South Carolina Coastal Planning & Management Council

GROUNDWATER In The Coastal Plain of South Carolina

BY: Stuart Greeter
August 1975

GROUNDWATER IN THE COASTAL PLAIN OF SOUTH CAROLINA

Stuart Greeter
August 1975

I. Introduction

Groundwater is a necessary resource that is often overlooked or ignored until it's too late. That is, until problems occur that have to be corrected with more costly investments of public monies. These problems may include water shortages, inadequate water quality, or contamination of a pure aquifer. Consequently, it would be wise to plan for and manage the use of groundwater resources, which are renewable if utilized properly. Planning for these resources should include adequate data collection, evaluation of the data to determine present and potential problems, and recommendations concerning future use of this resource.

It is a generally accepted fact that most groundwater problems, in our State, occur in the immediate vicinity of the coast. Given that this area is likely to experience the most rapid growth, there is a reason for concern. Presently, some aquifers are suffering from too much draw down, in certain instances salt water intrusion is occuring and many people must drink water that does not meet U.S. Department of Health drinking water standards. The purpose of this report is to collect and evaluate available information to determine what problems presently exist, potential problems that are likely to occur, what information is lacking, what information is being collected, and recommendations on future actions.

Section II is a summary of the geologic situation in the Coastal Plain of South Carolina. This must be understood by the reader, if the problems discussed in Section III are to be appreciated. Sections II and III are based on information that is presently available. Section IV reviews current and proposed studies, i.e. the information that will be available in the future.

TABLE OF CONTENTS

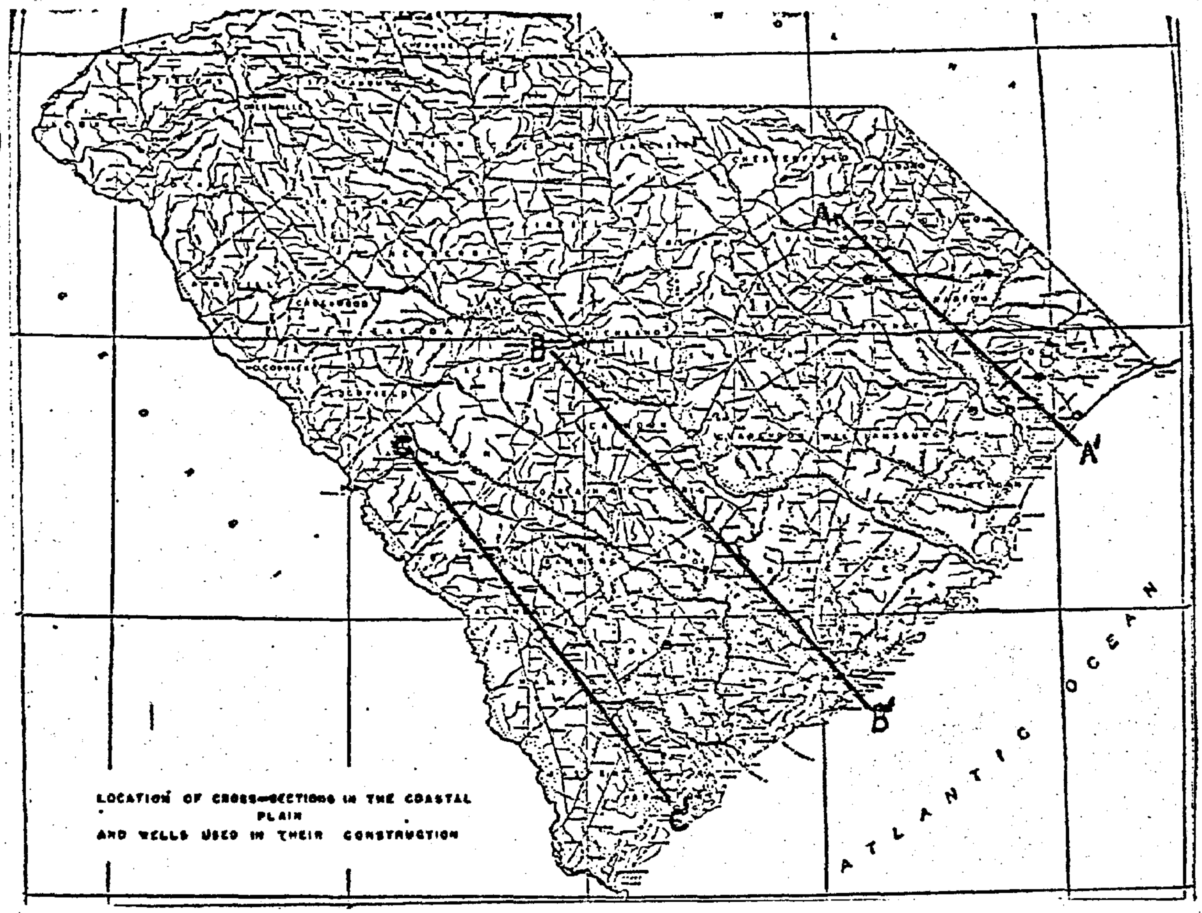
There seems to always be a need for more data, due to the fact that groundwater systems are rather nebulous entities. Section V will indicate perinent information that does not presently exist. Finally, Section VI lists conclusions that may be deduced from this report and recommendations that may serve as indications of future activities to pursue.

II. Geologic Structure and Major Aquifer Systems

Structure

To understand the problems associated with groundwater, one must first gain a general knowledge of the geologic structure of the Coastal Plain and the potential complexity of groundwater systems. The Coastal Plain is that area between the fall line and the coast line. The fall lines runs in a southwesterly-northeasterly direction through Columbia, at an elevation of approximately 400' to 500' above mean sea level. Basement rocks (igneous and metamorphic) outcrop northwest of the fall line. The Coastal Plain (southeast of the fall line) is composed of a wedge of sedimentary rocks resting on basement rocks. The structure is similar to that of a layered cake, only quite lopsided. The layers of sedimentary rocks thicken and dip to the southeast, as shown in the cross sections in figures 1 and 2. These layers continue past the coastline and compose at least part of the continental shelf.

Figure 3 is a stratigraphic section which shows all the sedimentary rocks present in the Coastal Plain. Nowhere are all these formations present in one single column. In other words, when drilling in the Coastal Plain, one may not be certain which rock layers will be encountered, but the relative order in which they will be encountered is certain. This is because the formations represent deposits that occured at different times when the sea



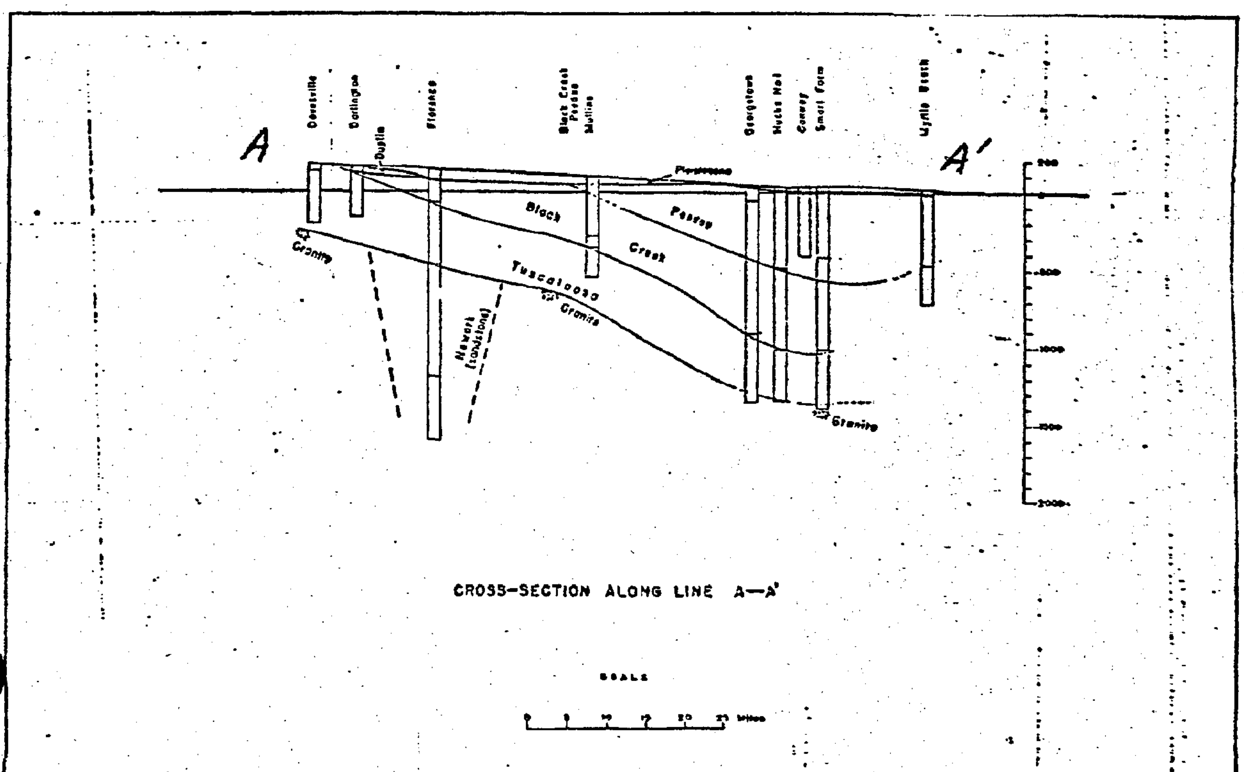
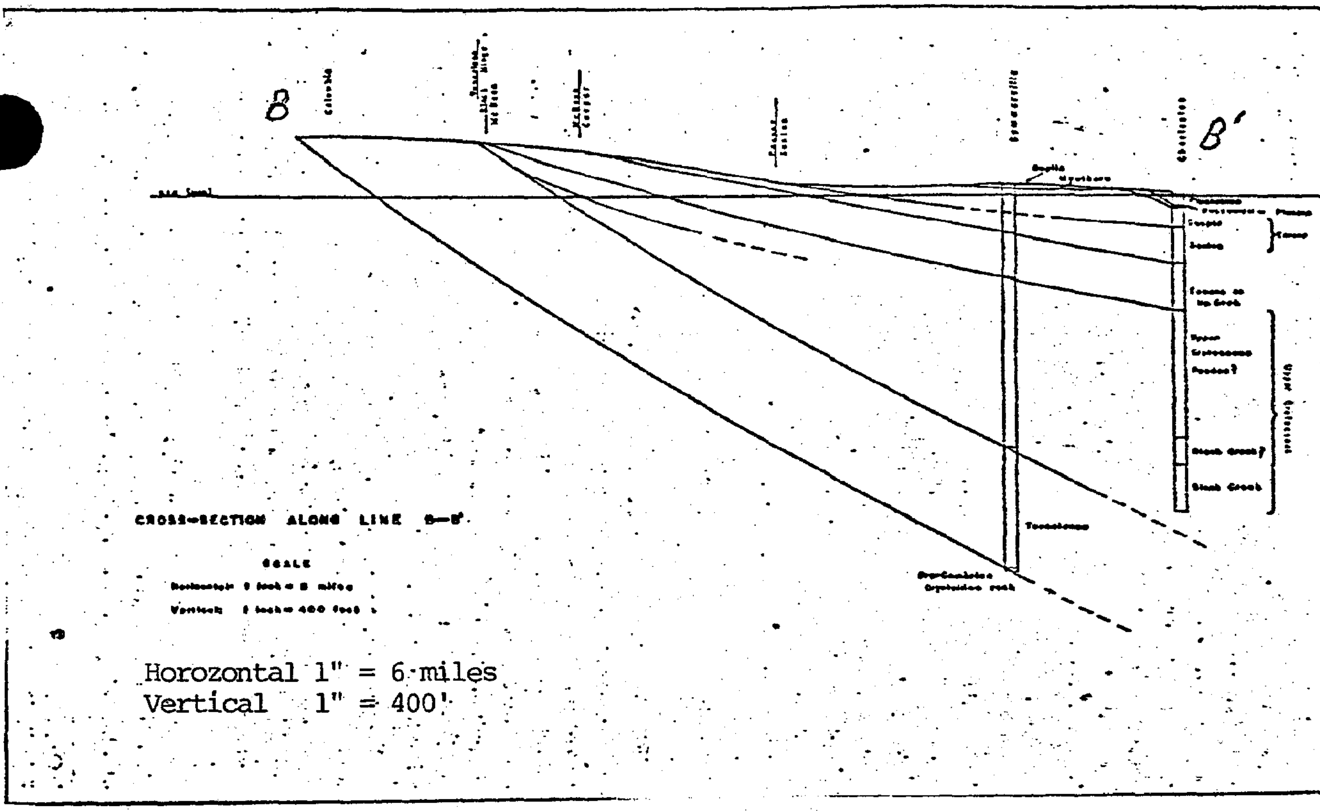


