HYDROLOGIC ASSESSMENT OF THE APALACHICOLA RIVER BASIN BELOW LAKE SEMINOLE AND THE CHIPOLA RIVER BASIN, NORTHWEST FLORIDA

PLAN OF STUDY

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

April, 1981

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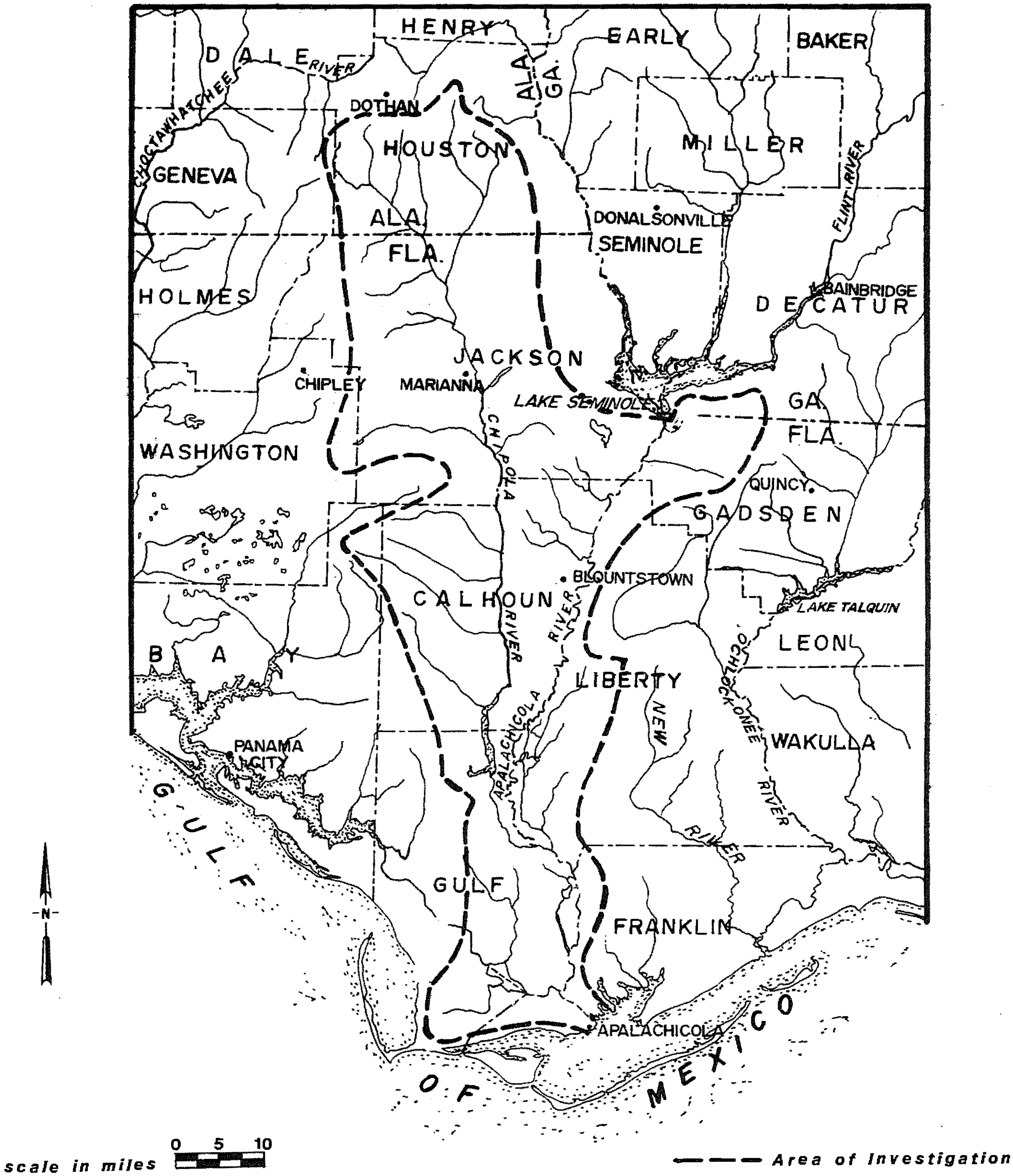

Figure 1 - Map Showing Area of Investigation.

1) Assess the climatological characteristics of the study area to determine the spatial and temporal distributions of temperature, rainfall, evaporation, and other parameters for which there is sufficient information, and to estimate rainfall probabilities for storms and droughts;
2) Determine the distribution and frequency of occurrence of streamflow in the study area and provide a detailed breakdown of the components of the water budget at each major subbasin including volumes of rainfall, base flow, direct runoff, ground water recharge, ground water inflow and outflow to the subbasins, and evapotranspiration;
3) Evaluate the chemical characteristics of the surface waters to determine seasonal and geographical variations in water quality and identify, to the extent possible, the origin of the various constituents in the surface waters;
4) Ascertain the nature of occurrence of the ground water resources of the study area, including upgradient inflow to the area, recharge and discharge from distributed leakage, and discharge to partially penetrating streams;
5) Determine the chemical quality of the ground water, delineate the approximate depth to, and altitude of, the base of fresh to slightly saline water in the principal aquifer and determine the thickness of the fresh to slightly saline water bearing zone;
6) Delineate the floodplains of the Apalachicola and Chipola rivers for the 100, 50, 25, 10, 5, and 2 year flood events;
7) Determine the effects including flood reduction, flow augmentation, water quality, and navigation, of the Jim Woodruff Dam on the streamflow distribution of the Apalachicola River;

