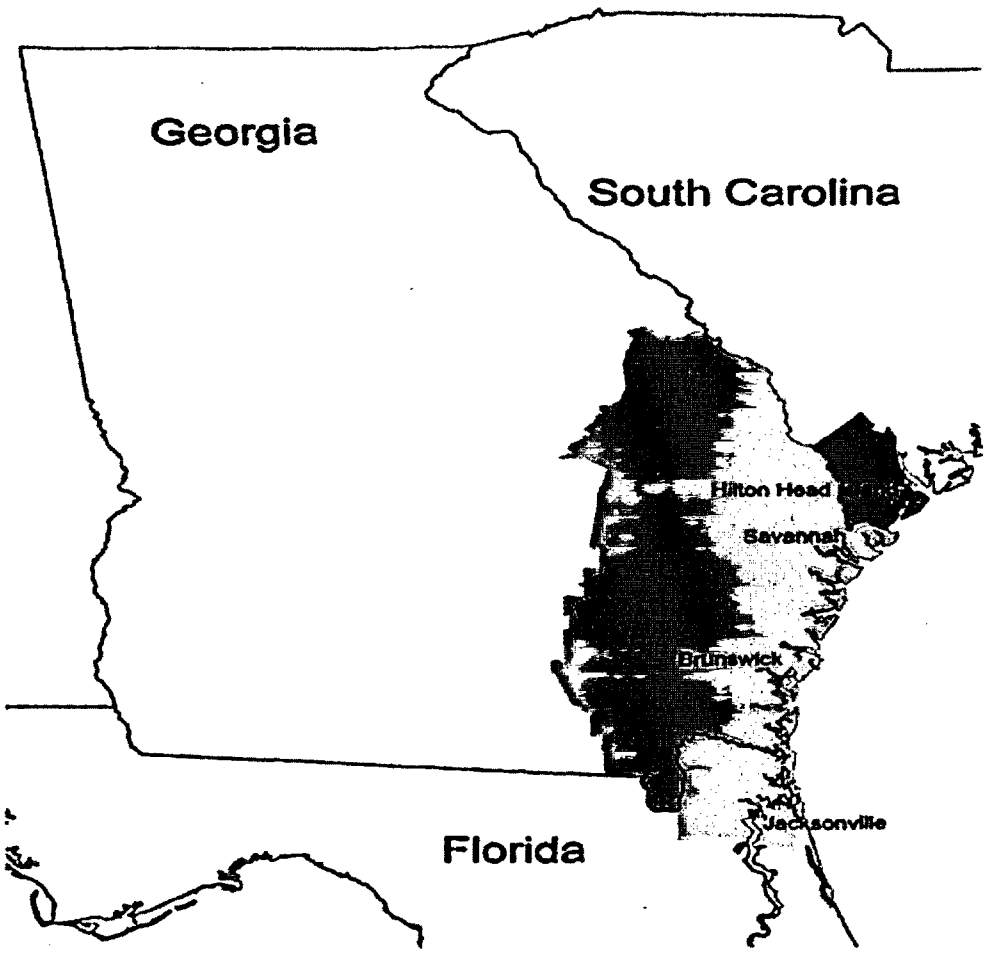
Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion



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Purpose and Scope of the Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion

The Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion describes the goals, policies, and actions the Environmental Protection Division (EPD) will undertake to manage the water resources of the 24-county area of coastal Georgia (Figure 1). The Plan is designed to support the continued growth and development of coastal Georgia while implementing sustainable water resource management.

The Plan replaces the "Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia" **http://www.ganet.org/dnr/environ/techguide_files/wrb/interim.htm**, and sets forth how EPD will conduct ground and surface water withdrawal permitting, and management and permitting of wastewater discharges. It advances requirements for water conservation, water reclamation and reuse, and wastewater management. Based on the findings of the Coastal Sound Science Initiative (CSSI), the Plan will guide EPD water resource management decisions and actions until superceded by the adoption of the General Assembly of a Comprehensive State-wide Water Management Plan in 2008.

The primary focus of the Plan is on stabilizing or halting the intrusion of salt water into the Upper Floridan aquifer, which is a dominant water supply source shared by coastal Georgia and neighboring areas of South Carolina and Florida. The Plan recognizes that actions taken to halt the intrusion of additional salt water into the aquifer will not result in the halting of the migration of the salt water that has already entered the aquifer.

Management strategies that abate the intrusion of salt water are primarily concerned with quantity and supply, but water supply strategies are incomplete without a corresponding array of actions that will address related wastewater issues. The additional water supply available through the water withdrawal permitting conducted under this Plan will increase the amount of wastewater to be discharged into the sensitive ecosystems of coastal Georgia. Therefore, the Plan also incorporates policies and actions needed to begin solving the wastewater discharge limitations that have become evident as coastal Georgia continues to grow.

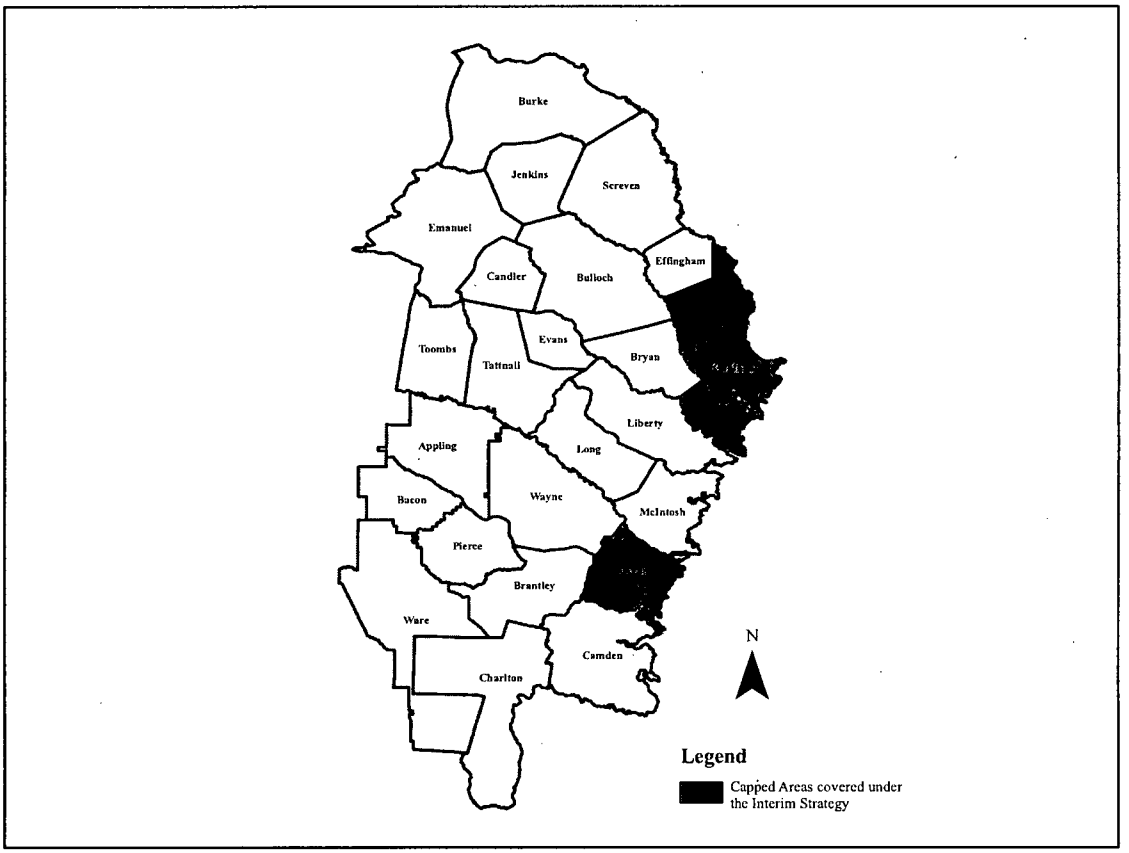


Figure 1: Counties covered under the Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion.

Guiding Principles of the Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion

The Comprehensive State-wide Water Management Planning Act (the Water Planning Act), passed by the General Assembly and signed into law by Governor Perdue in 2004, defines general policy and guiding principles for water resource management that guide this Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion. The incorporation of these policies and guiding principles into this Plan will facilitate its alignment with the Comprehensive State-wide Water Management Plan to be adopted in 2008.

The Water Planning Act provides the following policy statement:

"Georgia manages water resources in a sustainable manner to support the state's economy, to protect public health and natural systems, and to enhance the quality of life for all citizens."

It also sets forth the following guiding principle:

"Water resources are to be managed in a sustainable manner so that current and future generations have access to adequate supplies of quality water that supports both human and natural systems."

This Plan for managing coastal Georgia salt water intrusion, withdrawal permitting, and wastewater management reflects the State's goal of sustainable use of both groundwater and surface waters, it supports regional economic growth and development, and contributes to protecting the short-term and long-term health of both the public and natural systems. It is based on the best available scientific data and information on the stresses on the water resources within the region.

Please refer to the glossary (Appendix A) for definitions of technical terms shown in italics in this document.

Background on the Interim Strategy and the Coastal Sound Science Initiative

Prior to the industrial development and population growth of the first half of the 20th century in the coastal region of Georgia (and Florida and South Carolina), groundwater in Georgia's *aquifers* flowed from *recharge areas* in an east-southeast direction, extending in a broad arc from Valdosta to Waynesboro, eventually discharging offshore. After World War II as the region developed, centers of groundwater pumpage formed in Georgia around Savannah/Chatham County, Brunswick, Jesup, Riceboro, St. Marys; Hilton Head, South Carolina, and the Jacksonville-Fernandina Beach area of Florida. The bulk of the groundwater pumped is from what is now known as the Upper Floridan aquifer, which is a porous limestone geologic formation having extremely high productivity. At these pumping centers, *cones of depression* formed in the *potentiometric surface* and flow directions changed. Groundwater containing salt began to flow toward or into the Savannah-Hilton Head, Brunswick, and Jacksonville-Fernandina Beach pumping centers.

Salt is a naturally occurring mineral. At high concentrations salt makes water unpalatable to drink. The United States Environmental Protection Agency (EPA) has established secondary drinking water standards of 500 milligrams per liter (mg/l) for total dissolved solids and of 250 mg/l for the chloride ion. Since chlorides are relatively simple to measure, studies of salt water intrusion often use chlorides as a surrogate for measurements of salinity. Water having chloride levels of less than 250 mg/l is considered palatable to drink (assuming there are no other deleterious constituents exceeding other drinking water standards).

Since the early 1960's, the problem of salt water intrusion into coastal Georgia aquifers has been recognized (see Counts and Donsky, 1963). While the problem was first recognized in the Savannah-Hilton Head area, groundwater monitoring by the United States Geological Survey (USGS), on behalf of the precursor agency of the Georgia Environmental Protection Division (EPD), indicated the presence of elevated chloride levels in Upper Floridan aquifer wells at

Brunswick (Wait, 1965). Shortly thereafter, some water supply wells on the Brunswick peninsula had to be abandoned due to high chloride concentrations.

In the 1970's and 1980's additional hydrogeological studies were performed, monitoring wells constructed, and water resources alternative to the Upper Floridan aquifer were identified. As the salt water intrusion problem became more evident, efforts to conserve water and utilize alternative water supply sources followed. Conservation efforts resulted, for example, in a reduction in industrial pumpage from the Upper Floridan aquifer in Brunswick of about 30 million gallons per day (mgd) - from about 95 mgd to about 65 mgd. The City of Savannah expanded it's Industrial & Domestic (I&D) surface water treatment plant in 1998 - at considerable cost – to 62.5 mgd so that much of its future water needs could be supplied by surface water from the Savannah River rather than groundwater. Similarly, several golf courses on Jekyll Island substituted Miocene Aquifer wells for their Upper Floridan wells. South Carolina also promoted conservation and the use of alternative water supplies resulting in a reduction of Upper Floridan aquifer water use on Hilton Head of 5 mgd between 1997 and 2001, with current pumpage being on the order of 9.77 mgd.

Between 1985-1995, a series of events demonstrated that Georgia needed to aggressively develop a plan to address intrusion of salt water in coastal areas. These events included:

- Gradually increasing – with time - chloride concentrations in monitoring wells on the northern end of Hilton Head Island, and expansion of the salt water plume in the general direction of the Savannah/Chatham County pumping center.
- Gradually increasing – with time - chloride concentrations in monitoring wells at Brunswick.
- Declining water levels in monitoring wells in many parts of the coastal region.
- Substantial increases in irrigation pumpage from the Upper Floridan aquifer, particularly in the counties northwest of the coastal tier. For example, there was a 74% increase in irrigation pumpage in Tattnall County between 1980 and 1997.
- Substantial increases in the population of coastal Georgia, with corresponding increases in demands for water for public supply.
- Mathematical models of the region's aquifers showed that pumpage from one aquifer could impact other aquifers as well as surface water stream flows. Modeling also suggested that pumpage in areas distant from locations where salt water was entering the Upper Floridan aquifer could influence the rates of intrusion.
- Aquifer mapping showed that all of Georgia's aquifers were finite and exhaustible.

