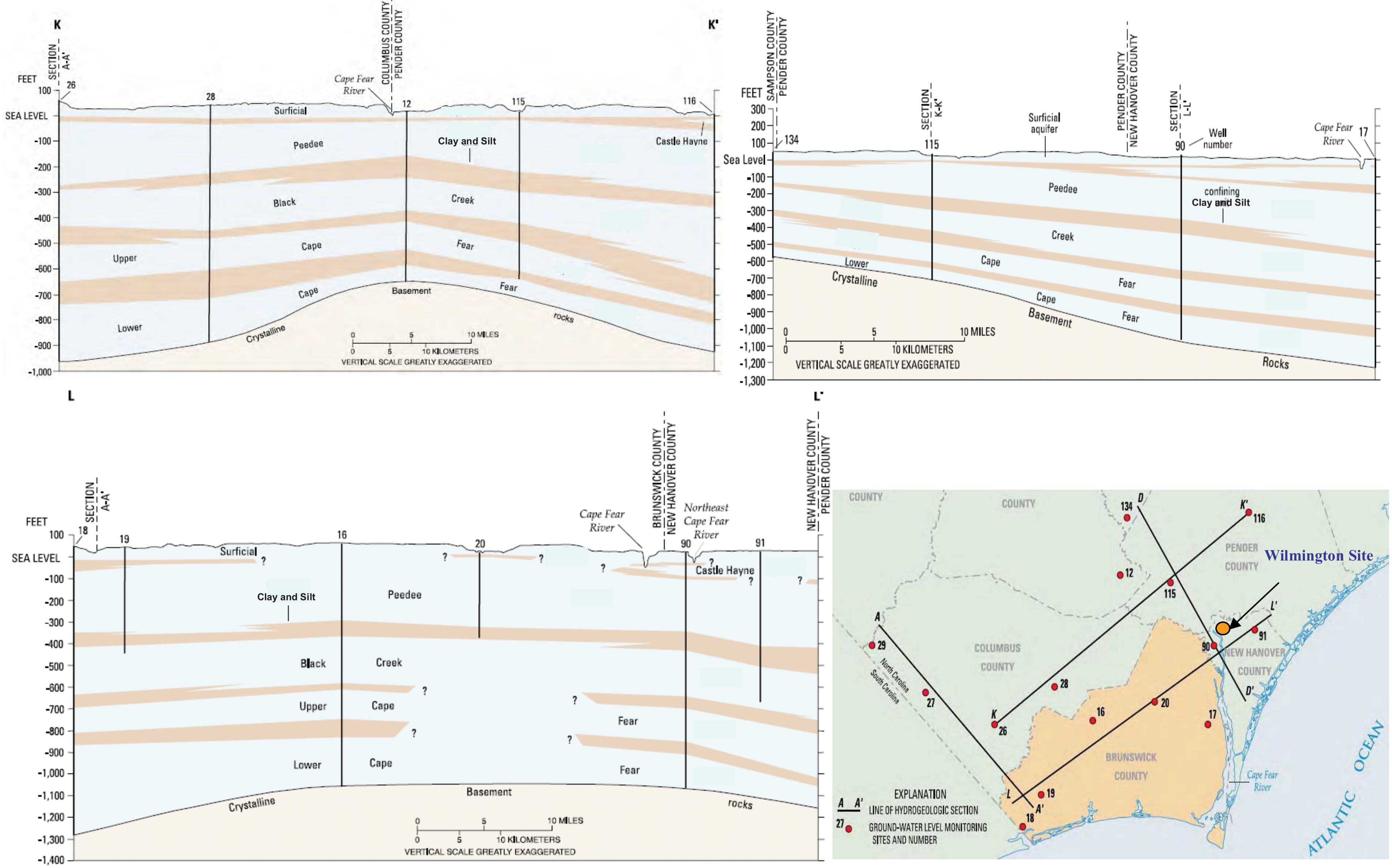


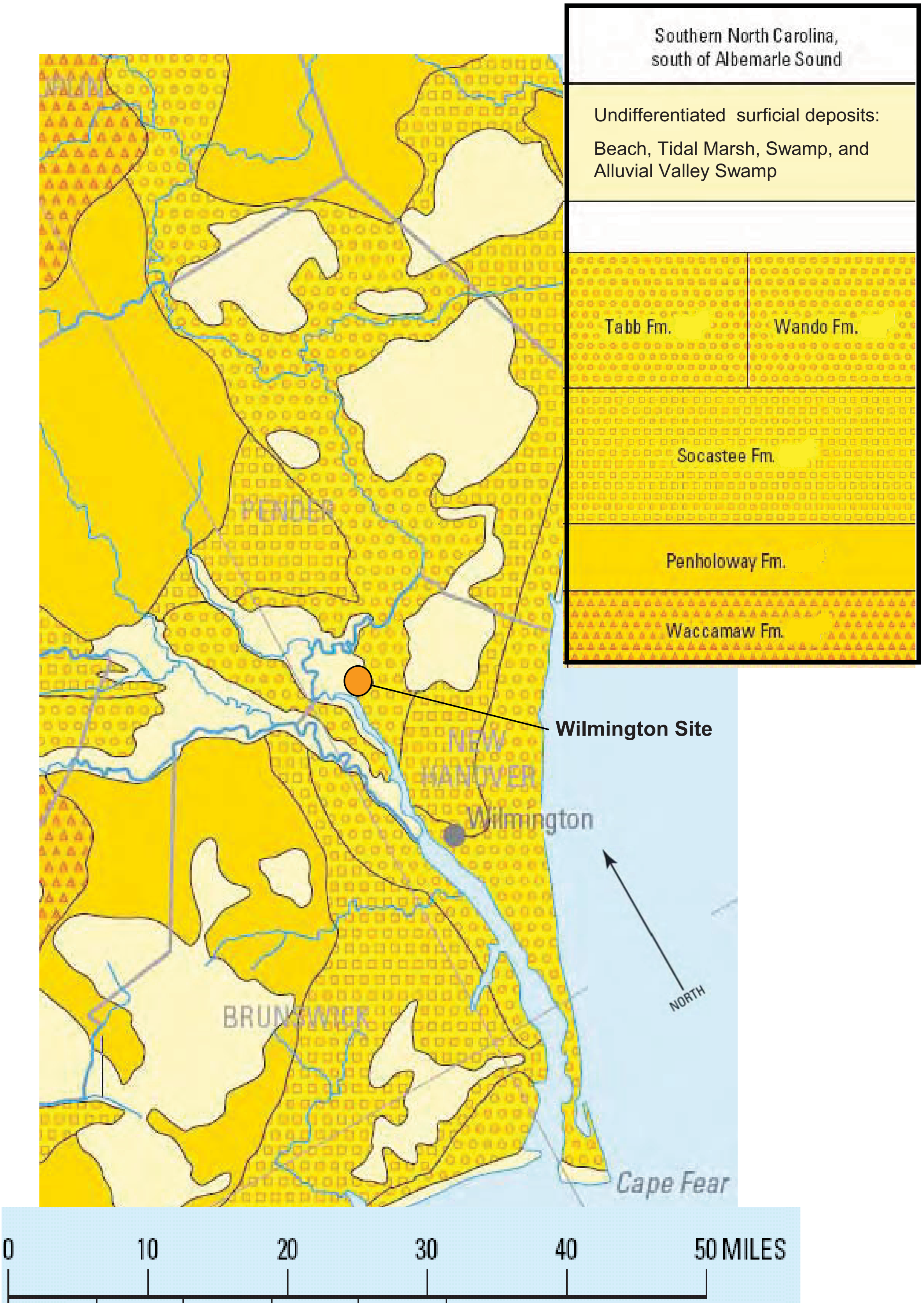

**Figure 3.3-15. Wilmington Site location in Cape Fear River basin.**

Date: 1-25-2008
Status: DRAFT




Reference: Fine and Cunningham, 2001

**Figure 3.3-16. Geologic cross-sections in the general vicinity of the Wilmington Site.**




Reference: Ator et al , 2005

**Figure 3.3-17. Quaternary deposits exposed at ground surface in the general vicinity of the Wilmington Site.**

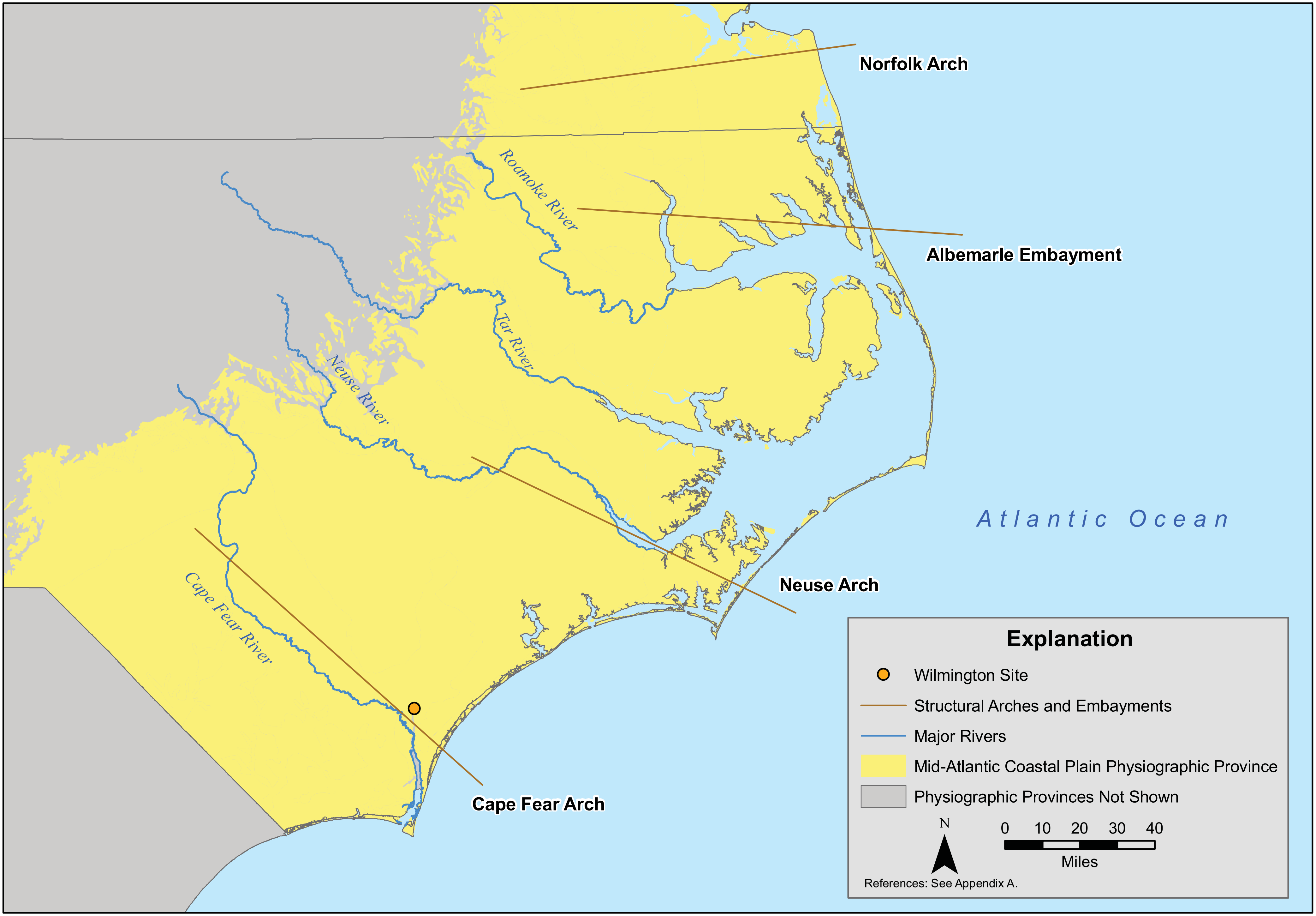