Figure 1A. Transverse cross-sections of the South Carolina coastal plain. From: Stock and Siple, Ground-Water Records of South Carolina Miscellaneous Report No. 5, 1969.



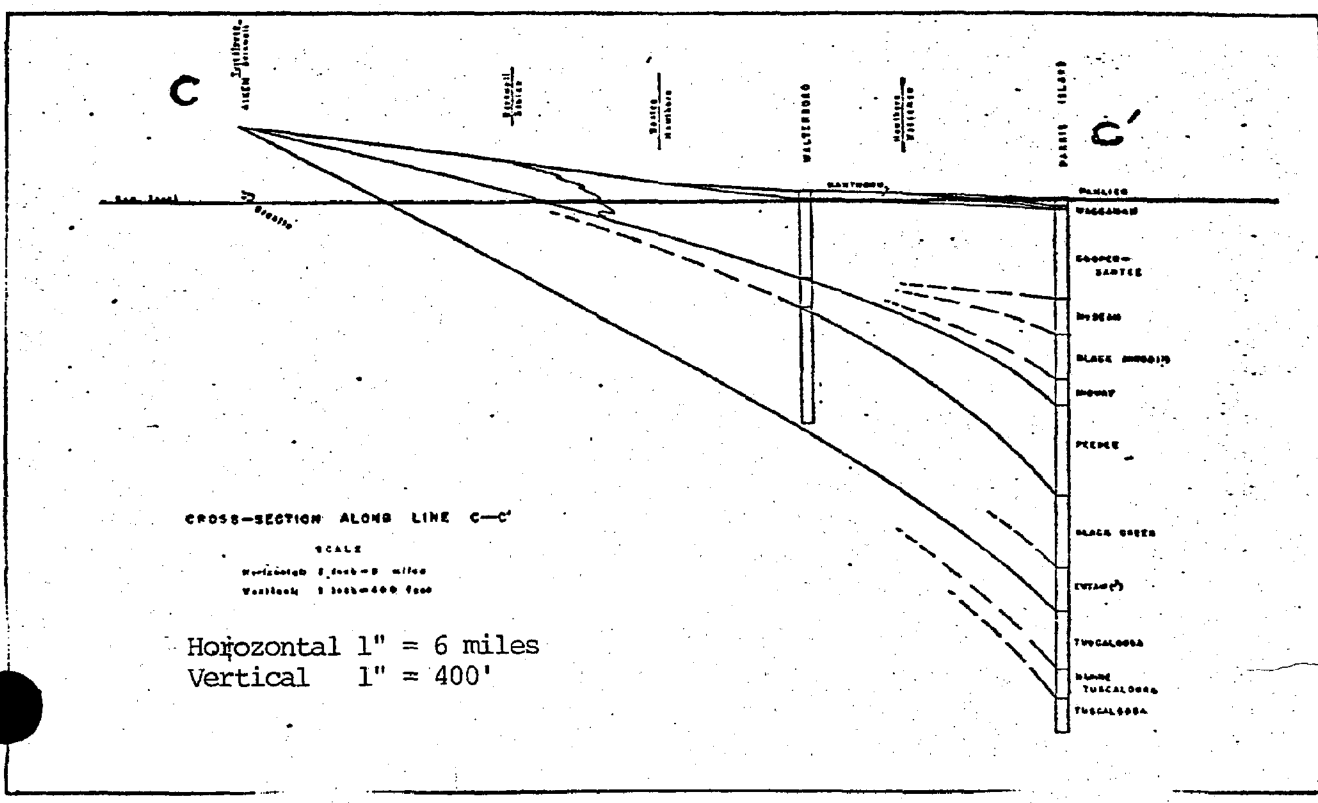
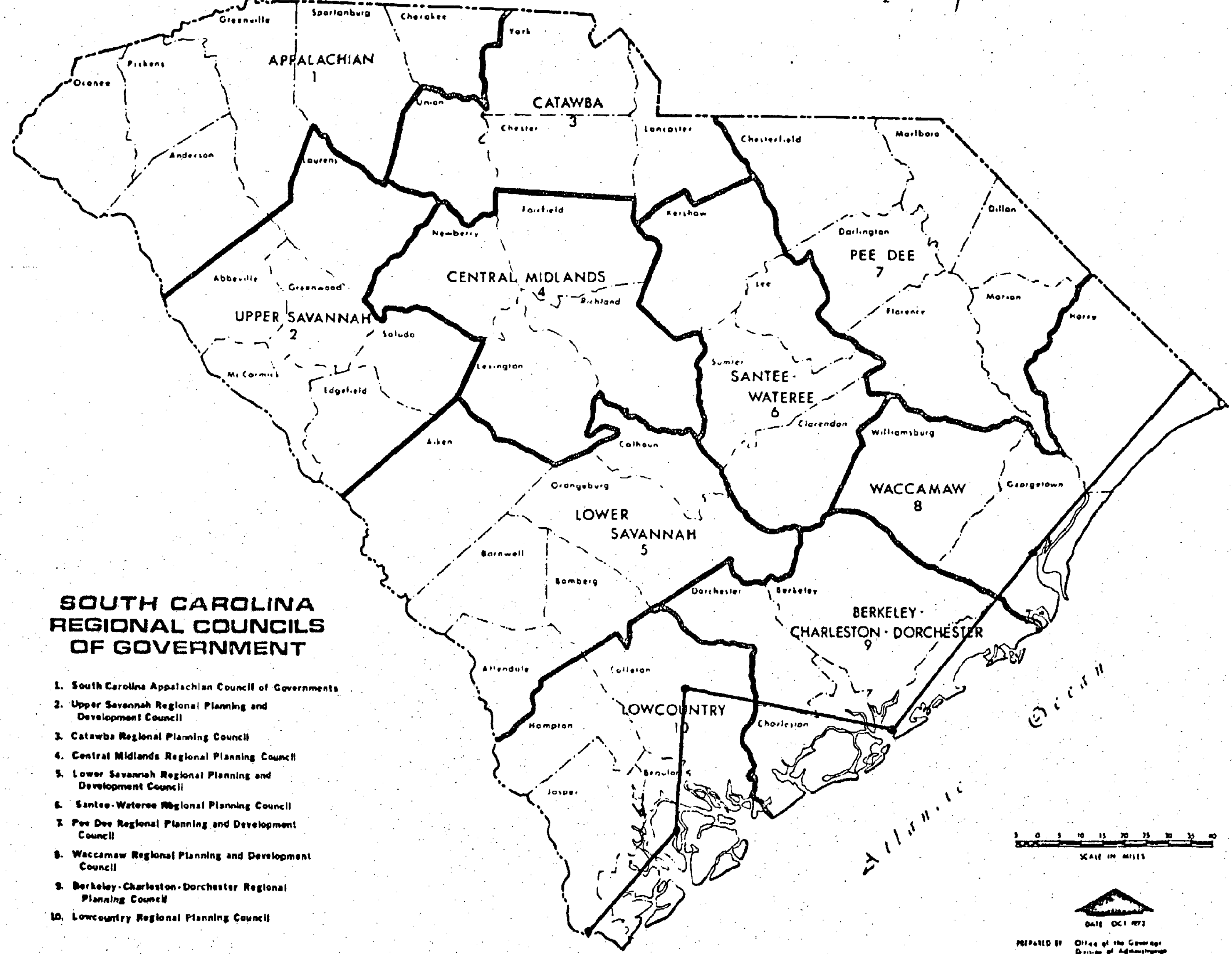


Figure 1-B. Transverse cross-sections of the South Carolina coastal plain. From: Stock and Siple, Ground-Water Records of South Carolina Miscellaneous Report No. 5, 1969.