In 1995, EPD embarked on a public education program – through a series of public meetings - to inform the residents of coastal Georgia of the salt water problem, and to solicit comments that might aide development of a plan for managing the problem. During the course of these meetings, it became apparent that the technical information needed to effectively deal with the problem was inadequate and that a solution to the salt water intrusion problem could not be addressed until additional scientific studies had been designed, funded, and completed.

After evaluating hundreds of verbal and written comments, in 1997 - with the concurrence of a Joint Senate-House subcommittee of the Georgia General Assembly – EPD embarked on a two-

stage approach to resolve the salt water intrusion problem. The first stage consisted of the development of an "Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia" –covering a 24-county area of coastal Georgia (refer to Figure 1) – that described how EPD would address groundwater withdrawal permitting during the period 1997-2005. The Interim Strategy instituted a moratorium on groundwater withdrawal permits for the Upper Floridan aquifer for municipal, industrial and agricultural uses within the 24-county area. The second stage, called the Coastal Sound Science Initiative (CSSI), included definition and execution of an array of scientific and engineering investigations intended to generate the data and information required to guide development of a more well-founded plan for managing salt water intrusion. Almost $18 million in funding for the scientific studies came from the three states (Georgia, South Carolina, and Florida), Glynn County, and four paper companies in coastal Georgia. The Interim Strategy went into effect on April 23, 1997 and the first monies became available for the Coastal Sound Science Initiative with the FY 1998 Georgia State Budget.

Funding Sources for the Sound Science Initiative

State (Georgia) Appropriations	$10,458, 000 (Sound Science Initiative)
	$800,000 (County Water Supply Plans)
U.S. Geological Survey Contributions (estimated)	$ 1,750,000
South Carolina Contributions	$1,000,000
Florida Contributions	$500,000
Glynn County Contributions	$200,000
Paper Companies Contributions	$3,260,415*
TOTAL	$17,968,415

* *Each of the four coastal Georgia paper companies agreed to contribute $1,000,000 over the course of the Sound Science Initiative; however, Durango entered into bankruptcy and ceased making contributions. This resulted in a shortfall of $739,585.*

The Joint Senate-House Study Committee also established a Technical Advisory Committee charged with developing the methodology and scope of the scientific studies.

The Interim Strategy and the CSSI were focused on the issue of salt water intrusion. The original goals of the Interim Strategy were: a) to stop the encroachment of salt water before municipal groundwater supplies at Hilton Head Island and Savannah/Chatham County were contaminated; and b) to prevent the existing salt water intrusion at Brunswick from worsening. These goals were based upon the best available – in 1997 - conceptual description of the manner in which salt water was entering the aquifer, and the factors that influenced the intrusion. The CSSI was designed to answer the following seven sets of specific questions:

1) Where is salt water entering the Upper Floridan aquifer and why is salt water entering at these locations? Are there any other likely areas where salt water is entering the aquifer that we do not know about?

2) How fast is salt water traveling under current and future pumping conditions? How does pumping affect the rate and direction of salt water travel? What is the life expectancy of the aquifer?

3) Other than Savannah and Brunswick, are there any other areas in coastal Georgia where salt water intrusion can be expected? When will Upper Floridan wells in Georgia, Florida, and South Carolina no longer meet drinking water standards?

4) Can areas having minimal impact on salt water intrusion be identified and what amount of water can be obtained from them? Does pumping in some parts of coastal Georgia not affect salt water intrusion?

5) What are the other fresh water sources in coastal Georgia and what amount of water can be obtained from them? What would be the approximate costs of these sources of water alternatives to the Upper Floridan aquifer?

6) What are the current data gaps and what additional data are needed? How should existing and future data be organized, integrated, and made available to the public? Can a long term monitoring system be established so that changes in salt water intrusion can be measured? How much water is used by industry, municipal governments, agriculture, and other users and where do these uses occur?

7) What engineered solutions can be used to prevent salt water from reaching Savannah and the uncontaminated parts of Hilton Head Island or expanding in Brunswick to uncontaminated areas? How can the salt water intrusion problem be stopped and about how much will it cost?

Summary of Findings of the Coastal Sound Science Initiative

Under the guidance of the Technical Advisory Committee, the CSSI has published approximately 45 peer-reviewed reports, and several additional reports are currently under review. A bibliography of these reports and related technical resources is available at http://www.gadnr.org/cws/. The following summarizes principal findings in a brief format that answers the specific questions posed by the CSSI.

Where are the known locations where salt water is entering the Upper Floridan aquifer and why is salt water entering at these locations? Are there any other areas where salt water is entering the aquifer that we do not know about?

When the Interim Strategy and Coastal Sound Science Initiative began in 1997 two intrusion processes were postulated: first, that a wedge of salt water originating in Port Royal Sound was moving through breaches (i.e., windows) in the *confining unit* overlying the Upper Floridan aquifer, then directly entering the aquifer and subsequently moving down-gradient beneath Hilton Head Island in the general direction of Savannah; and second, that salt water originating in the highly saline and higher pressured *Fernandina Permeable Zone*, which underlies the Lower Floridan aquifer in the Brunswick area, was moving upward through geologic fractures into the less pressurized Upper Floridan aquifer. Based on the information gathered as part of the Sound Science Initiative, the process postulated for the Brunswick area is essentially unchanged. However, the process postulated for the northern end of Hilton Head Island has been found to be only partially correct. Further, a third, new process has been identified with the area of most concern being offshore and east of Hilton Head Island and northeast of Tybee Island. This third process involves a regional downward leakage of salt water through the confining unit. The three known locations and processes of salt water intrusion are:

1. Salt water is entering the Upper Floridan aquifer along the northern shore of Hilton Head Island, Pinckney Island, and the Colleton River (see Figure 2.). Here three distinct salt water plumes have been mapped, and they extend several miles inland. Rather than a laterally moving wedge of salt water entering the aquifer through "windows" in Port Royal Sound, the salt water entering the aquifer is by virtue of downward leakage in geographically-restricted, localized – perhaps ancient sinkholes or river channels - areas where the confining unit is thin or absent. The three plumes each appear to behave differently due to locally varying hydrogeologic conditions.

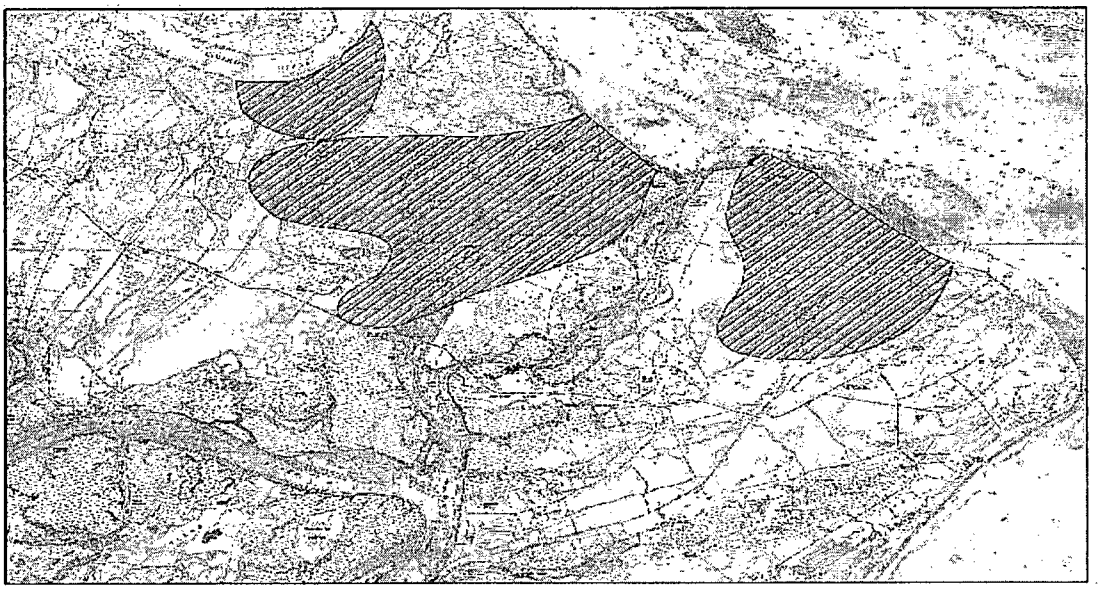


Figure 2: Current configuration of salt water plumes at northern end of Hilton Head Island

2. Studies performed as part of the Coastal Sound Science Initiative and elsewhere indicate that regional downward leakage of salt water through the confining unit is occurring. The rate of such leakage is a function of a combination of factors including the confining

unit's *vertical hydraulic conductivity,* the confining unit's thickness, and the vertical hydraulic gradient. Any area overlain by salt water is potentially susceptible to salt water intrusion; however, areas in proximity to thinner parts of the confining unit, in conjunction with other favorable hydrogeologic conditions, are most susceptible. Seismic studies show that east of Hilton Head and northeast of Tybee Island, the confining unit is thin and more susceptible to downward vertical leakage of salt water into the aquifer. Figure 3 shows an A – A' trace from the northern tip of Tybee Island to a point some 15 miles northeast of Tybee Island. A cross section down through the Upper Floridan aquifer for this trace is shown in Figure 4. The cross section of the A - A' trace shows that the upper confining unit begins to significantly thin at approximately the 2-mile mark, and gets progressively thinner at the 7-mile mark before a slight recovery. After the 10-mile mark the thinning gets more pronounced toward the 15-mile mark.