**Figure 3.3-18. Structural arches and embayments in the general vicinity of the Wilmington Site.**

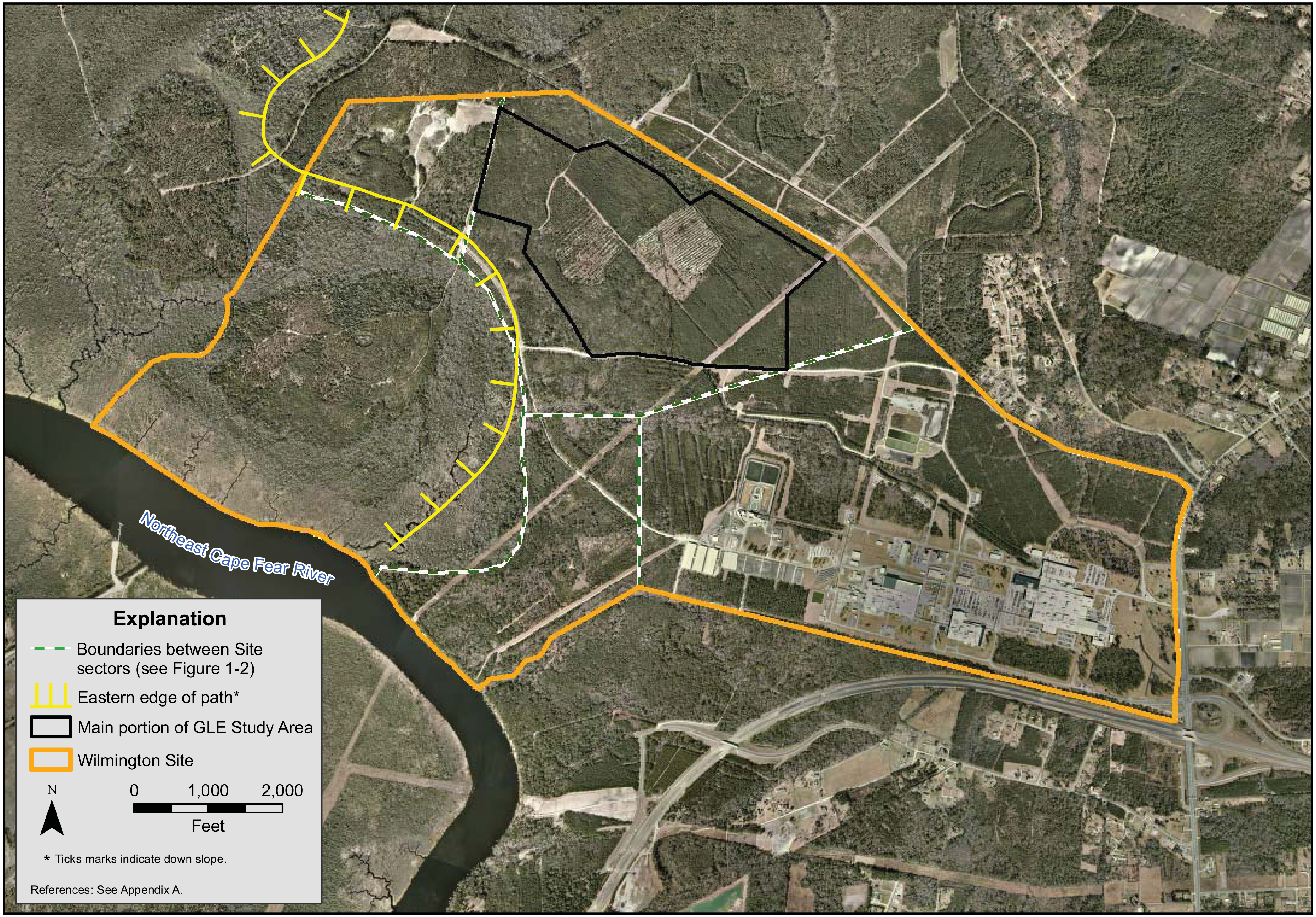
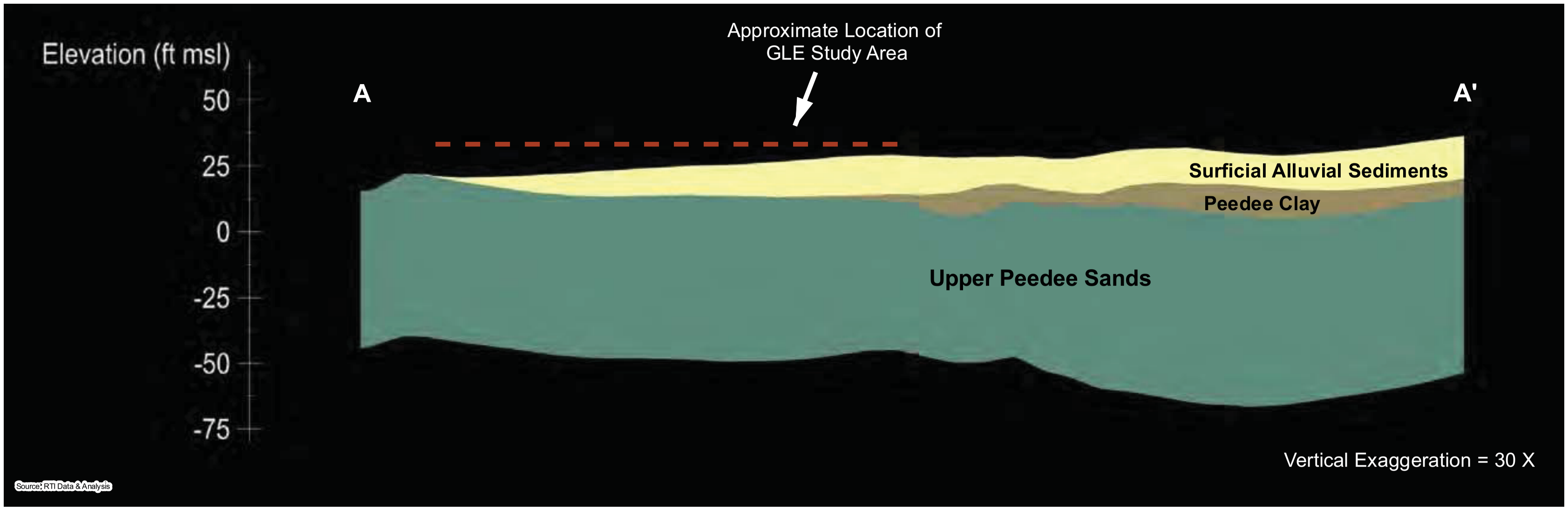



**Figure 3.3-19. Abandoned channel path of the Northeast Cape Fear River (west of the yellow line).**



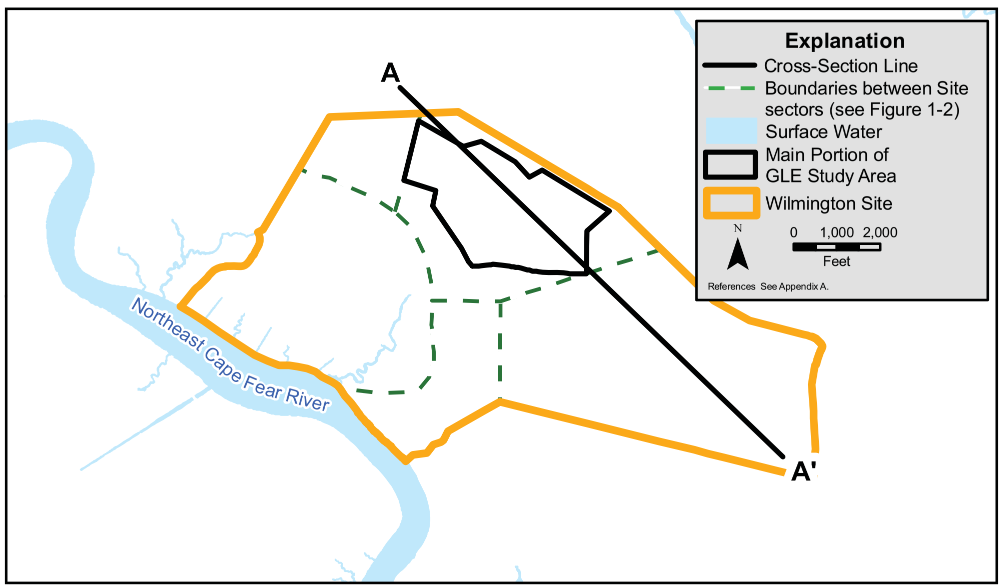




Figure 3.3-20. Conceptual stratigraphy of the Peedee Sands, Peedee Clay, and surficial alluvial sediments.

