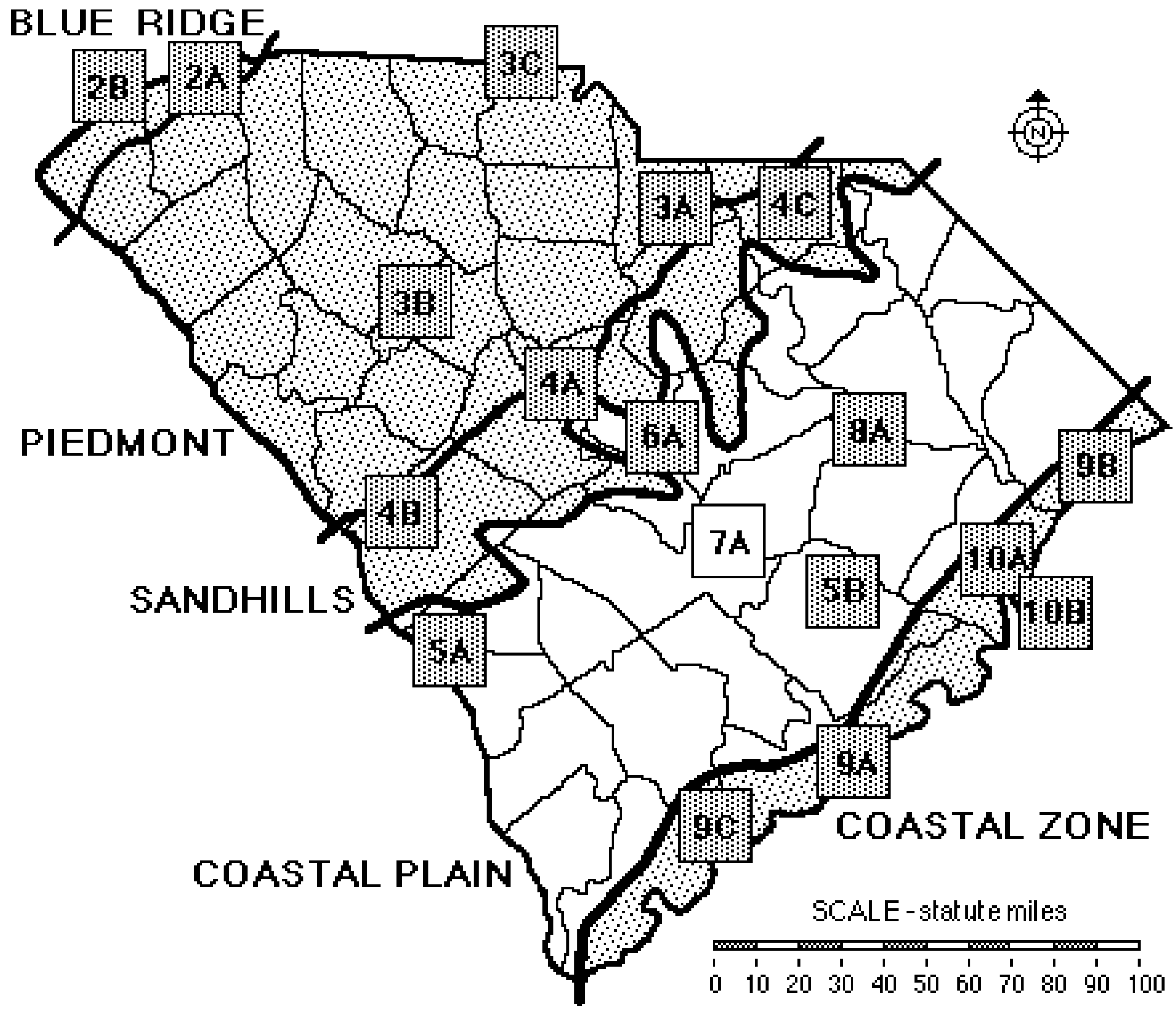
SECTION 7

COASTAL PLAIN REGION / KARST TOPOGRAPHY



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SECTION 7

COASTAL PLAIN / KARST TOPOGRAPHY

POWER THINKING ACTIVITY - "Indian Mound Maneuver"

Imagine you are a Native American warrior in the Santee Nation in A.D. 1250 living near a set of caves (presently located in the southern portion of Santee State Park) not far from the west bank of the Santee River (the position of the Santee River channel underneath Lake Marion is labeled on the LAKE MARION TOPOGRAPHIC MAP). You want to attend a festival at the famous ceremonial mound (known today as the Indian Mound) across the Santee River in what today is called the Santee National Wildlife Refuge. Locate both landmarks, the caves and the Indian Mound, on the LAKE MARION TOPOGRAPHIC MAP and the LAKE MARION LITHOGRAPH. Remember that Lake Marion is an artificial reservoir and did not exist in A.D. 1250. What will be your quickest route from the caves to the mound? Explain. How long would it take you to travel that distance? How would you travel, by canoe, on foot, or a combination? What factors would affect the speed you could travel? List three major obstacles that you might encounter on your journey. From how far away could you actually see the Indian Mound? Explain your answer.

PERFORMANCE OBJECTIVES

1. Recognize Karst topography by the presence of sinkholes, disappearing streams, and other features on topographic maps and lithographs.
2. Determine elevation of groundwater table in Karst areas by estimating elevation of surface water features.
3. Explain distribution of limestone rock in South Carolina by referring to geologic history of the state.
4. Assess environmental impact of depositing hazardous materials in areas underlain by Karst topography.
5. Evaluate environmental and economic impact of damming rivers to form lakes, including specific impact on wildlife refuge areas from variation in lake levels.
6. Calculate percentages, seasonal population changes, and probability of sighting specific waterfowl species using National Wildlife Refuge data.
7. Interpret meaning of color variations in lakes, ponds, creek tributaries, Carolina Bays, and other wetland areas as seen on lithographs.
8. Locate Fort Watson and evaluate historical significance of this site as both an Indian Mound and later as the location of a Revolutionary War skirmish.
9. Use fishing tales and other outdoor stories as a springboard for storytelling and writing activities.

BACKGROUND INFORMATION

Description of Landforms, Drainage Patterns, and Geological Processes

Characteristic Landforms of Karst Topography

Karst topography is the term taken from the name of a region in Eastern Europe which is given to landscapes which are sculpted primarily by groundwater activity. Any soluble rock can produce typical Karst features, but nearly all examples in the eastern United States occur in **limestone** belts. A major clue to the presence or absence of Karst topography is the pattern of stream drainage. An area with several **disappearing streams** and many springs is a likely candidate for Karst. Groundwater slowly dissolves underground rock until the surface becomes unstable and collapses, forming **sinkholes**. Sinkholes often merge to form a linear valley, called a solution valley, which has no visible stream in it and may have no visible outlet for surface water. Karst areas are often hilly if the geologic processes have progressed far enough for sinkholes and solution valleys to form. Extensive cave systems often underlie these surface features, but are rarely visible at the surface. Some sinkholes may fill with water, creating small lakes. Karst features may not be immediately noticed on maps or photographs because sinkholes are the only distinct landform feature easily visible at the surface. Other features can be seen only from ground level or underground.

Geographic Features of Special Interest

The Santee Limestone underlies a large portion of the South Carolina **Coastal Plain** Region but is exposed at the surface only along the Santee River valley and its surrounding counties. The most spectacular example of Karst topography is located in Santee State Park along the western shore of Lake Marion. The park contains sinkholes, caves, disappearing streams, solution valleys, and **sinkhole lakes**. Park naturalists conduct tours of the caves during times when visits will not bother the native bat population. Rock samples, many of which contain fossils, may be found outside of the park boundaries on both sides of Lake Marion. The limestone itself is composed of a mixture of limey sands, lime muds, and shell-hash layers. Accumulations of oyster beds, from the shallow continental shelf located here 40 million years ago, are found in several places within the major sinkhole area of Santee State Park.

