A HYDROLOGICAL, CHEMICAL, AND BIOLOGICAL ASSESSMENT OF BAYOU AUX CARPES, NEW ORLEANS, LOUISIANA

JANUARY 1985

by

Environmental Protection Agency

Environmental Services Division

Ecological Support Branch

Athens, Georgia 30613

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
SCIENCE AND ECOSYSTEM SUPPORT DIVISION
REGION 4

EPA

THOMAS R. CAVINDER, P.E.

980 COLLEGE STATION RD.
ATHENS, GA 30605-2720
CAVINDER.TOM@EPAMAIL.EPA.GOV

(706) 355-8719
FAX (706) 355-8726

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PROJECT PERSONNEL

*Delbert B. Hicks - Aquatic Biologist, Region IV, EPA
*Thomas R. Cavinder - Environmental Engineer, Region IV, EPA
Hoke S. Howard - Aquatic Biologist, Region IV, EPA
Donald W. Lawhorn - Engineering Technician, Region IV, EPA
Barbara Keeler - Biologist, Region VI, EPA

Project personnel wish to acknowledge the assistance of Sue Hawes, New Orleans District of U. S. Army Corps of Engineers, whose familiarity with the site was of great benefit.

*Authors

SUMMARY AND CONCLUSIONS

1. The Bayou Aux Carpes project area consists of approximately 3000 acres of wetlands comprised mainly of forested swamp and marshes. Although the project is bound on its perimeter by levees, the Southern Natural Gas Pipeline (SNGP) canal provides a direct hydrological connection between the site and the Barataria Intracoastal Waterway (ICW) and Barataria Bay. Navigation within the project area is provided by the SNGP canal, petroleum exploration canal, and bayou.

2. Wind appears to be the primary force effecting water levels in the project area and the Barataria Waterway. A diurnal tide range of 0.3 to 0.4 feet was recorded during the study. This range appears typical of the upper basin region of the Barataria Bay system. A rainfall event of 1.4 inches produced no discernible increase in water levels within the project waterways.

3. An average ground surface elevation of 1.24 feet National Geodetic Vertical Datum (NGVD) was determined from 22 survey observations within undisturbed swamp and marsh areas of the project site. During the study, the average depth of water inundating the marsh and swamp area was observed to be 0.3 feet. Surface elevation of the swamp and marsh water at most locations exceeded water level elevations in the Barataria Waterway and the SNGP canal. The relatively flat topography of the swamp/marsh areas and the broken berm line flanking a

majority of adjoining canals enhanced the capacity of the swamp to detain, store, and slowly release surface water to downstream systems.

4. The water storage capacity of the swamp was illustrated in the present study by the measured cyclic chloride concentration of swamp water discharged to the Barataria Waterway.

5. Dye tracer studies confirmed that water transport from Bayou Aux Carpes to the Barataria Waterway was rapid and directed towards Barataria Bay. Traced waters exiting the Bayou Aux Carpes site via the SNGP canal traveled downstream in the Barataria Waterway a distance of six miles in less than 24 hours.

6. During 1984, water levels in the Barataria Waterway exceeded the average swamp/marsh surface elevation of 1.24 feet NGVD at least 50 percent of the time. Water level elevations in the Barataria Waterway equaled or exceeded 1.24 feet NGVD between one and 26 days each month during 1984. The frequenc at which water levels equaled or exceeded 1.24 feet NGVD were most pronounced during the period from May through October 1984 and appeared as a response to southerly wind directions. During 1984, the average annual water level in the Barataria Waterway was 10 to 14 percent below the 20-year mean; hence, the potential for the flooding of the Bayou Aux Carpes swamp is greater during an average water year.

7. The Bayou Aux Carpes project area is a fresh to weakly brackish aquatic environment. Surface water salinity of the swamp drainage ranged from 0.5 to 0.8 ppt with a soil water salinity measuring 1.5 ppt in a marsh area. Salinity of the Barataria Waterway was 0.1 ppt. Based upon this salinity regime, the source of the salinity would ultimately be the Barataria Bay estuary. Winds from the south during the summer could drive saline water from the estuary into Bayou Aux Carpes area where it is stored and metered back into the estuary during the winter with the assistance of northerly winds.

8. Sampling of canal habitat yielded 14 taxa of macroinvertebrates and four species of fish. Three estuarine species were included in the catch -- blue crab, fiddler crab, and bay anchovy. From the marsh/swamp habitat, 27 taxa of macroinvertebrates including blue crab and 6 species of fish were collected. Many of the crustaceans collected are important fish food items such as juvenile crayfish, grass shrimp, and amphipods.

9. With the rise and fall of water levels in the Bayou Aux Carpes site, a hydrological mechanism was available for the exchange of nutrients and organic matter with the Barataria Waterway. Measurements of dye dispersion from the site and nutrient exchange at the mouth of SNGP canal confirmed an export mechanism. The Bayou Aux Carpes area was shown to be a source of organic carbon and nitrogen (detritus) to the Barataria Waterway which leads to Barataria Bay.

10. Water from the Barataria Waterway contains urban runoff from the New Orleans area which is frequently introduced into the Bayou Aux Carpes system where the surface water is temporarily detained. With detention, heavy metals are deposited in the sediments and inorganic nitrogen (NO_2-NO_3) is biologically processed into other compounds including plant and animal matter which are then subject to export to downstream areas.