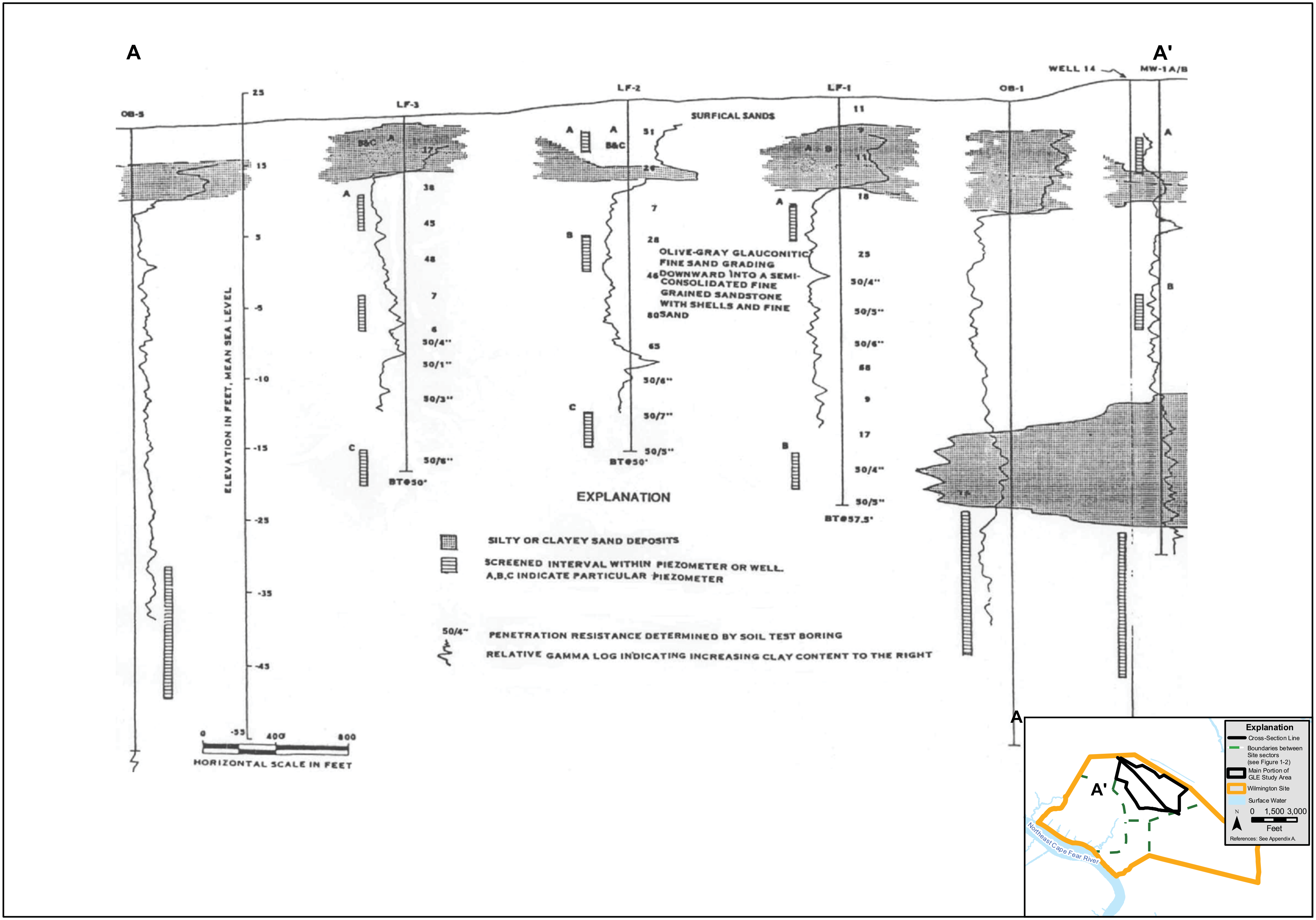



Figure 3.3-21. Northeast-southwest cross-section through the North-Central Site Sector (LF-Well Series).