The best place to see large amounts of limestone rock is in one of the many limestone quarries located to the west of Lake Marion and Lake Moultrie. Most of these quarries will permit visits by school groups. One example is the Giant Portland Cement quarry located about two miles from Harleyville in Dorchester County. Walls of limestone rise up to 40 feet out of the bottom of the quarry and provide diverse examples of sediment from several different sub-environments present on the long-ago continental shelf. Some of the limestone layers are highly **fossiliferous**, with bryozoa and mollusk fragments being the most common fossils.

How Limestone Forms

The limestone, which lies exposed along the western shore of Lake Marion, is given the formation name, Santee Limestone, because it was first described near the town of Santee. This limestone is very pure and generally extremely porous. Most limestones are chemically produced rocks formed in warm, shallow ocean environments far away from sources of sand and mud which would tend to contaminate the deposit.

Environmental conditions necessary for limestone deposition existed in parts of South Carolina during the Eocene Epoch about 40 million years ago. After limey material was deposited and buried by overlying sediment, additional calcium carbonate and magnesium carbonate were precipitated from groundwater to glue the rock together. This rock formation is characterized by high **porosity** and **permeability**, traits which give it the ability to hold and transmit water. This distinguishing feature makes the limestone a good **aquifer** or carrier for groundwater. Because the formation underlies most of the Coastal Plain, farmers and others can drill wells down into the limestone rock and pump out large quantities of good quality water for crops and human consumption.

Fossils

Many animals and plants that live in a marine environment leave behind shells or other indicators of their existence when they die. These may eventually turn into fossils within the rock, and they can be used to help identify and date the geological formation in which they are found. Many kinds of fossils are found in the Santee Limestone Formation, but the most common are shells of clams and snails and colonies of bryozoa, which resemble coral but are internally quite different.

Another important use of fossils is to help geologists interpret environmental conditions in the past, when these organisms were alive. For example, fossils with thick shells are more likely to be from animals that lived in higher energy, wave-dominated environments where thick shells were an important protective feature for the organism. Organisms with very fragile shells could not have survived extensive wave action, so geologists use their fossils as indicators of deeper water, lower energy environments. Many of the fossil layers are composed of a mixture of broken-up shell fragments, suggesting the aftermath of a large storm, perhaps a hurricane. Similar deposits can be observed today along beaches which have experienced storm activity.

Development of Karst Topography

The Santee Limestone is the only rock formation in the state in which Karst topography has developed on a large scale. The formation of Karst topography requires acidic groundwater and time. Most rainwater is slightly acidic due to the absorption of carbon dioxide from the atmosphere by raindrops. It is this rainwater containing carbonic acid which soaks into the ground to become groundwater, which becomes even more acidic as it assimilates organic acids from plant roots and decaying vegetation. The result is a weak but effective chemical agent that slowly dissolves limestone rocks and soil particles. As **dissolution** continues, the limestone develops cracks, holes, passageways, and eventually open caverns which allow even more water to penetrate the rocks. In limestone regions, more water travels underground than on the surface and caves can grow so large that their roofs finally collapse to form sinkholes.

Caves

Open caverns, or caves, are some of the most interesting features in areas of Karst topography. As long as caves are below the groundwater table, they will continue to grow larger as the dissolution of limestone slowly continues. However, once the groundwater table drops below cave level, a different process takes over. Highly acidic water dripping into an open cave will slowly evaporate, leaving behind a crusty accumulation of mineral salts, especially calcium carbonate (calcite). Stalactites, stalagmites, and other deposits, known collectively as dripstone, will eventually fill a cave completely if the process is not interrupted. Until that time, caves provide important specialized ecosystems for animals like bats.

Groundwater Flow and the Groundwater Table

Karst topography can influence land use patterns to some extent, but its most important effect is on groundwater flow. Even in Coastal Plain counties where the Santee Limestone is not exposed at the surface, most wells for agriculture and home drinking water are drilled into this formation. Not only do wells in this region take advantage of the abundant supply of water stored in the underground pore spaces, but they also benefit from the high permeability or flow rates at which water can be pumped from the ground. However, with so many interconnected passageways underground, it is very easy for pollution to spread quickly from one area to another. A single contamination site can affect wells and water supplies in areas many miles away. Once pollution is introduced into this type of groundwater system, it is extremely difficult to contain the pollutant or to clean it up.

An important component of any groundwater system is the precise elevation of the groundwater table, the top of the saturated part of the soil. This term actually refers to the level in rock or soil above which water can only move downward, under the influence of gravity, but does not remain. This boundary is not fixed but can rise or fall through time depending on long-term weather patterns. For example, during times of drought, the elevation of the groundwater table would be significantly lowered. Because wells must be drilled below the groundwater table to be able to pump water, it is important to know the elevation of the groundwater table so that a well can be drilled deeply enough to continue producing water even during a drought. The elevation of the groundwater table can be measured directly in wells, but it can also be approximated by observing water levels of lakes, **swamps** and other bodies of standing surface water. As is true for any humid region, the water elevation in a river, lake, or swamp is approximately the same as the groundwater table elevation in the immediate vicinity.

Santee Indian Mound

The Santee Indian Mound is a well-preserved example of flat-topped Native American ceremonial mounds that were once located throughout the southeastern United States. This particular mound was a gathering place serving much of the central Coastal Plain of South Carolina. It served as a platform on which a temple could be built. The temple was constructed of upright posts through which small sticks were woven and then plastered with mud. The roof was thatched with straw. The mound probably served as a central distribution point for food and other supplies as well. These mounds have sometimes been mistakenly identified as burial mounds, but their shape and function were very different from those of burial mounds.

Temple mounds first appeared in the Mississippi River Valley about A.D. 1000, and shortly thereafter became commonplace in the southeastern United States. Archaeologists theorize that the Santee Indian Mound was built sometime between A.D. 1200 and A.D. 1400 because it occurs along the easternmost extension of the region inhabited by the mound building culture. The spread of the mound culture coincided with the spread of large scale agriculture and trade among the Native American population.

It is highly probable that the Santee Indian Mound site was once a part of the Province of Cofitachiqui, a Native American cultural region with its center near present-day Camden. Cofitachiqui was visited between 1540 and 1542 by the Spanish explorer Hernando de Soto who wrote that the people he found around the mound site were generally healthy and taller than Europeans. The Province of Cofitachiqui was ruled at that time by a female priestess, a situation which was not uncommon in that culture. Nobody really knows why the mound builders died out over the next hundred years, but diseases introduced by Europeans, which are known to have killed thousands of Native Americans, may have played a significant role.

Francis Marion Captures Fort Watson

During the Revolutionary War, General Francis Marion became a hero because of the unconventional tactics he used to win battles. One of the most famous stories about his exploits is the capture of Fort Watson, formerly the Santee Indian Mound, within what is now the Santee National Wildlife Refuge. The British had established a fort on the mound by building a high wall around it, and this fort guarded one of the main roads from Charles Towne to Camden. They kept the fort closely guarded, and kept the bluff surrounding Fort Watson bare of trees. Marion and his brigade of southern patriots had recently been joined by General Light Horse Harry Lee and his Continental troops. After trying and failing to penetrate the wall by force, Lee requested a cannon from General Nathanael Greene, the commander of the Southern army, in Camden. The cannon was immediately dispatched, but, Greene's troops lost their way and wandered around for days before finally returning to Camden without delivering the cannon.

Prior to the battle, the water for Fort Watson had been taken from a nearby **oxbow lake**. When Marion and his troops arrived, their first objective was to cut off the British water supply. But while Marion and Lee were waiting for the cannon, they noticed that the British were digging a well at the base of the Indian mound. In the meantime, however, an epidemic of smallpox had broken out in Marion's camp, and many of the militiamen began to desert. Marion, realizing that they could not take the fort by storm, considered abandoning the siege. But Major Hezekiah Maham, a Continental officer, suggested building a tower higher than the fort. Immediately, Marion sent his horsemen to scour the neighboring plantations for axes so they could chop down pine saplings. Maham's tower was erected during the night. At daybreak on April 15, 1781, the best riflemen climbed into the crow's nest to fire on the British as they went to their well for water. The British immediately raised the white flag signifying surrender. Once again Francis Marion's ragged guerrilla troops had defeated the British in a clever, fox like manner. This episode added even more credence to Francis Marion's legendary nickname of "The Swamp Fox." His men, known for their ability to hide themselves in trees, make plates out of bark, and live for days on nothing but sweet potatoes and water, were greatly admired.