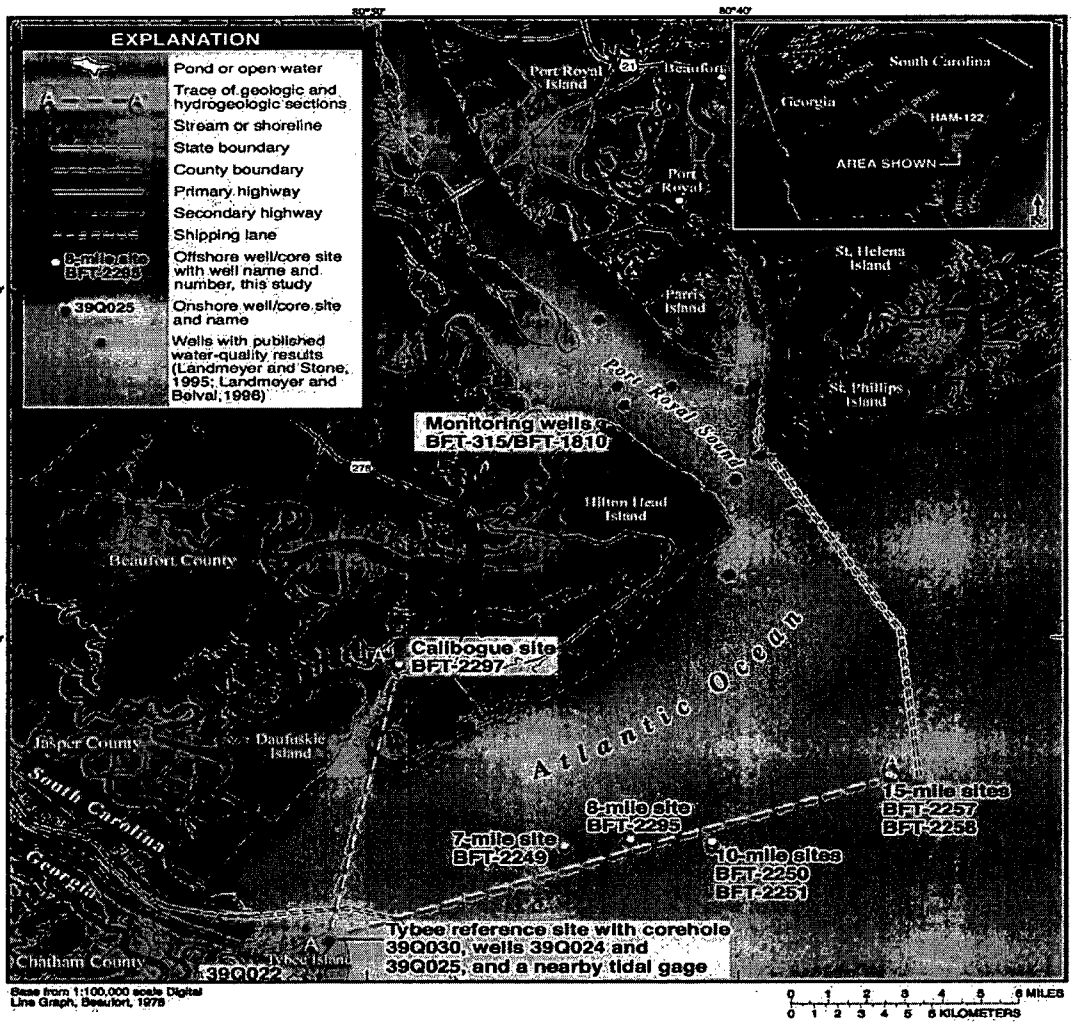


Figure 3: A – A' Trace from Tybee Island

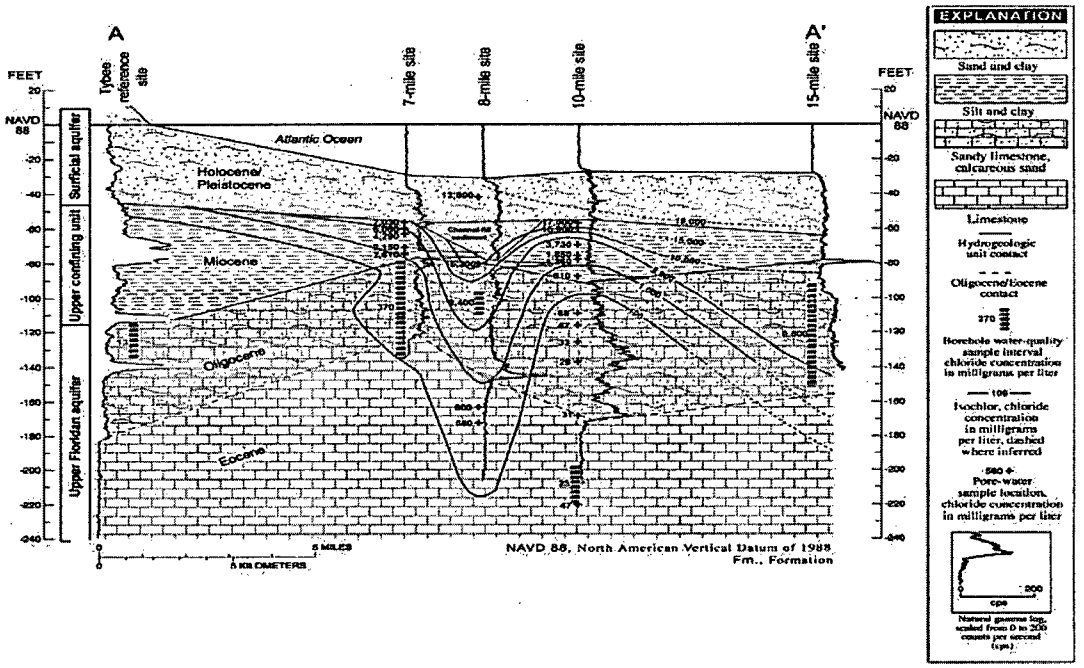


Figure 4: Cross-section of aquifers along A – A' Trace from Tybee Island

Studies of core samples where the confining unit is thin indicate that, in response to the reduced aquifer pressure in the cone of depression, salt water has migrated through the confining unit and can be detected in aquifer water. However, this newly identified process has not been fully characterized in geographic extent or risk of contamination of the aquifer. Corroboration of this process is provided by core samples taken during United States Corp of Engineer studies evaluating the effect of deepening of the Savannah Harbor ship channel. These studies suggest that deepening of the shipping channel could thin or breach the aquifer's confining unit, and potentially decrease the time period required for salt water to migrate into the aquifer in the vicinity of Tybee Island.

3. At Brunswick a T-shaped plume (see Figure 5) has developed since the 1960's, but it had remained relatively stable since the mid-1980's. The originally proposed process of saline brines moving upward along geologic fractures from the Fernandina Permeable Zone to the lower pressured Upper Floridan aquifer appears to be correct.

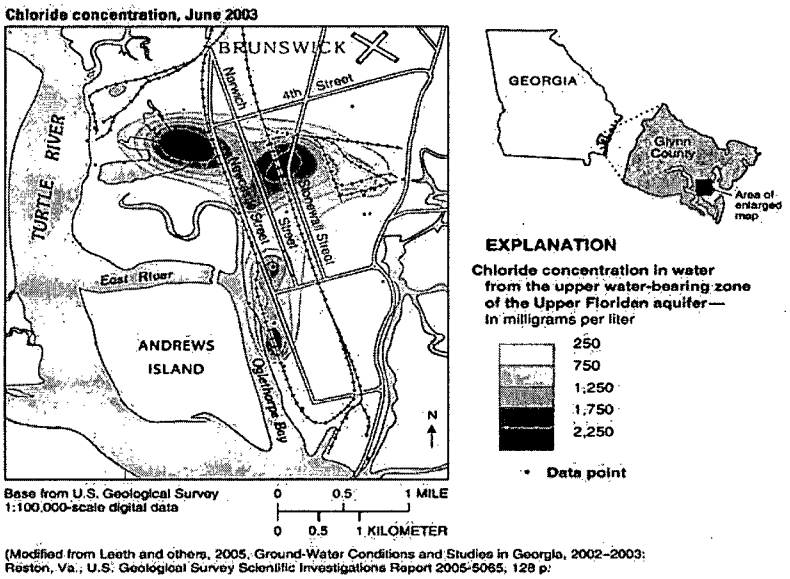


Figure 5: Chloride plume configuration, Brunswick, Georgia

Aquifer mapping and offshore geophysical studies demonstrate that salt water intrusion into the Upper Floridan aquifer of coastal Georgia under current and reasonably expected pumping conditions appears to be restricted to the known location of plumes under Hilton Head Island, the general area where the confining unit is thin offshore of Tybee Island, and beneath Brunswick.

How fast is the salt water traveling?

Model simulation indicates that the largest of the three salt water plumes in the vicinity of Hilton Head Island has moved to the south/southwest by about 2 miles since the mid 1960's, when intrusion into the aquifer is first estimated to have occurred. Modeling suggests that if current pumping rates are maintained through the 21st century (i.e., 2000 and 2100), the rate of movement of this plume will be about 130 feet per year. Offshore investigations indicate that some salt water has migrated into the Upper Floridan aquifer in an area 7-10 miles northeast of Tybee Island. Modeling also suggests that a plume in this offshore area will develop by the year 2100 and will enlarge to the west and southwest in response to pumping in the Savannah-Hilton Head area. Monitoring data indicate that the plume at Brunswick is stable and is not moving laterally.

How does pumping affect the rate and direction of salt water travel?

Modeling shows that increases/decreases in pumping from the Upper Floridan aquifer in or near the centers of Savannah and Hilton Head Island (including southern Beaufort County) will

change the potentiometric gradient in these areas and thus change salt water intrusion velocities. Pumping at centers near Savannah and Hilton Head interact to influence salt water intrusion. Increased pumping will accelerate intrusion velocities and decreased pumping will decelerate intrusion velocities in the vicinity of the northern end of Hilton Head as well as the broad area offshore from Hilton Head and Tybee Islands. Modeling indicates that pumping outside these centers will have insignificant impact on the rate or development of salt water intrusion at Savannah or Hilton Head. Preliminary results from continuing solute transport modeling indicate that if all pumping from the aquifer near Savannah were to be reduced to zero, the salt water that is already present in the aquifer would continue to disperse in multiple directions.

While the "T-shaped" plume at Brunswick is stable under current pumping conditions, increases or decreases in pumping in the immediate vicinity of the plume would cause the plume to enlarge/decrease in size. This is particularly true in the vicinity of the City of Brunswick's Perry Park well. Pumping in Glynn County away from the "T-shaped" plume would have little impact on the size or the configuration of the plume.

Continued monitoring in the vicinity of the plumes is critical for effective management of the groundwater resources in the Savannah-Hilton Head and Brunswick areas.

What is the life expectancy of the aquifer?

Modeling shows that under year 2000 pumping conditions, many decades will elapse before the known locations of salt water intrusion will affect Upper Floridan aquifer wells in Georgia. If the plumes in the vicinity of the northern end of Hilton Head Island and offshore from Hilton Head and Tybee Island continue to expand at the simulated 1965-2004 rate, then salt water from these plumes will not be a problem in Georgia for more than 100 years. However, some wells on Hilton Head have already been contaminated; and under current pumping others will be affected in the next several decades. As long as the plume at Brunswick remains stable, then the current wells should not be affected.

Modeling of the Upper Floridan aquifer also shows that large increases in groundwater withdrawals in the farming region north of the *Gulf Trough* would dewater the aquifer and may impact some surface water bodies. This is an environmental issue not related to salt water intrusion that, nevertheless, warrants further consideration and study.

Other than Savannah and Brunswick, are there any other areas in coastal Georgia where salt water intrusion can be reasonably expected?

With the exception of the known areas at Hilton Head and Brunswick, and the newly identified area offshore of Tybee Island, there is no evidence that the aquifer's upper confining unit at or near other areas near Georgia's mainland is under immediate threat of leakage or of being breached under current or foreseeable pumping conditions. Further, other than the Brunswick peninsula, there is no evidence that there are geologic fractures that extend from the Upper Floridan aquifer into the Fernandina Permeable Zone.

When will Georgia, South Carolina, and Florida drinking water wells in the Upper Floridan aquifer no longer meet drinking water standards?

Some wells in South Carolina have already become contaminated and others may become contaminated in the next few decades as the plume expands. There is no evidence of near-term threats to the Upper Floridan wells in the Savannah pumping center under current and foreseeable pumping conditions. Some wells within the plume at Brunswick have previously been abandoned because of contamination, but wells distant from the current stable "T-shaped" plume should not be affected as long as plume stability is maintained. The CSSI was not designed to address the condition of wells in Florida.

Can areas having minimal impact on salt water intrusion be identified and separated from areas having significant impact?

Yes, under simulated year 2000 conditions - and reasonably anticipated future pumping conditions – pumping from the aquifer in areas in the vicinity of the Savannah and Hilton Head pumping centers have the most significant impact on potentiometric surface at the discrete locations where the aquifer is experiencing salt water intrusion impacts. According to results from various modeling runs, the Savannah 'pumping center' generally consists of all of Chatham County and that portion of Effingham County south of Georgia Highway 119.

In the Brunswick area, creating and maintaining a "no new pumping" setback or buffer around the "T-shaped" plume will diminish – or eliminate - the impact of pumping on the size and configuration of this plume. The exact configuration of the buffer from the "T-shaped" plume still needs to be defined. Pumping from the Upper Floridan aquifer in other areas under current and anticipated future conditions will have less impact on salt water intrusion.

Can some or portions of counties be eliminated from the final permitting strategy?

The 24-county region will not require a uniform set of permitting strategies to address salt water intrusion. As described in this Plan, EPD proposes to subdivide the 24-county area into three sub-regions (see Figure 6); namely (1) a bifurcated sub-region consisting of all of Bryan and Liberty counties, and Chatham County and that portion of Effingham County south of Georgia Highway 119; (2) a Glynn County sub-region, and (3) the remaining 19 counties and that portion of Effingham County north of GA Highway 119.

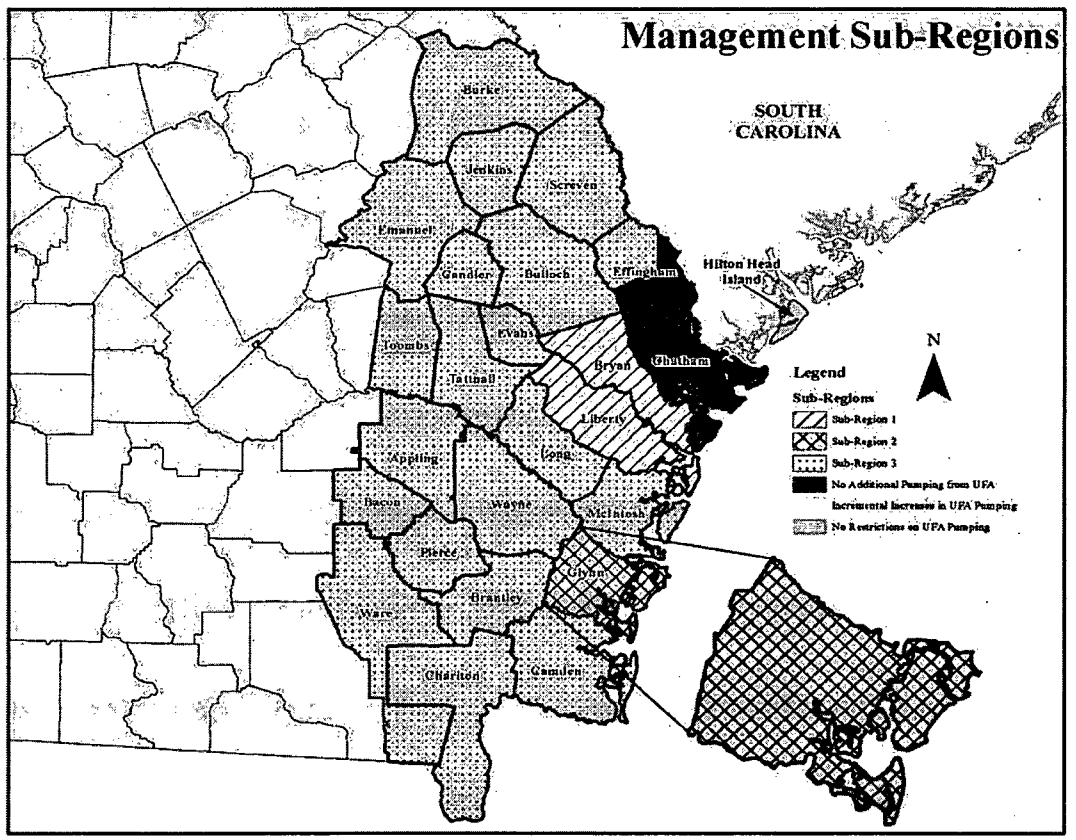


Figure 6: Sub-regions associated with the Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion

What are the other fresh water resources of coastal Georgia and what amounts of water can be obtained from them?