8) Evaluate the degree of interconnection between the surface and groundwater systems and determine the sensitivity of each regime to stresses imposed on the other;

9) Make recommendations regarding the areas most favorable for groundwater development and delineate the potential yield of the principal aquifers. Conversely, identify those areas where the aquifer yield and/or quality of water preclude effective developmnent of ground water; and

10) Determine what actions could be taken to protect or increase the availability of the surface and ground water resources of the basin.

The investigation will therefore provide essential information about the region's water resources which are almost unknown at present. Such an evaluation is a necessary initial step towards the planning, development, evaluation, and implementation of water management strategies.

1.2 Extent of Study Area

The proposed study area will comprise that portion of the ACF River Basin which lies principally within Florida. This includes the Apalachicola River Basin below Lake Seminole and the Chipola River Basin (Figure 1). The Chattahoochee-Flint River Basin, which forms the headwaters of the Apalachicola River, need not be explicitly included in the study since a long history of discharges at the outflow of the basin is available at the Chattahoochee streamflow gaging station below Lake Seminole. This data includes the past contributions from the Chattahoochee and Flint rivers to the streamflow in the Apalachicola River. Since the determination of the natural hydrologic characteristics of the study area will be based on an evaluation of past streamflow records, the data at the outflow of Lake Seminole is all that is required for a hydrologic assessment of the area of investigation.

Potentiometric maps of the Floridan aquifer in northwest Florida show water-level contours in the Apalachicola River Basin intersecting the Florida-Georgia border and the Florida-Alabama border at nearly right angles (Figure 2). Since the direction of ground water movement is at right angles to the contours, it is evident that comparatively little ground water flows into Florida from either Georgia or Alabama. As discussed in the following section of the study plan, much of the ground water flowing through the Florida part of the basin originates as recharge within the state in Jackson, Gadsden, and Calhoun counties. Consequently, the ground water investigation outlined herein can be confined to Florida due to the limited inflow of water from upgradient areas in Georgia and Alabama.

1.3 Background Information

The Apalachicola has the largest average flow of any river in Florida and is the 21st in the contiguous United States. Streamflow near Blountstown, Florida averages 24,762 cfs, with a maximum of 172,000 cfs and a minimum of 6,280 cfs. The total watershed area drained by the Apalachicola measures approximately 19,600 square miles. The Apalachicola begins downstream of the Jim Woodruff Dam and extends 113 miles to its mouth at an average rate of 0.4 feet per mile. The Jim Woodruff Dam impounds the headwaters of the Apalachicola, drained by the Chattahoochee and Flint rivers, to form Lake Seminole. The primary functions of the dam are navigation and hydropower generation. The reservoir has a total volume of 355,863 acre-ft. and a surface area of 37,541 acres at the normal pool elevation of 77 ft. msl.