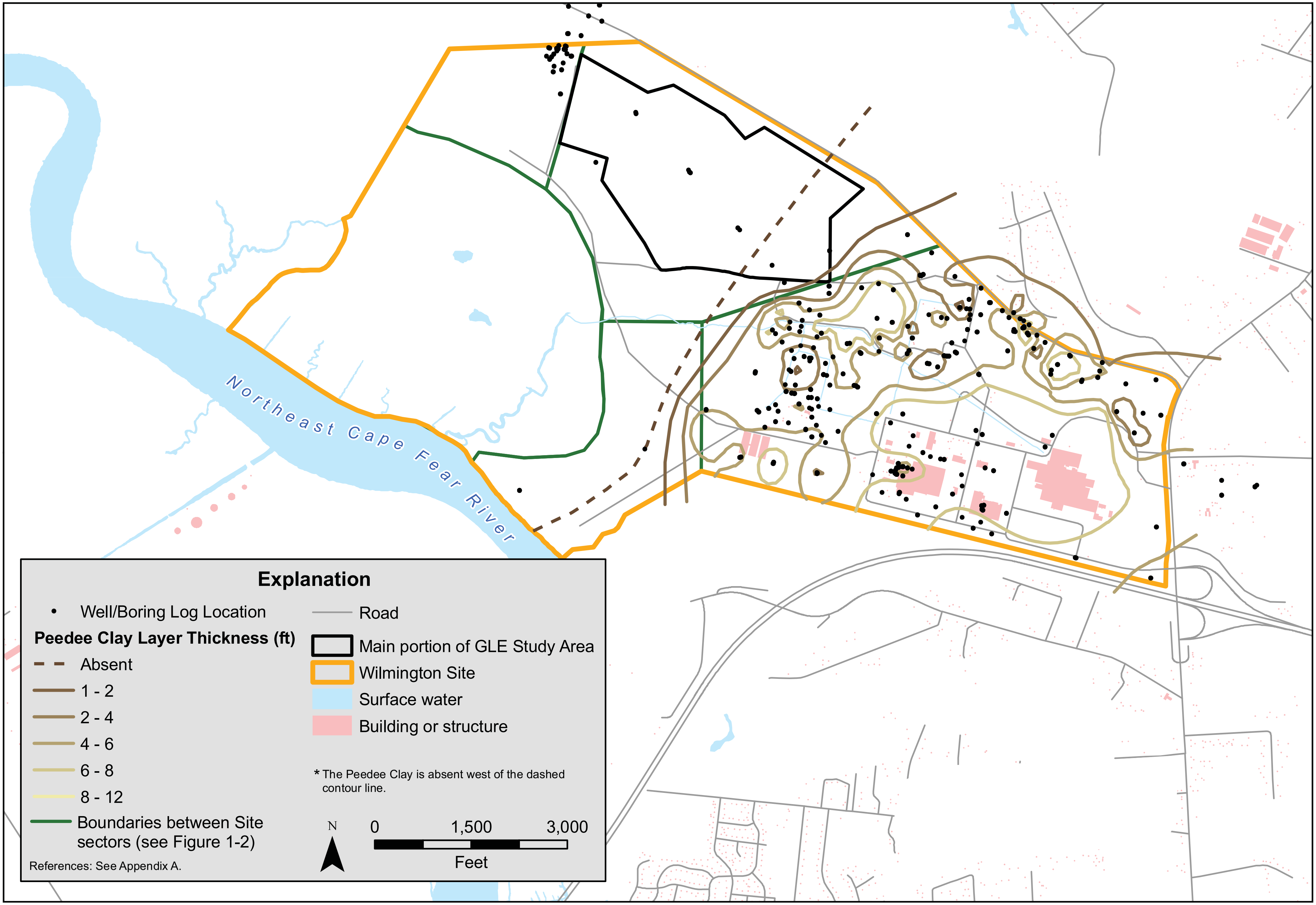



**Figure 3.3-22. Isopach map of Peedee Clay layer of marine origin at the Wilmington Site.**

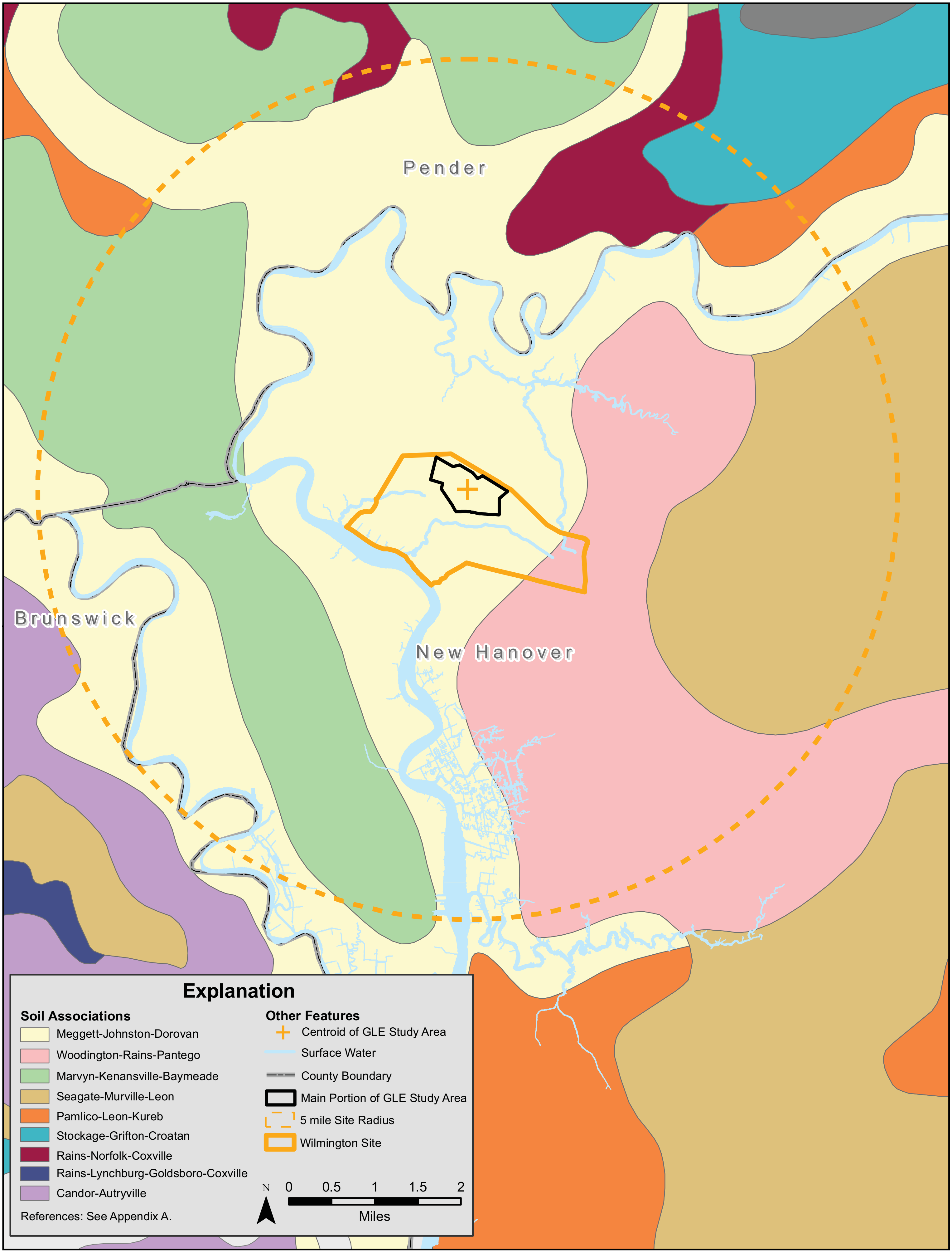



**Figure 3.3-23. Major soil associations within 5-miles (8 km) of the Wilmington Site.**

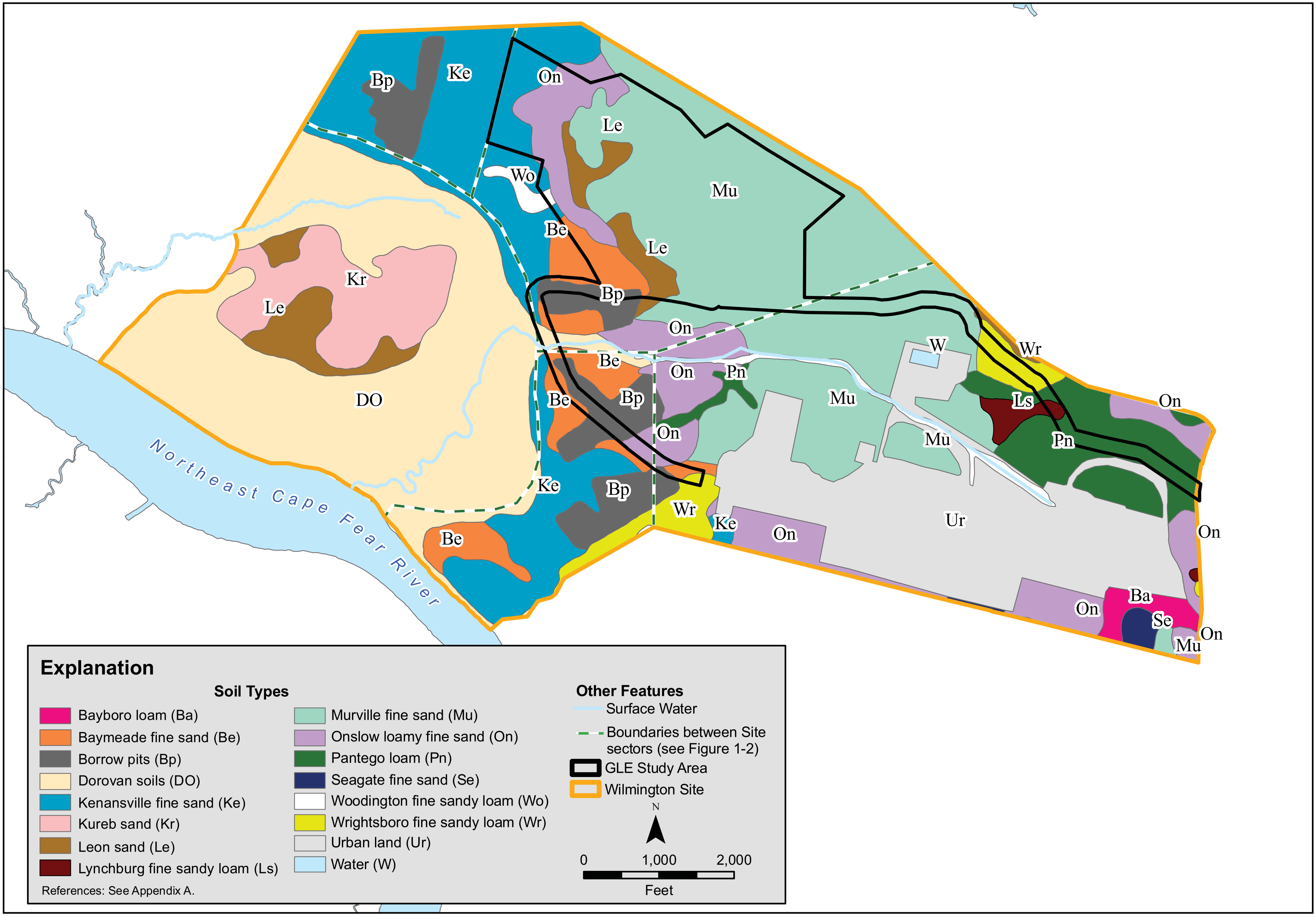



**Figure 3.3-24. Soil types within the Wilmington Site.**

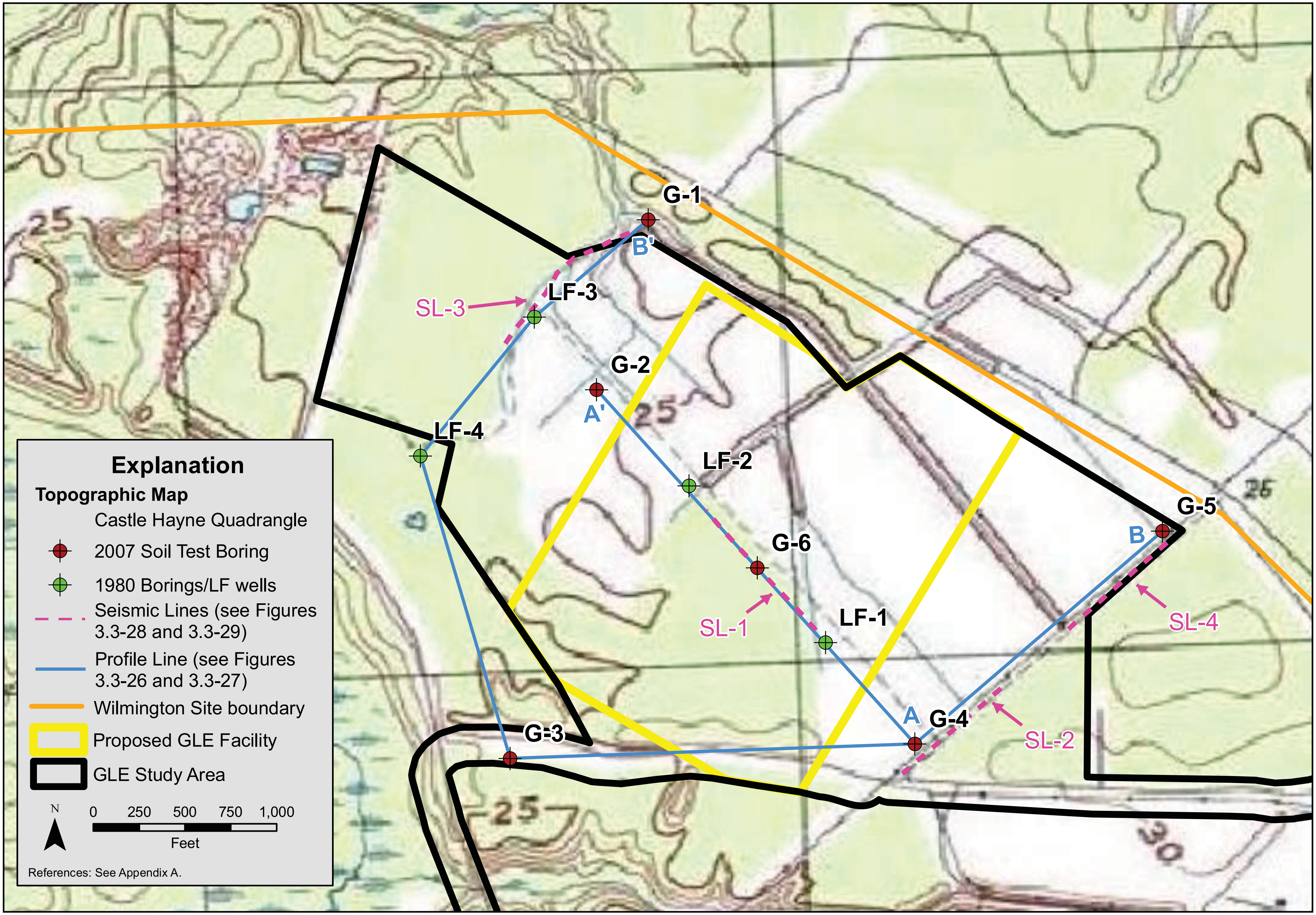



Figure 3.3-25. Geotechnical investigations in the GLE Study Area.