William Cullen Bryant wrote the following verse about Francis Marion, The Swamp Fox. Notice that Bryant emphasized the fact that Marion knew the Carolina swamps very well and used his knowledge to surprise the British troops. Notice how he has described the life of one of Marion's men who loves the moonlight rides and surprise attacks.

"Song of Marion's Men"
by William Cullen Bryant

Our band is few but true and tried, / Our leader frank and bold;
The British soldier trembles / When Marion's name is told.
Our fortress is the good greenwood, / Our tent, the cypress-tree;
We know the forest round us, / As seamen know the sea...

Well knows the fair and friendly moon / The band that Marion leads---
The glitter of their rifles, / The scampering of their steeds.
'Tis life to guide the fiery barb / Across the moonlit plain;
'Tis life to feel the night-wind / That lifts his tossing mane.
A moment in the British camp---/ A moment---and away
Back to the pathless forest, / Before the peep of day.

Grave men there are by broad Santee, / Grave men with hoary hairs;
Their hearts are all with Marion, / For Marion are their prayers...
For them we wear these trusty arms, / And lay them down no more
Till we have driven the Briton, / Forever, from our shore.

Storage of Hazardous Waste

Hazardous waste landfills exist in all regions of South Carolina but are considered to pose a special risk to groundwater in the Karst landscape around Lake Marion. Such landfills are a legitimate environmental concern because of the high porosity and permeability of the underlying limestone. Any pollutants entering this rock could easily be carried away from the site to contaminate not just local drinking water supplies but also the underground aquifers serving most of the lower Coastal Plain. One example of such a hazardous waste landfill is the GSX Landfill located near the town of Rimini near the northeastern shore of Lake Marion.

The land near Lake Marion was purchased for a hazardous waste storage area because it contained large quantities of fuller's earth. This substance. commonly used for kitty litter, has huge absorbing abilities. However, well over a billion pounds of hazardous waste already has been buried in this landfill, and the fuller's earth is losing its capacity to absorb. Instead, a polyurethane lining with only a 50 year warranty has been placed between the containers of hazardous waste and the underlying limestone rock. In time, the hazardous waste could seep through the polyurethane barrier and pollute the underlying aquifer that provides water for much of the Coastal Plain Region of South Carolina. It could also enter the head waters of Lake Marion and contaminate the entire Santee River basin as it flows on down to Charleston or through the Santee **Delta**. It is important for environmental regulators to work with industry representatives to ensure that adequate protection of drinking water will continue into the future.

Mining of Limestone

Limestone has been mined in South Carolina since the early 1800's. Most of the limestone is mixed with clay and sold as portland cement. Some is marketed as crushed rock and building stone. As recently as 1991 there were 25 active mines in the state located in seven counties. Cherokee County is the only **Piedmont** county which has produced limestone commercially, from marble deposits in the Kings Mountain Belt. Horry County along the coast produces mostly coquina, a mix of broken shells cemented together by lime. The majority of the state's limestone is quarried from the Santee Limestone Formation in Bamberg, Berkeley, Dorchester, and Orangeburg counties.

The first step in mining hard rock limestone is to remove the trees, soil, and other overburden from the top of the limestone formation. Bulldozers are normally used for this operation. In order for the quarry to be profitable, the limestone must be fairly close to the surface. Dynamite or other explosives are normally used to blast the rock into small pieces which are then hauled to processing areas to be ground up, sorted, and mixed with other materials when appropriate. The deeper the quarry extends, the more difficult it is to bring the material to the surface. Another common problem is water seepage. Because the formation is porous and a good aquifer, almost every quarry has great volumes of water flowing out of the fractured rock into the bottom of the pit. Pumps must be operated almost continuously to keep the lower portions of the quarry dry. When a quarry is abandoned, water will seep in to form a deep pond. These ponds are unsafe for swimming because of their great depth and the loose rock found around their edges.

Caves and Bats

It is not widely known that under Santee State Park, on the southern shore of Lake Marion, are caves, formed when the limestone that underlies the park was dissolved by the naturally acidic groundwater seeping down from the surface. Although not large like Mammoth Cave in Kentucky or Carlsbad Caverns in New Mexico, the caves at Santee State Park are big enough to provide visitors with exciting tours into the darkness. They also provide homes for bats. Several species of bats, such as the eastern *pipistrelle*, shelter in the protected environment of these caves for at least part of the year, some passing the entire winter huddled dormantly in small holes or cracks in the rock. However, one bat resident deserves special attention, the southeastern *myotis*.

This small bat is unique because in one cave at Santee they set up a maternal colony each summer, the only known maternal colony for this species in South Carolina. Hundreds, perhaps thousands, of female bats gather in one cavern, known as the birthing room, to give birth and to raise their young. The baby bats, called pups, are born like other mammals, and not hatched from eggs in a nest as many people think. This common misconception probably arises from the fact that bats fly, and so people assume that they must be related to and must reproduce similarly to birds. In fact, bat pups are like most mammal babies; they are nearly helpless, only able to cling to their mothers or to the rocky roof of their cave. Bat mothers must nurse and protect their pups until they mature.

During nursing time, bat pups face serious danger if their colony is disturbed. Like all mammals, bats must stay warm, and as tiny as they are (adults of this species weigh only a few grams) they can only do this in their cool cave by clinging to their mothers. If the colony is disturbed the mothers will suddenly fly, and there is a great chance that the bat pups will be shaken loose and fall into the water that covers the floor of their caves. Although older pups can swim and climb somewhat, their chances of being reunited with their mothers before dying of cold or hunger are slim. Therefore, access to the maternal cave is prohibited during summer, the birthing season. Tours are available during September and October, after the southeastern *myotis* have left and before the bats which do winter-over in Santee's caves begin their hibernation.

Karst Topography as a Unique Natural Habitat

In addition to caves and bats, Karst areas host a variety of unique **habitats** which attract certain species of plants and animals. To begin with, the limestone rock acts as a natural fertilizer for soils in these areas. Most farms elsewhere in South Carolina require applications of pulverized limestone and **dolostone** to add calcium and magnesium ions to the soil and to counterbalance the natural acidity of most South Carolina soils. Soils formed on limestone, however, are naturally fertile and are chemically alkaline (the opposite of acidic). Certain trees and other plants prefer an alkaline soil and can grow to great size under these conditions. Their normal competitors cannot do as well in this specialized chemical environment.

Sinkholes are an excellent example of a specialized microenvironment. Plants in sinkholes are protected from storms and high winds and also benefit from moisture funneled in from surface drainage and from humid air released from underground caves.
Cave environments maintain a temperature of about 60 degrees Fahrenheit (15 degrees Celsius) year round, so during hot summers, cooler air from caves will keep sinkholes cooler than their surroundings. During winters, warmer air from caves will keep the sinkhole environment warmer than the surrounding area.

Summary

Limestone, found in the coastal plain of South Carolina, is exposed in the Santee area near Lake Marion, allowing the formation of features characteristic of Karst topography. This porous limestone is the aquifer for much of the lower part of the state. Because of the rapid flow of groundwater through the Karst system around Santee, the aquifer is highly susceptible to contamination. Quality groundwater supplies for home use and farm irrigation could easily be lost if proper conservation measures are not taken. Loss of water quality would also have a significant impact on the entire Santee community including the Santee National Wildlife Refuge and Santee State Park. As recreation and tourism become an even greater economic resource to this region, a readily available source of groundwater is a critical requirement. The public must become aware of the special properties of limestone rock aquifers and protect such areas from pollution. Measures must be taken so that hazardous waste is not placed in a location that could affect major underground water supplies.

Once an important center for Native American culture, the area around Santee, South Carolina, became strategically important during the Revolutionary War. Built on the Santee Indian Mound overlooking the Santee River, British Fort Watson controlled movement through this important transportation route. Its siege and eventual capture by Francis Marion and his men highlights an interesting chapter of the American Revolution.