Figure 2-A. Location of longitudinal cross section of the coastal plain



CROSS-SECTION OF THE SOUTH CAROLINA COASTAL PLAIN

Horozontal Scale: 1 inch = 32 miles

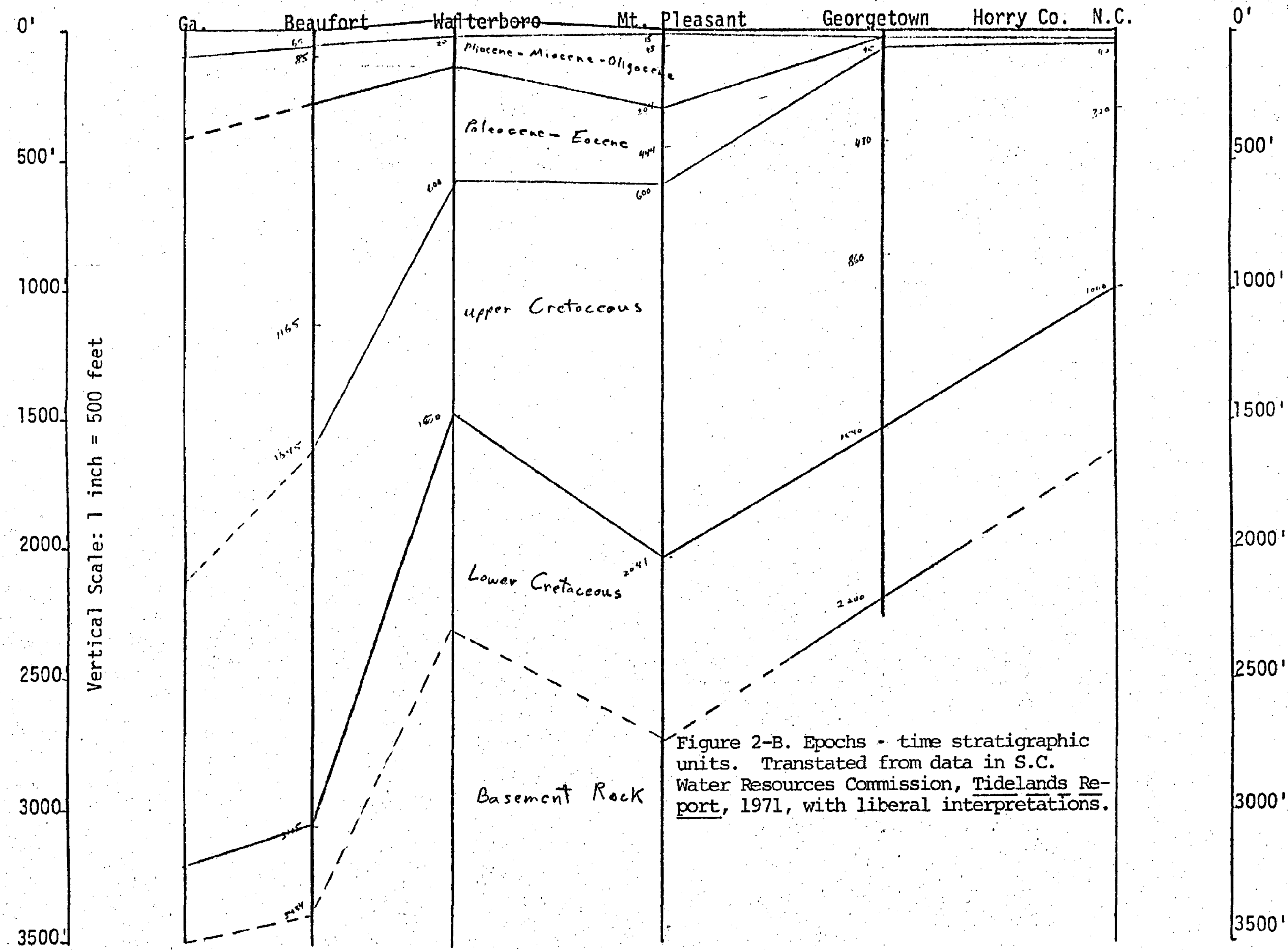


Figure 2-B. Epochs - time stratigraphic units. Transtated from data in S.C. Water Resources Commission, <u>Tidelands Report</u>, 1971, with liberal interpretations.

CROSS-SECTION OF THE SOUTH CAROLINA COASTAL PLAIN

Horozontal Scale: 1 inch = 32 miles

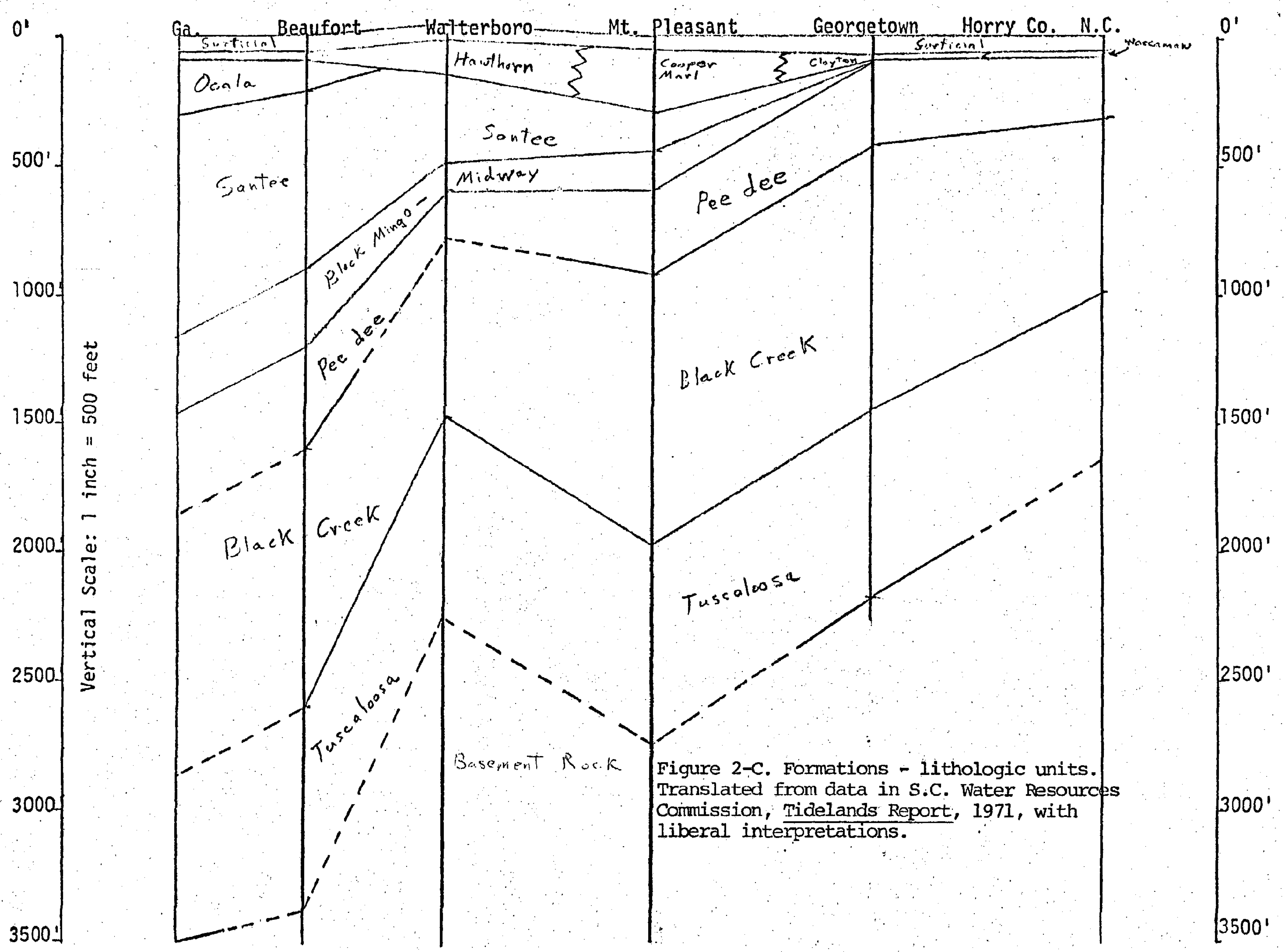


Figure 2-C. Formations - lithologic units. Translated from data in S.C. Water Resources Commission, Tidelands Report, 1971, with liberal interpretations.

SYSTEM	SERIES		GEOLOGIC UNIT	DISTRIBUTION	WATER SUPPLY
QUARTERNARY TO TERTIARY	RECENT TO PLIOCENE		SURFICIAL MATERIAL	Alluvial fill and terrace deposits in stream valleys, consisting of tan to gray sand, clay, silt and gravel; blanket deposits of coarse gravel on higher terraces. The surficial material lies as a blanket upon the underlying older Cenozonic strata of the coastal plain. The average thickness of the surficial material is 10 to 15 feet and the maximum thickness is on the order of 50 feet.	Minor importance as aquifers, domestic yields from thick sections only. Water may be high in iron, sulfate, and nitate, generally soft.
TERTIARY	MIOCENE		HAWTHORN FORMATION	Tan, red and purple sandy clay interbedded lenses of gravel and numerous classic dikes. The Hawthorn formation covers the high interstream areas of the inner-Coastal Plain.	The Hawthorne, because of its low permeability, is not considered a major aquifer. However, it does provide sufficient water for domestic purposes and for limited industrial use.
TERTIARY	EOCENE	UPPER	BARNWELL FORMATION	Red, brown, yellow and buff fine to coarse massive to cross bedded sand and sandy clay. Often contains beds of mottled-gray to greenish-gray sandy clay and ledges of ferruginous sandstone that range in thickness from 1 inch to 3 feet. The Barnwell formation is exposed in the uplands in most of Aiken & Barnwell Counties & form the area of recharge for its subsurface equivalent — the Ocala Limestone.	Does not yield large quantities of water readily to wells, partly because of too small size of the sand grains. Yields for domestic use may be obtained from wells in the Barnwell formation from localities where the sand is sufficiently coarse and free from admixtures of silt and clay.
TERTIARY	EOCENE	UPPER	OCALA LIMESTONE	White limestone, fossiliferous, somewhat calcitized and crystalline. Found only in the subsurface in the southern portion of the coastal plain.	A major source of water in Beaufort and Jasper Counties. Yields of 500, to 2,900 gpm are obtained from wells penetrating the entire principal aquifer. Water is moderately hard, low in iron and chloride. Water from the lower part of the aquifer may have relatively high chloride.
TERTIARY	EOCENE	MIDDLE	McBEAN FORMATION	The McBean formation is the shoreward equivalent of the Santee Limestone. This formation consists of yellow-brown to green fine to coarse sand, inter-bedded with green, red, yellow and tan clay, sandy marl or limestone and lenses of siliceous limestone. Crops out in Aiken, Barnwell, and Northern Calhoun counties.	The beds of sand and limestone in the lower part of the formation in Aiken and Barnwell Counties are fairly permeable and yield moderate to sizeable quantities of water to industrial and municipal wells.
TERTIARY	EOCENE	MIDDLE	SANTEE LIMESTONE	A creamy-white to buff colored highly fossiliferous limestone. The limestone is usually soft but weathered exposures may contain ledges or lenses of recalcified and indurated rock. The Santee limestone crops out in the central portion of the coastal plain.	Yields from this aquifer range from 50 to 500 gpm. The water is moderately hard, has a dissolved solids content normally between 150 and 250 mg/l and a pH of 7.1 to 7.9.
CRETACEOUS	UPPER CRETACEOUS		PEE DEE AND BLACK CREEK FORMATIONS	The Black Creek formation consists primarily of fine to medium phosphatic and glauconitic sands which may be locally interbedded with gray and black clay. The Pee Dee formations crop out in the northeastern third of the coastal plain and underlie younger sediments in the remainder. The formations dip south-southeast approximately 20-25 feet per mile. The confirmed thickness of these two formations is approximately 1400 feet near the coast.	Yields from 8-10 inch gravel-packed wells with screens placed opposite the sands in the Pee Dee and Black Creek vary from 60 gpm to 900 gpm. Yields as high as 1,200 gpm have been reported from wells in the Black Creek formation, but usually such quantities are obtained downdip from the outcrop area, where a thicket section of the unit is found.
CRETACEOUS	UPPER CRETACEOUS		TUSCALOOSA FORMATION	Tan, buff, and white cross bedded, micaceous feldspathic, quartz sand and gravel interbedded with red, brown, gray and purple impure clay and with kaolin. The Tuscaloosa formation is the basal unit of the formations in the coastal plain. The thickness of the formation ranges from a feather edge in the vicinity of the fall line to approximately 800 feet in wells near the coast. The outcrop area forms a belt that is from 10 to 35 miles wide and extends Northeastward across South Carolina from Augusta, Georgia, to the North Carolina line.	A potential source of large quantities of water in the coastal plain. The permeability is relatively high, and in several areas yields up to 3,400 gpm can be obtained from individual wells. The transmissibility of the Tuscaloosa formation is apparently greatest in areas 20 to 40 miles downdip from the outcrop area. This increase in transmissibility of the aquifer downdip from the outcrop area may be due to the increase in aquifer thickness in that direction, rather than an increase in permeability. Water is soft and low in total solids.