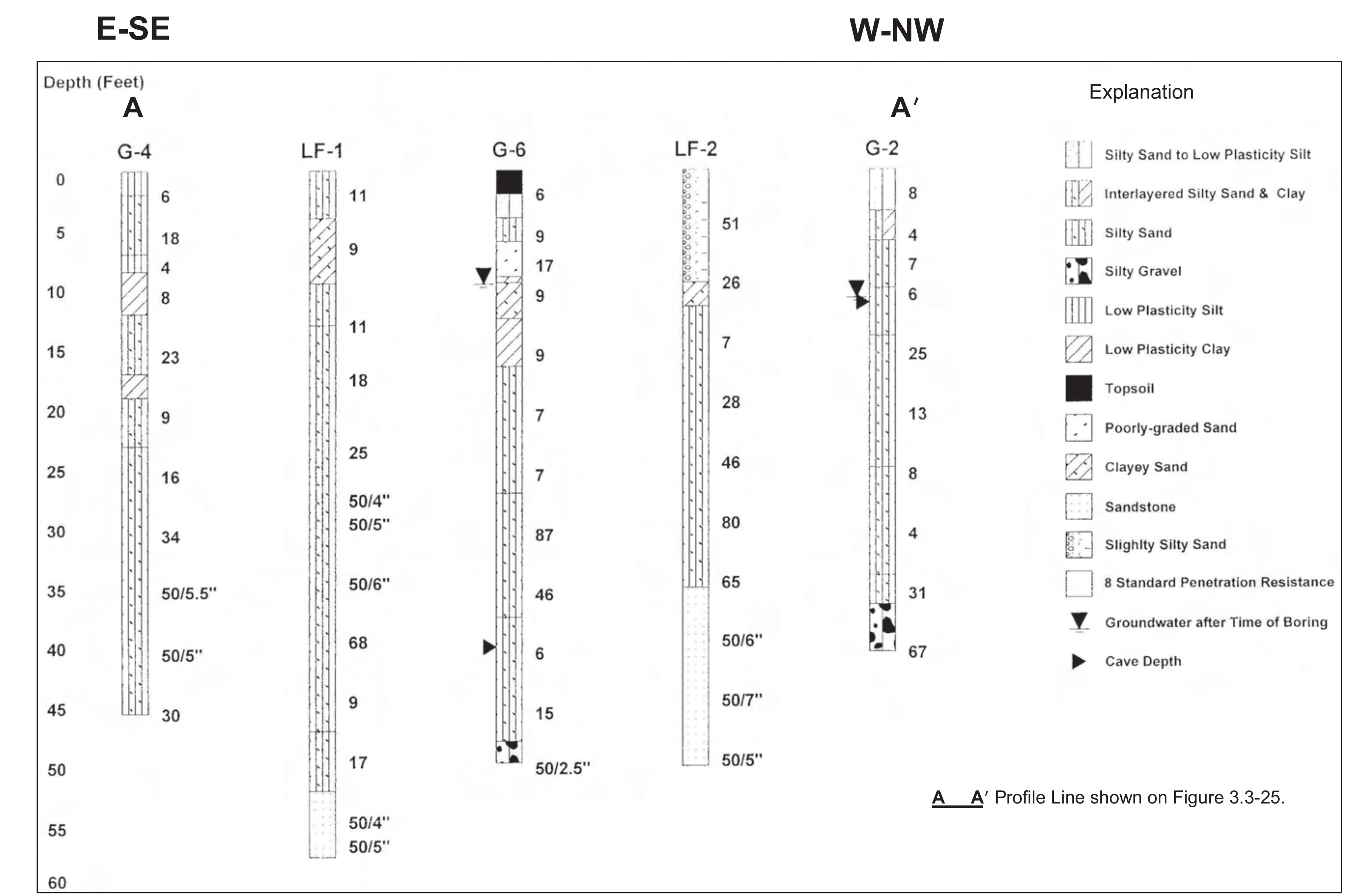



**Figure 3.3-26. Generalized subsurface profile (A–A′).**

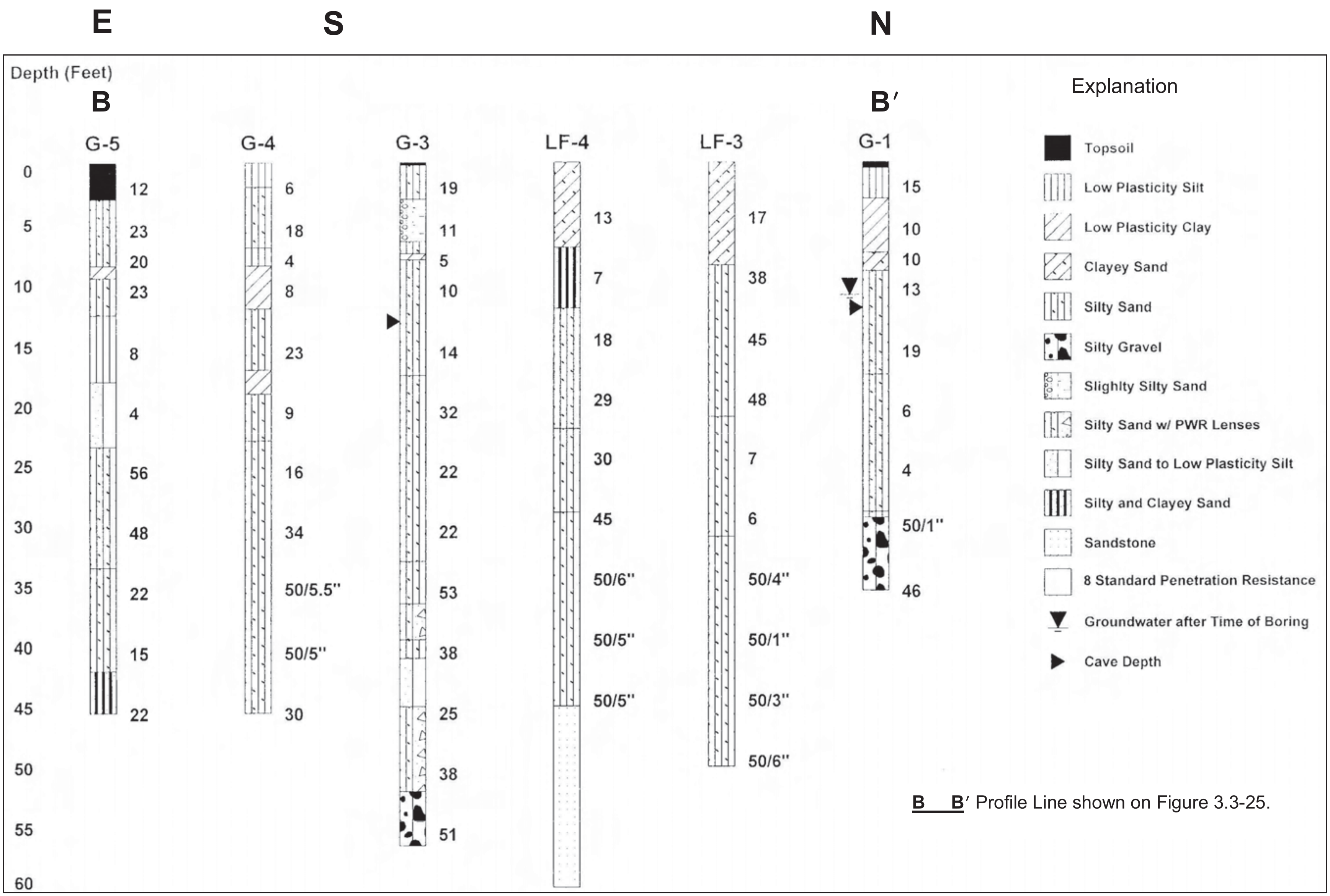
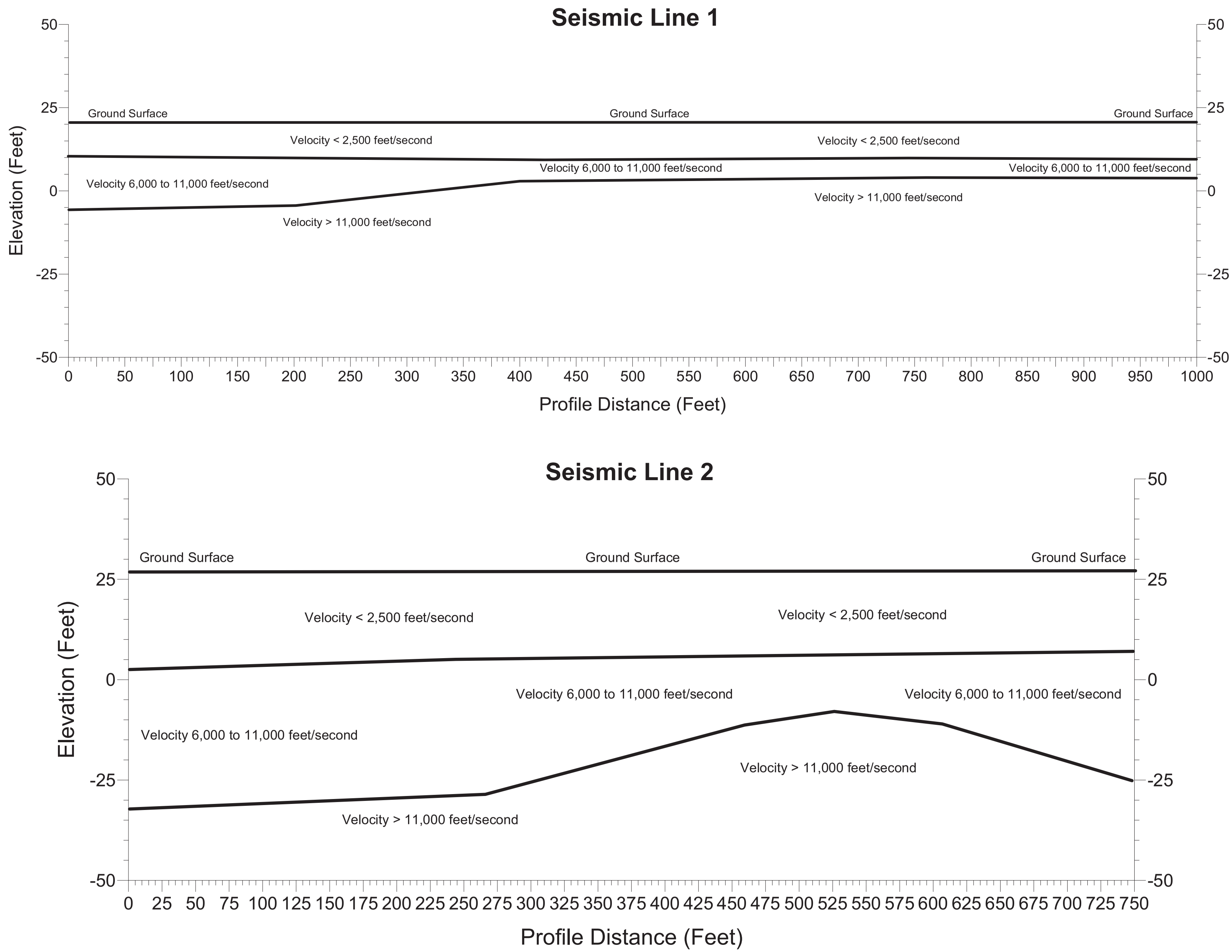



**Figure 3.3-27. Generalized subsurface profile (B–B′).**




Vertical exaggeration = 3:1.