This mound now stands within a stone's throw of Lake Marion, a large reservoir on the Coastal Plain, famous for its record fish. Fishing, camping, hiking, birdwatching--these are just examples of the recreation opportunities available around Lake Marion. For those with other tastes, numerous golf resorts exist. Given its easy access due to its location near the intersection of Interstate Highways 26 and 95, the future of recreation in this region looks bright.

PLACES TO VISIT ☎

Santee State Park. West side of Lake Marion off Highway 6. For information call 803-854-2408.

Fort Watson. 1.5 miles south of Santee on US 301 and SC Highway 15. For information call 803-478-2217.

Martin Marietta Aggregates. Georgetown Quarry, 803-469-5027. Berkeley Quarry, 803-753-2130.

Santee Cement Company. Located near Holly Hill. For information call 803-496-5027.

Santee National Wildlife Refuge. Rt. 2, Summerton, SC. For information call 803-478-2217.

Giant Portland Cement Company. 463 Judge Street, Harleyville, SC. For information call 864-462-7651.

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STUDY AREA 7: KARST TOPOGRAPHY OVERVIEW

Activity 7-1: Overview

Materials

6	STATE BASE MAP #1, SHADED RELIEF	1 : 500,000
6	STATE BASE MAP #2, WITH HIGHWAYS	1 : 500,000
6	COASTAL SATELLITE IMAGE	1 : 332,640
6	LAKE MARION TOPOGRAPHIC MAP	1 : 24,000
6	LAKE MARION LITHOGRAPH	1 : 18,000
6	GEOLOGIC AND MINERAL RESOURCE MAP	1 : 1,000,000
6	Transparent Grid Overlay	
6	Wipe-off Pens	

PERFORMANCE TASKS
(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 📖; Language Arts = ✍

1. **Outline counties with limestone resources.** ✈
   Use the GEOLOGIC AND MINERAL RESOURCE MAP to locate major deposits of limestone. Outline the approximate boundary of the limestone outcropping on the STATE BASE MAP #1, SHADED RELIEF, with a wipe-off pen. Determine which counties would be the most likely sites for mining limestone. Are there any Karst features on the base map? Why don't you see evidence of sinkholes and other Karst features on this map? Use the transparent grid overlay to estimate the total area of the limestone region. What percentage of South Carolina is covered by limestone?

2. **Locate approximate position of Eocene shoreline.** ✈
   Geologists think that the Santee Limestone formed about 40 million years ago during the Eocene Epoch of geologic time. Limestone forms today in the ocean far away from sources of sand and mud. Along coastlines like South Carolina's, limestone usually forms more than 100 miles seaward of the shoreline. Using that number as your estimated value trace on the GEOLOGIC AND MINERAL RESOURCE MAP, with a wipe-off pen, the approximate location of the Eocene shoreline, which should be 100 miles landward of the Eocene limestone deposits. Use a

broad tip wipe-off pen to shade in the area between your Eocene shoreline and the limestone region. This shaded area represents the area of Eocene sand and mud marine sediments. Approximately what percentage of this region is in the Coastal Plain Region today? What do you think happened to the rest of the Eocene deposits which are now missing? Where do you think they went? How did they get there?

3. **Write travel log on a trip through a cave.** ✍
   Caves are exciting places to visit. In some cases you can travel for long distances underground completely in the dark. Pretend you are a bat hiding in the deepest part of a cave or a drop of water dripping from a stalactite rock on the roof of the cave. Write a descriptive travel log explaining how you would get out of the cave, what you would see, and what problems you would encounter on the way out. Use lots of adjectives to make your story interesting. Locate on the LAKE MARION TOPOGRAPHIC MAP a sinkhole underneath which this trip could have occurred. Try to locate the point on the map where you would exit the cave.
4. **Locate limestone quarry on satellite image.** ☼
   The Giant Portland Cement quarry near Harleyville in Dorchester County is the largest in the state, and it is visible on the COASTAL SATELLITE IMAGE. First locate Harleyville on the STATE BASE MAP #2, WITH HIGHWAYS (locate the intersection of Interstate Highways 95 and 26, then go south on Interstate 26 about 9 miles to reach Harleyville). The quarry is located on the south side of Four Hole Swamp along State Highway 453 and the adjacent railroad line. Now locate the corresponding site on the coastal image and find the bright blue spot which indicates the quarry site. Locate another bright blue quarry site on the opposite side of the swamp. Approximately how many square miles of ground does each quarry cover? Why do quarries appear blue on the infrared image? How can you distinguish among quarry blue, water blue, and urban area blue? Using this information and the GEOLOGIC AND MINERAL RESOURCE MAP as a reference, see if you can locate other quarries on the satellite image. How many other quarries are you sure of? Share your findings with other groups and see if you agree on which blue spots are quarries and which are not. How could you find out whether some of your questionable spots are really quarries or not?

5. **Evaluate significance of location of Santee Indian Mound / Fort Watson.** 📖
   The Santee Indian Mound and Fort Watson were located along strategic early transportation routes. Mark with a wipe-off pen on the STATE BASE MAP #1, SHADED RELIEF, the approximate location of the Indian Mound (just west of the town of St. Paul in Clarendon County). Divide into two groups and evaluate the

strategic importance of that location based on your historical and geographical knowledge of the Coastal Plain Region. Share your results with other groups. Remember that Lake Marion did not exist before the 1930's. Is this site of strategic importance today, considering that it is located next to Interstate Highway 95? Refer to the STATE BASE MAP #2, WITH HIGHWAYS. Why do people come to visit the Santee Indian Mound / Fort Watson site today?

Group I **Santee Indian Mound** - consider trade and travel route options for Native Americans in the 1500's. Recall that the center of the local mound-building culture was near present day Camden in Kershaw County. Why do you think the Santee site was a good location for a ceremonial meeting place?

Group II **Fort Watson** - consider trade and travel route options for both the British and the Americans in the 1700's during the Revolutionary War. Why was the Santee site such a good location for a fort? Why do you think Francis Marion considered it important to capture this fort?

6. **Analyze poem for landscape references.** ✍
   Read the poem "Song of Marion's Men." Underline each word which refers to a landscape feature or a description of the local landscape. Which words or phrases match up with something you can see on the LAKE MARION LITHOGRAPH? Are these words enough to convince you that the scene is the coastal plain of South Carolina? Explain your answer.

7. **Trace the path of a pollutant.** ☼ 💻
Using the STATE BASE MAP #2, WITH HIGHWAYS, locate Rimini on the east bank of Lake Marion in Sumter County. A hazardous waste disposal site is located in this area 200 feet from the headwaters of Lake Marion. Using a wipe-off pen, trace the possible route of this hazardous waste if it were to enter Lake Marion in that general area and flow all the way to the ocean. Assuming an average surface water flow of 1 foot per minute, how long will it take the pollutant to reach the ocean? Use the map scale to determine distance. Do you think groundwater transport would be faster or slower? Explain your answer.

8. **Assess potential for non-point source pollution of lake.** ☼
Lake Marion is one of the primary water sources for the City of Charleston, as well as for other communities in the Coastal Plain Region. If you were the reservoir manager, which land uses along Lake Marion would you especially want to monitor to reduce the chances of non-point source pollution entering the lake? If necessary, refer to the Background Information. Use the LAKE MARION LITHOGRAPH as your reference. Which uses could you realistically expect to control? Explain your answer.

ENRICHMENT

1. **Write to a limestone quarry company.** ☼
Write to a limestone quarry such as the Martin Marietta Aggregates facilities located in Eutawville or Georgetown; the Giant Cement Company, in Harleyville; the Santee Cement Company, in Holly Hill; or the Gifford-Hill Cement Company, in Harleyville. Ask for information about limestone deposits. Also, ask for a sample of limestone rock, preferably with fossils. Soak the sample in water and measure how much water is absorbed into the pore spaces of the rock. Break off a very small piece of the rock and soak it in a container of vinegar or other weak acid. Do you observe any reaction? How long does it take for the sample to totally dissolve?

2. **Research the life history of bats, in particular their association with caves.** ☼ Why are most caves with bat colonies open to tourists only part of the year? How can visitors to caves help preserve bat habitat?

Orangeburg Times and Democrat

Santee Sinkhole

by Carol Woodward

Mother Nature pulled the plug on a 30-acre pond at Santee State Park last week. Park Superintendent Phil Gaines said a sinkhole measuring at least 35 feet across and 8 feet deep caused the man-made pond to drain.