11. Results of this study confirm the earlier findings of the 1976 EPA assessment of Bayou Aux Carpes. The 1976 study concluded that Bayou Aux Carpes is a valuable and viable parcel of swamp and marsh in terms of production and export of organic matter, habitat for important fish and shellfish, storage of surface water, processing of nutrients. Therefore, the project area remains a functioning component of the Barataria Bay system.

INTRODUCTION

The Regional Administrator of EPA, Region 6, has initiated a 404(c) action on a wetland tract in Jefferson Parish, Louisiana, south of New Orleans. The purpose of this action is to preclude the loss or alteration of wetlands through the filling and/or forced drainage of approximately 3000 acres of marsh and forested swamp in the Bayou Aux Carpes area. The filling and forced drainage of such areas impairs and destroys several natural functions presently providing public benefits. With this particular project, loss of aquatic habitat for the production of fish, shellfish, fish food items, primary production, and water storage are some of the primary issues.

The Administrator for Region 6 requested personnel of the Environmental Services Division of Region 4 to assist Region 6 members in evaluating these issues in early 1976. At that time, a team of aquatic biologists and an environmental engineer assessed pertinent documents and conducted an inspection of the project area. This inspection produced findings indicating the value of the Bayou Aux Carpes swamp in terms of ecological functions (Appendix A). In 1984, the Environmental Services Division of Region 4 was requested to conduct a technical study to gather additional site specific facts regarding the chemical, biological, and physical character of the Bayou Aux Carpes swamp. The site study, initiated in mid-January 1985, had the following objectives:

- Determine the kinds of fish, shellfish, and benthic macroinvertebrates associated with the marshes, forested swamp areas and adjoining canals.

- Determine the water level dynamics associated with the Bayou Aux Carpes swamp, adjoining canals, and the Baratari Waterway (ICW) leading to Barataria Bay.

- Evaluate the potential nutrient and detrital exchange between the Bayou Aux Carpes swamp, associated canals, and Barataria Bay.

- Characterize the water and sediment quality associated with the Bayou Aux Carpes swamp and adjoining canals.

PROJECT AREA AND STUDY SITE

The project area of the Bayou Aux Carpes swamp measures approximately 3000 acres and is located south of New Orleans, Louisiana and is part of the Barataria Bay Basin (Figure 1). The area is irregularly shaped and is bounded to the east by the Barataria Waterway (ICW) and to the west by the Jean Lafitte National Park and the "V" levee-canal (Figure 2). The National Park is hydrologically connected to the Bayou Aux Carpes system via culverts under the Lafitte-Larose Highway (Day, 1984). Navigation to the interior of the study area is possible by way of the Southern Natural Gas Pipeline (SNGP) canal which connects with Bayou Aux Carpes and other canals created for petroleum exploration efforts.

Based upon inspection of the site by EPA personnel in 1976 and current aerial photography of the area, the Bayou Aux Carpes project area can be described as a diverse wetland composed of forest and shrub swamp, marshes, ponds, and open waterways. Bald cypress, tupelo-gum, green ash, and red maple are common upper story vegetation of the swamp while softstem bullrush, bulltongue, cattail, spikerush, and alligator-weed are typical of the marsh regions. Water hyacinth and duckweed characterize the floating vegetation of the Bayou and dredged canals.

Earlier work by Chabreck (1972) indicates that the Bayou Aux Carpes area to be part of the Barataria Basin hydrologic unit and is subject to slight tidal effects. Based upon his description of

vegetation and salinity for both surface and soil water, the Bayou Aux Carpes area appears primarily as a freshwater to intermediately brackish aquatic system.

Because of restricted accessibility, the present study focused on the areas of the Bayou Aux Carpes swamp associated with the SNGP canal and exploration canals. Location of stations for hydrographical, water quality and biological sampling are shown in Figures 3, 4, and 5, with station descriptions provided in Table 1.

METHODS AND RESULTS

Quality Assurance

Methodology involved in data gathering for this study followed EPA, Environmental Services Division Standard Operating Procedures (SOP) protocol.

Hydrographic Assessment

The hydrographic assessment included the determination of water level dynamics, water motion, and ground surface elevation.

The study of water level dynamics involved the placement of Stevens recorders within the project boundaries, in the east borrow ditch of the Lafitte-Larose Highway, at the mouth of the SNGP canal and on the ICW at the Lafitte-Larose Highway bridge (Figure 3). Additionally, water level records from gauging stations operated by the U. S. Army Corps of Engineers (COE) at the Algiers Lock, Barataria Waterway at Lafitte, and Barataria Waterway at Barataria

(Figure 1) were obtained for the current EPA period of study and for approximately the previous 20 years.

For the period of study, a recording rain gauge was installed in the Bayou (Figure 3). Wind direction and speed data for the study period were obtained from the New Orleans Moisant International Airport. Ground surface elevations of the marsh and swamp within the Bayou Aux Carpes area were determined by differential leveling between the water surfaces in the waterways and the marsh and swamp floor.