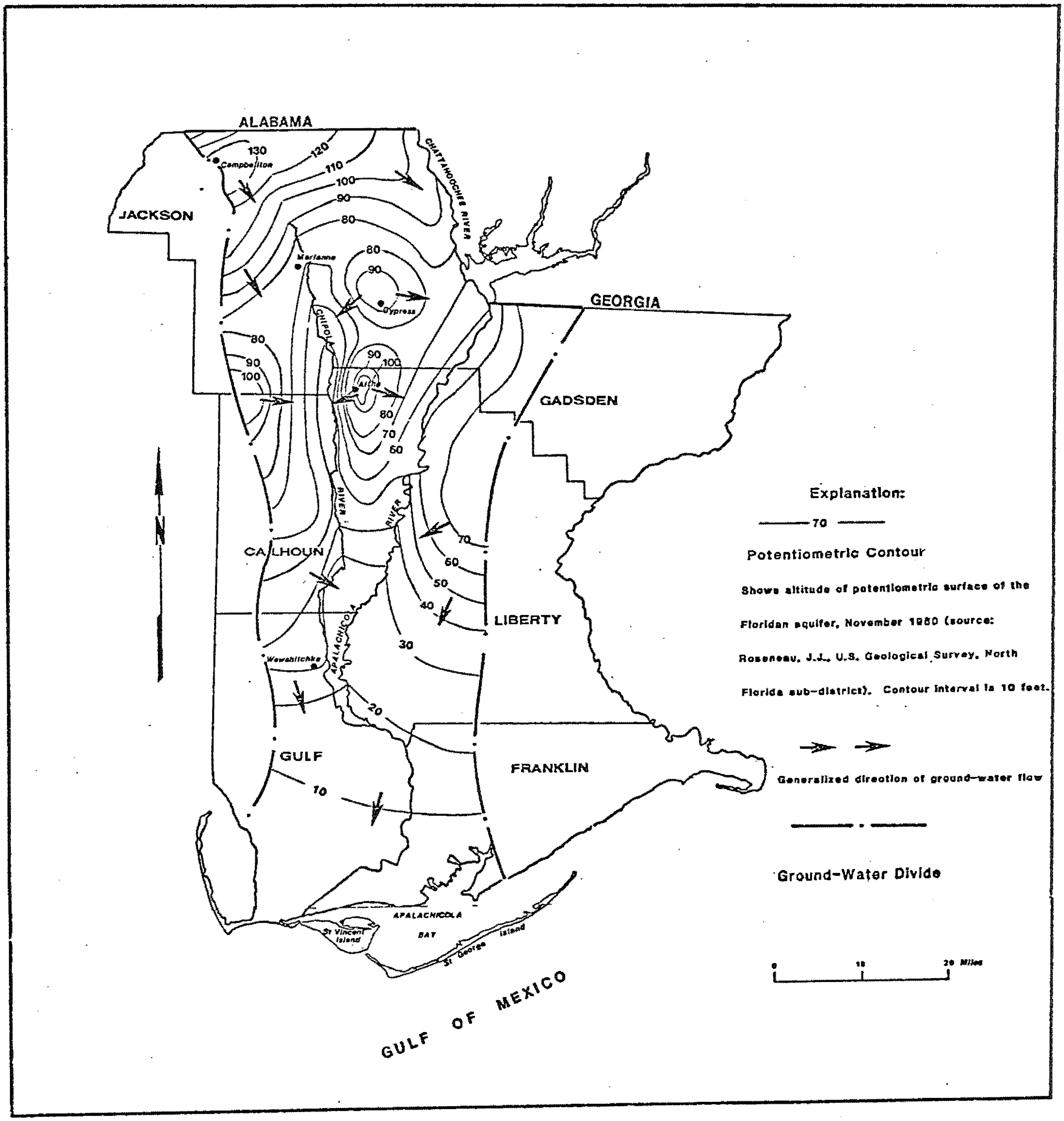

Figure 2 - Map Showing Generalized Direction of Ground-Water Flow in the Apalachicola River Ground-Water Basin.

The total drainage basin area above the dam is 17,200 square miles, of which 8,750 square miles (51%) are drained by the Chattahoochee River, and 8,450 square miles (49%) are drained by the Flint River.

The Apalachicola River Basin in Florida drains an area of approximately 2,400 square miles and is bounded by the following counties: Gulf, Calhoun, Gadsden, Liberty, Jackson, and Franklin. The principal communities in the area are Blountstown, Apalachicola, Marianna, Wewahitchka, Bristol, and Chattahoochee. The area is predominantly rural and the principal land uses are forestry and agriculture. As of 1970, about 70 percent of the population was rural.

The Apalachicola River is distinguished by its wide and flat floodplains which support a diverse and thickly forested wetland community. In addition, the river also maintains a broad estuarine environment at its mouth and supports a productive fishing industry. Studies by Dr. Robert Livingston have linked the productivity of the Apalachicola Bay to pulsed flooding of the river. His studies seem to indicate that patterns of floods and storms tend to recur every 6 to 8 years. On a seasonal basis, the river floods in the winter time. However, localized floods occur in the summer time when rainfall is heaviest in the Florida portion of the basin. The river is also subject to the influence of Gulf tides at its mouth which affect the elevation of the water surface some 25 miles upstream. Ground water discharge through springs and seeps contribute to the streamflow of the Apalachicola and most of its tributaries.

The proposed study area (Figure 1), which encompasses the Apalachicola River in its entirety, drains an area of approximately 2,617 square miles, of which 1,380 square miles are tributary directly to the Apalachicola, and 1,237 square miles are drained by the Chipola River. The Chipola is the largest tributary to the Apalachicola River in Florida. Its headwaters rise in Alabama where the river drains an area of about 217 square miles. The river slopes at an average 1.5 feet per mile from its headwaters to 25 miles below Marianna, and from there to Dead Lake its slope averages 0.4 feet per mile. To the north of Marianna, the river disappears into the ground and flows through underground caverns and solution channels in the limestone and then resurfaces to the south of Marianna. At Dead Lake, a short cutoff connects the Chipola to the Apalachicola. The Chipola finally joins the Apalachicola approximately 28 miles from the Gulf. The average discharge for the period of record in the Chipola River near Altha is 1,494 cfs, with a maximum and minimum of 25,000 cfs and 330 cfs.

Streamflow data in the study area have been collected at five sites on the Apalachicola River, two sites on the Chipola River, and one site on Little Sweetwater Creek, a tributary to the Apalachicola River. In addition, some water quality data are available at most sites. Of the five sites on the Apalachicola River, the one near Chattahoochee and the one near Blountstown have continuous long-term streamflow data. There are also two daily discharge stations with short records near Wewahitchka and Brickyard Landing, and a tidal gage with continuous short-term data located near the mouth of the Apalachicola River. Of the two stations located on the Chipola River, the one near Wewahitchka has a short record of continuous discharge data, and the one located near Altha has continuous long-term streamflow data. The station on Little Sweetwater Creek, which is tributary directly to the Apalachicola River, has a short record of continuous runoff data.