Figure 3: Stratigraphic section of all sedimentary formations in the coastal plain. From: S. C. Water Resources Commission and S. C. Society of Professional Engineers, The Proceedings of the Water Well Seminar for Professional Engineers, 1972.

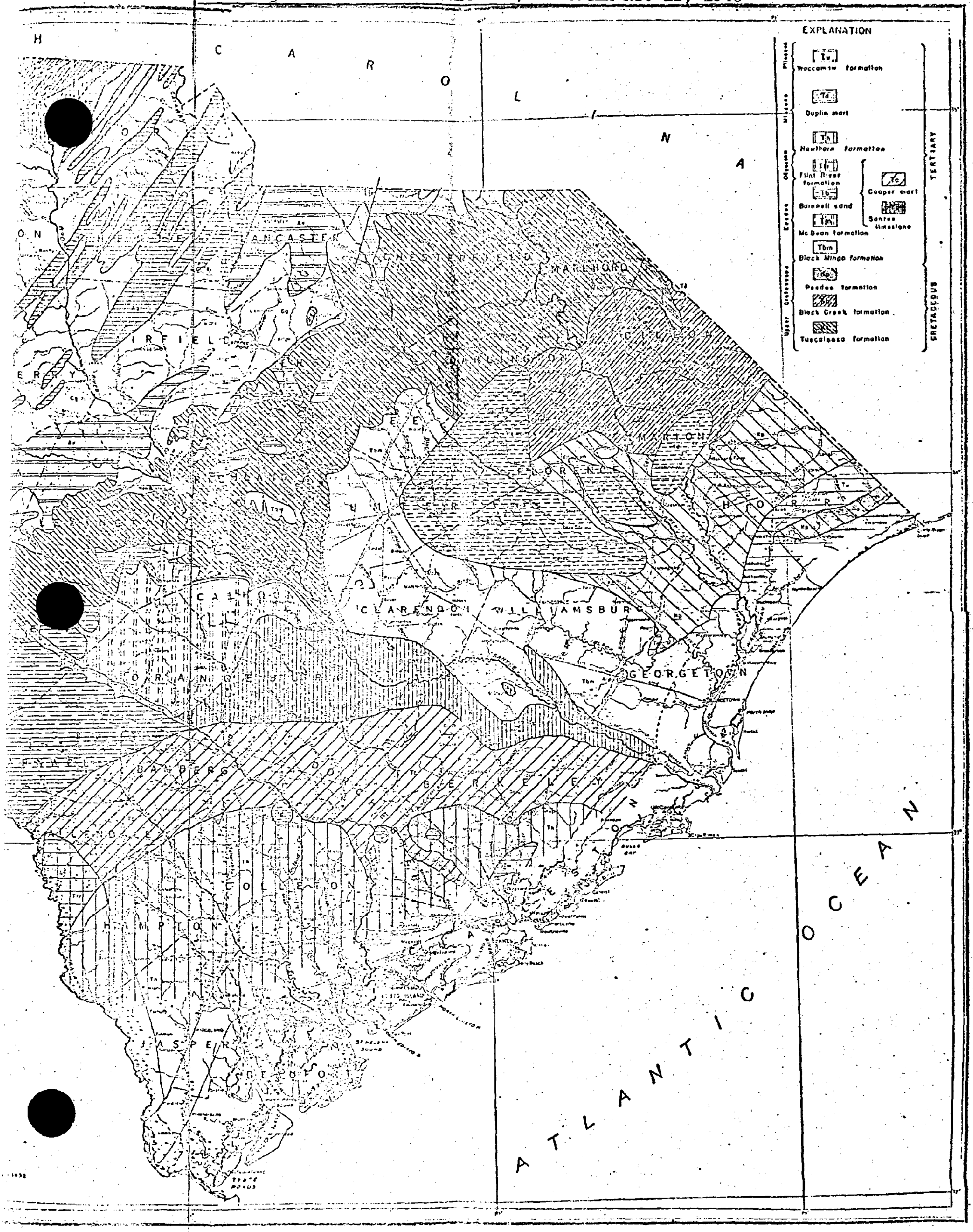
level, relative to the land, rose and fell, i.e. transgressed and regressed. This may have been a result of a rise and fall of the continental land mass, a eustatic rise and fall in sea level due to glaciation, or a combination of these two factors.

Figure 4 is a map of the surface geology. This represents what we would see if all the unconsolidated overburden were stripped off. This overburden may range from 0' to 150'. With the knowledge that all the sedimentary units dip to the southeast and the use of this map, one can be fairly certain of the formations to be encountered and the sequence in which they will be encountered, for a certain location.

This simple picture can be greatly complicated by faulting or tectonic shifting of rock bodies. This may be the case in the southern part of the coastline, in the vicinity of Beaufort County. Here, Siple indicates there is a stratigraphic high or dome, which would alter the groundwater flow.[1] (Figure 5). He calls it the "Burton High". There are also indications of faulting.[2] Thus, any generalizations made for this area could be false due to unknown alterations in rock structure.

<u>Groundwater flow</u>

Groundwater in the Coastal Plain moves from the Northwest to the Southeast. There are, of course, local variations, but it can generally be stated that groundwater will move at right angles to topographic contour lines. The reason for this is that topographic contours are usually synchronous with contours of equal groundwater level or head. Due to gravity, the groundwater will flow from topographic highs (hills) to topographis lows (rivers, swamps, ocean). (Figure 6) The water will flow easily through


EXPLANATION
Waccamaw formation
Duplin marl
Hawthorn formation
Flint River formation
Barnwell sand
McBean formation
Black Mingo formation
Peedee formation
Black Creek formation
Tuscaloosa formation
Cooper marl
Santee limestone
TERTIARY
CRETACEOUS
CAROLINA
MARLBORO
FLORENCE
MARION
HORRY
CLARENDON
WILLIAMSBURG
GEORGETOWN
BERKELEY
COLLETON
HAMPTON
JASPER
ATLANTIC OCEAN

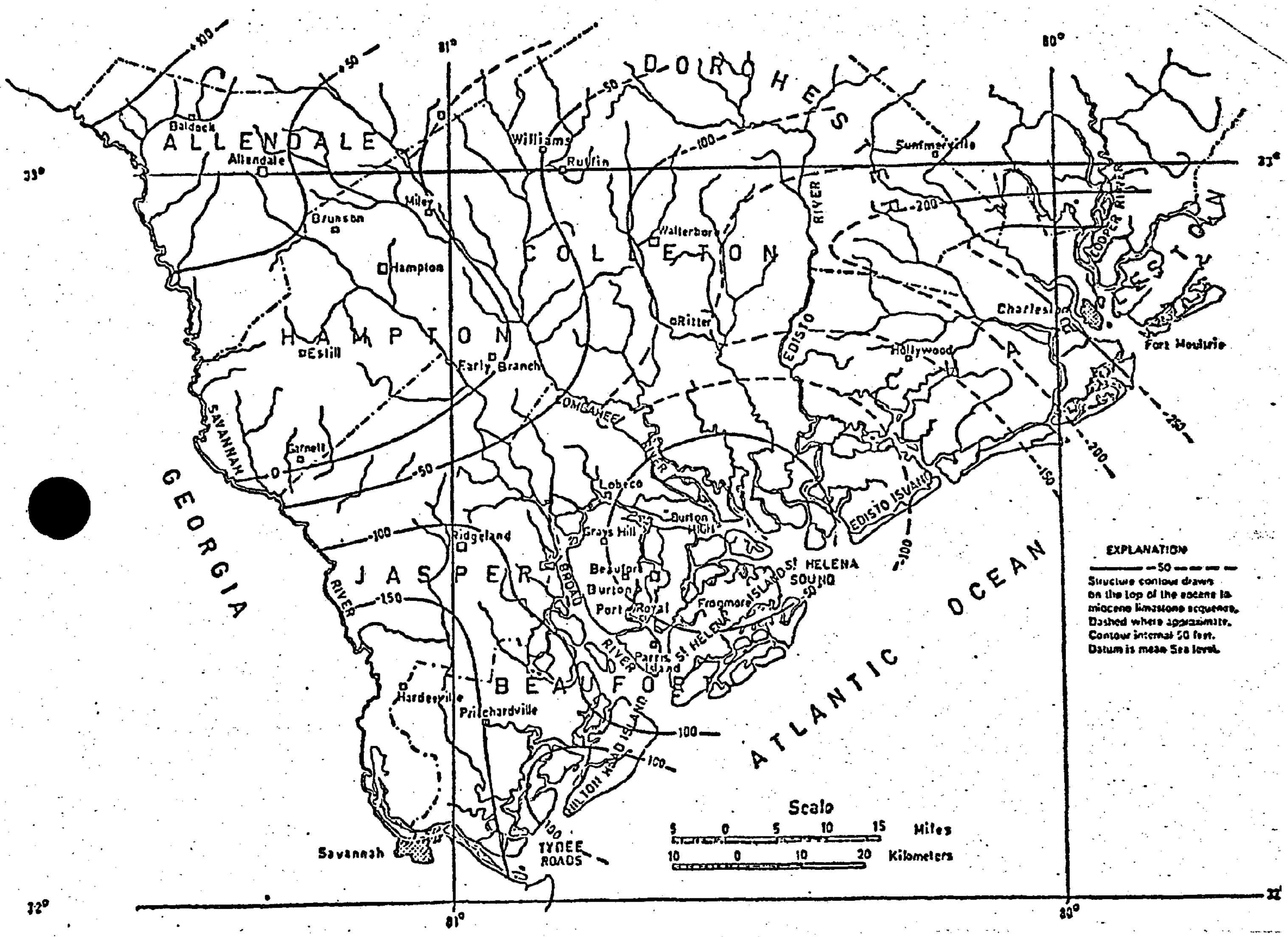


Figure 5. - Structure - contour map of the Eocene to Miocene limestone surface of Southeastern South Carolina.
From: Siple, Salt-Water Encroachment of the Tertiary Limestones Along Coastal South Carolina, Bulletin No. 15, 1965.