Water Level Responses

Water levels recorded in the Bayou Aux Carpes study site, and at the Algiers Lock (upstream of the site) and at Barataria (downstream of the site) were compared for the study period of 1/16-20/85 (Figure 6). By inspection, water levels at the three locations appeared to closely track each other. A small diurnal tide range of approximately 0.3 foot was evident in each record. Daily water level recordings for a one year period (January - December, 1984) were examined for the Barataria and Algiers gauging stations by comparing simultaneous 0800 hours observations (Figure 7. Mean water levels at the Algiers and Barataria stations were 1.28 and 1.24 feet NGVD (National Geodetic Vertical Datum), respectively. The similarity in water level dynamics was also evident in records spanning 17 to 22 years for the COE gauging stations (Table 2). From Table 2, a mean tidal range of 0.25 to 0.35 foot NGVD was derived from the difference between mean low and mean high

water levels calculated for the gauging records. The tidal range of 0.3 foot observed in the EPA study appeared typical of the long term records. Since tidal ranges are relatively small (about 0.3 foot), the effects of wind and rainfall on water level dynamics were also considered. Wind effects are particularly significant in shallow, open water bodies such as those associated with the Mississippi River estuarine system.

The effects of wind on water levels in the Barataria waterway and Bayou Aux Carpes were clearly evident during the study. In the afternoon of 1/16/85 a marked rise in water level occurred with a corresponding decrease following on 1/20/85 (Figure 6). Wind speed and direction data provided by the Moisant Internationl Airport, New Orleans, depicted a relatively strong wind from the south with gusts to 24 knots on the afternoon of 1/16/85 and a strong wind from the north with gusts in excess of 30 knots on 1/20/85 (Figure 8). From these data, it is apparent that winds from the south effected a rise in water levels whereas winds from the north lead to a decrease in water levels.

During this same period, a rainfall gauge installed in Bayou Aux Carpes recorded a rainfall of 1.4 inches between the hours of 2200 on 1/16/85 and 0500 on 1/17/85 (Figure 9). The effects of rainfall on water levels in the Barataria Waterway and Bayou Aux Carpes were not apparent in the records shown in Figure 6. The record probably reflects the masking effects of wind. However, the rainfall effected a sharp rise in the water level recorded at

the Lafitte-Larose highway borrow ditch (Figure 10, see Figure 3 for recorder location). Since the borrow ditch receives roadside runoff and drainage from the Jean Lafitte National Historical Park, the water level increase was probably accentuated by storm runoff, i.e. water level rise was 0.6 feet following a 1.4 inch rainfall event. Drainage maps of the Lafitte-Larose Hignway (Louisiana Department of Transportation) show several culverts under the highway connecting surface drainage of the Park to the Bayou Aux Carpes system.

Following the rain event, the water level in the borrow ditch slowly but steadily decreased. This pattern was unlike water level records for either the swamp or Barataria Waterway. For example, a water level recorder stationed in the swamp approximately 0.25 mile east of the recorder positioned in the borrow ditch (Figure 3) provided a water level record similar to the ICW records (Figure 11). The contrast between the swamp and borrow ditch hydrographs suggests, at least during the EPA study period, that water levels in the ditch were not responding simultaneously to hydrographic conditions in the Barataria Waterway.

Ground Surface Elevations

As previously reported, water level records for the ICW and Bayou Aux Carpes were nearly identical (Figures 6 and 7); hence, the recorded water levels at Algiers Lock and the Barataria gauges were used to adjust water levels in the Bayou Aux Carpes to NGVD. Ground surface elevations of the marsh/swamp within Bayou Aux

Carpes System were determined by differential leveling between the water surfaces in the canals and the marsh/swamp floor. Locations of the seven ground surface transects are shown on Figure 12. A total of 22 elevations were determined within the undisturbed marsh/swamp floor. Elevations ranged from 0.44 to 1.65 feet with a mean of 1.24 feet NGVD (Table 3).

The frequency of occurrence of water level elevations in the Barataria Waterway which can potentially flood into the marsh and swamp areas were determined for 1984. Water levels recorded each day at 0800 hours were plotted for the Algiers and Barataria water level gauges (Figure 13). As shown, the mean elevation of the marsh and swamp floor (1.24 ft. NGVD) was exceeded at least 50 percent of the time by water levels in the Barataria Waterway. Marsh-swamp elevations of 0.44 and 1.65 feet NGVD were exceeded 95 and 20 percent of the time by water levels in the waterway, respectively. Numerous breaks in the levees adjacent to the swamp and marshes including the unfilled areas at the head of the canals allow surface water to flow between the wetlands and adjacent waterways. Remnants of the original Bayou Aux Carpes waterway (Figure 2) was unleveed, thus allowing surface water to sheet flow to the adjoining wetlands. During the study period, depth of surface waters in the swamp averaged 0.3 foot (Table 3).

Water Circulation (Dye Tracer)

A dye tracer (Rhodamine WT) was released at 1200 hours on 1/17/85 in Bayou Aux Carpes at the rain gauge location (Figure 3).

Dye dispersion from the point of release was monitored by automatic samplers positioned near the mouth of the SNGP canal (Figure 3). The samplers were operated for a period of 36 hours with sample collections programmed at one-hour intervals. Samples were split with one portion measured with a fluorometer for dye concentrations and the other returned to the Athens Laboratory (EPA) for chloride analysis. In addition, a boat mounted flow-through fluorometer was used to monitor the travel of traced water within the project's navigable watercourses and in the Barataria Waterway.

Within 3.5 hours following release, the tracer was found at Station 10 near the mouth of the SNGP canal (Figure 14). The traced waters exited from the canal and into the Barataria Waterway on successive ebb tides. Dye concentrations increased through the ebbing phase of the tide. During the flood tide, water from the Barataria Waterway flooded into the SNGP canal resulting in a decrease in dye concentrations.