Gaines said engineers don't know exactly what triggered the appearance of the sinkhole, but pointed out there are "a number of sink holes" in the park.

This sinkhole apparently had been seeping for about one year and finally eroded to the point of caving in, Gaines said. "It was incredible," Gaines said.

"Wednesday a week ago, we noticed the water level was going down, and by 6:30 a.m. Thursday, the pond was empty. It looked just like a bathtub drain. The water was swirling down toward the sinkhole. It was amazing to watch."

The water went through the sinkhole and bubbled up in a creek across the road from the pond. Sinkholes are not an uncommon occurrence in the Santee area, "but this is the largest, by far," Gaines said.

Gaines said the fate of the sinkhole and the empty pond is not certain. "One thing is for sure," he said laughing. "We can't use the pond for holding water anymore. It can't be repaired."

RATIONALE

The Lake Marion study site highlights unique rock exposures, significant historical sites, and land use characteristic of a tourist-based economy. The Santee Limestone is an important Coastal Plain rock formation. It is exposed at the surface only in the south-central part of the state in the Lake Marion vicinity, even though it is buried beneath other sedimentary rocks throughout a much larger area. The formation tilts gently towards the Atlantic Ocean. The Santee Limestone is significant because it is the major aquifer or water producing unit for most Coastal Plain wells. Also, its occurrence around Santee has allowed the development of the only major area in South Carolina featuring Karst topography. A further attraction of the Lake Marion area is the Santee National Wildlife Refuge, a wintering area for migratory birds such as Canada geese, pintail and mallard ducks. Fort Watson, built on the site of the Santee Indian Mound, was the location of Francis Marion's skirmish with the British. These features provide the geological, environmental, and historical significance of the site.

Brief Site Description

Lake Marion Once a Floodplain

Before 1940, the Santee River, a Coastal Plain river, **meandered** through this area, but with completion of the dam water levels quickly rose, inundating its **floodplain**. Because the water level was rising faster than the timber could be cut and removed, many stands of trees were swallowed up by the rising water. Some of these tree trunks can still be seen in portions of Lake Marion. The original floodplain is now under water, and new **wetland** areas have formed as rising lake waters encircled forests and fields, encroached on depressions such as **Carolina Bays**, and occupied formerly dry areas. The result has been a large and diverse wetland region containing pine, hardwood forest, **marsh** and **swamp** habitat, and open-water ponds.

Santee National Wildlife Refuge

The Santee National Wildlife Refuge, located on the north bank of Lake Marion, offers a great, protected expanse of natural habitat for migratory waterfowl such as Canada geese. In addition, it serves as a temporary residence for a few species of migrating birds. Due to its abundant supply of food, the Refuge has become well known to flocks of ducks and geese that winter-over, generally from October to March. The Refuge is carefully managed to allow the waterfowl to range freely in their natural habitat while feeding in the nutrient-rich waters. Data are collected daily and analyzed so that migratory patterns and habits can be studied, creating a better understanding of the area's avian residents.

Flying in a "V" formation and honking to announce their presence, the Canada geese arrive on nearly the same date each year. Many people wonder how these birds know exactly when to leave the Hudson Bay area of Canada and begin their southern migration each year. While weather may change significantly and unpredictably from day to day, the length of time between sunrise and sunset varies only slightly each day and is totally predictable. Although humans do not notice these small daily changes, birds are apparently aware of them. It is thought that some birds may have an internal clock, which makes them extremely sensitive to these daily changes, allowing them to determine the appropriate time to begin their journey each year. How the same Canada geese find their way to a specific location like the Santee National Wildlife Refuge each year is also debated by scientists. It has been established that many birds rely on visual memory for short distances. For larger distances, birds might use the position of the Sun by day and the stars at night to guide them back to the same feeding grounds. Current data also suggests that birds use the Earth's magnetic field as a navigational tool.

In recent years the numbers of waterfowl species have decreased dramatically, although management practices have not changed significantly. This decrease is presumably due to the loss of breeding and nesting habitat in the northern United States and Canada. Perhaps the effects of acid rain and lead poisoning are also contributing to the population decline. The waterfowl population decrease may provide a warning sign of environmental problems that could soon affect humans.

Tourism and Fishing on Lake Marion

The Santee region has experienced a noticeable increase in rates of population growth and commercial development since Lake Marion was constructed. The development of Santee State Park and the opening of Interstate Highway 95 have brought increased visibility to the area and created a demand for a wide variety of tourist facilities. Several historical sites also exist locally, including the Santee Indian Mound at Lake Marion; Francis Marion's grave, near Eadytown; and the Revolutionary War battleground at Eutaw Springs.

Lake Marion is nationally known for its fine fishing. Fishermen from all over the country come here to test their skills against the famous landlocked striped bass, normally a saltwater fish, but now trapped in freshwater behind the Lake Marion dam. This ocean bass has adapted well to its new surroundings and thrives alongside other game fish such as catfish, largemouth bass, and crappie. Many record-breaking catches have been recorded during fishing tournaments in the Santee area. In one type of tournament, anglers fish for tagged fish--some worth up to $10,000. Wherever there are favorite fishing holes, large or small, there are also an abundance of stories about the ones that got away. Following is one teacher’s story of the big catch that she promised her students.

The Big Catch

A sixth grade teacher came back from a field trip to Lake Marion and told her class she had a riddle for them to figure out. Before departing her class the day before, the teacher, Ms. Mary Holmes, had told her class that she was going to catch a big tagged fish for them. Now, she pulled out a photograph of herself holding a large fish and told the class, "I caught this fish with my camera." She asked them to write a story about how that could happen. When they finished, and had shared their ideas, she finally agreed to tell them the real story.

During a hot summer day a group of 25 SC MAPS teachers were on a field trip to the Santee area and Lake Marion. After the teachers spent most of the day studying the Santee area, they arrived at Lake Marion. As they got out of their cars, Ms. Holmes saw an elderly couple by the water's edge struggling with a large fish that they had just caught. Ms. Holmes grabbed her camera, raced up to the couple, and begged them to let her hold the fish. The couple looked very, very confused. They had no idea why she wanted their fish--except maybe to eat it! Meanwhile the other teachers in the group continued on their trip leaving Ms. Holmes behind continuing to beg the couple. Finally, Ms. Holmes convinced the couple to let her hold the fish while they took her picture.

So Ms. Holmes really did catch that fish with her camera after all.

Activity 7A-1: The Effects of Groundwater

Materials

6	STATE BASE MAP #1, SHADED RELIEF	1 : 500,000
6	STATE BASE MAP #2, WITH HIGHWAYS	1 : 500,000
6	GENERAL SOIL MAP	1: 594,000
6	LAND USE/LAND COVER MAP	1 : 500,000
6	GEOLOGIC AND MINERAL RESOURCE MAP	1: 1,000,000
6	LAKE MARION LITHOGRAPH	1 : 18,000
6	LAKE MARION TOPOGRAPHIC MAP	1 : 24,000
1	MYRTLE BEACH TOPOGRAPHIC MAP	1 : 24,000
1	SILVERSTREET TOPOGRAPHIC MAP	1 : 24,000
1	WOODS BAY TOPOGRAPHIC MAP	1 : 24,000
1	TABLE ROCK TOPOGRAPHIC MAP	1 : 24,000
1	FORTY ACRE ROCK TOPOGRAPHIC MAP	1 : 24,000
1	CONGAREE SWAMP TOPOGRAPHIC MAP	1 : 24,000
1	State Map of Major Drainage Basins	Figure 1-2
6	Transparent Grid Overlay	
6	Wipe-off Pens	

PERFORMANCE TASKS
(Icon Key) Overview = ✈; Science = ☼; Math = 🖳; History = 🕮; Language Arts = ✍

1. **Locate the study site.** ✈ ☼
   Locate the Lake Marion Study Site on the STATE BASE MAP #2, WITH HIGHWAYS, on the LAND USE/LAND COVER MAP, on the GEOLOGIC AND MINERAL RESOURCE MAP, and on the GENERAL SOIL MAP by drawing a small box around the correct site on each map using a wipe-off pen. Briefly summarize the one or two most important land uses at this site, the age (Geologic Period), the type of rock at the site, and the predominant soil type at the site. Use the Scale Bar on the base map to estimate the straight-line distance between this study site and your school. In which local river drainage basin (watershed) is this site located? Through which of the major river systems, Savannah, Santee, Pee Dee, or Coastal Plain, does this site drain? Refer to Figure 1-2, "State Map of Major Drainage Basins."