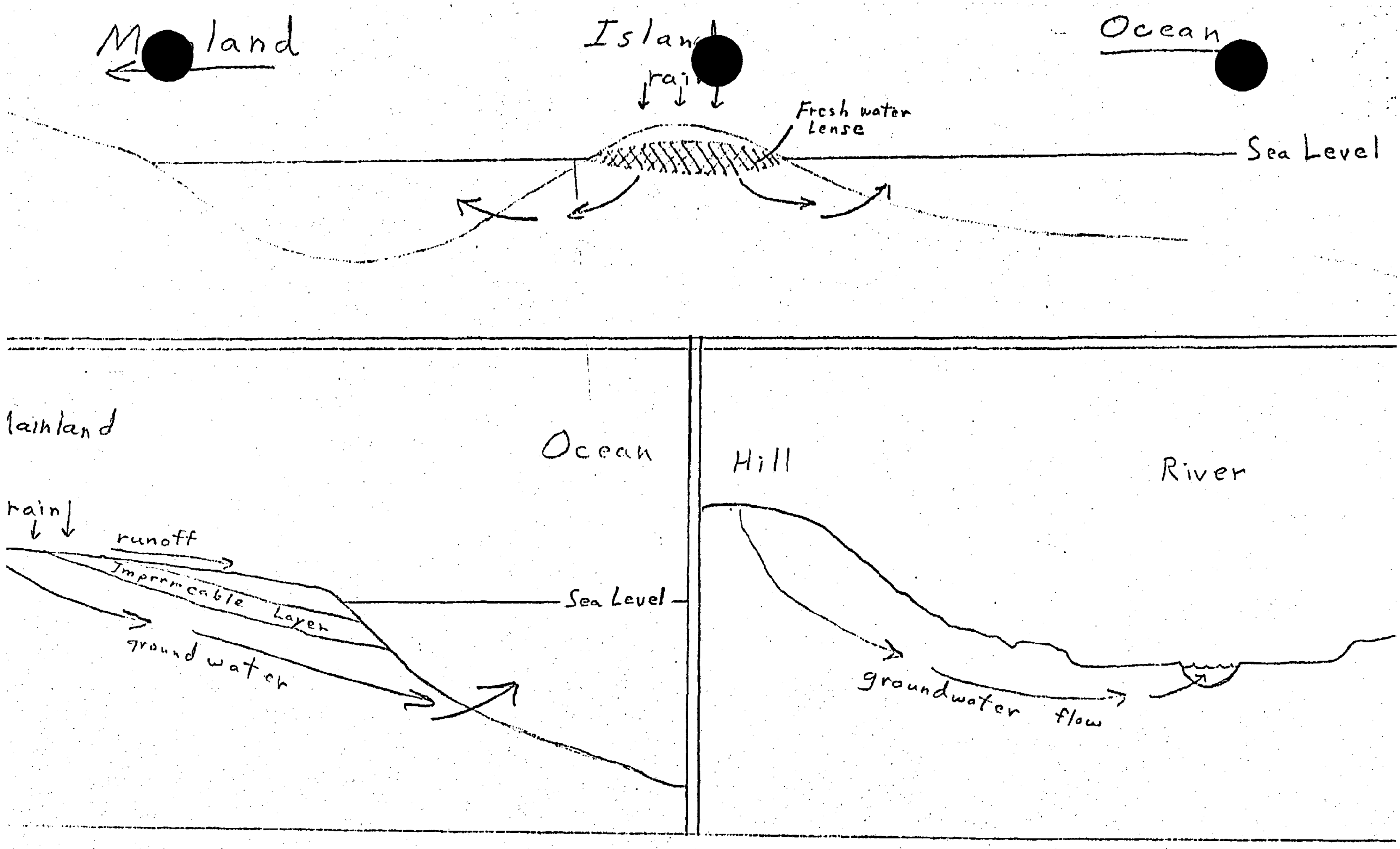


Figure 6: Ground water flow under given situations.

permeable layers (sand) and be contained by impermeable layers (clay). In addition to the horizontal movement, the groundwater may move vertically from one aquifer to another. The vertical movement is much slower than the lateral movement because it is retarded by layers of silt and clay which separate the aquifers.[3] It is even possible for one rock formation to have several zones, each containing water of different quality or quantity. Understandibly, this greatly complicates our ability to predict acceptible groundwater sources.

In the coastal zone, the two major acquifer systems are the Black Creek - Pee Dee formations and the Eocene limestones (Ocala and Santee formations). (Figure 3) In the immediate vicinity of the coast the Tuscaloosa (or Middendorf) formation tends to be salty, but further inland on the Coastal Plain, it is the highest producing aquifer in the State.[4] The following section will give indications of the water quality in these aquifer systems in different areas.

How much groundwater?

Statistics seem to indicate that the majority of groundwater resources in South Carolina are untapped. "About 23.7 tillion gallons of water per year falls in the State from precipitation. If only 10 percent of the annual precipitation is added to groundwater, then the recharge is about 2.37 trillion gallons annually. Thus the estimated average use (1970) is only about 3.6 percent of the total recharge. The extent to which the draft on groundwater can be increased will depend largely on whether a proper balance can be achieved locally between the rate of withdrawal from wells and rate of replenishment of groundwater by natural and/or artificial means."[5]

The problem of groundwater quality was not taken into account in the foregoing statistics. The question of how much usable groundwater exists cannot be answered at this time.

The reasons for this are that the quality and quantity of water available in a given rock formation may differ at different locations. Also, the same rock formation may have more than one producing zone with disimilar water characteristics. One zone of very poor quality may make other adequate zones look poor. A well must be properly tested and cased in order to tell for sure. We don't have enough of this type of information to estimate how much water of a satisfactory quality is available. Surely it is more than 3.6% of the total recharge. In the coastal area, the question of how much is most important.

Another factor to consider is the rapidly increasing demand for fresh water. In South Carolina the total use of water increased 100% between 1960 and 1970, while the population increased by only 8.8%.[6] This increase is largely a result of agricultural and industrial users. The average person is responsible for the use of 180 gallons of water per day. Future demand for water will, no doubt, rise. While the demand is increasing, the quantity available remains constant. Therefore, those who develop water management policy must keep in mind that there are limits to the use of such a resource, if it is to remain a renewable resource. This is especially true when withdrawing ever increasing amounts from the same aquifer at the same location.

Cost

Published estimates indicate the average cost of surface water is approximately thirteen center per 1,000 gallons, and the anticipated cost of groundwater, in most instances, is less than five cents per thousand gallons.[7] In the city of Georgetown, a surface water source costs about 24¢ per thousand gallons while the groundwater source costs approximately 10¢ per thousand gallons.[8] Thus, it is fair to generalize that an adequate groundwater source will always be cheaper than a surface water source. This is an important factor to both industrial and domestic users. A domestic user will probably put up with the excess cost, but an indistrial user may be forced to locate elsewhere. It is therefore imperative that a determination be made as to whether or not adequate groundwater resources do exist in the coastal area of South Carolina. Most groundwater specialists feel that adequate resources do exist, if properly utilized and managed. However, one should be aware of future population projections for the coastal zone, when making this determination.

Recharge

The recharge areas for the major aquifers are where these rock formations outcrop, or are exposed to permeable overburden. The geologic map in Figure 4 shows this. The recharge areas for the Tuscaloosa, Pee Dee-Black Creek and Santee aquifers have been shaded in. Actually, the actual recharge areas are much larger than shown. For instance, even though a realtively impermeable bed overlies an aquifer near the surface, some water will perculate through to recharge the aquifer. So, the recharge area for the Tuscaloosa can be represented by a wide band running southwest-northeast across the State. The recharge area for the Santee limestone can be represented by a wide curved band running east-west across the southern corner of the State. The band would include the outcrop of the Cooper Marl, even though it is relatively impermeable. Likewise, the Pee Dee-Black Creek recharge is much larger than that shown by shading.

There is some disagreement about where the Santee formation leaves off and the Ocala formation begins. The Ocala formation is present in the Southern corner of the State, but probably pinches out somewhere between Beaufort and Edisto Island. The recharge area for this formation is, likewise the southern corner of the State.[9] The recharge for a large portion of the water used in Savannah goes into the aquifer in Hampton and Jasper counties.

Recharge areas for the major aquifers are large enough so that there is no danger of covering them with impermeable man-made surfaces. The quantity of groundwater is limited by aquifer transmissivities, not size of recharge areas. However, the possibility of polluting the aquifer through recharge of contaminants from surface activities always exists. Present laws governing solid waste disposal sites, septic tank fields, and deep well injunction seem to be adequate protection against such a possibility.

III. Groundwater Problems in the Coastal Plain

<u>Problems in the Beaufort area</u>:

A report by McCollum and Counts (1964) indicates that the city of Savannah obtains water from the Ocala formation (Upper Eocene) and the Lisbon formation (Middle Eocene). There is some disagreement among experts as to whether the Ocala and Santee formations are actually separate entities. For the purposes of this report, it will be assumed that the Ocala formation overlies the Santee formation,with the separation being rather indistinct. Keep in mind that the Santee formation may be equivalent to the Lisbon formation in Georgia.

Within these shallow aquifer formations are five major water-yielding zones, separated by rather impermeable layers. (See Appendix I) Before pumping began in 1880, the original groundwater flow was east toward Port Royal Sound. (see Appendix II) It is uncertain whether or not the lower permeable zones extend into South Carolina. By 1939 the piezometric surface (height to which the groundwater rises above the aquifer) had decreased 60 or 80 feet. The piezometric surface shown in Appendix II indicates that by 1961, the water level in Savannah had dropped a total of 120 feet from the original surface.[10]

The wells are still artesian. That is, the piezometric surface is still above the aquifer. However, remembering that the groundwater flow is at right angles to the contour lines of the piezometric surface, one may observe that the groundwater flow in the Hilton Head Island area has exactly reversed. This reversal is a direct result of the pumping in Savannah.

If maps of the piezometric surface contours are compared from 1958 (Counts and Donsky 1963) and 1961 (McCollum and Counts 1964), the 10 and 20 foot contours on Hilton Head Island are in approximately the same position. The contours further inland continue to decline over time. This indicates that ocean water is being recharged into the aquifer at Hilton Head Island.[11] Originally being a freshwater discharge area, Port Royal Sound has become a salt water recharge area.