The traced waters from Bayou Aux Carpes moved rapidly downstream through the SNGP Canal and then into the Barataria Waterway (Figure 15). The dye path from the point of release tracked primarily to the SNGP Canal and then south to the Barataria Waterway and then towards Barataria Bay. Virtually no dye moved in a northerly direction along the SNGP canal nor did it disperse upstream of Station 6, the long east-west drill hole canal. The leading edge of the dye cloud entered the Barataria Waterway within 4.5 hours of

its release. After 21.5 hours, the traced waters had traveled downstream in the ICW to the community of Barataria (Figure 1), a distance of 31,000 feet or nearly 6 miles (Figure 15).

Chloride concentrations responded to tidal phase much in the manner depicted for the dye (Figure 14). At Station 10 near the mouth of the SNGP canal, chloride concentrations increased on the ebbing tide with a decrease occurring on the flooding phase. Swamp drainage appeared as the source of chlorides during the study period. Surface water from the Barataria Waterway (Station 11) contained the lowest chloride concentration of 49 mg/L. Chloride concentrations for other locations in the project area ranged from 250 to 430 mg/L (Table 4). Soil water collected from a screened well point driven to a depth of two feet in the marsh floor (Station 10a) yielded a chloride concentration of 800 mg/L or about 1.5 ppt salinity. Surface salinity of the swamp drainage ranged from about 0.5 to 0.8 ppt (Table 4). As discussed later, the ultimate source of the chlorides in the swamp drainage is presumably the estuary.

Water Chemistry (Nutrients)

The nutrient exchange regime of surface water exchanging between the Bayou Aux Carpes swamp and Barataria Waterway was sampled over a 36-hour period. Automatic samplers were positioned at the mouth of the SNGP Canal (Station 10) and programmed to collect samples at hourly intervals. In addition, surface water grab samples were collected from the Barataria Waterway and at other sites in the swamp and adjoining canals (Figure 4). All samples were preserved and returned to the Athens Laboratory (EPA) for analyses.

Organic carbon and organic nitrogen concentrations at the mouth of the SNGP Canal responded to tidal effects as described for the dye and chlorides observations. Concentrations increased on the ebbing tide and then decreased during the flooding phase (Figure 16). This trend suggests that the Bayou Aux Carpes system is a source of organic matter to the Barataria Waterway. The NO_2-NO_3 concentration regime at the mouth of the SNGP canal was reversed in terms of the tidal effects. Concentrations increased during the flooding phase and decreased when ebbing tides occurred (Figure 17). The observed relationship between tidal, organic nutrients and chloride concentrations indicates that with decreasing water levels in the ICW, flow at the mouth of SNGL Canal is driven primarily by swamp drainage. In contrast, the rising water in the Barataria Waterway provides the energy to disperse water from the Barataria Waterway to the canal.

Nutrient concentrations of surface water collected from the swamp, canals, and Barataria Waterway are shown in Table 5. Concentrations for ammonia (NH_3) and nitrite-nitrate (NO_2-NO_3) were greater in the Barataria Waterway than in the swamp or associated canals. Concentrations of NO_2-NO_3 were nearly 28 times greater in the Barataria Waterway compared to the marsh-swamp drainage (Figure 18). In contrast, higher levels of organic carbon (TOC) and organic nitrogen (Org. N) were associated with swamp drainage (Figure 18). Marsh-swamp drainage featured at least a two-fold increase in TOC and organic nitrogen concentrations compared to Barataria Waterway (ICW).

Sediments

Particle size and organic content of sediments are factors affecting the kinds and numbers of benthic macroinvertebrates dwelling in or upon the bottom. Bottom sediments also serve as a sink for many kinds of heavy metals and man-made compounds such as pesticides. To characterize these physical and chemical aspects, sediments were obtained from the bottom of selected stations in forested swamp, marshes, canals, and the Barataria Waterway. Samples analyzed for particle size, organic content, and heavy metals were collected as 10 cm bottom cores.

Results for priority pollutant pesticides and PCB analyses of sediment samples indicate all designated compounds examined were below the detection limits for the chemical procedure employed (Table 6).

Particle size composition of core samples from the Barataria Waterway and canals was predominately silt particles (0.0039 to 0.0625 mm in Figure 19). Total organic content of the core samples ranged from 12 to 20 percent, by dry weight. The sediment profiles for Station 2 (a forested swamp area) and Station 10a (a marsh area) were similar to those characterizing the canals and Barataria Waterway (Figure 20). Stations 7 and 8 (a marsh and swamp site, respectively) were in sharp contrast to other sites. Sediments were primarily comprised of coarser materials (identified as decomposing vegetation), 2 to 32 mm, with a total organic content of 64 to 67

percent (Figure 21). Sediments featuring an organic content exceeding 50 percent by dry weight are generally typical of peat substrate (Chabreck, 1972). Chabreck further indicates that sediments with less than 15 percent organic content tend to represent mainly mineral soils comprised primarily of silt, clay, and sand. Based upon these distinctions, the sediments (top 10 cm) associated with the Barataria Waterway and canals appear alluvial in origin. In this case the silt and clay particles originated elsewhere and were trapped by the stilling effects of the canals and wetlands.

The contrast in sediment profiles for the two swamp or marsh areas sampled appeared related to their hydrological connection to the canals. As indicated by the general station description (Table .), Stations 2 and 10a were in the direct pathway of surface water exchanging between the canals and the wetlands via breaks in the berm line. Stations 7 and 8 were not proximate to breaks in the canal berm. The surface water exchange between the canals and wetlands was more characteristic of sheet flow. By the time the surface water originating from the canals reached the more interior ites, its silt load was probably relieved via the deposition process.