**Figure 3.3-28. Seismic refraction velocity profiles (Seismic Lines 1 and 2).**

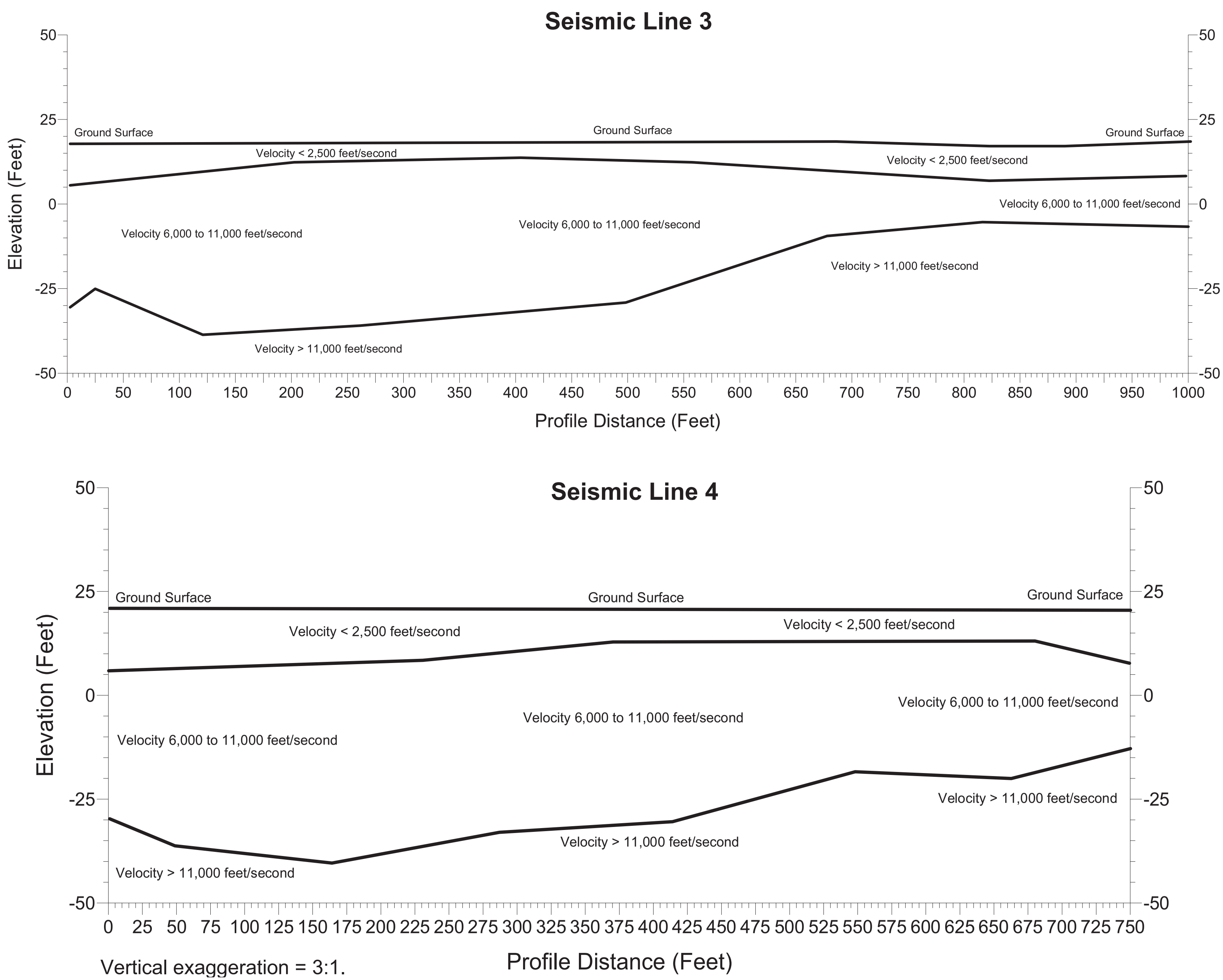



**Figure 3.3-29. Seismic refraction velocity profiles (Seismic Lines 3 and 4).**

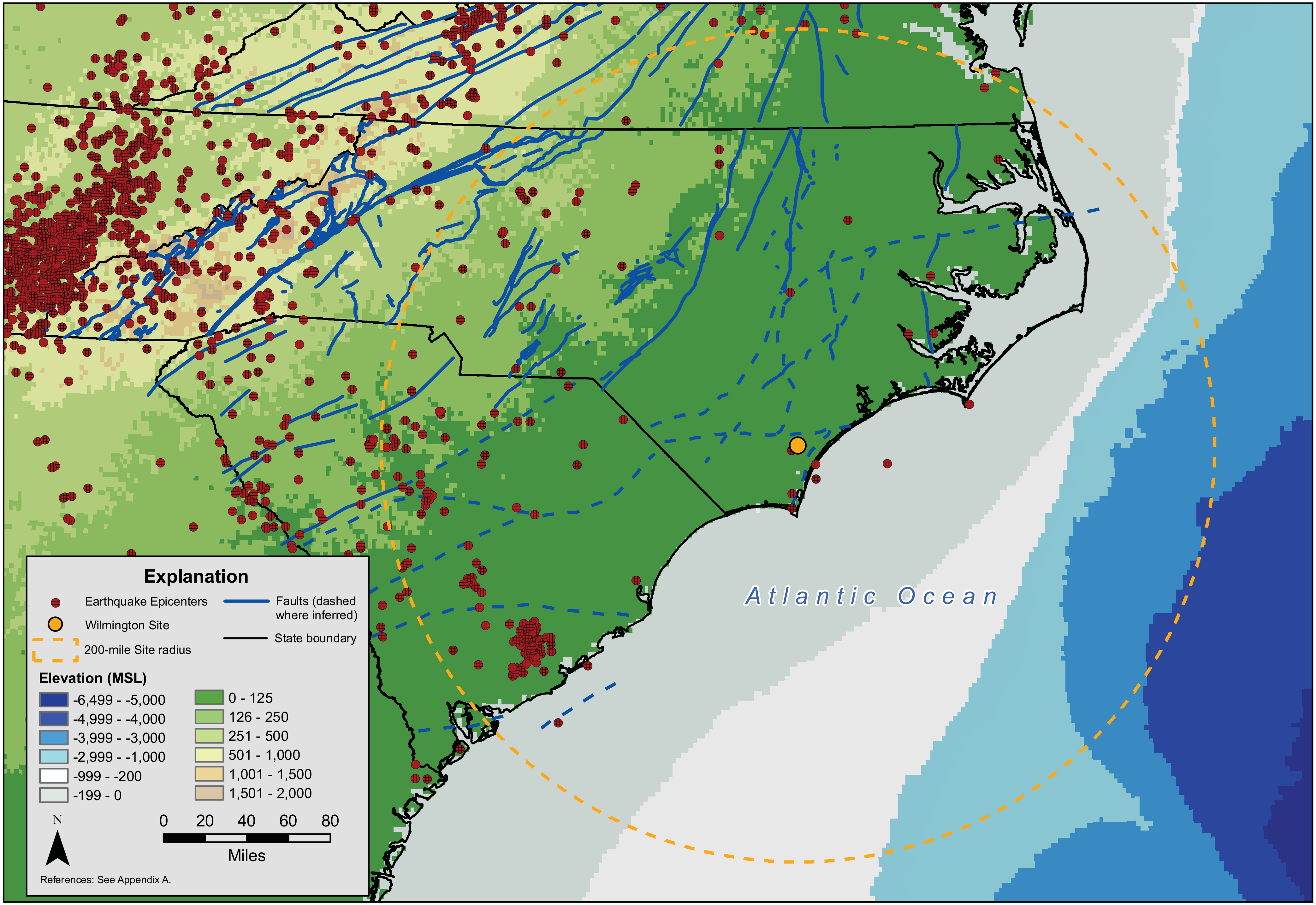
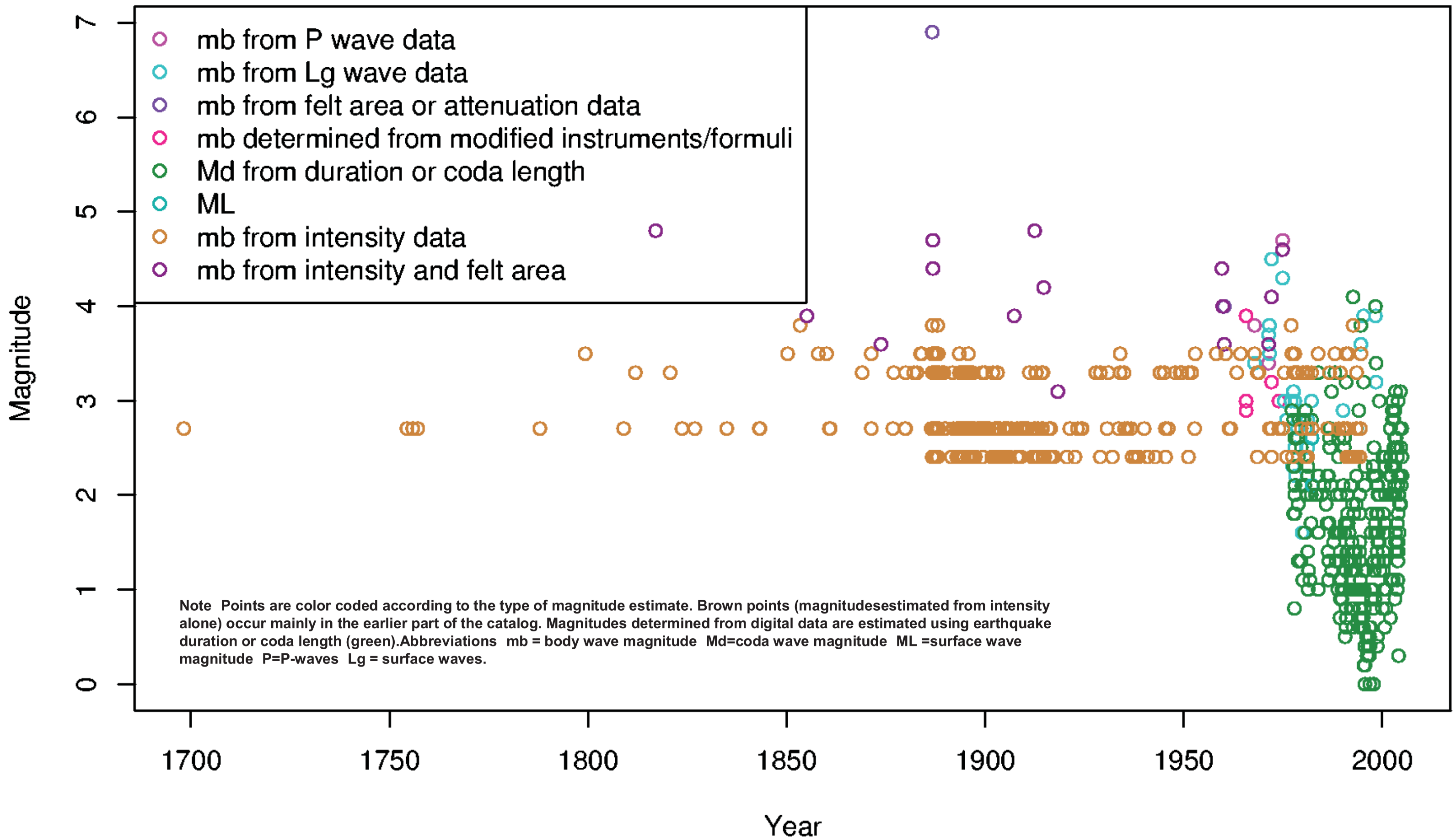



Figure 3.3-30. Regional topographic relief map showing faults, inferred faults, and earthquake epicenters.