2. **Analyze the newspaper article.** ☼ ✍
   Read the newspaper article on page 7A-1, "Santee Sinkhole." Explain how the story relates to the Coastal Plain Landform Region. Identify a possible location on the LAKE MARION TOPOGRAPHIC MAP (refer to the LAKE MARION LITHOGRAPH if needed) where the story could have taken place. Explain why the publisher thought this story would be of interest to newspaper readers. Using the same people as characters and the same location as your setting, write another newspaper article related to this same incident, but date it either before or

after the given story occurred. Choose a title and draw an appropriate picture to illustrate your main point.

3. **Locate sinkholes on topographic map and lithograph.** ☼
Compare the LAKE MARION LITHOGRAPH with the LAKE MARION TOPOGRAPHIC MAP. Locate and mark as many sinkholes as possible on the topographic map by looking for depression contour markings (contour lines with slash marks pointing inward). Ignore all oval-shaped depressions outlined by blue dashed lines. These are Carolina Bays and are formed by a different process. Can you find the sinkholes on the lithograph? Why or why not? What color of blue on the infrared image do you expect a sinkhole lake to have? Do you think the sinkhole lakes should have a lot of sediment? Remember that bodies of water carrying a lot of sediment should be lighter blue than clear water, which appears black on the infrared photographs.

4. **Determine the elevation of the groundwater table.** ☼
Locate the following features in the center section of the LAKE MARION TOPOGRAPHIC MAP and determine the elevation of the groundwater table for each location. Assume that the water level in the ponds and swamps is the same elevation as the groundwater table. Divide into groups. Each group should be assigned one of the following locations and share its results with the rest of the class so each group can construct their own groundwater map.

GROUNDWATER ELEVATION TABLE		
GROUP	**FEATURE**	**ELEVATION OF WATER TABLE**
I	Small pond near Mt. Pisgah Church, north of the	
II	Small pond, Santee State Park, along the	
III	Lake in sinkhole in golf course along Lake	
IV	Either pond in town of Santee, north of US Hwys	
V	Larger pond south of Bell Cem., West side of SC	

Groundwater flows downhill just like surface water. In fact, the groundwater table slopes downhill, and groundwater flows in the direction of that slope toward the lower groundwater table elevations. Plot your class's data about the elevation of the groundwater table on the topographic map and predict in which direction a contaminant would flow if it escaped from the sewage disposal pond near the landing strip west of the junction of Interstate Hwy. 95 and SC Hwy. 6. Assume the contaminant enters the groundwater system.

5. **Trace disappearing stream.** ☼

Locate on the LAKE MARION TOPOGRAPHIC MAP the stream which flows past Chapel Hill Church in the southernmost part of Santee State Park. Note the dot-dash blue line which indicates this is an intermittent stream. Trace, with a wipe-off pen, the pathway of this stream from the left-hand edge of the map to the first crossing of the trail near the caves. Between the first crossing and the second crossing of the stream by the trail, the water flows underground through an interconnected system of caves. Do not mark the stream path between the two crossings. Continue tracing the stream path from the second trail crossing to Chapel Branch and Lake Marion. Why is this stream intermittent in this area even though there is lots of annual rainfall? What do you think happens to the stream water between the two trail crossings?

6. **Calculate stream density in Karst areas.**
Place the transparent grid overlay over the Karst region on the LAKE MARION TOPOGRAPHIC MAP (all of the land west of Lake Marion). Count the total number of squares covering this area (estimate partial squares). Now count the number of squares which have at least one perennial (permanent) stream in them. Divide the number of squares containing perennial streams by the total number of squares to get the average stream density for the Karst area. Divide into groups and repeat this same procedure for the following topographic maps. Calculate the perennial stream density for each site and compare your answers with other groups. Discuss what factors influence the perennial stream density in each area. What special features influence this density in Karst regions?

Group I The northern half of the MYRTLE BEACH TOPOGRAPHIC MAP

Group II The southern half of the SILVERSTREET TOPOGRAPHIC MAP

Group III The northern half of the WOODS BAY TOPOGRAPHIC MAP

Group IV The southern half of the TABLE ROCK TOPOGRAPHIC MAP

Group V The northern half of the FORTY ACRE ROCK TOPOGRAPHIC MAP

Group VI The northern half of the CONGAREE SWAMP TOPOGRAPHIC MAP

7. **Evaluate effects of Karst topography on land use.**
Analyze land use on the western side only of Lake Marion using the LAKE MARION LITHOGRAPH. List the most common land uses in this Karst region in order of abundance. Which are affected positively by the presence of Karst topography? Which ones are affected negatively? What environmental problems could affect this region in the next ten years?

ENRICHMENT

1. **Research sinkhole problems in South Carolina and compare to Florida.** ☼
   Research sinkhole collapse in Santee State Park. The newspaper article, "Santee Sinkholes," page 7A-1 highlights the sudden sinkhole collapse event in March 1992 in Santee State Park. Research this event in more detail by writing to Santee State Park or the South Carolina Geological Survey in Columbia. Has sinkhole collapse been a common problem in South Carolina? Also, research the problems caused by sinkholes in Florida. Compare the size of the Florida sinkholes to the South Carolina sinkholes.

2. **Research GSX hazardous waste landfill controversy.** ✍
   Research newspaper and magazine articles on the GSX hazardous waste landfill controversy in the Rimini area. The Item, Sumter's newspaper, is an excellent source for research information. What are the greatest potential hazards? What solutions have been recommended? What type of legislation would you recommend to protect the area from pollution by hazardous waste? Formulate a set of site suitability standards. Write these in a formal request to your legislator. Discuss the pros and cons of selecting a hazardous waste disposal site near Rimini 200 feet from the headwaters of Lake Marion. What type of material is classified as hazardous waste? How is it stored? How long will the lining last that is between the hazardous waste and the aquifer?

Activity 7A-2: Lake Marion Brings About Changes in Land Use

Materials		
6	STATE BASE MAP #2, WITH HIGHWAYS	1 : 500,000
6	LAKE MARION TOPOGRAPHIC MAP	1 : 24,000
6	LAKE MARION LITHOGRAPH	1 : 18,000
6	Transparent Grid Overlays	
6	Wipe-off Pens	

PERFORMANCE TASKS
(Icon Key) Overview = ✈; Science = ☼; Math = 💻; History = 📖; Language Arts = ✍

1. **Locate land use features.** ✈
   Using the STATE BASE MAP #2, WITH HIGHWAYS, locate Lake Marion and its dam, and the area designated as the Santee National Wildlife Refuge. Lake Marion is mainly in which two counties? Which counties have boundary lines located within Lake Marion? Why do you think the river was originally used as a boundary line between these two counties before the lake was constructed? Where can you cross Lake Marion by car? By train? Name the highways which have bridges that cross Lake Marion. Identify the area on the LAKE MARION TOPOGRAPHIC MAP which is covered by the LAKE MARION LITHOGRAPH. Locate the large golf course on both the topographic map and the lithograph. What specific landform features make this a desirable location for a golf course? Explain. Identify the characteristic geometric pattern of a golf course. Now identify lakes, rivers, Carolina Bays, I-95, US 301, roads, bridges, pine tree crowns, fields, ditches, and the boundaries of Santee State Park. Also locate State Highway 6, the rest areas on both sides of I-95, sewage disposal ponds, landing strips, and a railroad line. How do you think the small town of Santee, located on this map, got its name?