One of the better sources of additional fresh water is through conservation, particularly irrigation conservation. There are opportunities in using reclaimed water, particularly for lawn and golf course irrigation.

The rivers that drain the Piedmont (i.e., the Savannah, the Altamaha, and the Ogeechee) offer fresh water resources. The Ogeechee River however experiences periodic low flows and is not a viable water supply source on a year-round basis. For the most part the flow regimes of the Savannah and Altamaha rivers do not reflect significant low flow intervals, and are generally much more reliable sources than the Ogeechee. However, with regard to the Savannah River, two factors could dampen the reliability of this surface water source. First, during extended drought periods, flows in the lower river are largely controlled by the operation of large federal reservoirs in the upland reaches of the basin – in accordance with agreed upon reduced reservoir releases as reflected in a drought management plan adopted by South Carolina, Georgia, and the Corps of Engineers. The drought-related controlled flows in the lower reaches of the river could therefore be substantially less than what might otherwise occur during droughts. Second,

unexpected episodic events at the Savannah River Site could conceivably compromise the quality of the waters of the lower river, and render the source temporarily less desirable as a water supply source.

In the Glynn County area, the Miocene-aged Brunswick Aquifer System is a secondary source of groundwater. Water from the Brunswick aquifer has significant taste and odor problems that may make additional treatment desirable. In the Chatham-Bryan County area, the Lower Floridan aquifer also is a secondary source of groundwater; there is, however, leakage between the Upper Floridan aquifer and the Lower Floridan aquifer. Some Lower Floridan aquifer wells may require treatment for naturally occurring higher dissolved solids concentrations (chloride and sulfate).

What would be the approximate costs of these alternate sources of water?

Extending the life of current water supplies through a water conservation program has been widely shown to be an inexpensive water supply option. Water reclamation as a source of golf course irrigation currently is taking place on Hilton Head Island, as well as in Savannah and a number of communities in northern Florida. Reclaimed water involves a relatively high level of treatment, in addition to the cost of laying new reuse water lines. This option would take some time to fully implement. A water supply conservation and/or water reuse plan has not been developed for the coastal area, so specific cost figures are not available at this time.

There is excess fresh water capacity at the current Savannah I & D plant, which could be utilized without additional capital investment in plant infrastructure. A study conducted as part of the Sound Science Initiative indicates that the cost of development of new surface water supply options will be about five times the cost of new groundwater supply options on a per-gallon basis.

Miocene-aged wells would need to be screened and developed, with lower well yields, and greater drawdowns. This would mean that drilling and pumping costs would be higher than Upper Floridan aquifer wells. Lower Floridan aquifer wells would be considerably deeper and yields would be lower. This also would mean that drilling and pumping costs would be higher. In addition, water from some Lower Floridan aquifer wells may require treatment. Such costs, however, would have to be developed on a site-by-site basis. Other than higher drilling, pumping costs, and possible treatment costs, development costs for these two aquifers would not differ significantly from Upper Floridan well costs.

What are the current data gaps and what additional data are needed?

The Sound Science Initiative had a limited and well-defined scope of work. With the exception of some engineering analyses that were not performed, all defined studies were completed. Modeling needs to continue in those areas where salt water is entering the aquifers, and the models need to be updated as new wells come on line or new studies are completed. Further, established monitoring programs need to be continued in order to better define and track plume migration and pumping impacts.

The Corps of Engineers has collected a substantial amount of information and data relative to the susceptibility of the Upper Floridan aquifer to salt water intrusion due to proposed deepening of the Savannah Harbor. This information and data need to be incorporated into the model development assumptions and the groundwater models developed by USGS. Additionally, a finer resolution model grid needs to be employed in the offshore area. Improved agricultural water-use estimates after 2000 also need to be incorporated into groundwater models.

How should existing and future data be organized, integrated, and made available to the public.

The USGS has developed a web site (http://ga.water.usgs.gov) that provides information and data from monitoring wells in coastal Georgia and the Sound Science Initiative. This site contains links to downloadable copies of various reports. This web site should be maintained and updated as additional publications are prepared and as new monitoring data become available.

During the course of a series of EPD-sponsored public meetings that were held in coastal Georgia counties during August 2005, there was support for an EPD web site dedicated to coastal Georgia water resources. The web site now exists (http://www.gadnr.org/cws) and has appropriate links to USGS web sites that have technical reports as well as monitoring data.

Can a long-term monitoring system be established so that changes in salt water intrusion can be measured?

Yes, the framework for such a system, including an "early-warning" system, has been established in Georgia and should be maintained. A comprehensive groundwater monitoring network has been established in South Carolina, and it too should be maintained.

How much water is used by industry, municipal governments, agriculture, and other users and where do these uses occur?

A water use program for the coastal region of Georgia has been established and is being maintained by the USGS.

What engineered solutions can be used to prevent salt water from reaching Savannah and uncontaminated parts of Hilton Head Island or expanding in Brunswick to uncontaminated areas?

Because of the aquifer's high porosity and high hydraulic conductivity, there do not appear to be any physical or hydraulic barriers that will permanently prevent/stop the dispersal of the salt water that is already in the aquifer.

It appears that one certain way to stop further salt water intrusion at those points along the northern end of Hilton Head Island is to return to the pumping conditions that would allow the potentiometric surface at those points of entry to recover to at least sea level. Modeling indicates that if all the pumpage in the vicinity of Chatham County had never occurred, we

would have nevertheless experienced some amount of salt water intrusion at the three entry points along the northern end of the Island (due in large measure to the Island's own pumpage).

As long as pumpage in the vicinity of the "T-shaped" plume at Brunswick remains constant and a "no new pumping" buffer is created and maintained, this plume is not expected to expand into uncontaminated areas. In both the areas, however, intrusion velocities can be slowed by reductions in pumping.

Because the cone of depression at Brunswick is relatively small (i.e., having a radius of some 1 ½ miles), relocation of well fields outside of the cone to dampen the depth of the cone appears to be more viable than in the Savannah vicinity where the cone radius is on the order of 30 miles. Also in the Savannah vicinity, relocation of wells would involve other governmental entities.

Sub-Regional Management Areas

The Coastal Georgia Water & Wastewater Permitting Plan for Managing Salt Water Intrusion establishes three sub-regions for purposes of implementing region-specific policies and permitting requirements to stop salt water intrusion, manage wastewater and implement water conservation and reuse practices. The three sub-regions are:

Sub-region 1:	Chatham County and that portion of Effingham County south of GA Highway 119; Bryan and Liberty Counties.
Sub-region 2:	Glynn County
Sub-region 3:	The remaining 19 counties within the 24 county coastal area, and that portion of Effingham County north of Highway 119

These sub-regions are defined based on their varying vulnerability for or contribution to salt water intrusion as determined by the CSSI. Sub-region 1 (Chatham, Bryan, Liberty, and part of Effingham Counties) overlays the cone of depression that extends into South Carolina. The Gulf Trough bisects Effingham County roughly in a line defined by the location of Highway 119. The Gulf Trough is a feature of the aquifer whose low permeability acts as a barrier to the development of the cone of depression toward the northwest. Groundwater pumping on the northern side of the Gulf Trough has insignificant influence on the cone of depression. In Sub-region 2, Glynn County, salt water intrusion is caused by very localized pumping that does not contribute significantly to the development or extent of the cone of depression underlying Sub-region 1. The remaining 19 counties contained in Sub-region 3 do not contribute significantly to the development or extent of salt water intrusion at Savannah-Hilton Head or Brunswick (see Figure 6).

Described below is a set of water management elements unique to each sub-regional area and pertinent to the issues and influencing factors within that area.

Elements of the Management Plan for the South Effingham-Chatham-Bryan-Liberty Sub-Region

Sub-Region 1 Red Zone: Chatham County and Effingham south of GA Highway 119

No net increases in Upper Floridan aquifer withdrawals above amounts withdrawn in 2004: The management goal for Sub-region 1 Red Zone is to restrict withdrawals from the Upper Florida aquifer to withdrawal amounts that occurred in 2004, and to reduce actual withdrawals by at least an additional 5 million gallons per day (mgd) by the end of 2008. As permits are renewed the permittees will be required to implement water conservation, efficiencies, and reuse strategies that will create opportunities for additional municipal withdrawals from the Upper Floridan while holding to the no net increase goal.

Conservation and Reuse: Employ aggressive and practical measures that will ensure efficient and effective use of those quantities of water that must be removed from our water systems to meet human needs.

Justification of Need: Ensure that each gallon of water sought under any permit application is justified using clear and consistent criteria.

Diversification of Sources: A blend of surface water and groundwater sources is a preferred approach for meeting the increased water needs of Sub-Region 1 Red Zone in the years ahead. Through such a 'blending' of sources to meet area-wide needs, preserving and protecting the water resources becomes a more reachable goal. Use of the Lower Floridan aquifer in the area will continue to be allowed based upon technical guidance provided by EPD. Other non-Upper Floridan aquifer sources should also be investigated for future water supplies for the area.

Monitoring: Continuously monitor the reactions of the Floridan aquifer as management actions are implemented; determine the extent to which the management actions require additions and modification to achieve aquifer management goals.

Sub-Region 1 Yellow Zone: Bryan and Liberty Counties

Allow step increases in use of Upper Floridan aquifer; monitor impact on the potentiometric surface: Allow up to an additional 5 mgd of water to be withdrawn from the Upper Floridan aquifer through 2008, while monitoring the impact these withdrawals have on the Upper Floridan aquifer cone of depression. Beyond 2008, allow additional 5 mgd step withdrawal increases from the aquifer pending the 2006 – 2008 cone of depression monitoring results.

Conservation and Reuse: Employ aggressive and practical measures that will ensure efficient and effective use of those quantities of water that must be removed from our water systems to meet human needs.

Justification of Need: Ensure that each gallon of water sought under any permit application is justified using clear and consistent criteria.

Major Water Resources Issues in Sub-Region 1

Salt Water Intrusion Influences

Scientific investigations have conclusively shown that withdrawals from the Upper Floridan aquifer are major contributors to reducing aquifer water levels by more than 100 feet in areas within Chatham County. These withdrawals have grown over the past 60+ years in this sub-region, and there have been water level reductions of 10-20 feet in counties more than 75 miles inland from Georgia's coast (see Figure 7). This phenomenon of higher water level reductions at or near the points of withdrawal, coupled with lower water level reductions at points away from the withdrawals, creates an inverted cone of water levels. This is generally referred to as a 'cone of depression'.

The depth of this 'cone of depression' is influenced most by withdrawals – from the aquifer – that occur in or near the so-called 'center of the cone' in the Chatham County area, but the cone of depression is dynamic and takes on different characteristics with changes in the timing, location, and amounts of withdrawal from the aquifer. The size and shape of the cone is very sensitive to where withdrawals occur within the aquifer and the amount of each withdrawal. Withdrawals of a lower magnitude to the east side of the cone of depression appear to have more pronounced influences on the slope of the cone – as it approaches Hilton Head, SC - than other lesser withdrawals placed to the west, south, and north (above the 'Gulf Trough') of the current cone.

It is impractical to restrict any and all future uses of the Upper Floridan aquifer that might have some small measure of impact on this dynamic cone of depression. It is, however, quite practical to describe a smaller area where aquifer withdrawals have the greatest impact on movement of the cone, and circumstances that are affected by this movement. For purposes of managing present and future uses of the aquifer in Georgia, this smaller area is here taken as the area underlying all of Chatham County and the area south of Georgia Highway 119 in Effingham County (see Figure 6).