The ability of canals and the swamp/marsh habitat to trap inely divided particles was also evident in the heavy metals concentrations determined for the sediments (Figure 28). The ICW ppeared to retain greater concentrations of zinc compared to the wamp and marsh areas. Copper, lead, and iron, concentrations

appear uniformly distributed between the swamp, marsh, canal, and Barataria Waterway (ICW). This distribution pattern indicates the capacity of the marsh/swamp system to trap these heavy metals typically associated with urban runoff.

Biological

Qualitative sampling for benthic macroinvertebrates was conducted in Bayou Aux Carpes marsh and forested swamp environs (Stations 2, 7, 8 and 10a). Various methods, such as standard biological dip nets and drift nets (.5 mm mesh) and hand sorting from available substrates including aquatic plants, stumps, rocks and debris were employed.

To sample nektonic animals in the canals, a channel net was stretched across the canal segment leading from the SNGP canal to Station 4 and anchored to stakes deeply driven into the adjoining banks. The net was constructed of 1 mm nylon mesh with a 5/16-inch chain secured to the foot line of the net. It measured 8 x 50 feet with an 8 x 8 x 8 feet center bag. The canal channel measured approximately 60 to 70 feet in width, hence, the net when in place only partially blocked the canal. The net was fished for approximately four hours on an ebbing tide. Specimens collected from the net were stored in widemouth plastic containers with 90 percent ethanol as a preservative and returned to the Athens Laboratory for identification to the lowest possible taxa.

Swamp and Marsh Biota

Sampling of benthic macroinvertebrates indicated a relatively low level of species richness associated with the swamp and marsh habitat (Table 7). Crustaceans and odonates appeared as the predominate groups of taxa observed in the samples. Nine and 14 taxa of macroinvertebrates were found associated with the swamp areas sampled at Stations 2 and 7, respectively. Five of these taxa were common to both stations which included two kinds of amphipods, aquatic snails, and juvenile crayfish. Aside from the difference in number of taxa (9 versus 14), hydrology and substrate quality were also different.

Station 7, when compared to Station 2, was more of an interior site in the swamp where the water was deeper (3 to 4 inches) and its movement characteristic of sheet flow. Station 2 was characterized by a more vigorous flow regime because of its closer proximity to a primary surface water connection between the canal and swamp. The sediment of the interior swamp site (Station 7) was characterized as peat substrate compared to a more finely divided substrate of silt and sand at Station 2.

Samples from two marsh sites (Stations 8 and 10a) each yielded nine taxa of benthic macroinvertebrates (Table 7). As in the case of the two swamp stations sampled, the quality of substrate and surface water movement were also distinctly different. Three species of amphipods and one species of snail were common to both marsh areas. Grass shrimp, P. kadiakensis, and blue crab, C. sapidies,

were found associated with the small drainage cuts extending from the SNGP canal into the marsh at Station 10a. The presence of blue crabs, a juvenile specimen, reflects the hydrological and biological interaction between the project area and the estuary.

In addition to the benthic macroinvertebrates collected in the swamp and marsh habitat, several species of fish were found associated with these areas (Table 8). Livebearers, such as mosquitofish, least killifish, and sailfin molly, were observed. Mosquitofish appeared as the most abundant species. In addition, spotted sunfish, banded pygmy sunfish, and one species of killifish were collected. Except possibly for the banded topminnow, the fish collected are considered euryhaline species with mosquitofish being common to tidal swamps and marshes (Odum, 1984).

Canal Biota

Sampling of canal biota was limited to a single blocknet set. Because the net only partially blocked the canal channel, the data collected by this means must be viewed in qualitative terms.

The blocknet catch yielded 14 taxa of macroinvertebrates and 4 taxa of fish (Tables 7 and 8). Eight invertebrate taxa were common to the macroinvertebrate communities associated with the marsh and swamp environment. In addition to the blue crab, a second estuarine crab (*Uca* sp.) was captured by the channel net.

The fish species were represented by juvenile specimens and included bay anchovey, gizzard snad, sunfish, and least killifish

(Table 8). The bay anchovy is an estuarine species which generally migrates to tidal freshwater in the early spring to feed and then returns to the estuary to spawn in late spring. Larvae of this species move upstream to weakly brackish and freshwater tidal nursery areas in the summer (Odum, 1984).

DISCUSSION

Presently, levees span virtually the entire perimeter of the Bayou Aux Carpes project area. The Southern Natural Gas Pipeline (SNGP) canal provides the primary hydrological connection between the swamp and the Barataria Waterway (ICW) and ultimately Barataria Bay. With construction and maintenance of the SNGP canal and associated drill hole canals, dredged materials were spoiled along the canal banks thus forming berms which in some areas measured several feet high. Numerous breaks in the berm line, especially at the end of the canals, provide a pathway for surface water to exchange between the swamp marshes and canals. Determining the potential for exchange of water between these systems was one of the primary objectives of the hydrological assessment.

The mean water level for the Barataria Waterway in the vicinity of the project area was 1.38 to 1.45 feet NGVD. Ground surface elevations of swamp and marsh areas surveyed averaged 1.24 feet NGVD. Accordingly, the potential for the flooding of the Bayou Aux Carpes by rising water in the Barataria Waterway appears to occur at least 50 percent of the time (Figure 13). Furthermore, the frequency of water levels at or above 1.24 feet NGVD in the Barataria Waterway appeared strongly seasonal (Figure 23).