2. **Locate catfish beds by analyzing sediment load.** ☼
   On the LAKE MARION LITHOGRAPH note the different intensity of blue (indicating sediment load) carried by the water in various parts of Lake Marion. One of the properties of infrared photographs is that the color of the water indicates the amount of sediment carried by the water: the lighter the blue the greater the sediment load. What is indicated by very dark blue water? Where do you find this color on the lithograph? Where is the smallest amount of sediment in Lake Marion? Where do you predict the water is flowing the fastest? Can you locate the position of the old river channel, before the river was dammed to form Lake Marion? Explain your answer.

Look for the former Santee River channel on the LAKE MARION TOPOGRAPHIC MAP. Notice that the former Santee River channel is marked with blue dashed lines. These lines mark the county boundary lines. Also notice that north of the I-95 bridge the river channel meanders extensively, while south of the bridge the channel is much straighter. What does this fact tell you about the flow pattern and characteristics of the original river? Use a wipe-off pen to trace the position of the old river channel onto the lithograph. This deep channel is where many huge catfish, or "cats," are caught.

3. **Analyze land use changes through time.** ☼
Look in the margins of the LAKE MARION TOPOGRAPHIC MAP and the LAKE MARION LITHOGRAPH to determine the year the map was printed and the year the aerial photograph was taken. Examine each cartographic product carefully to identify any changes which have occurred during the interval. How many of these changes are man-made? How many have occurred naturally?

4. **Estimate size of peach orchards.** 💻
Special symbols are used on the topographic map to indicate orchards. Locate several peach orchards on the LAKE MARION TOPOGRAPHIC MAP. Use the number of printed symbols to estimate the orchards' size. Find these same orchards on the LAKE MARION LITHOGRAPH. Outline them, with a wipe-off pen, and estimate the total number of trees in each orchard without counting each individual tree. Explain your method. A magnifying lens will be helpful.

5. **Determine average width and volume of Lake Marion.** 💻
Measure the width of Lake Marion at the I-95 Highway bridge and also near the top and side edges of the LAKE MARION TOPOGRAPHIC MAP. Average these three measurements to obtain an average value for the width of Lake Marion. How consistent are your three measurements? What is the deviation of each measurement from the average value? Would it matter where you chose to determine lake width? Why?

   Estimate the volume of water in Lake Marion. Using the topographic map, and a wipe-off pen, draw a line from the campground at the top of Santee State Park to the north end of Persanti Island. Next, draw a segment from the southern tip of Persanti Island to Adams Landing just north of Interchange #102 on I-95. Follow the shoreline southward to the bridges. Use the old Francis Marion Bridge and Santee State Park as your other boundaries. The geometric shape you have just drawn is approximately rectangular, so use the formula for the area of a rectangle to calculate the approximate surface area of this part of Lake Marion. Also, determine the approximate area of this same part of Lake Marion using the transparent grid overlay. Which method do you think is more accurate? Why? Determine the total volume of water in this small area by using the formula for the volume of a rectangular solid. Assume the average depth is 15 feet. On the STATE BASE MAP #2, WITH HIGHWAYS, compare this small region to the entire surface area of Lake Marion. From your figures, use a ratio to estimate of the total amount of water in the lake.

6. **Compare topography of the east and west banks of Lake Marion.** ☼ 💻

Compare the east and west banks of Lake Marion as seen on the LAKE MARION TOPOGRAPHIC MAP. Note especially the differences in contour line spacing. What are the major elevation and slope differences between these two shorelines? How is the major land use different on each side of the lake? If the dam had been built higher and the water level had risen to 100 feet in elevation instead of 77 feet as it is now, which shoreline would change the most? Why? How would the Santee National Wildlife Refuge be affected? Locate two boat ramps indicated on the topographic map. Determine their slope based on the slope of the road. Compare your results. Does one have a greater slope than the other one? Is the water level the same for each of the boat ramps? Explain how boat ramps are used.

7. **Locate Santee Indian Mound on map and lithograph. ✈**
On the LAKE MARION TOPOGRAPHIC MAP locate the historic Santee Indian Mound (later Fort Watson) on the east bank of Lake Marion, north of Interchange #102 on Interstate Highway 95. How can you determine the elevation of this Indian Mound on the map? How high is the Indian Mound above the surrounding land? Now look at that same site on the LAKE MARION LITHOGRAPH. Can you recognize the Indian Mound? What clues did you use to locate this feature on the lithograph? Does the lithograph give you any information about the elevation of the mound?

8. **Determine size of Santee Wildlife Refuge. 💻**
Santee National Wildlife Refuge is located on the north-central section of Lake Marion. Locate this site on both the LAKE MARION TOPOGRAPHIC MAP and LAKE MARION LITHOGRAPH. This wildlife refuge is the winter home of a number of waterfowl. The open fields are used to plant corn and grains to feed the migratory birds. Mark, with a wipe-off pen, the boundary line of the Santee National Wildlife Refuge as indicated on the topographic map. Use the transparent grid overlay to estimate the size of the wildlife refuge. What percent of the wildlife refuge is land? Water? Outline these same boundary lines on the lithograph. What information does the lithograph tell you about the land use? Estimate the percentage of swampland and open fields for the refuge area.

9. **Calculate average weight of fish caught in Lake Marion. 💻 ☼**
An average of 1,066,313 fish are caught in Lake Marion each year. Their total weight is 577,886 pounds. Find the average weight in pounds for each of the following fish species.

STATISTICS ON FISH CAUGHT IN LAKE MARION			
FISH TYPE	**NUMBER**	**POUNDS**	**AVERAGE**
Large Mouth Bass	72,392	84,839	

Crappie	167,498	91,604	
Striped Bass	5,924	33,508	
Bream	702,369	196,029	
Catfish	118,130	171,906	
Total Catch	1,066,313	577,886	

If 1,000,000 fish were swimming an equal distance apart from each other in Lake Marion, how many cubic yards of lake water would each fish have for itself? Use the value for the total volume of water in Lake Marion you calculated in Performance Task #5. If this number is correct, how many fish would be in the average cubic yard of lake water? What is the relationship between the cubic yards of lake water per fish and the number of fish per cubic yard of water? Based on your experience fishing, would you expect the fish to be equally distributed throughout the lake? Refer to the LAKE MARION TOPOGRAPHIC MAP and identify areas you think would be best for fishing and explain your reasoning. Why do you think fish tend to prefer certain areas in the lake?

10. **Calculate weekly percentage change in waterfowl population.**

Locate the Santee National Wildlife Refuge on the LAKE MARION TOPOGRAPHIC MAP. The Refuge monitors a variety of migratory birds that winter over in this area. Part of this monitoring requires that a count of the waterfowl be taken each week. The population data from several species of ducks and geese that spend the winter at the Santee National Wildlife Refuge are listed in the table below. Find the percent of increase or decrease for each species from week to week.

POPULATION DATA FOR WATERFOWL AT SANTEE NWR			
ANIMAL TYPE	**DATE**	**NUMBER**	**PERCENTAGE CHANGE**
Canada Geese	1-06-95	650	XXXXX
	1-13-95	495	
	1-27-95	430	
Mallards	1-06-95	785	XXXXX
	1-13-95	555	
	1-27-95	1,196	

11. **Analyze seasonal population changes in Santee waterfowl.**

Locate the Santee National Wildlife Refuge on the north-central section of the LAKE MARION TOPOGRAPHIC MAP and on the LAKE MARION LITHOGRAPH. Use a wipe-off pen to outline the Refuge boundary on the topographic map. Transfer these lines to the lithograph. Describe the terrain of the Refuge. Is it mostly water or land; is it mostly hilly or flat? Use Data Tables 1 and 2 to determine which months usually have the highest total bird population. Make a list of possible reasons why the bird count could vary from year to year.

Divide the class into six groups. Have each group use the monthly data provide to construct line graphs showing seasonal changes for the wood ducks and one of the other six species listed. Use your graphs to answer the following questions:

In which months do the bird species arrive and in which months do they leave?
In which month is the peak population recorded for each species?
Which bird species migrate to the Refuge during winter months?
Which bird species migrate to the Refuge during Summer months?
Which bird species have yearlong residents?
Do the graphs show the same general pattern of seasonal change each year?

As a class, construct a statement that best describes the migratory pattern of each bird listed in Data Tables 1 and 2. Which year had more migratory birds visit the Refuge? Would you expect most birds to arrive and leave in flocks or as individuals? Explain your answer.