The study area lies in the north Gulf Coast Sedimentary Province, a part of the eastern Gulf of Mexico Sedimentary Basin. Rock units of interest are principally marine sedimentary rocks of Eocene and younger ages.

The formations beneath the near-surface sands and clayey sands of the study area include, from youngest to oldest, the Jackson Bluff Formation; Intracoastal Formation; Bruce Creek Limestone; Chipola Formation, Tampa Stage, Suwannee and Marianna limestones; and the Ocala Limestone Group. The formations can be grouped lithologically into three major sequences of hydrologic significance. From youngest to oldest, these include:

1) Surficial sand deposits, generally less than 100 feet thick;
2) A confining bed consisting of a heterogeneous clastic and carbonate section of interbedded limestone, dolomite, sand, clay, and marl, generally a few tens of feet to several hundred feet thick; and
3) A carbonate section of limestone and dolomite more than 500 feet thick, and in some places over 1000 feet thick, which make-up the Floridan aquifer.

The surficial sand aquifer underlies much of the study area and consists predominantly of fine to very fine sand and clayey sand. Lithology is highly variable and locally the aquifer may contain beds of limestone, gravel, marl, and shell deposits. Clay content commonly increases with depth, and the contact between the aquifer and the underlying confining bed is in many places indistinct.

The surficial aquifer thickness is generally less than 100 feet, but it ranges from a few feet or less in the northern areas where limestone or clay is at or near the surface, to over 150 feet in the coastal areas beneath the dune ridges and terraces. The aquifer serves three important functions in the basin. First, it is a source of good quality water for domestic and small municipal users and is also used for irrigation; second, the aquifer maintains base flows by discharging ground water into the streams; and third, it provides recharge water to the Floridan aquifer, particularly in the northern areas of the basin.

Other than generalized descriptions, there is little or no quantitative informaion available on the surficial aquifer. The water-bearing properties have not been determined because pumping tests have not been conducted on the aquifer. Similarly, maps showing the thickness, lithology and altitude of the water table are not available.

The principal source of ground water in the basin are highly transmissive zones in the Floridan aquifer. The Floridan is the principal source of water for consumptive use and also contributes large volumes of water by direct discharge to the Apalachicola River, the Chipola River, smaller tributaries, and the Apalachicola Bay. Within the area of investigation, the top of the Floridan is defined as the horizon below which carbonate rocks persistently occur. Generalized regional maps show the top of the aquifer dipping to the south-southwest, ranging in altitude from 100 feet above sea level in the north to 250 feet below sea level in the area of Apalachicola Bay. Because it crosses formational boundaries and is in places erosional, the top of the aquifer is highly irregular and has not been mapped in detail.

The Floridan aquifer consists of limestone and dolomite containing solution-enlarged fractures and bedding planes. The highly permeable sections containing pronounced solution features are commonly bounded by thicker units of lower permeability limestone. As a result, the vertical permeability of the aquifer is highly variable. Also, the permeability of the aquifer, as a whole, is significantly lower along the coast. This is attributed to higher contents of limey clay and sand which reduce the aquifer's permeability and well yields. The thickness of the Floridan aquifer has not been precisely defined but, approximations based on regional studies indicate that the thickness of the fresh to slightly saline water-bearing zone generally ranges from less than 500 feet in the coastal areas to approximately 1200 to 1500 feet in the northern areas of the basin. In some coastal areas and in the vicinity of the principal rivers and streams, the thickness of the potable water-bearing zone may be considerably less than the regional studies indicate.

Patterns of recharge and discharge of the Floridan aquifer in the Apalachicola Basin are more complex than anywhere else in northwest Florida, indicative of a highly complex ground water flow regime. Relatively steep water-level gradients of up to 32 feet per mile adjoin the major stream courses in the north while relatively gentle gradients of less than 1 foot per mile prevail in interstream areas and the broad coastal area (Figure 2). Much of the water which flows through the aquifer in the southern parts of the basin enters the aquifer from recharge areas within Florida. Important recharge areas are located in the Altha area of Calhoun County, the Compass Lake area, Grand Ridge area, and Campbellton areas of Jackson County, and a broad area trending northeast-southeast through Gadsden and Liberty counties.

The freshwater flow system in the basin is bounded coastward by a saltwater flow system. The two systems are separated by a zone of transition in which the salinity of the water, as measured by the chloride concentration, is highly variable. In much of the inland areas of the basin, chloride concentration is 10 to 25 mg/l. Values in this range can be considered "background" values for fresh ground water unmixed with saltwater. Parts of the Floridan along the coast contain saline water with a chloride concentration above the drinking water standard of 250 mg/l.