The chloride content of the groundwater increases to the east and northeast of Savannah. Chlorides in the lower zones are thought to be from connate water (original interstitial water in the rock) which has not been flushed completely due to low permeability. Chlorides in the upper zones are believed to come from saltwater intrusion in the Port Royal Sound area. Evidence pointing toward this conclusion is as follows:

1. In Port Royal Sound, the limestone aquifer is less than 100 feet below sea level.

2. Upon lowering the piezometric surface and reversing the groundwater flow, the discharge area becomes a recharge area.

3. Many tidal waterways are deep enough to channel the limestone and provide access for the salt water.

4. The upper confining layer (Hawthorn formation) is absent in some locations thus providing possible access for salt water.

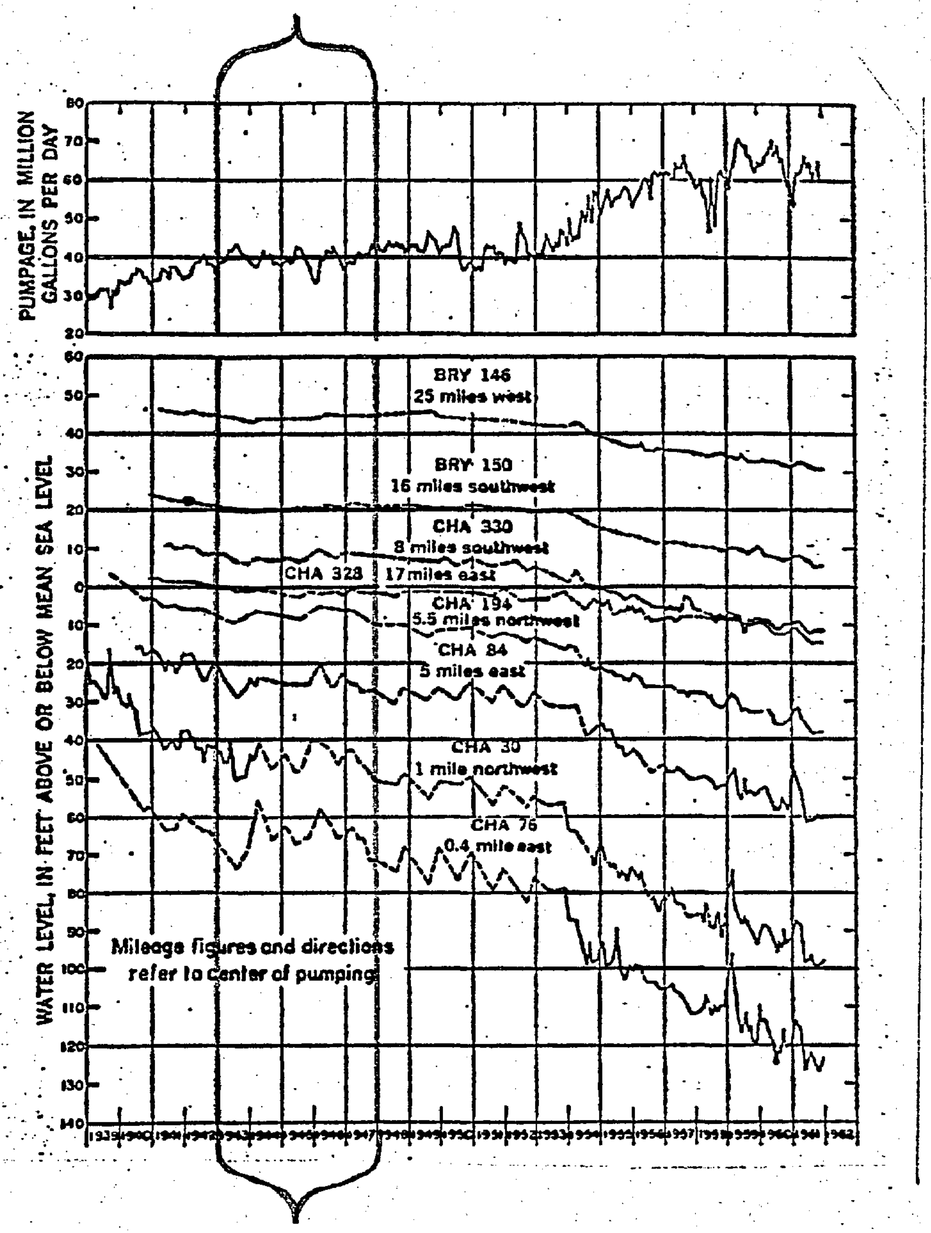
5. Limestone resembling that of the upper aquifer has been dredged from the Beaufort River adjacent to Parris Island, thus providing access for salt water.[12]

6. Groundwater analysis indicates the chloride content, of water obtained from test wells on Hilton Head Island, to be increasing.[13]

Thus the evidence denoting salt water intrusion in the Port Royal Sound area is almost uniquivocal. Estimates of the time required for salt water to reach Savannah, via the aquifer, range from 100 to 400 years. Brackish water in the lower producing zones is much closer to Savannah, but those zones are also less permeable. There is understandibly disagreement and uncertainty among experts about when salt water may reach Savannah. It is certain, however, that the shallow aquifer on Hilton Head Island will turn brackish long before that water reaches Savannah. Beaufort has already been forced to a surface water supply and Hilton Head Island may be next. This once renewable groundwater source is now being depleted, as saltwater intrusion will permanently alter the water quality. The fact that this is a shallow aquifer makes the problem more serious. Rural areas may be without a drinking water source, as they cannot afford to drill deep wells.

There are possible solutions, or at least deterrents, to the problem. In 1944, Warren estimated that 25 mgd could be pumped in Savannah without continual decline in the piezometric surface of the acquifer. Based on the information presented in Figure 7, McCollum and Counts estimate 40 mgd can be pumped without continual decline in the piezometic surface. Present pumping in

Constant volume pumping



Constant water level

Figure 7. Constant water level at 40 MGD pumping.
From: McCollum and Counts, "Relation of Salt-Water Encroachment to the Major Aquifer Zones Savannah Area, Georgia and South Carolina," Water Supply Paper 1613-D (1964).

Savannah is approximately 70 mgd, and 25 mgd is obtained from the Savannah River and treated. If half the required groundwater could be obtained from a well drilled 20 miles west of Savannah, the problem might be solved. This would result in a rise in the piezometric surface at Savannah and an elongation of the cone of depression to the west. The piezometric surface at Hilton Head Island is also likely to rise. The movement of salt water would at least be retarded, and might be stopped.

Another possible solution is to tap a deeper aquifer. This could be done at either Hilton Head Island or Savannah. The city of Savannah is presently drilling a deep well to test water quality in the deeper aquifers. The water quality in the deep aquifers at Hilton Head Island are unknown, at this time.

Another solution may be for Savannah to expand their surface water treatment plant, or for Hilton Head Island to develop a water treatment plant. It is unlikely that the industrial users in Savannah are willing or able to pay for a surface water source. It is also expensive to obtain a surface water source on an island surrounded by sea water. However, it might be economically feasible to treat water obtained from the shallow or deep aquifers on Hilton Head Island.

The Grand Strand Area

At the northern end of the South Carolina coast, the deep aquifers are much closer to the surface and easier to reach. But, there are more problems with water quality. Flouride content may average around 4.0 ppm. This exceeds U.S. Department of Health safe drinking water standards (figure 8). Children drinking high flouride water may have mottled teeth as a result. When this happens, the teeth are discolored, but no other

LIMITS ESTABLISHED ACCORDING TO PUBLIC HEALTH SERVICE DRINKING WATER PROPOSED STANDARDS, 1973

Total Solids	500 ppm
Turbidity	5 t. u.
Color	15 c. u.
Alkalinity	No est. limits
Calcium	No est. limits
Magnesium	No est. limits
Hardness	No est. limits (0-50 ppm Soft) (51-100 Med-Hard) ppm (101-200 Hard) ppm
Sodium	No est. limits
Iron	0.3 ppm
Chlorides	250 ppm
pH	6.5 - 8.5 ppm acceptable
Manganese	0.05 ppm
Copper	1.0 ppm
Zinc	5.0 ppm
Fluoride	Controlled (0.7 - 1.0 ppm)
Potassium	No est. limits
Mercury	1.0 ppb
Chromium	0.05 ppm
Cadmium	0.01 ppm
Lead	0.05 ppm
Arsenic	0.01 ppm
Barium	1.0 ppm
Cyanide	0.2 ppm
Selenium	0.01 ppm
Silver	0.05 ppm

MBAS	0.5 ppm
CCE	0.2 ppm
Nitrate	10 ppm
Nitrite	1 ppm
Phosphate	No est. limits
Sulfate	250 ppm
Odor	3 T. O.
PESTICIDES	
Hydrocarbons:	
Aldrin	0.001 ppm
Chlordane	0.003 ppm
DDT	0.05 ppm
Dieldrin	0.001 ppm
Endrin	0.0005 ppm
Heptachlor	0.0001 ppm
Heptachlor Epoxide	0.0001 ppm
Lindane	0.005 ppm
Methoxychlor	1.0 ppm
Toxaphene	0.005 ppm
Organophosphates & Carbamates	0.1 ppm (parathion)
Herbicides:	
2, 4-D	0.02 ppm
2, 4, 5,-T	0.002 ppm
2, 4, 5-TP (Silvex)	0.03 ppm

ppm = parts per million
[illegible]

Figure 8: U. S. Department of Health drinking water standards.

physical damage can be detected. Water from the Black Creek - Pee Dee formations are high in flouride throughout the Grant Strand area. There is no economically feasible way to remove the flouride from the water.

Near North Carolina, these formatinos increase in chloride content. Presently, this poses no health problem. Locally, high sulfur and/or bicarbonate content may occur. The sulfur gives the water an odor and the bicarbonate makes it more difficult to wash clothes. No health problem has been related to occurrences of these contaminants in drinking water. As one moves inland,the quantity and quality of the water is this aquifer system increases.

The Tuscaloosa is salty near the coast, but fresh further inland. It has not been determined whether the chlorides result from sea water or unflushed connate water.

The city of Georgetown has five wells near the Pee Dee River. A deep well was drilled when the others began to get salty. It has not been determined whether the chlorides are from sea water or unflushed connate water. Upon encountering basement rock (igneous and metamorphic rocks) at a depth of 1,875 feet, the water from the well had between 1,200 and 1,800 ppm chlorides. At that point, the decision was made to develop a surface water source.

If the chloride content in Georgetwon's wells is due to unflushed connate water, it is possible that the problem could be alleviated by proper well development and construction. First the well would have to be tested with a flow meter to determine the location of the producing zones, and the quantities of groundwater available. At the same time, water samples from various levels in the well would have to be taken. Then a determination could be made as to whether or not there is an adequate fresh water zone available. If so, the well could be properly cased and screened to produce fresh water. It is impossible to know if fresh water zones exist in the well when water from all the producing zones is mixed and the end result is the only thing that is measured.