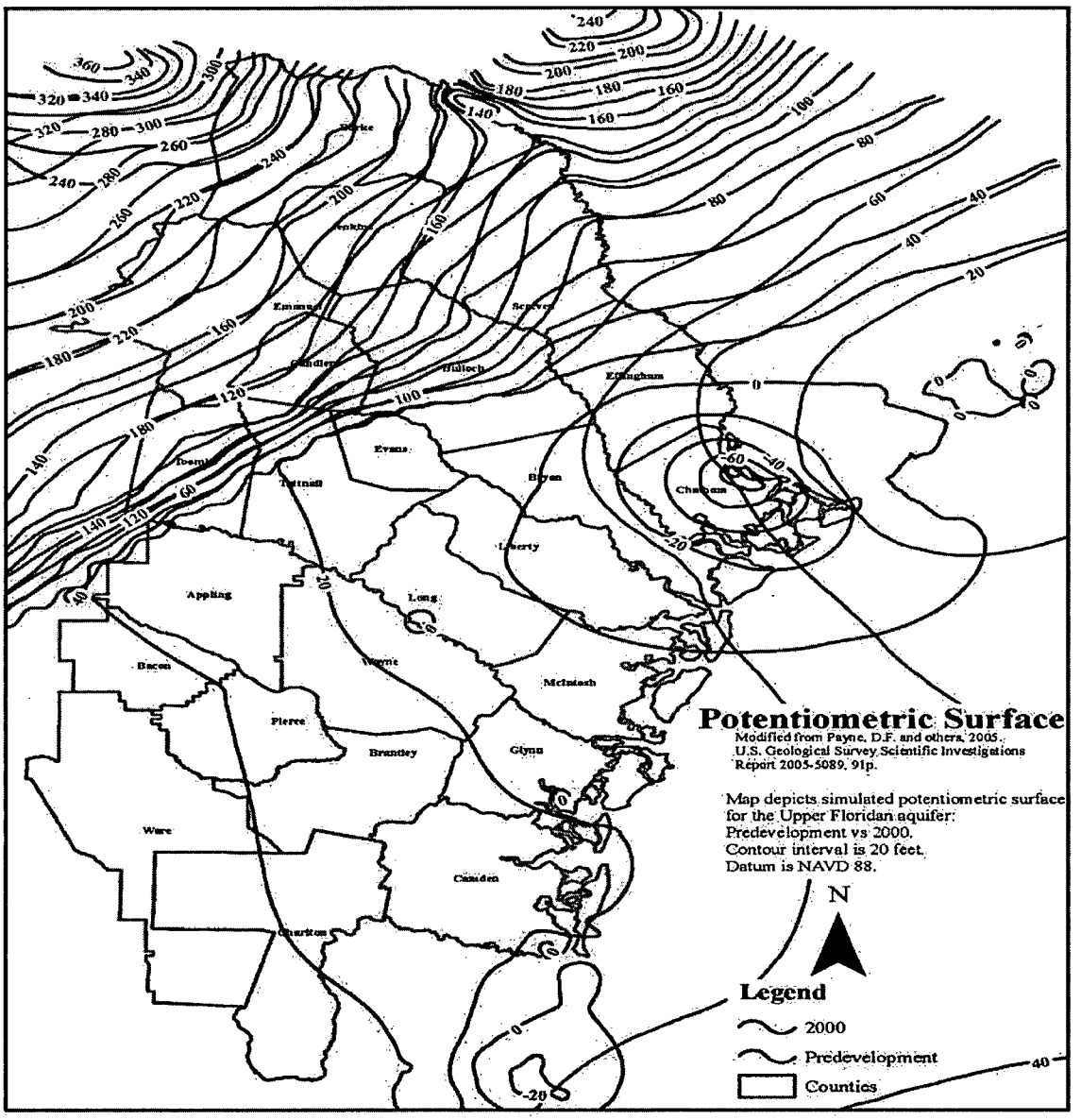


Figure 7: Potentiometric Surface map of Upper Floridan aquifer

This cone of depression induces a hydraulic gradient that contributes to the spread of three distinct salt water plumes at the northern end of Hilton Head Island, South Carolina. Withdrawal activities from the center of the cone, then toward its eastern extremity, are likely to most affect the shape of the cone's hydraulic gradient in the vicinity of the salt water plumes at the northern end of Hilton Head Island. Modeling studies show that a separate cone of depression created by South Carolina's withdrawals from the Upper Floridan aquifer have a more pronounced impact on the movement of these salt water plumes than the impact induced by the cone of depression created by Georgia's withdrawals from the aquifer. As these salt water plumes expand in South Carolina, they move into areas where domestic and municipal wells are located, and the water in these wells may become undrinkable because of elevated chloride concentrations. Water from

municipal wells in these areas can only be rendered drinkable with higher – and generally more expensive – stages of treatment to reduce chloride concentrations to acceptable levels.

This cone of depression creates a downward hydraulic gradient that influences the rate at which salty water migrates downward through the upper confining layer and into the Upper Floridan aquifer in areas where the confining unit is thin or absent. Studies done by the USGS and the US Army Corps of Engineers indicate that salt water is migrating through the confining unit overlaying the Upper Floridan aquifer offshore and in the Savannah area. Although much of this salty water is diluted by freshwater from the Upper Floridan aquifer, it is possible that in the future this salty water may first impact wells at Tybee Island, which is located within the cone of depression in an area where the ancient Savannah River channel has thinned the overlying confining unit.

Population/Economic Growth & Water Supply Diversity

Within coastal Georgia, Sub-Region 1 is expected to experience the highest rates of growth in population during the next 25 years. This growth is likely to be widely distributed over all the political jurisdictions within the sub-region, and will dramatically increase the stresses on the area's current highly fragmented array of smaller and larger water and wastewater management systems. With the exception of the City of Savannah, which had the financial capability to construct the Savannah I&D plant to supply water from the Savannah River, most communities have relied largely on water supplied from the Upper Floridan aquifer. Diversification of sources is particularly important to communities in southern Effingham or Chatham, but should be investigated by others in the sub-region as well.

The groundwater and surface water resources of the sub-region are best managed for the collective well being of the entire sub-region. In the future the area's economic vibrancy and growth patterns will almost assuredly take on regional characteristics that reflect the rich diversity of local jurisdictions, while taking advantage of the area's collective strengths. Sustainable management of the waters of the region will require sharing of the resources across political boundaries in an equitable fashion.

Wastewater

Assimilative capacity in area streams will be strained all across the sub-region as the population grows. This will be particularly evident in the area of the Savannah Harbor and environs upstream. The amount of oxygen demanding substances in the waters being discharged to the Savannah River and its tributaries below Augusta is of great concern even under current conditions. Since the mid-1990's EPD has not issued discharge permits that would increase the point source loadings of oxygen demanding substances to the Savannah Harbor and streams upland that send their discharge to the Harbor. The policy has been based on field and modeling work completed by EPD in the 1980's to determine the dissolved oxygen assimilative capacity of the harbor and the lower Savannah River. In 1994 EPA took issue with EPD's assessment of the dissolved oxygen standard established by EPD, and in August of 2004 EPA public noticed its draft dissolved oxygen (DO) Total Maximum Daily Load (TMDL) for Savannah Harbor. The TMDL includes two scenarios; one using the existing Georgia EPD criterion for dissolved oxygen (which was been disapproved by EPA in 1994), and one using a criterion recommended

by EPA. Using the disapproved Georgia criterion, the DO TMDL would establish a 100% reduction of oxygen-demanding substances from all NPDES regulated discharges in the watershed (from the Thurmond Dam near Augusta, Georgia to the Savannah Harbor) in order to attain the existing, applicable site-specific dissolved oxygen criterion. Using EPA's alternative dissolved oxygen criterion mentioned in EPA's public notice would require a 30% reduction in the total load of oxygen demanding substances currently being discharged (as measured during the summer of 1999) by NPDES regulated sources. Any new criterion for dissolved oxygen proposed by EPA or the State will face serious scrutiny by industry, local governments, endangered species advocates, environmental groups, port authorities, Federal agencies, and the State of South Carolina.

Management Goals

Manage Influence of Georgia's Withdrawals on Hilton Head Plumes

The management actions in Sub-region 1 are largely founded on the best available scientific explanation of the relationship between past and current Upper Floridan aquifer water withdrawals in Georgia, and the existence and movement of salt water plumes in the vicinity of the northern end of Hilton Head Island. The management actions in the sub-region are also founded on the best available data and information that relate Upper Floridan aquifer withdrawals to the diffuse movement of salty water downward through the thinnest portions of the upper confining layer as the aquifer reaches seaward. One goal of management actions in the Red Zone portion of the sub-region is, therefore, to restrict future permitted uses of the Upper Floridan aquifer in ways that best reflect our scientific findings related to these relationships. Another goal is to try to ensure that management actions best reflect a practical appreciation of the extent to which water users in the sub-region have in the past committed extensive financial resources to development and operation of water infrastructure; water infrastructure that will undoubtedly continue to be essential to meeting present and future water needs in the sub-region. Significant attention is therefore given to measures directed at water use efficiency, reuse of reclaimed water where appropriate and technically feasible, and the sustainable and diversified use of all reasonably available water sources.

Management actions in the Yellow Zone of Sub-region 1 are also based upon the best available scientific data and information. The data and information strongly suggests that withdrawals in this zone have an appreciably smaller impact on the salt water plumes at and near Hilton Head than withdrawals from the aquifer that occur in the Red Zone. This has resulted in a decision to allow step increases in the use of the Upper Floridan aquifer in this Yellow Zone area, while monitoring the impacts of these increases to determine if there are discernible impacts on the cone.

Meet Reasonable Future Water Needs

Reasonable use of Georgia's water resources is a right accorded to Georgia's citizens by Georgia Code. As the protector of that right, the State is responsible for managing those resources in a way that ensures Georgians have access to reasonable quantities of water both now and into the future. To better avail citizens to the right to reasonable use, the Plan focuses on actions designed to ensure that forecasts of water needs by various entities within the region be done in

accordance with a standardized protocol; and that reasonable and consistent actions be taken by all permit applicants to implement aggressive water conservation programs; and that future water supplies come from a combination of groundwater and surface water sources; and future water sources include the use of reclaimed water to the maximum practical extent.

Wastewater

The management goal here is to avoid wastewater discharge permit actions that would increase the mass of oxygen-demanding substances discharged into waters eventually flowing into the Savannah Harbor. EPD will therefore continue its long-standing policy of only approving wastewater solutions that do not increase permitted point source discharges of oxygen-demanding substances into the affected waters.

Key Elements

Sub-Region 1 Red Zone Withdrawal Restrictions

Hold UFA Withdrawals to Actual 2004 Levels

The following Upper Floridan aquifer withdrawal elements are central to Georgia's approach to managing the use of water in the Red Zone of Sub-Region 1 (i.e., all of Chatham County and that portion of Effingham County south of GA highway 119).

- The amount of withdrawals provided under renewals of current permits will be based on the conditions set forth in the remainder of this section, but total withdrawal permit limits will not be allowed to exceed quantities actually withdrawn in 2004. Total withdrawals from the Upper Floridan aquifer during 2004 were approximately 64 million gallons per day (mgd). Further conditions are described in the 'Conservation and Reuse', 'Justification of Need', and 'Monitoring' sections of this document.

- Some current users of the Upper Floridan aquifer in the Red Zone have withdrawal permit limits that exceed demonstrated needs. Reductions in many of these permit limits in the Red Zone will be necessary to allow the State to achieve its sustainable management goal. Additional aquifer savings in the sub-region are expected to come as conservation and reuse programs (described below), are implemented over time.

- Applications for increased withdrawals from the Upper Floridan aquifer within the Red Zone will be allowed only when such withdrawals meet the requirements identified in this document, and are consistent with managing the resource under the 'hold UFA withdrawals to actual 2004 levels' policy. Generally these applicants will be required to connect to available surface water sources, or use some other alternate source.

Sub-Region 1 Yellow Zone Withdrawal Restrictions

Allow Up to 5 mgd of Additional UFA Withdrawals through 2008; Allow Additional Step Increases in UFA withdrawals beyond 2008

The following Upper Floridan aquifer withdrawal elements are central to Georgia's approach to managing the use of water in the Yellow Zone of Sub-Region 1 (i.e., all of Bryan and Liberty counties).

- The amount of withdrawals provided under renewals of current permits will be based on the conditions set forth in the remainder of this section, but total Upper Floridan aquifer withdrawal permit limits – and actual withdrawals - will be allowed to approach a level that is up to 5 mgd above the actual withdrawals of 2004. Total withdrawals from the Upper Floridan aquifer in the Yellow Zone during 2004 were approximately 15.3 mgd. Further conditions are described in the ensuing sections on 'Conservation and Reuse', 'Justification of Need', and 'Monitoring' sections of this document.

- Applications for new or increased withdrawals from the Upper Floridan aquifer within the Yellow Zone will be allowed only when such withdrawals meet the requirements identified in this document, and are consistent with managing the resource under the 'allow up to 5 mgd of additional UFA withdrawals... ' policy.

Conservation and Reuse

The system of laws governing water permitting decisions in Georgia is founded on the principle of 'reasonable use' of state waters to meet the 'reasonable needs' of those seeking to use those waters. Our statutes provide that the state not allow the meeting of these needs to have "...unreasonably adverse effects upon other water uses in the area." Our statutes mandate that the State make these 'reasonableness' decisions within the context of the capability of the water sources and present and future needs of other uses of the waters. Regarding the capability of the water sources within the sub-region, it is clear from the work conducted under the Coastal Sound Science Initiative that while the major groundwater resource in the region (i.e., the Upper Florida aquifer) is quite capable of supplying ample supplies of fresh water to the region for a great number of years to come, permitting unrestricted use of that source within certain areas will contribute to unreasonable adverse effects on other users and uses. Regarding the future demands expected to be placed on the region's water sources, it is clear from all available forecasts of the sub-region's future needs that demand on the water resources will increase quite substantially.

Because of these circumstances, in determining 'reasonableness of need' the State will attach a higher degree of importance in this sub-region to the extent to which users of the sub-region's waters employ practices that are intended to minimize the volume of water withdrawn to meet specific needs. The State will also attach more importance to assuring that measures are implemented that result in the efficient use of all water withdrawn. Toward these ends a series of water conservation and efficiency actions will be required of water users within the sub-region. Some of these prescribed actions build upon the success many of the sub-region's water utilities have had in implementing conservation practices, particularly since 1997. Other actions described below are based upon federal guidance documents and national research that apply to this area of the state.