The 1984 water level record for the Barataria Waterway (ICW) reveals three aspects of the flooding regime. First, the 1984 record depicts the average monthly water level as generally peaking during the period of May through October. Since the average ground elevation of the Bayou Aux Carpes swamp was 1.24 feet NGVD, water stages attaining or exceeding this elevation could initiate flooding of the swamp. It is only coincidental that the annual monthly water levels in 1984 averaged 1.24 feet, which is identical to the average surface elevation of the swamp in the study area transects. Secondly, the 1984 annual water level average of 1.24 feet NGVD in the Barataria Waterway was about 0.14 to 0.21 of a foot less than the 20-year average reported in Table 2, i.e., about 10 to 14 percent less in amplitude than the 20-year average. Finally, the lower graph in Figure 23 shows that flooding of the swamp could have occurred in each month of the 1984 water year and possibly even daily as suggested in the case of October during an average or above average water year.

The primary factor controlling the water level appeared to be wind. Short term effects of wind were clearly apparent during this study. Winds from the south increased water levels; whereas, winds from the north effected a measured decrease in water levels (Figures 6 and 8).

Historically, winds from the south prevail during the summer while winds from the north dominate during the winter (Figure 24). Rain events do not appear to effect water levels as readily as the wind (Figure 25). As indicated by Day (1984), winds from the south

provide the necessary energy to drive estuarine waters into the Bayou Aux Carpes region of the Barataria Basin, which would account for the weakly brackish character of the waters draining from the swamp during this study. The capacity of the Bayou Aux Carpes swamp to detain surface waters was evident in the chloride data reported for this study. Chloride concentrations increased with ebb flows from the swamp and decreased when the direction of flow reversed and originated from the Barataria Waterway (Figure 14).

The relatively flat topography of the swamp, in combination with the broken berm line of the canals, undoubtedly served as factors enhancing the capacity of the swamp to detain surface waters and effect its slow release to downstream systems. The average depth of water over the swamp and marsh floor was 0.3 foot (Table 3). This value when added to the average ground surface elevation of the swamp resulted in an average water level elevation of 1.54 feet NGVD. This elevation was above the maximum water level height recorded in the ICW and study canals (Figure 6). The water stored in the forested swamp would seek breaks in the berm line where it's gradually discharged into the canals and ICW. Such a hydraulic gradient would explain the observed net movement of organic carbon, organic nitrogen, chlorides, and dye to the Barataria Waterway.

The seasonal flooding and storage regime of the Bayou Aux Carpes area provides numerous and unique benefits in terms of nutrient processing, primary and secondary production, flood control, salinity control, and as a nursery habitat for freshwater and estuarine fish and shellfish.

The hydrological connection between Bayou Aux Carpes and the Barataria Waterway and the capacity of the Bayou system to detain surface water combined to buffer effects of urban runoff from the New Orleans area on downstream regions like Barataria Bay. Results of the sediment analyses demonstrate the function of Bayou Aux Carpes as a mechanism for trapping finely divided materials thus interrupting their transport to the estuary. Heavy metals, whether absorbed to silt, clays, organic matter, or precipitated as metallic sulfides, are deposited in the sediments.

By detaining the surface water particularly associated with summer flooding, nutrient cycling in the swamp is enhanced. Detention increases the contact time of overflow water with the forest floor of the swamp which is the principal site of denitrification processes and nutrient uptake by rooted vegetation (Brinson, 1981). The timing of the annual flooding regime coincides with the primary growth period of the swamp plant community in southern Louisiana freshwater swamps (Conner and Day, 1976).

The denitrification process (NO_2-NO_3 to N_2) is an efficient, rapid, and important function in forested swamps as well as tidal marshes (Brinson, 1981; EPA, 1984; and Brinson, et al., 1984). Denitrification is an anaerobic process involving specialized bacteria which utilize the nitrogen bound oxygen (NO_3) as an energy source. In this manner, the NO_3 is reduced to nitrogen gas (N_2) as the bacteria assimilate organic matter. Thus, the decomposition of organic matter proceeds in the absence of dissolved oxygen and the

nitrite-nitrate load of the overflow water is diminished. At virtually all marsh and swamp stations sampled, disturbed sediments yielded the odor of hydrogen sulfide, which is characteristic of a reducing environment.

The biological cycling of inorganic nitrogen (NO_2-NO_3) was evident in the Bayou Aux Carpes swamp. The NO_2-NO_3 concentration gradient decreased from sampling points in the Barataria Waterway to stations in the forested swamp and marshes (Figure 18). In this context, the Barataria Waterway emerges as a primary source of NO_2-NO_3 and the Bayou Aux Carpes swamp a principal area for its assimilation into other nitrogen forms such as animal or plant protein. Accordingly, the elevated concentrations of organic nitrogen in the swamp drainages as compared to those in the Barataria Waterway is not surprising (Figure 18).