Presently the city of Georgetown services about 12% of the region's population (12,000 people) with surface water. Present use is about 2MGD while the treatment plant capacity is 6 MGD. The surface water source costs about 23 - 24¢ per thousand gallons, while the groundwater source costs approximately 9 - 10¢ per thousand gallons.[14] Consequently, the wells are used on week-ends.

The Charleston Area:

The Black Creek - Pee Dee formations have a high flouride content along the coast north of Charleston. Very near the coast the chloride content is high. For instance, wells at Sullivan's Island and Isle of Palms mix deeper high chloride water with the shallow fresh water table to obtain enough potable drinking water. The shallow reserve does not have enough quantity to be used alone. This aquifer system is also salty south of Charleston. However, on Edisto Island the wells were properly screened and cased and they now have at least one fresh water well. It should be noted that no direct health problems have been related to a chloride content of 500 - 600 ppm which occurs here. Again, the Tuscaloosa is salty near the coast and fresh further inland.

At one time, Charleston utilized the Black Creek - Pee Dee system as a source of drinking water. A surface water source was developed as a result of increased demand and some increase in chloride content. Again, it was never determined whether the chlorides were from connate water or sea water.

IV. Current and Proposed Studies Pertinent to Groundwater Systems.

Past Studies: Numerous studies that pertain to groundwater in the Coastal Plain have been done in the past. They generally pertain to a very limited area and a single rock formation. The studies are published in U.S.G.S. Bulletins and Professional Papers, Geologic Society of American reports, and others. Pertinent information from applicable reports has been incorporated into Section III and the cross section of the coast (Figure 2).

Safe Drinking Water Act (PL 93-523): The Safe Drinking Water Act was enacted by Congress in December 1972 and signed by the President in December 1974. The Administrator of EPA has 90 days, after enactment, to publish primary drinking water standards. The standards have not yet been determined but will eventually be published in the Federal Register. Within 180 days, the Administrator shall promulgate regulations as he deems appropriate. The regulations shall take effect 18 months after their date of promulgation.

Primary drinking water standards are those which refer to contaminants which may have an adverse effect on human health. The States have primary enforcement responsibility. If a state does not comply, the Administrator may bring civil action in a U.S. district court. The State may grant variances and exemptions to local water systems, based on reasons listed in Section 1416. The Administrator will reivew all exemptions.

The Administrator will also publish regulations for underground injection, to protect underground sources of drinking water. A state may issue injection permits if the regulations are adopted. The regulations do not pertain to injection associated with the recovery of oil or gas.

Underground injuection has been considered as a means of disposal for nuclear wastes. However, the Nuclear Regulatory Commission has not yet determined an acceptible means of disposal.

The Act authorizes 15, 25, and 35 million dollars for three consecutive years, 1975-77.

A fifteen member National Drinking Water Advisory Council will be appointed to advise the administrator (Section 1446).

The administrator will consult with the Secretary of Agriculture and various states and conduct a survey of the quantity, quality, and availability of rural drinking water supplies. There are 1, 2, and 1 million dollars authorized for these studies in the three respective years 1975-77.

The South Carolina Department of Health and Environmental Control plans to apply for funding under this Act.

South Carolina Department of Health and Environmental Control: An "Economic and Environmental Impact of Land Disposal of Wastes in the Shallow Aquifers of the Lower Coastal Plain of South Carolina" proposal will be submitted by DHEC to the Coastal Plains Regional Commission for funding of $233,529. The proposal is presently in draft form and will be submitted by the Hydrology and Quality Control Section of the Water Supply Division of the Office of Environmental Quality Control.

The project will take two years to complete, and drill 400 fifty foot average depth wells. The study area will be from the immediate coastline to 20 miles inland, a 4,000 square mile area, or the coastal segment of eight counties. The drilling locations will be chosen by the geologist, based on previous information (soil surveys, geological studies), test wells, population centers, groundwater pollution sources, and information obtained from previous wells in this study.

The study should supply the following information:

1) A compilation of published and unpublished reports on groundwater and geology in the area

2) An inventory of potential pollution sources.

3) Groundwater samples will be analyzed for bacteriological and chemical composition and the wells will be continually monitored.

4) Yield tests will be undertaken where water quality is high.

5) A map showing locations of potential solid waste and wastewater sites.

It is significant to note considerable overlap between this proposal and the 208 planning guidelines. The 208 guidelines refer to establishing "guidelines to protect ground and surface water quality through controls on the deposition of residual wastes and on land disposal of pollutants." Section 208(b)(2)(F-K);(2) The purposes of the Act include protection of groundwater quality and assurance of adequate water supplies. The guidelines refer specifically to delineation of aquifer recharge areas and solid waste disposal sites. However, it is doubtful that the COG's have the technology and equipment that is required for such a detailed subsurface study as DHEC proposes. Hence, they should utilize the information obtained in DHEC's proposal, if it is funded. The only problem is that the DHEC's program takes two years to complete. The 208 program must also be completed in two years.

United States Geological Survey: U.S.G.S., in conjunction with the South Carolina Water Resources Commission, is undertaking two "capacity use" studies. One is for the Waccamaw region and the other is for the Lowcountry region. The Waccamaw Study is near completion and the Lowcountry study may take another three years to complete. U.S.G.S. will not release any of the data or information collected until their studies are published.

The "capacity use" studies are primarily a result of our State's Groundwater Use Act of 1969. (R520,H1009). The Act indicates that the studies will contain the following results:

1) The number of persons using an aquifer and the object, extent and necessity of their respective withdrawals or uses;

2) The nature and size of the aquifer;

3) The physical and chemical nature of any impairment of the aquifer, adversely affecting its availability or fitness for other water uses (including public use);

4) The probable severity and duration of such impairment under forseeable conditions;

5) The injury to public health, safety or welfare which result if such impairment were not prevented or abated;

6) The kinds of businesses or activities to which the various uses are related;

7) The importance and necessity of the uses claimed by permit applicants (under this section), or of the water uses of the area (under section 5) and the extent of any injury or detriment caused or expected to be caused to other water uses (including public use);

8) Diversion from or reduction of flows in other water courses or aquifers; and

9) Any other relevant factors.

However, Phil Johnson indicates that some of these results will not be achieved. The Waccamaw study is based on a total of ten wells, with possibly one or two going down to basement rock. Twenty-five wells are planned for the Lowcountry region, but it is more likely that only ten will be drilled.

The Groundwater Use Act requires permits from the Water Resources Commission for consumptive uses of over .1MGD, after a "capacity use" study has been completed. Granting of permits will, of course, be based on the study. The Water Resources Commission is represented on our Coastal Zone Council, hopefully poviding a check on groundwater factors when permit applications are considered.

It should be noted that the biggest problem in the State, related to capacity-use, is in the Lowcountry region. The pumping in Savannah is resulting in drawdown as far away as Hilton Head Island and the city of Beaufort. The capacity use study for this area may not be completed for another three years.

EPA 208 Program

Waccamaw: (Bob Barker) As of July-75, the Waccamaw region is still in the consultant selection phase of their 208 program. A work program has not been developed yet. Mr. Barker indicates that aquifer recharge areas, spray irrigation sites, and solid landfill sites will probably be mapped, but the details are not presently known.

Berkeley-Charleston-Dorchester: (Ken Fujishiro)

The B-C-D 208 program will address groundwater sources but this will not be their major concern. A water resources study for the entire region will be printed in another month. Ken Fujishiro indicates that the results of this study show the only reliable source for good quality drinking water to be a surface water source. Presently, approximately 60% of the region's population rely on surface water. In twenty years, it is likely that only 10% of the population will rely on ground water.[15] This will be a rural population with shallow wells (less than 100').

Presently, Charleston gets water from the Edisto River, through an underground aquaduct. The tunnel is in good condition and is likely to last many years. Lake Moultrie is seen as the major future water source for the region. The Corp's potential rediversion project will not affect this source.[16]

Offshore islands will have to pay a higher price to have water piped out. The method of disposal will either be treatment with an ocean outfall or spray irrigation. Spary irrigation is a possibility for many other areas of the region, particularly forest lands and golf courses. Solid landfill recommendations will not be site specific, but indicate general areas that are suitable. Shredding and spreading may be a feasible alternative to the solid landfil method.

Lowcountry: (Commander Charles Baggs) Commander Baggs indicates that the Lowcountry region will have a definite and detailed work program by late October 1975. They will probably map aquifer recharge areas, solid landfill sites, and spray irrigation areas. Commander Baggs feels that the Lowcountry Region will probably be going to a surface water supply, in the future because of the numerous problems encountered with groundwater in this region. At least, that will hold true for Beaufort County and the coastal portions of Jasper and Colleton Counties. Presently, the city of Beaufort, Port Royal, Parris Island, and parts of Lady's Island are served by a surface water source. This represents about 35% of the population in the Lowcountry region.

State Laws

1. Proposed Water Well Contractors Licensing Act: This bill was introduced in '72 and '73 by the Department of Water Resources and then in '74 and '75 by DHEC. Originally the bill would have been implemented by the Water Resources Commission, now the commission of Health and Environmental Control. It seems that small drilling operaters are the major opposition to the bill, and as of January 1976 the bill has not passed.

The bill states that the Commission has authority to issue, withold, deny, revoke or suspend licenses to drillers. A driller must have two years experience, pass a written or oral exam, and pay a fee ($25) to obtain a license. The driller is also required to supply the Commission with a well log and water quality information for each well. The information will be compiled and open to the public.

2. Groundwater Use Act of '69: Upon request of a local government, the South Carolina Water Resources Commission may designate a "capacity use area". In a capacity use area, the Commission has the authority to:

1) require water users to submit periodic reports on quantity and sources of water used;

2) regulate timing of withdrawals

3) regulate well depth, spacing controls, and pumping rates.

Permits are required for groundwater withdrawal in excess of .1MGD. In adopting rules and regulations, the Commission shall consider:

1) the number of persons using an aquifer and the object, extent and necessity of their respective withdrawals or uses;

2) the nature and size of the aquifer;

3) the physical and chemical nature of any impairment of the aquifer, adversely affecting its availability or fitness of other water uses (including public use);

4) the probable severity and duration of such impariment under forseeable conditions;

5) the injury to public health, safety or welfare which result if such impairment were not prevented or abated;

6) the kinds of businesses or activities to which the various uses are related;

7) the importance and necessity of the uses claimed by permit applicants (under this section), or of the water uses of the area (under section 5) and the extent of any injury or detriment caused or expected to be caused to other water uses (including public use);

8) diversion from or reduction of flows in other water courses or aquifers; and

9) any other relevant factors.