The saltwater front, zone of transition, and configuration of the 250 mg/l isochlor line have not been mapped in the Apalachicola River ground isochlor line have not been mapped in the Apalachicola River ground water basin. It appears that the intersection between the freshwater and saltwater flow systems with the top of the aquifer occurs somewhere offshore in the Gulf of Mexico. The intersection of the toe of the front and the base of the Floridan aquifer probably ranges from a few miles to about 20 miles inland from the coastline, although this is merely speculation based on very limited data. Beneath much of the study area, the lower part of the Floridan aquifer contains either salt water or water in the zone of transition. Due to the drain effect of the streams on the aquifer, the position of both the saltwater front and the zone of transition most likely occur higher in the aquifer section in the vicinity of the principal streams.

2.0 SCOPE OF WORK

The work involved in the appraisal of the hydrologic characteristics of the waters in the study area is summarized into a series of tasks and presented herein. The tasks are listed under four main subjects: Climate, Surface Water Hydrology, Surface Water Hydraulics, and Ground Water Hydrology. A literature review will be conducted to assure that previous studies are utilized to their maximum in order to avoid duplicating work efforts.

The scope of the water resources investigation in the study area is outlined below.

2.1 Climate

- Inventory existing sources of climatological data and determine the location of stations, type of data, frequency of measurements, and period of record.

- Computerize all climatological data for the area and develop relationships between the various parameters for each station and between the same parameters at different stations.
- Prepare a summary of climatological data showing monthly maximums, minimums and averages, yearly distributions, and geographical variations of rainfall temperature, evaporation, evapotranspiration, etc.
- Develop a continuous record of basin average rainfall from point rainfall data for use in modeling the hydrology of each sub-basin. Also, prepare estimates of rainfall frequencies.

2.2 Surface Water Hydrology

- Compile all sources of streamflow and water quality data in the area of investigation. Design and implement a streamflow and water quality data collection network to provide adequate coverage of the study area.
- Computerize all streamflow and water quality data and develop relationships between the two.
- Separate base runoff from streamflow and determine spatial and temporal distributions of base flow volumes. Corroborate base flow volumes using volumes of ground water discharge into streams determined from digital ground water model.
- Determine the degree of interconnection between the surface and ground waters and evaluate the sensitivity of streamflow volumes to changes in the potentiometric surface of the groundwater aquifer.
- Use digital optimization model to extract unit hydrographs and abstraction rates from basin rainfall and concurrent runoff data.

Regionalize unit hydrographs and abstraction rates. Also, perform correlations between rainfall and runoff.

- Incorporate necessary data into digital surface water model and generate continuous streamflow records at selected sites. Estimate the accuracy of generated data by correlating runoff peaks and volumes of actual and generated data.
- Prepare a summary of generated streamflow data showing monthly distributions at selected sites and geographical variations in mean flows. Also, prepare a detailed breakdown of the water budget for each major subbasin. Perform frequency analysis of the data to determine flood-frequency, low flow-frequency, and flow-duration relationships at selected sites. Also, regionalize frequency data to the extent possile.
- Evaluate the effect of the Jim Woodruff Dam on the natural streamflow characteristics of the Apalachicola River.

2.3 Surface Water Hydraulics

- Inventory existing data on the geometry of the Apalachicola and Chipola rivers, gather additional cross-sectional data as necessary, and plot all cross sections. Also, perform a visual inspection of the study area and determine roughness coefficients to be used in digital hydraulic model.
- Input necessary data into step backwater model, calculate water surface elevations for a range of discharges, and calibrate the model using existing rating curves. Once calibrated, determine storage-outflow relationships for selected reaches to be used in the hydrologic model to route flows through the river. Also, extract rating curves for selected sites.

- Execute step backwater model using discharges generated by hydrologic model and calculate surface water profiles for floods of various frequencies. Also, compute floodways.
- Prepare plan-profile sheets showing flood profiles and develop floodplain maps for both rivers.
- Combine rating curves and flow-duration curves at selected sites to develop stage-duration curves.

2.4 Ground Water Hydrology

- Inventory existing municipal, irrigation, and private wells to determine depth, diameter, location, yield, and information about the aquifer penetrated by the well.
- Describe the surficial and subsurface geology, including the compilation and analysis of geologic and geophysical logs of water wells and oil, gas, and stratigraphic tests.
- Collect and analyze water-level data and prepare water-level maps of the principal aquifers, particularly in the vicinity of major rivers and streams.
- Define the hydrologic boundaries of the principal aquifers including recharge and discharge areas, particularly in the vicinity of streams which create a natural upward component of flow that brings more mineralized water from depth into the upper parts of the aquifer. Determine the effect of changing streamflow patterns on the groundwater regime.
- Perform quantitative studies to determine the hydrologic properties of the principal aquifers, the source, occurrence and movement of water in the aquifers, and the degree of hydraulic interconnection between them.

- Collect and tabulate the physical and chemical quality of water data for the principal aquifers in the basin, to determine any spatial and/or temporal changes in water quality.
- Embody data from previous five tasks into an appropriate numerical ground water model to determine the volumes of ground water inflow to the basin, recharge and discharge through a really distributed leakage, ground water outflow to streams, and ground water discharge to bays, estuaries, and the Gulf of Mexico. That is, determine each component of the ground water budget and the manner in which each is distributed across the basin.
- Perform calibration checks on the model results whenever possible.