With the rise and fall of water levels in the swamp, a hydrological mechanism is established for the exchange of nutrients between the swamp and Barataria Waterway. The export of these materials can be frequent (Figure 23). The lower graph of Figure 29 indicates the number of days each month in 1984 when the water level in the ICW equaled or exceeded the average ground elevation of the swamp and marsh. For each day that the water level in the ICW falls below 1.24 feet NGVD, a net drainage of surface water from the swamp to the Barataria Waterway is possible as demonstrated in this study. Results of the dye dispersion measurements confirmed the net movement of surface waters was from the Bayou Aux Carpes

swamp to the Barataria Waterway and downstream towards the estuary. Although the exchange of organic matter between the swamp and Barataria Waterway was not quantified in terms of loadings (tons/year), net export of organic nitrogen and total organic carbon (TOC) from the Bayou to the Barataria Waterway was evident. Concentration of dye, chlorides, organic nitrogen, and TOC increased at the mouth of the SNGP canal during the ebb phase of the tide (Figures 14, 16, and 17). The concentration gradient depicted in Figure 18 for TOC and organic nitrogen indicates the swamp and marshes as the principal source of organic matter in the export regime.

In terms of annual export of organic carbon and nitrogen from a forest swamp such as Bayou Aux Carpes, the work of Day, et al. (1977) provides a point of reference for judging the potential of the export regime in terms of mass loading from forested wetlands. These investigators conducted a 14-month study of net production and export of nutrients from a swamp forest in the upper drainage basin of the Barataria Bay estuary. Annually, the 770 km^2 swamp exported 8016, 1047, and 154 metric tons of organic carbon, nitrogen, and phosphorus, respectively, to the estuary. The hydrological regime of the swamp studied by Day, et al. (1977) was somewhat different from the Bayou Aux Carpes area. Both were subject to seasonal flooding; however, rainfall was the principal source of surface drainage in the swamp studied by Day, et al. (1977). For the Bayou Aux Carpes area, surface water drainage was primarily controlled by wind; rain and tide were secondary influences.

A source of organic matter (detritus) for export from the swamp would be its forest and marsh community of plants. Since the Bayou Aux Carpes site is a relatively typical cypress-tupelo swamp in terms of vegetational characteristics and seasonal flooding, its annual primary production would probably be similar to the swamp studied by Conner and Day (1976). These authors reported total primary production for the seasonally flooded Louisiana swamp at 1,574 g/m^2/yr at a bottomland hardwood site and 1,140 g/m^2/yr at a cypress-tupelo site. The net primary production in forested swamps is generally greater in seasonally flooded systems (Brown, et al., 1979).

The present study demonstrated a hydrological connection between the Bayou Aux Carpes swamp and the Barataria estuary. The pathway between the estuary and swamp appears operational each month of the year at least in the 1984 water year; thus, providing a route for the exchange of nutrients and aquatic life between the swamp and estuary.

Day (1984) provides insight to the seasonal migratory patterns of fish and shellfish in the Barataria Bay and its associated freshwater basins. He identifies the more traditionally reported migratory patterns of estuarine species using the freshwater regions of an estuarine basin as nursery habitat. He documents the presence of bay anchovy, sheepshead minnow, spot, striped mullet, tidewater silverside, and lady fish in the vicinity of the Jean Lafitte National Historical Park which is part of the Bayou Aux Carpes swamp. Hawes (1984) expanded this list of estuarine species for

Bayou Aux Carpes to include both juvenile and adult blue crab. The present study confirmed continual use of the Bayou Aux Carpes by estuarine species (Tables 7 and 8). Juvenile forms of estuarine crabs and bay anchovies were found in the mid-January sampling.

From Day (1984), Hawes (1984), and the present study, at least 15 species of freshwater fishes are reported to be associated with the Bayou Aux Carpes drainage area. Many of these species such as channel and blue catfish, sunfish, and bass, are recognized as important to both commercial and sport fisheries. Day (1984) further elaborated on the potential for a number of freshwater species to seasonally expand their territory in the winter. As he explains and documents, adult and juvenile forms of some freshwater species move from the traditional freshwater regions towards the Gulf in the fall and early winter where they replace marine species immigrating from the estuary to the Gulf. As summer approaches, salinity and temperature increase and the freshwater forms retreat back to the upper freshwater zones of the basin. This cycle would appear particularly significant in terms of assigning a fishery resource value to the Bayou Aux Carpes area. The assessment work of Day (1984) clearly indicates that the potential benefits of fishery production can extend well beyond the geographical boundaries used to describe Bayou Aux Carpes.

For the Bayou Aux Carpes project site, the benthic macroinvertebrate data indicated a relatively restricted community in terms of species richness (Table 7). For the two marsh stations and one

site in the forested swamp, only nine taxa were observed. However, many of the taxa found can tolerate a wide range of environmental conditions including low concentrations of dissolved oxygen and salinity. For several reasons, the relatively low diversity of the community is not surprising. As explained by Odum (1984), the relatively simple structure of the benthic macroinvertebrate community in a tidal freshwater system can be linked to a lack of diverse habitat. Non-tidal systems tend to yield a substantially more diverse community of benthic macroinvertebrates than a tidally effected system. The chloride data gathered in this study coupled with the findings of Chabreck (1972), indicate that the Bayou Aux Carpes site is seasonally brackish which would favor the survival of euryhaline species and impair the success of pure freshwater forms. Several of the taxa found in the Bayou Aux Carpes system can tolerate both fresh and saline environments. Although the benthic community may be represented by relatively few taxa (a total of 27), many of the taxa are important processors of organic matter and fish food items including crayfish, grass shrimp, and other crustaceans such as amphipods (Hyalella azteca and Gammarus sp.).