3. The South Carolina Pollution Control Act created the South Carolina Pollution Control Authority. The Pollution Control Authority was absorbed by DHEC, but the rules and regulations promulgated under the Act remain the same. DHEC is presently the implementor of the following guidelines:

a) South Carolina Landfill Regulation (PC-SW Regulation 1): Approved September 1971; as of July 1972, an old or new solid waste system requires a permit from the State Board of Health. All open dumps are prohibited. Site location requirements consider potential water pollution, surrounding environment, cover material, and future development of the area. Site design requirements include a map, a plot plan with cross sections, soil borings, leachate containment, observation test wells (when necessary), and geologic and hydrologic information to a depth of 10 feet below proposed excavations or lowest site elevation.

b) South Carolina Industrial Solid Waste Disposal Site Regulation (Regulation PC-SW-2) Approved and Effective March 1972. As of July 1972 all new or old systems for disposal of industrial solid waste shall require a permit from the South Carolina Department of Health and Environmental Control Discharge of organic or inorganic solid matter into waters of the State is prohibited. The permit application shall include a map and plot plan. The disposal facility shall be designed by a soil scientist, geologist or engineer.

c) South Carolina Guidelines for Waste Disposal Permits (SPCA - SWG -2). February 1973. This is the guideline on the minimum submission requirements for a permit to dispose of inert, nonburnable, nontoxic wastes by earth burial in a manner such that environmental pollution does not result.

V. What Information is Needed

1. One important component of information that is lacking is a good indication of the rock structure in the coastal plain. The cross section in Figure 2 was translated from published reports and is inadequate because of lack of detail and adequate number of controls, i.e. validity of information. U.S.G.S. (Columbia Office) should be prompted to release this type of information as soon as possible. This is especially true for the Lowcountry region where the rock structure may be very complex.

2. A determination of how much usable groundwater exists in the coastal zone is needed. This can be accomplished by plotting the producing zones on the cross section referred to in the previous paragraph. Well tests must be run to determine the quality and quantity available from each zone. We know that the total quantity available exceeds demand, but water quality is a limiting factor here. We also know that water quality generally deteriorates nearest the coastline. U.S.G.S. is presently collecting this information and it is the author's recommendation that the data be made available to the public as soon as possible. An indication of the availability of drinking water on sea islands is most important.

3. A reliable population projection for the coastal zone is needed. The projection should not only indicate how much growth, but the type of growth that will occur, i.e., industrial, residential, recreational, etc. Then the future demand for potable water can be determined. If the demand is high, it may be wise to develop a surface water source.

The EPA-208 program should supply the type of information required here. The Charleston-Berkeley-Dorchester region will probably rely heavily on a surface water source, while the Waccamaw and Lowcountry regions are yet undecided.

4. Some type of water well monitoring system would be helpful. All new and old wells should be monitored as to water level and water quality. Any permanent drawdown (taking seasonal fluctuations into account) will indicate overpumping. A change in water quality may indicate salt water intrusion, which is also a result of overpumping. When this occurs, a new well can be drilled further away and usually both wells can be pumped without any permanent damage to the aquifer. A monitoring system would give us an indication of the capacity of a particular aquifer, thus safeguarding its perpetual usefulness.

VI. Conclusions and Recommendations

Conclusions

1. In the short-run, surface water is always more expensive than groundwater.
2. Some people will always be using groundwater (rural homes, industry, agriculture), so these resources should be preserved.
3. The recharge areas for the major deep aquifers in the Coastal Plain are so large that it is extremely unlikely they could ever be covered up to the point of hindering recharge. However, these aquifers could be polluted from improper waste disposal in the recharge areas.
4. The quantity of water in the major producing aquifers is limited by the formations' transmissivities, not the recharge areas.
5. Most groundwater problems are in the immediate vicinity of the coast.
6. Growth is likely to occur most rapidly in the immediate vicinity of the coast.
7. The largest quantities of groundwater are available from the deeper aquifers in the Coastal Plain.
8. Groundwater problems could result in large economic loss, i.e. the Grand Strand area, Hilton Head Island, etc.

Recommendations

1. A study should be undertaken to determine the maximum capacity of groundwater systems underlying sea islands along the coast. Development and the need for new public water supplies will occur most rapidly there. Priority should be given to the Beaufort area because the problems seem to be most serious there. Secondly, the Grand Strand and thirdly the Charleston area, because the B-C-D region is most likely to rely on a surface water source. The affect of septic waste systems on sea islands should also be considered.

2. An intensive study should be undertaken at Hilton Head Island to determine how long it will take for their primary water source, the Ocala fm. (Santee fm.) to become salty. Other possible drinking water sources should be evaluated. These include the Black Creek - Pee Dee formations, the Tuscaloosa formation, and the surface water source at Parris Island. Possible methods to improve the situation should also be considered.

3. The proposed Well Driller's licensing Act should be endorsed as it would: serve to supply much needed groundwater information; aid in insuring proper well design and construction; and protect public investments and existing pure aquifers.

4. Reliable projections of future water requirements for the coastal area must be developed. These should be based on population and industrial growth projections. The decision to rely on groundwater or develop a surface water source will be facilitated once future water needs are determined.

5. A study should be undertaken to determine the capacity of various fresh water producing aquifers in the coastal zone. This will also facilitate the groundwater - surface water decision. Again, priority should be given to the Beaufort area.

6. A survey to determine potential contamination of shallow aquifers in the coastal zone is advised. Shallow aquifers are likely to be of great importance to the growth, economic development, and quality of life here. There will always be those who rely on shallow water supplies in rural areas, suburban areas, recreation areas and sea islands.

VII. Summary

Most groundwater problems occur in the immediate vicinity of the coast where the highest demand for groundwater is likely to occur. The three urban centers along the coast (Charleston, Georgetown, Beaufort) are already utilizing a surface water source. Areas immediately adjacent to these urban centers are served by a surface water source. There will always be rural communities that must depend on groundwater. These communities can usually utilize a shallow well even though the largest quantities are available from deeper aquifers. Problems of drawdown, salt water intrusion, or septic contamination are most likely to occur in the shallow aquifers. This is especially true for offshore islands which are likely the first areas to be developed.

Presently, the most serious problem seems to be salt water intrusion occurring in the Beaufort area. Information on the water quality in the deeper aquifers is needed here. The other major problem is that of water quality in the Waccamaw region. Hopefully, the U.S.G.S. study will supply enough information so a solution can be proposed. A third area where water problems are very likely to occur in the immediate future, is the sea islands. Information on the shallow and deep aquifers is needed. Costs of piping out a water source should be estimated, but they are likely to be prohibitive.

The most perplexing problem seems to be; should a surface water source be emphasized or should we continue to take our chances with groundwater? Additional geologic and hydrologic information, along with reliable growth projections, is needed to make this determination. Large users may be forced to a surface source while small users may find groundwater adequate. The U.S.G.S. studies and the 208 studies should aid in answering this question.

Footnotes

[1]George E. Siple, Salt Water Encroachment of the Tertiary Limestone Along Coastal South Carolina (International Symposium of Dubrovnik, 1965), p. 444.

[2]Conversation with Don Duncan, S. C. Department of Health and Environmental Control, Columbia, South Carolina, July 1975.

[3]Donald A. Duncan, "Ground Water Resources of South Carolina" Proceedings of the Water Well Seminar for Professional Engineers (February 1972), pp. 16-25.

[4]Ibid., p. 20.

[5]Ibid., pp. 20-21.

[6]Ibid., p. 21.

[7]Ibid.

[8]Conversation with George Hewitt, Georgetown Waterworks, Georgetown, South Carolina, July 1975.

[9]Conversation with Alan Zupan, Geology Division, State Development Board, Columbia, South Carolina, July 1975.

[10]M. J. McCollum and H. B. Counts, "Relation of Salt Water Encroachment to the Major Aquifer Zones Savannah Area, Georgia and South Carolina," Water-Supply Paper 1613-D (1964).

[11]Ibid., p. D16.

[12]Conversation with Alan Zupan, Geology Division, State Development Board, Columbia, South Carolina, July 1975.

[13]Unpublished test well records obtained from the U.S.G.S. office in Atlanta, July 1975.

[14]Conversation with George Hewitt, Georgetown Waterworks, Georgetown, South Carolina, August 1975.

[15]Conversation with Ken Fujishiro, Berkeley-Charleston-Dorchester Council of Governments, Charleston, South Carolina, August 1975.

[16]Ibid.

Bibliography

Boggs, Commander Charles. Lowcountry Regional Planning Council, South Carolina. Personal communication, August 1975.

Barker, Bob. Waccamaw Regional Planning Council, South Carolina. Personal communication, August 1975.

Counts, H. B. and Ellis Donsky. "Salt water encroachment, geology, and groundwater resources of the Savannah area, Georgia and South Carolina" U.S.G.S. Water Supply Paper 1611 (1963).

Duncan, Donald A. South Carolina Department of Helath and Environmental Control, Columbia. Personal communication, periodically.

Fujishiro, Ken. Berkeley-Charleston-Dorchester Council of Governments, South Carolina. Personal communication, August 1975.

Georgia Department of Natural Resources. The Value and Vulnerability of Coastal Resources, Background Papers for Review and Discussion. Atlanta, Georgia: Resource Planning Section, DNR, (1975). pp. 137-170.

Gill, Harold. United States Geological Survey, Atlanta. Personal communication, August 1975.

Glowacz, Michael E. South Carolia Department of Health and Environmental Control, Columbia. Personal communication, periodically.

Hewitt, George. Georgetown Waterworks, South Carolina. Personal communication, July 1975.

McCollum, M. J. and H. B. Counts. "Relation of Salt-Water Encroachment to the Major Aquifer Zones Savannah Area, Georgia and South Carolina." Geological Survey Water-Supply Paper 1613-D (1964).

Odum, Ole. United States Geological Survey, Savannah. Personal communication, August 1975.

Siple, G. E. Progress Report on Ground Water Investigations in South Carolina, Bulletin No. 15 Columbia: Reserach Planning and Development Board and U.S.G.S., Department of the Interior, (1946).

-----Salt Water Encroachment of the Tertiary Limestones Along Coastal South Carolina. International Symposium of Dubrovnik, 1965.

Spigner, B. C. South Carolian Water Resources Commission, Columbia. Personal communication, January 1976.

South Carolina Water Resources Commission. South Carolina Tidelands Report. Columbia: South Carolina Water Resources Commission, 1971.

South Carolina Water Resources Commission and South Carolina Society of Professional Engineers. The Proceedings of the Water Well Seminar for Professional Engineers. Columbia, South Carolina: 1972.

Stock, G. W. and G. E. Siple. Ground Water Records of South Carolina, Miscellaneous Report No. 5 South Carolina State Development Board and United States Geological Survey, (1969).

United States Geological Survey, U. S. Department of the Interior Water Resources Data for South Carolina. Columbia: Water Resources Division, U.S.G.S., (1975).

Zupan, Alan. Geology Division, State Development Board, Columbia, South Carolina. Personal Communication, August 1975.