Reference: SEUSSN, 2008

**Figure 3.3-31. Plot showing earthquake event magnitude estimates over time for earthquakes within 200 miles (322 km) of the Wilmington Site.**

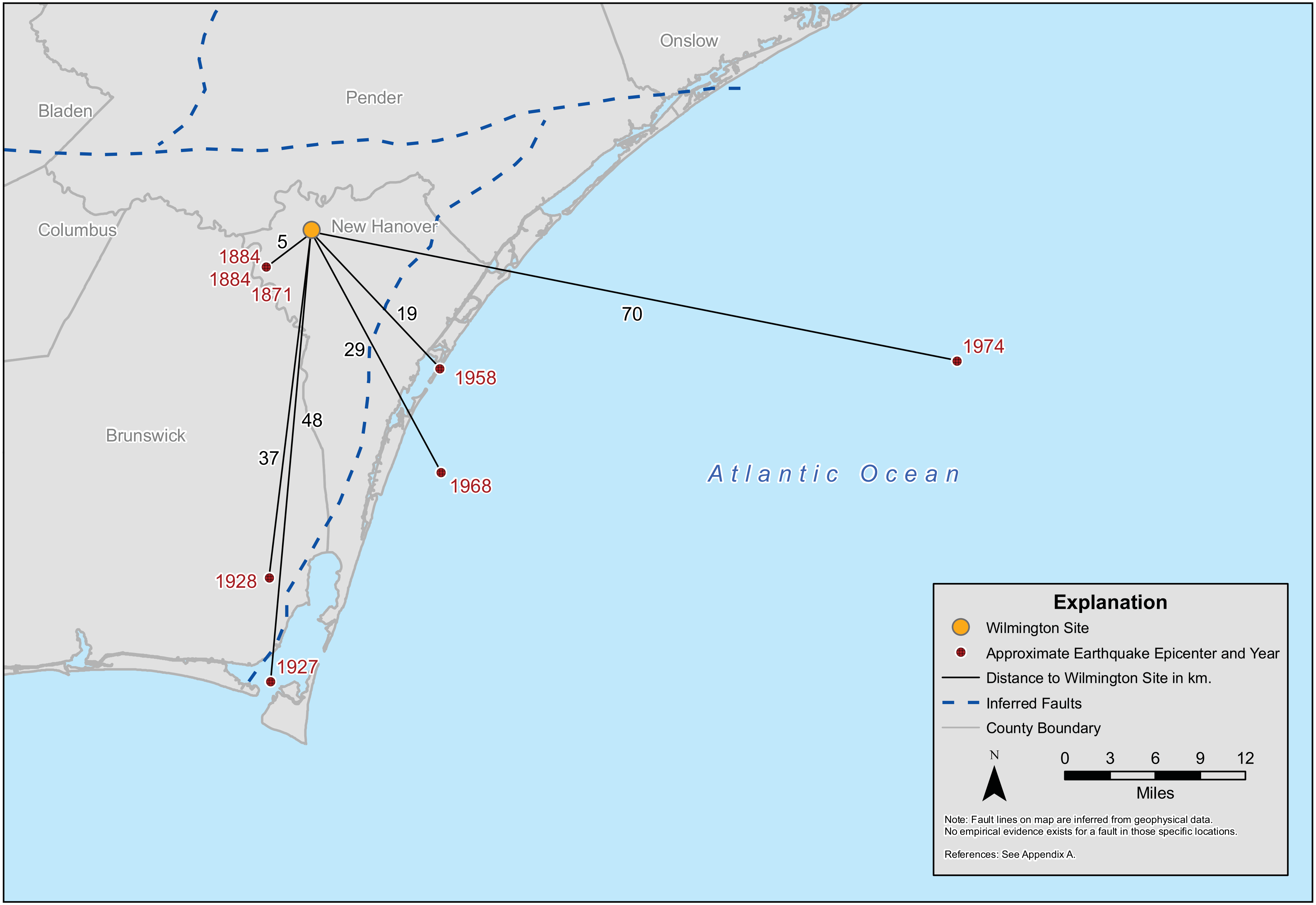



**Figure 3.3-32. Recorded earthquake events and inferred faults within 43.5 miles (70 km) of the Wilmington Site.**

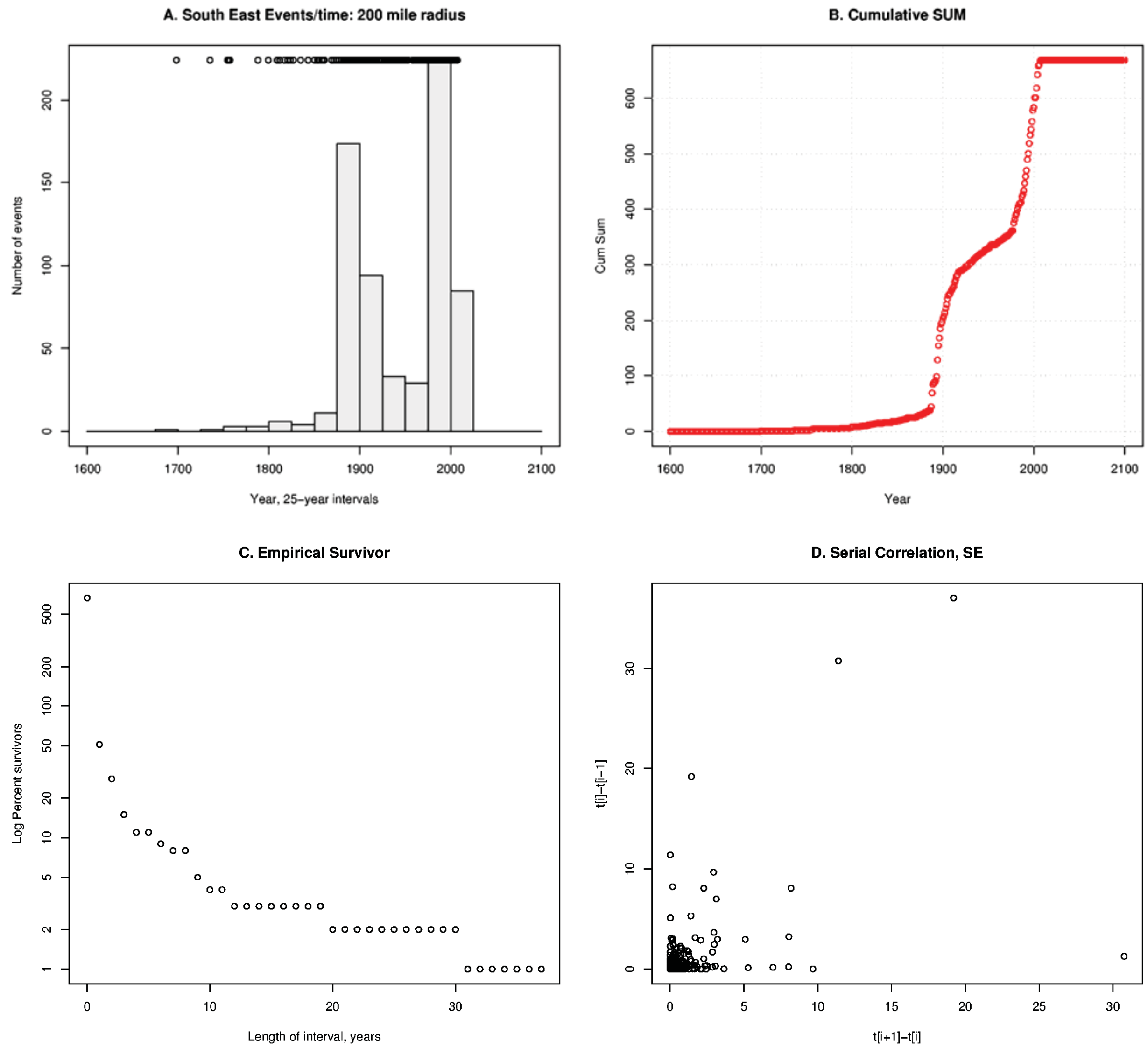



**Figure 3.3-33. Statistics of earthquake occurrence within 200 miles of the Wilmington Site.**

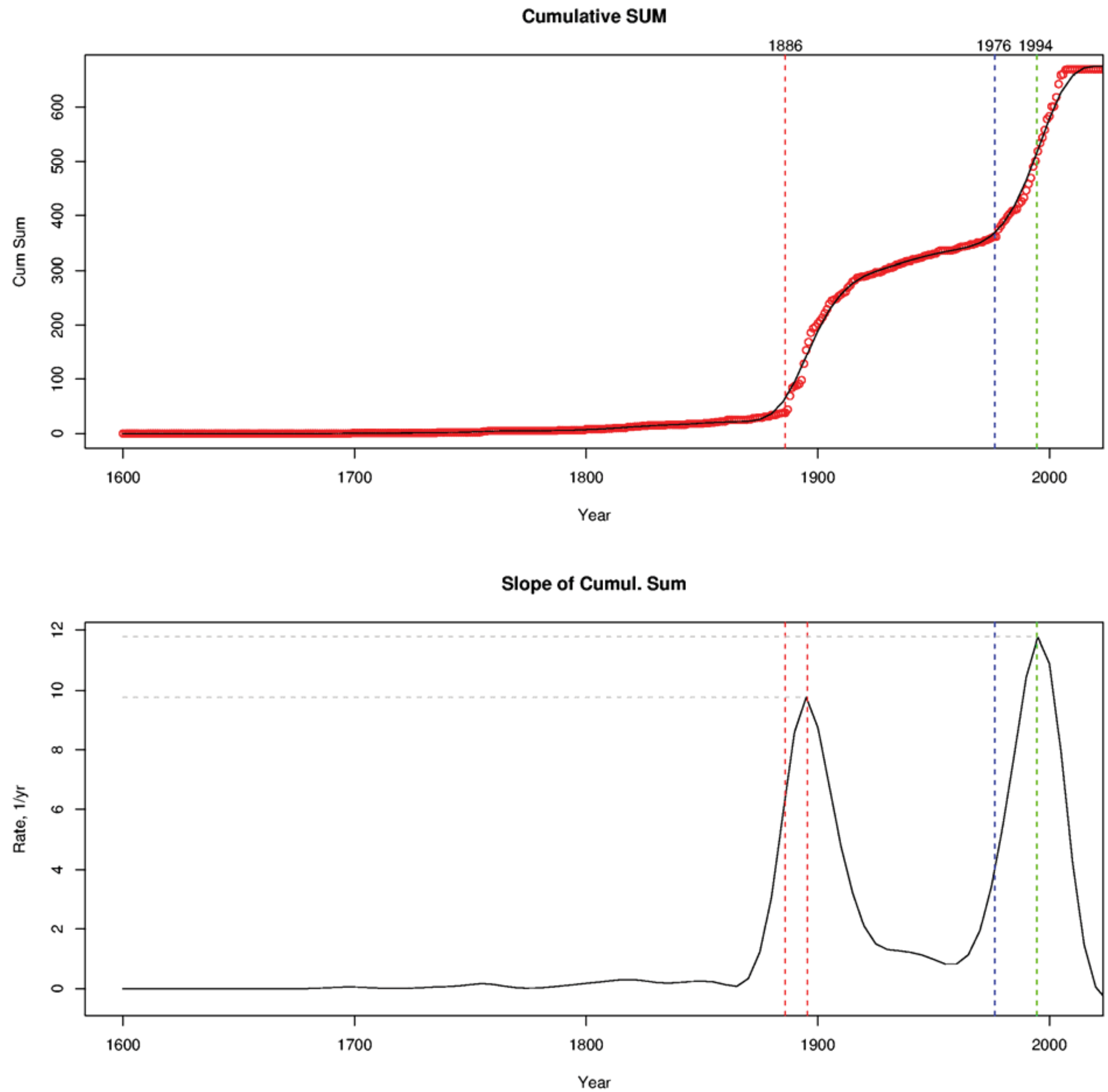