3.0 STUDY PLAN

The investigation will span a three-year period and will cover the following work elements:

3.1 Compilation of Existing Data

A search will be made through existing literature, computer files, office files, and the files of other agencies to establish a data base of: 1) well information (including geophysical logs, water levels, geologic cores and cuttings, depth of casing and open borehole, etc.); 2) geologic information; 3) ground water quality information (sample site distribution, constituents analyzed, conditions of sampling, etc.); 4) climatological data (temperature, rainfall, evaporation, etc.); 5) streamflow data; 6) geometric data for the Apalachicola and Chipola rivers; and 7) surface water quality information.

3.2 Well Inventory and Ground Water Monitoring Network

A number of test borings drilled by the Florida Bureau of Geology have yielded valuable information on the subsurface lithology of the study area.

In addition, a preliminary well inventory of private, municipal, industrial, and monitor wells is already available for each of the counties in the basin. However, it is anticipated that a more complete inventory of wells will have to be made over the entire basin. Pertinent information will be obtained on each well, including the location, owner, well depth, casing depth, casing diameter, and water level.

Following completion of the well inventory, selected wells will be included in the project monitoring network to obtain baseline data on the hydrogeology of the area. The monitoring program will include measurement of both the water levels to determine the direction and rate of ground water movement and collection of ground water samples to define the lateral and, in part, vertical variations in water quality. The observation well network will be monitored bi-monthly throughout the duration of the investigation. When possible, borehole geophysical logs will be obtained and well performance tests will be conducted on the monitoring wells to obtain additional hydrogeologic information. The District has the capability of running a full range of geophysical logs and has all the necessary equipment for conducting well performance and aquifer tests.

3.3 Surface Water Monitoring Network

The few existing streamflow stations in the Apalachicola River Basin are all located on the Apalachicola and Chipola rivers. Additional stations will be established at the outflow of subbasins that are tributary directly to the Apalachicola and Chipola rivers in order to quantify the subbasins' contribution to the flow in the rivers. Continuous streamflow stations will be situated strategically to provide adequate coverage of watershed sizes and physiographic, geologic, and climatological regimes. Streamflow data from each of the basins is representative of their particular responses to rainfall events and will thus be used to develop rainfall-runoff relationships for the basins. The stations will operate continuously for one year in order to monitor stream flow throughout a full annual cycle.

3.4 Surface Water Quality Testing

In order to define the natural physical and chemical characteristics of streamflow, monthly water samples will be taken at each of the proposed gaging stations for one year. The purpose is to determine the presence and concentration of various constituents and any seasonal variations that may occur. Following is a list of constituents for which water samples will be analyzed:

Parameter List for Surface Water Samples

Temperature	Color
Specific Conductance	Nitrate
pH	Nitrite
Dissolved Oxygen	Phosphorus
Total Dissolved Solids	Total Suspended Solids
Hardness	Alkalinity
Iron, Dissolved	Bicarbonate
Turbidity	Acidity
Chloride	Sulfate

3.5 Ground Water Quality Testing

In order to determine the lateral and vertical variations in water quality, ground water samples will be obtained from each of the wells in the monitoring network. Initially, the samples will be analyzed for the parameters listed below. Following the initial water quality screening, this list will be modified and shortened for subsequent water quality testing depending upon the results of the initial screening.

Parameter List for Ground Water Samples

Alkalinity	Magnesium
Bicarbonate	Nitrate
Calcium	pH
Carbonate	Potassium
Chloride	Sodium
Specific Conductance	Total Dissolved Solids
Fluoride	Sulfate
Hardness	Temperature
Iron, Dissolved	

3.6 Aquifer Testing

The purpose of this part of the study is to determine the hydraulic characteristics of the Floridan aquifer. These characteristics will be used to assess aquifer drawdowns that would occur under pumping conditions and will also provide information needed for making an accurate assessment of the area's ground water regime.

Only two aquifer tests have been conducted within the basin; one at Marianna in Jackson County and one southwest of Wewahitchka in Gulf County. It is anticipated that two additional tests will be needed in Jackson County, two in Calhoun County, and one in Liberty County. Each test should consist of a production well for pumping the aquifer and three observation wells for recording drawdown. Multiple observation wells are required because of the multilayer nature of the aquifer and the number of parameters to be calculated from the tests. Every effort will be made to find existing wells suitable for testing purposes. In the event that suitable wells cannot be found in each of the five test areas, test wells will be drilled by a qualified drilling contractor under the supervision of a District geologist.

Each test will consist of pumping one of the wells at each test site at a constant rate of 200 gal/min or more using the District's submersible pump. During the tests, periodic measurements will be made in the pumping and observation wells. Water samples will be collected and analyzed for specific conductance, pH, temperature, and chloride. Duplicate samples will be obtained for more complete analysis should significant changes in specific conductance, pH, temperature or chloride indicate that saline water migrated to the well during the test.