DATA TABLE 1: Monthly Waterfowl Population 1993-1994
Santee National Wildlife Refuge

Month	Coot	Canada Goose	Mallard	Northern Pintail	Wigeon	Wood Duck	Ring-Necked Duck
Septembe						428	
October		48	15		100	315	126
November	745	473	476	95	4,956	277	6,471
December	1,547	560	1,792	79	3,534	168	6,545
January	1,642	535	4,702	134	4,561	240	7,705
February	649	624	2,344	59	1,343	263	929
March	277	74	211	1	115	311	106
April		6				443	
May						555	
June						632	
July						650	
August						615	

DATA TABLE 2: Monthly Waterfowl Population 1994-1995
Santee National Wildlife Refuge

Month	Coot	Canada Goose	Mallard	Northern Pintail	Wigeon	Wood Duck	Ring-Necked Duck
Septembe						460	
October	23	82	15		48	371	66
November	4,042	276	362	12	3,710	114	5,758
December	6,880	509	1,801	111	6,016	132	4,993
January	4,669	497	873	180	3,359	63	5,587
February	2,310	283	1,670	150	407	142	1,166

March	730	40	245	12	52	330	192
April	43					475	
May	10					565	
June	10					650	
July						655	
August						615	

12. **Determine probability of sighting a particular waterfowl species.**

Wildlife biologists cannot possibly count each individual in a population so they often take a random count of a small number of animals and assume that their small sample has the same percentage distribution as the larger total population. The methods of statistics allow us to determine how reasonable a particular assumption might be. As part of a waterfowl census, your class has been selected to do a population survey for the Santee National Wildlife Refuge. Divide the class into six groups. Refer to the 1993-1994 Waterfowl Population Chart provided below.

1993-1994 WATERFOWL POPULATION CHART

DATE	CANADA GEESE	MALLARDS	OTHERS
11-05-93	239	210	354
11-12-93	431	537	325
11-29-93	677	467	135
12-09-93	420	790	140
12-16-93	424	1,531	160
12-23-93	630	2,660	210
01-05-94	722	3,136	185
01-13-94	532	5,710	140
01-21-94	237	4,160	140
01-28-94	590	5,910	280
02-10-94	800	2,120	280

Group I Use data from 11-05-93 Group IV Use data from 12-23-93
Group II Use data from 11-29-93 Group V Use data from 1-13-94
Group III Use data from 12-09-93 Group VI Use data from 2-10-94

Each group should carry out the following set of instructions for its assigned data. When each group has completed setting up its sample, the containers should be exchanged among various groups so that no group knows whose container it is using.

Instructions

1. Divide each data number for your assigned date by ten and round off to the nearest whole unit.
2. Select the appropriate number of pieces of colored candy (or other small markers of different colors) so that the number of Canada Geese (reduced and rounded off) is equal to the number of brown pieces, the number of Mallards (reduced and rounded off) is equal to the number of green pieces, and the number of

other waterfowl (reduced and rounded off) is equal to the total number of pieces consisting of a mixture of other colors.

3. Put the correct number of colored pieces into a small bag and shake it until the pieces are randomly distributed. Make a mark on the outside of the bag that your group will recognize but other groups will not.
4. Exchange bags with another group.
5. Repeat the following procedure five times.
   a. Pull ten pieces out of the bag, one at a time, without looking.
   b. Record the color distribution on the chart.
   c. Calculate the average number chosen and the percentage of each color.
   d. Put those ten pieces back in the bag and shake the bag well.

FREQUENCY DISTRIBUTION BASED ON SAMPLE SIZE OF TEN PIECES

GROUP	**TRIAL 1**	**TRIAL 2**	**TRIAL 3**	**TRAIL 4**	**TRIAL 5**	**AVE. # CHOSEN**	**% OF SAMPLE CHOSEN**
Canada Geese (brown)							
Mallards (green)							
Other (various)							

6. Repeat the following procedure five times.
   a. Pull fifty pieces out of the bag, one at a time, without looking.
   b. Record the color distribution on the chart.
   c. Calculate the average number chosen and the percentage of each color.
   d. Put those fifty pieces back in the bag and shake the bag well.

FREQUENCY DISTRIBUTION BASED ON SAMPLE SIZE OF FIFTY PIECES

GROUP	**TRIAL 1**	**TRIAL 2**	**TRIAL 3**	**TRAIL 4**	**TRIAL 5**	**AVE. # CHOSEN**	**% OF SAMPLE CHOSEN**
Canada Geese (brown)							
Mallards (green)							
Other (various)							

7. Look at the results from parts 5 and 6 and compare these percentages with the weekly numbers of each species as recorded on the waterfowl chart for 1993-1994. You will need to convert the numbers on the waterfowl chart to percentages. Based on the results of your sampling, make your best guess of which week your observations were taken. Return your bag to the group that prepared it and find out if your guess was correct. Which procedure, selecting ten pieces at random or fifty pieces at random, gave you more confidence in your answer?

8. As a class, discuss some of the factors which could influence the variability of your results. Separate these factors into a statistical category and a landscape category. Refer to the LAKE MARION LITHOGRAPH.

13. **Analyze population changes in the Lake Marion area.** ☼ 💻

Note the trend of population growth in the Lake Marion area since the early 1940's when the Pinopolis Dam was built. Refer to the following data table for specific numbers. Graph the data for both Clarendon and Orangeburg counties in ten-year intervals and project total population numbers for the years 2000 and 2010. (Your vertical axis should measure population and your horizontal axis should measure time in years.) Then calculate the percentage increase in population for each county for each of the ten year intervals and graph those results. (Your vertical axis should measure percent increase and your horizontal axis should measure time in years.) Which county has experienced the greatest population growth over that time period?

POPULATION IN CLARENDON AND ORANGEBURG COUNTIES

YEAR	CLARENDON	ORANGEBURG	YEAR	CLARENDON	ORANGEBURG
1940	31,500	63,707	1980	27,464	82,276
1950	32,215	68,726	1990	28,450	84,883
1960	29,490	68,559	2000		
1970	25,604	69,789	2010		

Look at the area surrounding Lake Marion on the STATE BASE MAP #2, WITH HIGHWAYS, and also on the LAKE MARION TOPOGRAPHIC MAP and the LAKE MARION LITHOGRAPH. Make a list of land uses on the Orangeburg County side of the lake versus land uses on the Clarendon County side. Are there any significant differences in land use? Are there any landform-related reasons for those differences? Try to explain the differences in population growth in Clarendon and Orangeburg counties by referring to landform characteristics or land use patterns. Are there other factors, besides the development of Lake Marion, which might account for some of the population growth differences between these two counties?

14. **Predict reaction of Ms. Holmes' students.** ✍
Read the story "The Big Catch" on page 7A-3. What do you think the reactions of Ms. Holmes' students were when she told them her riddle? Would you have believed her? After all, she did have a picture. Where on Lake Marion do you think Ms. Holmes had her picture taken? Locate this spot on the LAKE MARION TOPOGRAPHIC MAP and explain why you chose that spot. Do pictures always tell the exact truth? How would you have answered her riddle? Have you ever heard a tall story or fish tale? Has an unusual event happened to you while you were fishing? Tell your story to others. Can you find the location of your fish tale on a map?

ENRICHMENT

1. **Interview people in school or community for fish tales.** ✍
Interview both younger and older members in your community to collect fish tales. You may even want to broaden your collection to include animal stories in general. Don't forget to include your own story and the stories from your classmates.

2. **Research how a saltwater fish got into Lake Marion.** ☼
How did the striped bass, a saltwater fish, come to reside in Lake Marion? Find out what conditions made this lake a natural habitat for the striped bass. Contact the Fisheries Division of the Department of Natural Resources for references.

3. **Estimate attendance at a school sporting or musical event.** 💻
During a game or a performance, randomly select a section of the stands or of the auditorium seating. Count the number of filled versus empty seats in your chosen section. Ask a school administrator to tell you the total number of available seats for the event. Use ratios to calculate the approximate attendance. Check your answer against the actual attendance

recorded for the event. How close was your number? How did your selection of the sample section affect your answer?