- *Industrial Water Use*

Many industrial processes demand high volumes of water, including washing and rinsing, heating and cooling, shop clean-up and outdoor water use. No two operations are alike; therefore, it is critical that a water audit be performed to assess the facility's system and identify potential for water savings. For all current industrial permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

1. Each industrial water user will perform an audit of the facility's water system and identify locations where practices can be employed to conserve water. The Pollution

Prevention Assistance Division of the Georgia Department of Natural Resources can provide assistance with the audit.

2. Each industrial water user will adopt an industrial leak detection and repair program.

3. All industrial water users will adopt a metering, meter calibration, and repair and replacement program to be approved by the Georgia Environmental Protection Division.

4. All industrial permit holders, who do not produce a food product, shall conduct a reuse feasibility study for an alternate water source (i.e. reclaimed water or surface water) as a substitute for ground water used for operational practices (such as washing, cooling, etc...). This assessment will be conducted using guidance to be provided by the Georgia Environmental Protection Division.

5. All industrial water users will maximize the use of recycled or reclaimed water to supply their internal operation needs as well as their outdoor watering requirements.

- *Public and Private Drinking Water Providers*

Public and private drinking water providers constitute the majority of the water use in Sub-Region 1. Over time it is possible to achieve significant reductions in residential per capita water use. Already some communities within the Sub-Region are targeting household water use through educational campaigns, metering and retrofit programs. For all current public and private drinking water withdrawal permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Reductions in actual withdrawals from the aquifer are expected through implementation of these conditions. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

Public and private water providers will develop or expand their water conservation program to include, but not be limited to, the following elements:

1. Each water utility serving water customers (residential, commercial, institutional, and industrial) will develop a water conservation education program (including both school and public information programs) assistance to be provided by the Georgia Department of Natural Resources and the Georgia Department of Community Affairs.

2. All public and private water providers will adopt and implement a conservation-oriented rate structure. The rate structure must be developed using guidelines to be provided by the Georgia Environmental Protection Division. Water wholesalers must ensure that all municipal customers have adopted conservation-oriented rate structures.

3. Each water provider and its customers (residential, commercial and industrial) will adopt a policy requiring all of its water customers to abide by the outdoor watering schedule adopted by the Board of Natural Resources (in the Drought Management plan of 2003),

or an alternate outdoor watering schedule approved by the Georgia Environmental Protection Division. In the Effingham, Chatham, Bryan, and Liberty Sub-region, the local governments will enhance the outdoor watering schedule to include a volume or time limitation.

4. All public and private drinking water providers will submit to EPD a schedule for conducting a reuse feasibility study for alternate water sources (i.e. reclaimed water or surface water) as a substitute for ground water used for outdoor watering purposes. This assessment will be conducted using guidance to be provided by the Georgia Environmental Protection Division.

5. All public and private drinking water providers will adopt a meter calibration, repair, and replacement program to be approved by the Georgia Environmental Protection Division prior to issuance of the permit. This program is to include:

    a. A program and schedule for installing meters for all wells and connections that are not currently metered.
    b. Annual calibration for meters for those users representing at least the top 10% of water users.

6. All local governments within the sub-region will adopt ordinances requiring all new developments served by public and private sewage services to install purple pipe reuse lines.

7. Each water utility serving municipal customers will adopt a water loss control program using guidance provided by the Georgia Environmental Protection Division. All providers in the sub-region will implement the water loss control program.

    a. EPD will use the International Water Association methodology as endorsed by the American Water Works Association.
    b. In addition, the sub-area will meter all fire hydrant flushing events.

Many of the elements listed above can be accomplished through participation in area wide, regional, or aquifer-wide public water conservation programs where plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

- *Agricultural Water Users*
    1. Enhance partnerships between EPD, the Wildlife Resources Division (WRD), the Natural Resources Conservation Service (NRCS), the Soil and Water Conservation Service (SWCC), the Extension Service and other entities in the area to develop messages about the importance of implementing efficient irrigation practices and reducing water withdrawals. Refine and target initial educational efforts to the Effingham, Chatham, Bryan and Liberty Sub-region and the Glynn County Sub-region and then extend educational efforts to the remaining 19 county area.

2. Permittees will be required to install water meters and report annual water use on forms provided by the Georgia Environmental Protection Division, developed in conjunction with the SWCC metering program, using standard methodology approved by the Director.

3. EPD will partner with NRCS and SWCC and other interested parties to develop a program to help irrigators identify and fix leaks and eliminate off-target application. Program development should include the irrigation manufacturers and providers in Southwest Georgia. Initially the program should target the largest irrigation water users in the sub-region, then expand to the other irrigation users.

4. EPD will use information collected and compiled by the SWCC through the water metering program. This information will help EPD and other state and federal agencies to identify target areas where enhanced water conservation practices are needed. This type of monitoring can help target education and outreach and financial assistance programs most appropriately.

5. EPD will work with various State and federal agencies to develop a process for determining success of water conservation practices. This process should be built around the research currently being conducted by the SWCC and used to identify those areas that need additional resources for more conservation implementation and/or education efforts.

6. To eliminate water loss and water waste, all new farm permits will be required to use cost/effective, water efficient irrigation technology. These technologies will include, but not be limited to, end gun shutoffs and sprays on drops. Also new, modified, or transferred water withdrawal permit applicants will be advised to implement technology to minimize runoff and control evaporative loss of water. Practices and technology that qualify as water efficient will be identified by EPD and others by December 31, 2006 and periodically reviewed to ensure information is up to date.

7. No new traveler irrigation systems will be allowed in the Effingham, Chatham, Bryan and Liberty Sub-region.

8. All new, modified or transferred water withdrawal permit applicants, who do not produce a food product, will conduct a reuse feasibility study for reclaimed water as a substitute for ground water.

- *Golf Course Water Use*

1. Golf course water users in the sub-region that hold a non-farm water use withdrawal permit – as defined by statute - will conduct a study of the feasibility of using reclaimed water as a substitute for Upper Floridan aquifer water. The results of this feasibility study will be included in the application for renewal of the non-farm water use withdrawal permit. Upon completion of review of each such renewal application, EPD shall set a schedule for such golf courses to convert to the use of reclaimed water or other non-Upper Floridan aquifer water for irrigation purposes.

2. As withdrawal permits are issued and/or renewed for golf courses in the sub-region, a condition will be placed in the terms of the permit setting a schedule for implementation of Best Management Practices (BMPs) developed and agreed to in the Memorandum of Agreement (MOA) adopted by Georgia Golf Course Superintendents Association and the EPD on May 14, 2004.

Justification of Need

The principle of 'reasonable use' is at the heart of Georgia's statutes governing water permitting decisions. It is important for the State to fully consider the extent to which 'reasonable use' is reflected in each water withdrawal application. This consideration is critically important when data show that increased use of a limited water resource within a region will compromise the quality and quantity of water available to other near-term users and uses of that water resource. Clearly this is the circumstance that surrounds use of the waters of the Upper Floridan aquifer in this sub-region.

- *Industrial Water Use*
  1. As EPD issues renewed industrial withdrawal permits, the withdrawal limits will reflect water demands that demonstrate reasonable use after considerations of water savings opportunities generated by application of the water conservation strategies outlined above.

- *Public and Private Water Providers*
  1. By September 30, 2006, EPD will develop – in conjunction with the Georgia Municipal Association, the Association of County Commissioners of Georgia, and the Association of Regional Development Centers – and distribute a water demand forecasting protocol to be employed by ALL municipalities within the 24-county area as part of the 'justification of need' for withdrawal quantities cited in ALL applications for new, modified, and renewed water withdrawal permits.

  2. As EPD issues new, modified, and renewed water withdrawal permits, the withdrawal limits will reflect water demands that demonstrate reasonable use as largely determined by use of this demand forecasting protocol.

- *Golf Course Water Use*
  1. EPD will develop and distribute – in conjunction with the Georgia Golf Course Superintendents Association – a guide for forecasting golf course irrigation water needs. In justifying need, ALL golf courses that meet the statutory definition of non-farm water uses in the sub-region will be required to employ the guidance for forecasting irrigation water needs. This guide will also be used for forecasting irrigation water needs by all NEW golf courses within the sub-region that meet the statutory definition of a farm water use. EPD will only consider golf course irrigation water allocations that are supported by the forecasts derived from use of this guide.

Monitoring

Groundwater and surface water monitoring networks have been established for coastal Georgia and currently are being maintained by the USGS. Water level data are collected from the groundwater monitoring stations, stream flow data from the surface water stations. Once a year grab samples are collected from wells on Tybee Island, Fort Pulaski, and Skidaway Island and analyzed for chloride concentration. Subject to the availability of funds, all existing water level, stream flow, and water quality monitoring stations will be maintained.

Beneath the Savannah River channel offshore of Tybee Island, pore water concentrations as high as 500 milligrams per liter have been measured in the lower portion of the confining unit near the top of the Upper Floridan aquifer. To track changes in chloride concentration and water levels that could indicate salt water contamination, an early warning "real time" system at Tybee Island needs to be established.

South Carolina Department of Health and Environmental Control maintains a groundwater monitoring network in the vicinity of the northern end of Hilton Head Island. It is expected that this monitoring network will be maintained.

Elements of the Management Plan for the Glynn County Sub-region

Sub-Region 2: Glynn County

Avoidance: The management goal for Sub-region 2 is to manage withdrawals from the Upper Florida aquifer in such a manner so that the current configuration of the "t-shaped" plume does not change to any great extent. No new wells will be permitted within the area of the plume, or within a setback from the plume.

Conservation and Reuse: Employ aggressive and practical measures that will ensure efficient and effective use of those quantities of water that must be removed from our water systems to meet human needs.

Justification of Need: Ensure that each gallon of water sought under any permit application is justified using clear and consistent criteria.

Monitoring: Continuously monitor the reactions of the Floridan aquifer as management actions are implemented; determine the extent to which the management actions require additions and modification to achieve aquifer management goals.

Major Water Resources Issues in Sub-Region 2

Salt Water Intrusion

In Glynn County salty water is entering the Lower and Upper Floridan aquifer from the so-called Fernandina Permeable Zone, which lies beneath the lower confining unit of the Lower Floridan aquifer. The saline water within the Fernandina Permeable Zone travels upwards into the Lower and Upper Floridan aquifer due to a couple of factors. First, there are fractures in the confining units between the Fernandina Permeable Zone and the Lower Florida aquifer, as well as within the semi-confining unit between the Lower Floridan and Upper Floridan. These fractures provide a pathway for the saline water from the Fernandina Permeable Zone to travel upward. Second, over the middle decades of the 20th century there was a gradual increase in withdrawals from the Upper Floridan aquifer in Glynn County. These withdrawals decreased the residual water pressure in the aquifer, which when combined with the existence of the fractures in confining units, resulted in the upward movement of the salty water.

Population/Economic Growth & Water Supply

Glynn County is expected to experience moderate population growth over the next several decades. Indeed circumstances could arise that would result in growth well beyond that which might be reasonable to anticipate today. Wherever along the spectrum of possible growth scenarios the County actually falls in the coming decades, it is reasonable to expect that the present and future water needs of the County, as well as municipalities and industries therein, will continue to largely be reliant on the waters of the Upper Floridan aquifer.

The two major municipal water suppliers within Glynn County are the County itself and the City of Brunswick. Additionally, there are many private water service providers filling service vacuums in faster growing areas not served by Glynn County or the City of Brunswick. The County has a fair amount of excess withdrawal permitted capacity in some areas; the City too has some excess withdrawal capacity, but less. Viewed collectively, there is likely sufficient water to meet most, if not all, of the reasonably foreseeable municipal growth in water and wastewater services demands within the county over the next couple of decades.