**Figure 3.3-34. Estimation of earthquake recurrence rates.**

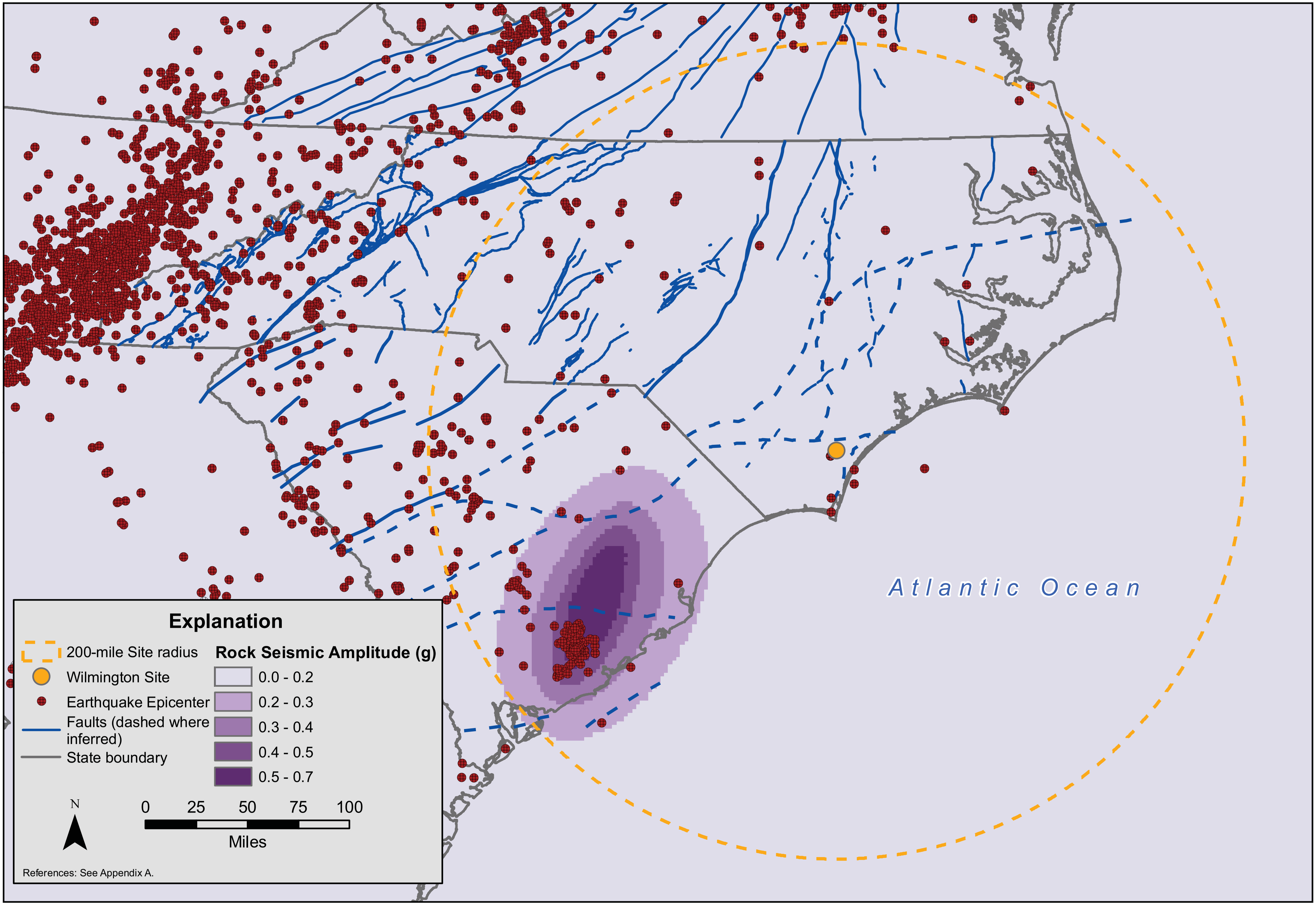



**Figure 3.3-35. Map showing 50-year 2% exceedance probability for ground motion shaking at 5-Hz frequency.**

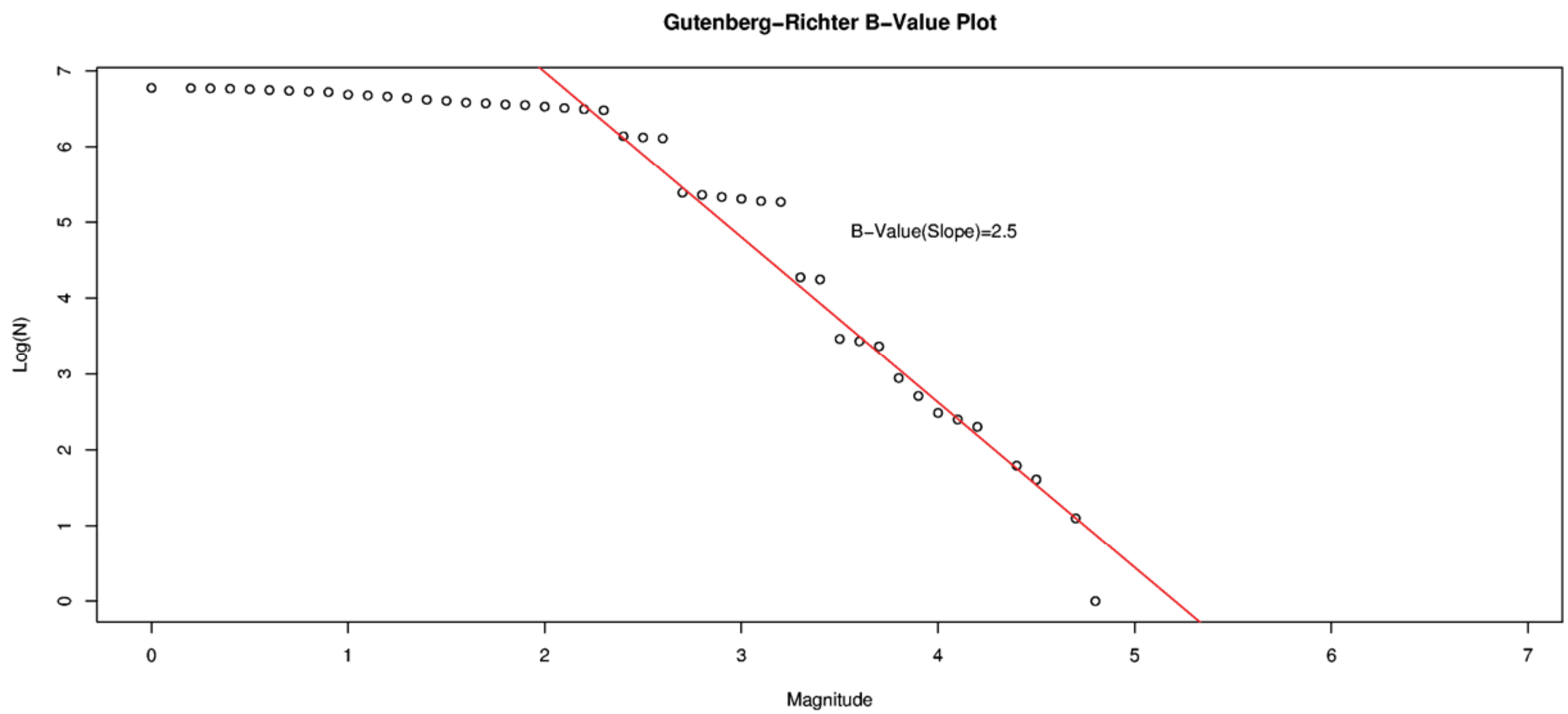



**Figure 3.3-36. Gutenberg-Richter relationship (b-value) for earthquake events within 200 miles of the Wilmington Site.**