The data obtained from the tests will serve as the basis for determining regional variations in the aquifer parameters. Additional data from well performance, specific capacity tests, and analysis of variations in the gradient of the potentiometric surfaces of the aquifers will also be used as guides in preparing regional maps of the aquifer characteristics.

3.7 Laboratory Testing

Subsurface cores of the principal aquifers and confining beds will be obtained from the Florida Bureau of Geology core files, and from any test wells drilled for the project, for laboratory testing. The purpose of this testing is to obtain additional information on the physical characteristics of the hydrogeologic units that is not obtainable from the aquifer tests.

Laboratory testing of selected unconsolidated sands and clays may include grain-size analysis, vertical permeability and porosity. Laboratory compressibility tests will be conducted on selected cores of limestone and dolomite.

3.8 Climatological Analysis

Climatological data will be computerized and summarized to provide information about monthly maximums, minimums, and averages, yearly distributions, and geographical variations of temperature, rainfall, and other climatological parameters for which there is sufficient data.

The technique of regression analysis will be applied to available climatological data in order to develop relationships that may be useful in extrapolating data between stations, filling in any missing data, and extending short records. Where evaporation data is available, it will be correlated to other available parameters such as temperature, radiation, relative humidity, etc. If any significant relationship exists, it will be used in an effort to develop evaporation estimates at other climatological sites for which this data is not available.

The main thrust of the climatological analysis will be concentrated on the rainfall data. Correlations will be developed between concurrent rainfall data at the various stations in the study area. This relationship will be used to fill in data gaps and extend short record stations using data from longer record stations. Once the rainfall data is adjusted, a frequency analysis will be performed to determine depth-frequency-duration relationships for storms and droughts at the various long-term stations. Also, point rainfall data at each station will be processed to develop long-term area-average rainfall records for each major subbasin. Basin average rainfall records will be utilized for developing rainfall-runoff relationships.

3.9 Ground Water Hydrologic Analysis

Following completion of the field work and the laboratory testing, a description of the hydrogeologic conditions in the basin which incorporates data obtained from this investigation and previous studies will be developed. This description will include potentiometric maps showing the level and direction of ground water movement in the basin, thickness maps of the various hydrogeologic units, and other tables and maps necessary to depict the hydrogeology of the area including the areal and vertical distribution of chemical constituents dissolved in the ground water. Emphasis will be placed on both mapping the depth, altitude, and thickness of the zone of freshwater and on identifying areas with poor quality native ground water. Also, a description of the physical properties of the aquifers and confining beds will be made based on an analysis of aquifer tests, well performance tests, and permeability tests.

Due to the complexity of analyzing the flow of ground water through a multi-layered ground water system, a three-dimensional or quasi three-dimensional ground water model will be developed for the basin. The variable lithology (sand, clay, and limestone) and complex recharge/discharge and boundary conditions require an analysis procedure beyond ordinary analytical methods. A computer model applicable to these conditions will predict the effects on aquifer water levels of seasonal variations in pumpage, stream levels, and climatic conditions. Head changes predicted by the model can be used to analyze directions of ground water movement, the recharge/discharge conditions, their distribution over the basin, likely movement of saline water, and potential impacts of increased ground water development.

It is anticipated that the following sets of model simulations will be made:

1) The first series of simulations will be made to provide information on the boundary conditions and geometry of the ground water regime;
2) The second series of simulations will be directed at obtaining a set of physical properties which coupled with the boundary conditions will provide an accurate duplication of the actual aquifer water levels;
3) Taking the results from the second group of simulation, the impact parameters will be varied within reasonable limits to determine the sensitivity of the water level distribution and ground water budget

to individual parameters. From this analysis the steady-state model will be calibrated;

4) Utilizing data on well distribution and pumping rates, the calibrated model will be used to analyze the drawdown distribution resulting from ground water pumping, aquifer discharge, recharge, leakage,etc., and their distribution over the basin.

3.10 Surface Water Hydrologic Analysis

Short-term continuous streamflow data collected at the outflow of selected basins will be utilized in conjunction with basin average rainfall to develop rainfall-runoff relationships. In turn, these relationships will be utilized to generate long-term runoff records from more readily available rainfall data. One approach will be to correlate runoff to concurrent basin rainfall. This method is very easy to apply but it usually lacks in accuracy.

In order to improve the reliability of streamflow estimates, a digital model will be utilized. The streamflow model will have the capability for continuous intrabasin flow simulation and for channel and reservoir routing. Direct runoff will be calculated from effective rainfall using the unit hydrograph method. The abstraction phase will be simulated using a soil-moisture accounting technique which is considered particularly applicable to the study area. Basin rainfall, streamflow, and evapotranspiration data will be utilized for calibrating the model. The calibration will produce a unit hydrograph and several abstraction constants for each basin. Once these components are determined for all the basins monitored, the abstraction constants and unit hydrograph parameters will be correlated to the physiographic characteristics of the basins in an effort to obtain regional relationships which will permit the development of unit hydrographs and abstraction constants for ungaged basins. Regionalized dimensionless unit hydrographs will also be developed for the study area. After all these parameters have been determined for each basin, this information, in conjunction with rainfall data, will be incorporated into the digital streamflow model to generate continuous long-term runoff data at each basin and at selected sites along the Apalachicola and Chipola rivers. The reliability of the generated data will then be determined from correlations between generated and actual data using both peak flows and runoff volumes.