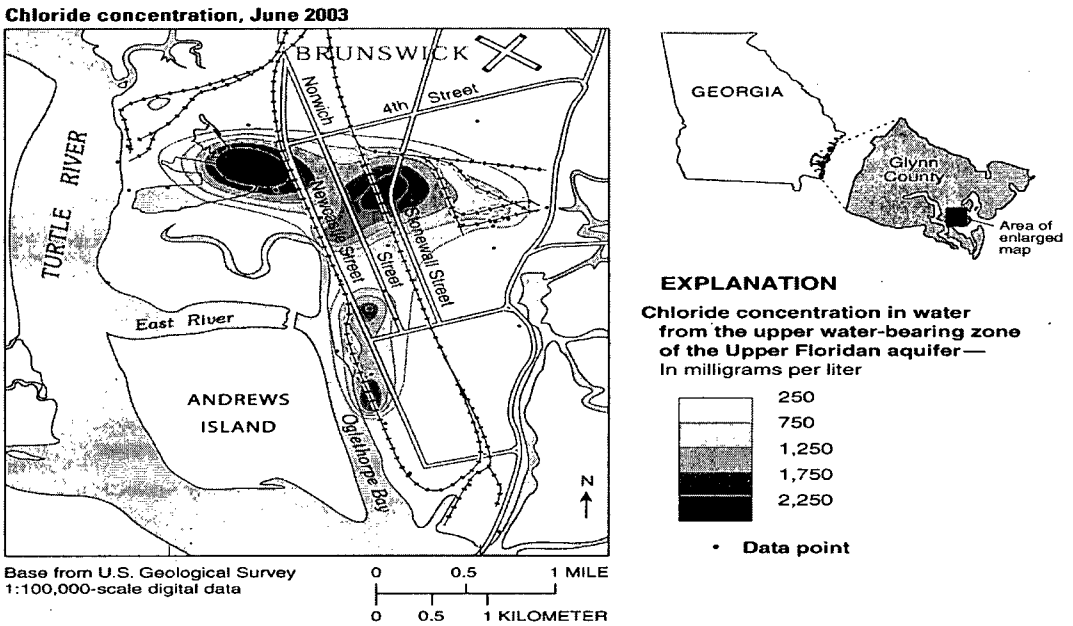
Wastewater

With regard to wastewater, the City has a fairly sizable amount of excess wastewater treatment capacity in some locations; the County on the other hand is pressed for wastewater treatment capacity (more in some areas than others). State and local efforts to manage the sub-region's water resources to maintain the stability of the T-shaped plume could potentially be aided by continuation of discussions between the County and City toward development of a county-wide water and sewer authority. Such an authority would also likely result in a sizable reduction in future water demands that would otherwise be placed on the water resources in the sub-region (including the Upper Floridan aquifer), and a cost-effective county-wide water and sewer infrastructure with which to address the growth needs.

Management Goals

Avoidance

Monitoring data have shown that the T-shaped salt water plume in Glynn County (Figure 8) has not demonstrated appreciable advancement for more than 20 years. This stability is owed to reductions in the quantity of water withdrawn from wells located within the Upper Floridan aquifer within the plume area. Industrial users have been particularly effective, and the City of Brunswick has more recently also implemented effective water conservation and leak detention/prevention programs. Since the early 1980's actual withdrawals have decreased by 30 mgd. Restricting the siting of new wells to points well removed from locations that would influence expansion of the plume has also greatly aided the stability of the plume.



(Modified from Leeth and others, 2005, Ground-Water Conditions and Studies in Georgia, 2002–2003: Reston, Va., U.S. Geological Survey Scientific Investigations Report 2005-5065, 128 p.

Figure 8: T-shaped plume beneath Brunswick, Georgia

Meet Reasonable Future Water Needs

Reasonable use of Georgia's water resources is a right accorded to Georgia's citizens by Georgia Code. As the protector of that right, the state is responsible for managing those resources in a way that ensures Georgians have access to reasonable quantities of water both now and into the future. To better avail citizens to the right to reasonable use, the Plan focuses on actions designed to ensure that forecasts of water needs by various entities within the region be done in accordance with a standardized protocol; and that reasonable and consistent actions be taken by all permit applicants to implement aggressive water conservation programs; and that future water supplies come from a combination of groundwater and surface water sources; and future water sources include the use of reclaimed water to the maximum practical extent.

Sub-Region 2 Key Elements

Avoid Increasing Size and Shape of Current Plume

The following elements are central to managing the use of water in the Glynn County sub-region.

- The amount of withdrawals provided under renewals of current permits will be based on the conditions set forth in the remainder of this section, including those conditions set out in the 'Conservation and Reuse', 'Justification of Need', and 'Monitoring' sections of this document.

- No increases in permitted withdrawal quantities of industrial users of the Upper Floridan aquifer currently within the limits of the salt water plume.

- No approval of any new applications that site Upper Floridan aquifer wells within the current salt water plume boundary.

- Establish a buffer zone around the plume boundary area and require all new applicants to drill wells outside buffer limits.

Conservation and Reuse

In the Glynn County sub-region the State will attach a higher degree of importance to the extent to which users of the sub-region's waters employ practices that are intended to minimize the volume of water withdrawn to meet specific needs. The state will also attach more importance to assuring that measures are implemented that result in the efficient use of all water withdrawn. Toward these ends, a series of water conservation and efficiency actions will be required of water users within the sub-region. Some of these prescribed actions build upon the success many of the sub-region's water utilities have had in implementing conservation practices. Other actions described below are based upon federal guidance documents and national research that apply to this area of the state.

- *Industrial Water Use*

Many industrial processes demand high volumes of water, including washing and rinsing, heating and cooling, shop clean-up and outdoor water use. No two operations are alike; therefore, it is critical that a water audit be performed to assess the facility's system and identify potential for water savings. For all current industrial permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

1. Each industrial water user will perform an audit of the facility's water system and identify locations where practices can be employed to conserve water. The Pollution Prevention Assistance Division of the Georgia Department of Natural Resources can provide assistance with the audit.

2. Each industrial water user will adopt an industrial leak detection and repair program.

3. All industrial water users will adopt a metering, meter calibration, and repair and replacement program to be approved by the Georgia Environmental Protection Division.

4. All industrial permit holders, who do not produce a food product, shall conduct a reuse feasibility study for an alternate water source (i.e. reclaimed water or surface water) as a substitute for ground water used for operational practices (such as washing, cooling, etc…). This assessment will be conducted using guidance to be provided by the Georgia Environmental Protection Division.

5. All industrial water uses will maximize the use of recycled or reclaimed water to supply their internal operation needs as well as their outdoor watering requirements.

- *Public and Private Water Providers*

For all current public and private water withdrawal permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

1. Each water utility serving water customers (residential, commercial, institutional, and industrial) will develop a water conservation education program (including both school and public information programs); assistance to be provided by the Georgia Department of Natural Resources and the Georgia Department of Community Affairs.

2. All public and private water providers will adopt and implement a conservation-oriented rate structure. The pricing structure must be developed using the guidelines to be provided by the EPD. Water wholesalers must ensure that all municipal customers have adopted conservation-oriented rate structures.

3. Each water provider and its customers (residential, commercial and industrial) will adopt a policy requiring all of its water customers to abide by the outdoor watering schedule adopted by the Board of Natural Resources (in the Drought Management plan of 2003), or an alternate outdoor watering schedule approved by the EPD. In the Glynn County sub-region, the local governments will enhance the outdoor watering schedule to include a volume or time limitation.

4. All public and private water providers will submit to EPD a schedule for conducting a reuse feasibility study for alternate water sources (i.e. reclaimed water or surface water) as a substitute for groundwater used for outdoor watering purposes. This assessment will be conducted using guidance to be provided by the EPD.

5. All public and private domestic water providers will adopt a meter calibration, repair, and replacement program to be approved by the EPD prior to issuance of the permit. This program is to include:
    a. A program and schedule for installing meters for all wells and connections that are not currently metered.
    b. Annual calibration for meters for those users representing at least the top 10% of water users.

6. All local governments within the sub-region will adopt ordinances requiring all new developments served by public and private sewage services to install purple pipe reuse lines.

7. Each water utility serving municipal customers will adopt a water loss control program using guidance provided by the EPD. All providers in the sub-region will implement the water loss control program.
    a. EPD will use the International Water Association methodology as endorsed by the American Water Works Association.
    b. In addition, the sub-area will meter all fire hydrant flushing events.

Many of the elements listed above can be accomplished through participation in regional water conservation program where plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

Agricultural Water Users

1. Enhance partnerships between EPD, the Wildlife Resources Division (WRD), the Natural Resources Conservation Service (NRCS), the Soil and Water Conservation Service (SWCC), the Extension Service and other entities in the area to develop messages about the importance of implementing efficient irrigation practices and reducing water withdrawals.

2. Permittees will be required to install water meters and report annual water use on forms provided by the Georgia Environmental Protection Division, developed in conjunction with the SWCC metering program, using standard methodology approved by the Director.

3. EPD will partner with NRCS and SWCC and other interested parties to develop a program to help irrigators identify and fix leaks and eliminate off-target application. Program development should include the irrigation manufacturers and providers in Southwest Georgia. Initially the program should target the largest irrigation water users in the sub-region and then expand to the other irrigation users.

4. EPD will use information collected and compiled by the SWCC through the water metering program. This information will help EPD and other state and federal agencies to identify target areas where enhanced water conservation practices are needed. This type of monitoring can help target education and outreach and financial assistance programs most appropriately.

5. EPD will work with other state and federal agencies to develop a process for determining success of water conservation practices. This process should be built around the research currently being conducted by the SWCC and used to identify those areas that need additional resources for more conservation implementation and/or education efforts.

6. To eliminate water loss and water waste, all new farm permits will be required to use cost/effective, water efficient irrigation technology. These technologies will include, but not be limited to, end gun shutoffs and sprays on drops. Also new, modified, or transferred water withdrawal permit applicants will be advised to implement technology to minimize runoff and control evaporative loss of water. Practices and technology that

qualify as water efficient will be identified by EPD and others by December 31, 2006 and periodically reviewed to ensure information is up to date.

7. No new traveler irrigation systems will be allowed in the Glynn County sub-region.

8. All new, modified or transferred water withdrawal permit applicants, who do not produce a food product, will conduct a reuse feasibility study for reclaimed water as a substitute for ground water.

9. Those operations not required to obtain a permit must register with the EPD and show proof that approved water-conserving irrigation technology and practices will be used.

- *Golf Course Water Use*
  1. Golf course water uses in the sub-region that hold a non-farm water use withdrawal permit – as defined by statute - will conduct a study of the feasibility of using reclaimed water as a substitute for Upper Floridan aquifer water. The results of this feasibility study will be included in the application for renewal of the non-farm water use withdrawal permit. Upon completion of review of each such renewal application, EPD shall set a schedule for such golf courses to convert to the use of reclaimed water or other non-Upper Floridan aquifer water for irrigation purposes.

  2. As withdrawal permits are issued and/or renewed for golf courses in the sub-region, a condition will be placed in the terms of the permit setting a schedule for implementation of Best Management Practices (BMPs) developed and agreed to in the Memorandum of Agreement (MOA) adopted by Georgia Golf Course Superintendents Association and the EPD on May 14, 2004.

Justification of Need

The principle of 'reasonable use' is at the heart of Georgia's statutes governing water permitting decisions. It is important for the state to fully consider the extent to which 'reasonable use' is reflected in each water withdrawal application. This consideration is critically important when data show that increased use of a limited water resource within a region will compromise the quality and quantity of water available to other near-term users and uses of that water resource.

- *Industrial Water Use*
  As EPD issues renewed industrial withdrawal permits, the withdrawal limits will reflect water demands that demonstrate reasonable use after considerations of water savings opportunities generated by application of the water conservation strategies outlined above.

- *Public and Private Water Providers*
  1. By September 30, 2006, EPD will develop – in conjunction with the Georgia Municipal Association, the Association of County Commissioners of Georgia, and the Association of Regional Development Centers – and distribute a water demand forecasting protocol

to be employed by ALL municipalities within the 24-county area as part of the 'justification of need' for withdrawal quantities cited in ALL applications for new, modified, and renewed water withdrawal permits.

2. As EPD issues new, modified, and renewed withdrawal permits, the withdrawal limits will reflect water demands that demonstrate reasonable use as largely determined by use of this demand forecasting protocol.

- *Golf Courses*
  1. EPD will develop and distribute – in conjunction with the Georgia Golf Course Superintendents Association – a guide for forecasting golf course irrigation water needs. In justifying need, ALL golf courses that meet the statutory definition of non-farm water uses in the sub-region will be required to employ the guidance for forecasting irrigation water needs. EPD will only consider golf course irrigation water allocations that are supported by the forecasts derived from use of this guide.

Monitoring

Since 1959, the USGS has conducted a cooperative water-resources investigative program at Brunswick. The program resulted from the noticeable impact of salt water contamination in the Upper Floridan aquifer during the mid-1950's, and features well networks that continuously monitor groundwater levels and annually sample wells for chloride concentration. Recently the program has included projects to better define the mechanisms of groundwater flow and the movement of salt water in the Floridan aquifer system as well as an assessment of alternative sources of water supply. It is EPD's expectation that the USGS/City of Brunswick cooperative agreement will continue.

Monitoring wells at Koch Cellulose and Southside Baptist Church (both in Brunswick) were utilized to delineate the outer edge of the salt water plume in these vicinities; however these wells are no longer being monitored. When funding allows, EPD will opt to restart monitoring at these wells. Additionally, the Perry Park production well (near the eastern edge of the plume) has been taken offline due to chloride contamination. It would likewise be appropriate to include this well as part of the monitoring network when funds permit.

Taken together, operation of the aforementioned monitoring sites will alert the state and the region to any significant shifting of the plume.

Elements of Management Plan for the 19-County plus North Effingham Sub-Region

Sub-region 3: 19 counties plus Effingham County north of Highway 119

Conservation and Reuse: Employ aggressive and practical measures that will ensure efficient and effective use of those quantities of water that must be removed from our water systems to meet human needs.

Justification of Need: Ensure that each gallon of water sought under any permit application is justified using clear and consistent criteria.

Monitoring: Continuously monitor the reactions of the Floridan aquifer as management actions are implemented; determine the extent to which the management actions require additions and modification to achieve aquifer management goals.