The data generated at each site will be summarized to show monthly flow distributions (maximums, minimums, and averages) and geographical variations of mean flows. The data will also be analyzed to determine flood-frequency, low flow-frequency, and flow-duration relationships at each site. Frequency data will be processed in an effort to develop regional relationships. Also, base flow will be separated from direct runoff to determine base flow volumes and percentages of base flow to total runoff at each site. In addition, a detailed breakdown of each of the components in the water budget will be prepared for each major subbasin. This section will also include a detailed evaluation of the effect of the Jim Woodruff Dam on the temporal distribution of streamflow in the Apalachicola River. The analysis will include a comparison of flood-frequencies, low flow-frequencies, flow-durations, and stage-durations for the "with dam" and "without dam" conditions.

3.11 Surface Water Hydraulics of the Apalachicola and Chipola Rivers

The hydraulics of the Apalachicola and Chipola rivers will be studied in order to delineate the floodplains for the 100, 50, 25, 10, 5, and 2 year flood events, and to determine the rating characteristics of both rivers.

Cross-sectional data will be gathered to complement existing data on the geometry of both rivers. This data will be plotted so that it may be inspected visually. A field inspection of both rivers will be performed in order to determine roughness coefficients and other physiographic characteristics. All this data will be incorporated into a one-dimensional steady-state step backwater model. Existing rating curves will be used to calibrate the model. After calibration, the model will be executed using a range of discharges to determine storage-outflow relationships at selected reaches to use in hydrologic model for routing hydrographs through the river channel.

Flood flows of selected frequencies, generated by digital hydrologic model, will be used as input to the step backwater model to develop surface water profiles and floodways. Floodplains will be delineated and plan-profile sheets showing flood profiles will be prepared for both rivers. Also, rating curves and flow duration curves will be combined to develop stage duration curves at selected sites along the Apalachicola and Chipola rivers.

4.0 EXPECTED RESULTS

This study will provide the following information:

- Summary of the climatological characteristics of the study area: monthly, yearly, and geographical distributions of temperature, rainfall, evaporation, evapotranspiration, etc. Also, rainfall frequencies for storms and droughts will be provided.
- Breakdown of water budget at each subbasin: average annual evapotranspiration, rainfall, net ground water inter-basin transfer, ground water recharge, direct runoff, ground water discharge into streams (base flow), etc.

- Regional hydrological relationships: rainfall-runoff correlations and regional unit hydrographs and abstraction rates.
- Long-term continuous streamflow records generated at selected sites. Also, an estimate of the accuracy of the generated data will be provided.
- Summary of streamflow data at selected sites: spatial and temporal distrubutions of streamflow and flood-frequency, low flow-frequency, and flow-duration relationships.
- Development of regionalized flow-frequency relationships.
- Evaluation of the effects of the Jim Woodruff Dam on the hydrology of the Apalachicola: effects on flood-frequency, low flow-frequency, flow-duration, and stage-duration relationships.
- Summary of the chemical characteristics of streamflow: analysis of spatial and temporal distributions of the various constituents.
- Evaluation of the hydraulics of the Apalachicola and the Chipola rivers: surface water flood profiles, floodplain maps, floodways, and stage-duration relationships at selected sites along both rivers.
- Maps showing the elevation of the top, bottom, and thickness of the principal hydrogeologic units.
- Potentiometric (water levels) maps showing the level and direction of ground water movement in the basin.
- Description of the distribution of chemical constituents dissolved in the ground water, with emphasis placed on identifying areas with poor quality ground water.
- Variations in the hydraulic properties of the principal hydrogeologic units.

- The volume of ground water inflow to the basin from upgradient areas in Alabama and Georgia.
- The volume of ground water recharge from infiltration and leakage.
- The rate of ground water discharge into the principal streams in the basin as well as bays, estuaries, and the Gulf of Mexico.
- Recommendations regarding areas most favorable for ground water development and delineating the potential yield of the principal aquifers in the area. Conversely, identify those areas where the yield or quality of ground water preclude effective development.
- Identify those areas in which ground water is particularly important for maintaining surface water flow or quality.
- Determine what actions could be taken to protect or increase the availability of the surface and groundwater resources of the basin.

5.0 SUMMARY OF PROJECT COST

Professional Staff		
Senior Hydroengineer		$ 58,000
Senior Hydrogeologist		51,000
Associate Hydrologist		87,000
Associate Hydrogeologist		65,000
Assistant Hydrologist		29,000
Illustrator		15,000
	SUB-TOTAL	$305,000
Field Data Collection		
Personnel		$117,000
Equipment		47,000
Recorders		100,000
	SUB-TOTAL	$264,000
Other		
Chemical and Laboratory Analyses		$ 30,000
Computer		$ 30,000
	SUB-TOTAL	$ 60,000
	TOTAL	$629,000

NOTE: Personnel figures include salary, benefits, and overhead.