Major Water Resources Issues in Sub-region 3

Potential Decrease in Water Levels
While not yet an issue of concern, mathematical modeling of the Upper Floridan aquifer shows that large – and as yet unanticipated - increases in groundwater withdrawals in the farming region north of the so-called Gulf Trough would significantly reduce the residual water pressure in the Upper Floridan aquifer. If this unanticipated circumstance were to develop, some surface water bodies could be adversely impacted. This is an environmental issue not related to salt water intrusion but warrants further consideration and study.

Management Goals

Meet Reasonable Future Water Needs
Reasonable use of Georgia's water resources is a right accorded to Georgia's citizens by Georgia Code. As the protector of that right, the state is responsible for managing those resources in a way that ensures Georgians have access to reasonable quantities of water both now and into the future. To better avail citizens to the right to reasonable use, the Plan focuses on actions designed to ensure that forecasts of water needs by various entities within the region be done in accordance with a standardized protocol; and that reasonable and consistent actions be taken by all permit applicants to implement aggressive water conservation programs; and that future water supplies come from a combination of groundwater and surface water sources; and future water sources include the use of reclaimed water to the maximum practical extent.

Sub-Region 3 Key Elements

The following elements are central to managing the use of water in the 19-County sub-region.

- The amount of withdrawals provided under renewals of current permits will be based on the conditions set forth in the remainder of this section, including those conditions set out in the 'Conservation and Reuse', 'Justification of Need', and 'Monitoring' sections of this document.

Conservation and Reuse

As in the other sub-regions, in the 19-county area the state through its permitting will emphasize the degree of importance to the extent to which users of the sub-region's waters employ practices that are intended to minimize the volume of water withdrawn to meet specific needs, and will attach more importance to assuring that measures are implemented that result in the efficient use of all water withdrawn. A series of water conservation and efficiency actions will be required of water users within the sub-region.

- *Industrial Water Use*

Many industrial processes demand high volumes of water, including washing and rinsing, heating and cooling, shop clean-up and outdoor water use. No two operations are alike; therefore, it is critical that a water audit be performed to assess the facility's system and identify potential for water savings. For all current industrial permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

1. Each industrial water user will perform an audit of the facility's water system and identify locations where practices can be employed to conserve water. The Pollution Prevention Assistance Division of the Georgia Department of Natural Resources can provide assistance with the audit.

2. Each industrial water user will adopt an industrial leak detection and repair program.

3. All industrial water users will adopt a metering, meter calibration, and repair and replacement program to be approved by the Georgia Environmental Protection Division.

4. All industrial permit holders, who do not produce a food product, shall conduct a reuse feasibility study for an alternate water source (i.e. reclaimed water or surface water) as a substitute for ground water used for operational practices (such as washing, cooling, etc…). This assessment will be conducted using guidance to be provided by the Georgia Environmental Protection Division.

All industrial water users will maximize the use of recycled or reclaimed water to supply their internal operation needs as well as their outdoor watering requirements.

- *Public and Private Water Providers*

For all current public and private water withdrawal permit holders seeking to renew their withdrawal permits, conditions will be placed in such permits to set a schedule for completion of the items described below. Additionally, the permit conditions will require that withdrawal permit limits in the renewed permits be revisited and revised after EPD completes its review of the elements submitted in accordance with the items described below.

1. Each water utility serving water customers (residential, commercial, institutional, and industrial) will develop a water conservation education program (including both school and public information programs) assistance to be provided by the Georgia Department of Natural Resources and the Georgia Department of Community Affairs.

2. All public and private water providers will adopt and implement a conservation-oriented rate structure. The pricing structure must be developed using the guidelines to be provided by the Georgia Environmental Protection Division. Water wholesalers must ensure that all municipal customers have adopted conservation-oriented rate structures.

3. Each water provider and its customers (residential, commercial and industrial) will adopt a policy requiring all of its water customers to abide by the outdoor watering schedule adopted by the Board of Natural Resources (in the Drought Management plan of 2003), or an alternate outdoor watering schedule approved by the EPD.

4. All public and private water providers will submit to EPD a schedule for conducting a reuse feasibility study for alternate water sources (i.e. reclaimed water or surface water) as a substitute for ground water used for outdoor watering purposes. This assessment will be conducted using guidance to be provided by the EPD.

5. All public and private domestic water providers will adopt a meter calibration, repair, and replacement program to be approved by the EPD prior to issuance of the permit. This program is to include a plan and schedule for installing meters for all wells and connections that are not currently metered.

6. Each water utility serving municipal customers will adopt a water loss control program using guidance provided by EPD.
    a. EPD will use the International Water Association methodology as endorsed by the American Water Works Association.

Many of the elements listed above can be accomplished through participation in area wide, regional, or aquifer-wide public water conservation programs where plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

- *Agricultural Water Users*

1. Enhance partnerships between EPD, Wildlife Resources Division (WRD), Natural Resources Conservation Service (NRCS), Soil and Water Conservation Commission (SWCC), FVSC, the Extension Service of the University of Georgia, and other

appropriate entities in the sub-region to develop outreach messages pertaining to the importance of implementing efficient irrigation practices and reducing water withdrawals. Refine and target initial educational efforts to the Effingham, Chatham, Bryan and Liberty Sub-region and the Glynn County Sub-region and then extend educational efforts to the remaining 19 county area.

2. EPD will partner with NRCS and SWCC and other interested parties to develop a program to help irrigators identify and fix leaks and eliminate off-target application. Program development should include the irrigation manufacturers and providers in Southwest Georgia. Initially the program should target the largest irrigation water users in the sub-region and then expand to the other irrigation users.

3. EPD will use information collected and compiled by the SWCC through the water metering program. This information will help EPD and other state and federal agencies to identify target areas where enhanced water conservation practices are needed. This type of monitoring can help target education and outreach and financial assistance programs most appropriately.

4. EPD will work with other state and federal agencies to develop a process for determining success of water conservation practices. This process should be built around the research currently being conducted by the SWCC and used to identify those areas that need additional resources for more conservation implementation and/or education efforts.

- *Golf Course Water Use*
  1. As withdrawal permits are issued for golf courses in the sub-region, a condition will be placed in the terms of the permit setting a schedule for implementation of Best Management Practices (BMPs) developed and agreed to in the Memorandum of Agreement (MOA) adopted by Georgia Golf Course Superintendents Association and the EPD on May 14, 2004.

Justification of Need

It is important for the state to fully consider the extent to which 'reasonable use' is reflected in each water withdrawal application.

- *Industrial Water Use*
  As EPD issues renewed industrial withdrawal permits, the withdrawal limits will reflect water demands that demonstrate reasonable use after considerations of water savings opportunities generated by application of the water conservation strategies outlined above.

- *Public and Private Water Providers*
  1. By September 30, 2006, EPD will develop – in conjunction with the Georgia Municipal Association, the Association of County Commissioners of Georgia, and the Association of Regional Development Centers – and distribute a water demand forecasting protocol to

be employed by ALL municipalities within the 24-county area as part of the 'justification of need' for withdrawal quantities cited in ALL applications for new, modified, and renewed water withdrawal permits.

2. As EPD issues new, modified, and renewed withdrawal permits, the withdrawal limits will reflect water demands that reflect reasonable use as largely determined by use of this demand forecasting protocol.

- *Golf Courses*
  1. EPD will develop and distribute – in conjunction with the Georgia Golf Course Superintendents Association – a guide for forecasting golf course irrigation water needs. This guide will also be used for forecasting irrigation water needs by all NEW golf courses within the sub-region that meet the statutory definition of a farm use. EPD will only consider golf course irrigation water allocations that are supported by the forecasts derived from use of this guide.

Monitoring

All existing groundwater monitoring wells and all existing surface water gauging stations should be maintained. There is no need for chloride monitoring in Sub-region 3.

APPENDIX A

GLOSSARY AND REFERENCES

GLOSSARY

Aquifer:
Rock or sediment in a formation or a group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water to a well. A confined aquifer is an aquifer that is overlain by a unit (or bed).

Breakthrough:
This occurs when the concentration of salty water leaking through the confining unit into the aquifer exceeds 250 mg/l of chlorides.

Cone of Depression (or pumping cone):
The area around a discharging well (or group of wells), where pumping has lowered the hydraulic head in the aquifer.

Confining Unit:
A rock or sediment that has significantly lower permeability than the aquifer. In coastal Georgia the much less permeable Miocene strata overlies the permeable Upper Floridan Aquifer.

Fernandina Permeable Zone:
A geologic formation underlying the Floridan Aquifer, which is characterized by highly saline water.

Gulf Trough:
This is a subsurface geologic feature in which the sediments are finer-grained and have lower permeability. The feature acts as an impediment to ground-water flow.

Potentiometric Surface:
A surface that represents the level in which water will rise in tightly cased wells. If the water level rises above the top of the aquifer, the well is referred to as an artesian aquifer.

Recharge Areas:
An area in which there is a downward component of hydraulic head in the aquifer. In general, the term refers to geographic areas where the aquifer is recharged from precipitation. It is important to note that aquifers also may be recharged from lateral flow and leakage from overlying and underlying materials.

Vertical Hydraulic Conductivity:
A mathematical coefficient that is a measure of the vertical rate of movement of water through a permeable material.

REFERENCES CITED

Counts, H.B., and Donsky, Ellis, 1963, Salt-water encroachment, geology, and ground-water resources of Savannah area, Georgia and South Carolina: U. S. Geological Survey Water Supply Paper 1611, 100 p.

Wait, R. L., 1965, Geology and occurrence of fresh and brackish water in Glynn County, Georgia: U. S. Geological Survey Water-Supply Paper 1613-E, 94 p.

APPENDIX B

UPPER FLORIDAN
TECHNICAL ADVISORY COMMITTEE

Mr. James Baker	Union Camp Corporation
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Dr. William Segars	Georgia Farm Bureau
Mr. James Durrett Ms Patricia McIntosh	Georgia Conservancy
Mr. William Francis	City of Brunswick
Mr. Camille Ransom	S.C. Dept. of Health and Environmental Control

APPENDIX C

Public Participation Process

Prior to developing the draft management plan, EPD solicited public comments regarding the salt water intrusion occurring in the Upper Floridan aquifer. The results of the Coastal Sound Science Initiative (CSSI), a series of field investigations and scientific modeling efforts, were presented at four public meetings during the first two weeks of August 2005. The meetings provided the public an opportunity to offer comments on the scientific results, and to provide input on directions for management of the area's water resources. Written comments were also sought, with a dedicated link for input set up on the EPD website. Taken together, the comments obtained from the public meetings, written statements submitted following the meetings, and the scientific and technical results of the CSSI, provided the starting point fro development of this draft water management plan.

Public meetings were held in Jesup on August 2nd, Kingsland on August 4th, Statesboro on August 8th, Pooler on August 9th, and Brunswick on August 11th. Over 190 people participated in the meetings. Each of the public meetings opened with presentations summarizing the seven years of scientific and technical work that comprise the CSSI. Participants were then asked to respond to two questions: Of the information presented tonight, what do you think are the most important findings or conclusions?

1. The Sound Science Initiative provides a scientific foundation for the management plan being developed to replace the interim salt water intrusion management strategy.

2. Do the results you've heard tonight point to any specific directions for that management plan?

Responses to the first question can be summarized in the following general categories:

1. *Mechanisms of salt water intrusion*. Comments in this category highlighted both conclusions and uncertainties about the mechanisms of salt water intrusion.

2. *Timeline for migration of Hilton Head plumes*. Some commentators highlighted the conclusion that risk of contamination in the Savannah area is long-term, while others concluded that, despite the projected timeframe for migration of the Hilton Head plumes, there is a responsibility to take action now to protect the resource in the future.

3. *Localized cause-effect*. This category of comments concerned the cause-effect relationships apparent in study results, with a number of respondents highlighting the conclusion that the causes of salt water intrusion are more localized than initially suspected.

4. *Better understanding of the system*. The fourth category of comments includes positive assessments of the overall results of the CSSI and improved understanding of groundwater conditions in coastal Georgia.

5. *Additional information needs*. Some comments highlighted the information gaps that should be addressed in the future.

Management-Related Conclusions

Comments in this category included a range of specific management approaches or strategies. The vast majority of responses to the second question could be divided into four categories:

1. *Alternate sources of water*. The majority of responses to the second question focused on surface water sources, conservation and reuse, and other aquifers as alternate sources of water.

2. *Geographic targeting*. A number of respondents recommended reducing the capped area and focusing management strategies on known problem areas.

3. *Adaptive management of interconnected resources*. A number of comments addressed information gaps, uncertainties, and the need for adaptive management of coastal water resources as a whole.

General comments and guidance

A number of comments provided wide-ranging guidance and goals for the management strategy. Detailed written comments from the public meetings are available on the Coastal Water Study page on the EPD website (www.gadnr.org/cws/).

Following completion of the draft plan for managing salt water intrusion and water withdrawals in the 24-county region, another round of public meetings will be scheduled during the first two weeks of January 2006. There will be a 30-day public comment period on the Draft Plan. EPD will review the comments and prepare a revised document. EPD intends to present the Management Plan to the Department of Natural Resources Board early in 2006.