In the findings of the 1976 assessment by EPA personnel, Barataria Bay was described as the singly most productive estuarin area along the Louisiana coast (Appendix A). Also indicated was the fact that Louisiana estuaries owe their high level of producti ity to the extensive system of marshes and swamps of the upper basins. These upper basin regions of swamps and marshes provide

the drainage necessary to maintain the broad, stable brackish zones in the estuary. The Bayou Aux Carpes system is one of these upper basin swamps draining to Barataria Bay.

The results of this study corroborate the findings of the EPA assessment in 1976 and the later assessment by Day (1984). Despite the present alterations of the swamp, mainly the presence of levees and canals, the Bayou Aux Carpes area provides local and regional benefits in terms of water storage and release, habitat for the production and growth of freshwater and estuarine fish and shellfish, nutrient processing, and a source of organic matter for export to Barataria Bay.

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Table 1. Station Descriptions, Bayou Aux Carpes Study, Louisiana, January 1985

Barataria Waterway (ICW):

- Station 11 -- located approximately 100 yards from north shore in Barataria Waterway; soft, silty substrate; depth of 12-14 feet.

Canals:

- Station 3 -- mid-channel, located approximately 50 yards from head of short drill canal; silty substrate; bottom depth of 6-7 feet; hyacinths (Eichornia crassipes) at head of canal; berm vegetation consisted of red maple (Acer rubrum), mainly sweetgum (Liquidambar styraciflua) and wax myrtle (Myrica cerifera).

- Station 4 -- mid-channel, about 200 yards north of original Bayou Aux Carpes waterway; silty substrate; bottom depth of 6 feet; macrophytes along shore consists of alligatorweed (Alternanthera philoxeroides), bulltongue (Sagittaria falcata), pennywort (Hydrocotyl).

- Station 9 -- mid-channel, northernmost station in SNGP canal; approximately mid-point of canal length; soft, silty substrate; bottom depth of 5-6 feet; berm vegetation consisted of mainly red maple (Acer rubrum), willow (Salix), sweetgum (Liquidambar styraciflua), wax myrtle (Myrica cerifera), elderberry (Sambucus).

- Station 10 -- mid-channel, approximately 50 yards upstream from mouth of SNGP canal; soft, silty substrate; bottom depth of 4-5 feet; berm vegetation consisted of mainly willow (Salix), elderberry (Sambucus), water oak (Quercus nigra).

Marsh:

- Station 8 -- Marsh area, open canopied, located off west side of SNGP canal ($\tilde{=}$ 1/4 mile from canal mouth); substrate appeared to be rich in organic matter (decayed and partially decomposed vegetative material); depth of water overlying substrate was generally less than one inch; most macrophytic vegetation was dead at time of study except for some Hydrocotyl.

- Station 10a -- Marsh area east of Station 10; station has a break in berm and egress and ingress of water was noted during the study period; most marsh vegetation was dead at the time of the study except for Hydrocotyl; substrate composition in the drainage cut appeared to be fine organic matter overlying fine sand; water depth in the marsh was approximately 1-2 inches while the drainage cut was approximately 10-12 inches

Table 1 (Continued)

Forested Swamp:

- Station 1 -- Located in forested swamp 50 yards off western end of shorter drill canal; station was located in drainage cut which emptied into the drill canal; flow between swamp and drill canal was evident during the study; vegetative community consisted of cypress, water tupelo with understory of lizard's tail (Saururus cernuus), bulltongue (Sagittaria falcata), coontail (Ceratophyllum demersum), water depth of approximately one foot; substrate appeared to be composed of fine silt overlying fine sand.

- Station 2 -- Located in forested swamp 50 yards off eastern end of shorter drill canal; station was located in drainage area which had flow emptying to the drill canal during the study period; vegetation same as described for Station 1; water depth was approximately one foot; substrate appeared to be fine silt overlying fine sand.

- Station 5a -- Located in drainage cut at end of longest drill canal; forested swamp composed of cypress and water tupelo with an understory of bulltongue, lizard's tail; water depth was approximately one foot; substrate appeared to be fine silt and sand.

- Station 9a -- Located in forested swamp, east of Station 9 which is approximately one mile from the mouth of the SNGP canal; vegetation consisted of mainly cypress, water tupelo; depth of water approximately 3/4 - 1 inch; substrate appeared to be high in organic content, especially decaying or partially decomposed vegetation.

- Station 7 -- Located in forested swamp off west side of SNGP canal (approximately 1/2 mile from canal mouth); cypress, water tupelo, red maple were predominant trees; understory vegetation consisted of bulltongue (Sagittaria falcata), banana lily (Nymphoides aquatica) and lizard's tail; water depth of 6 inches, substrate appeared to contain large amounts of decomposing organic matter.

TABLE 2
WATER LEVEL SUMMARY (FT - NGVD)
BARATARIA WATERWAY

	ICW at[1] Algiers Lock	Bayou[2] Barataria at Barataria	Bayou[3] Barataria at Lafitte
Mean Annual Extreme High	3.07	2.92	2.94
Mean High	1.55	1.57	1.60
Mean Annual Extreme Low	-0.10	0.23	-0.05
Mean Low	1.20	1.32	1.25
Mean Water Level[4]	1.38	1.45	1.43
Mean Tide Range[5]	0.35	0.25	0.35

Date Source: COE

1 - 1958 through 1980

2 - 1962 through 1980

3 - 1963 through 1980

4 - Based upon average of mean high and mean low stage

5 - Based upon difference of mean high and mean low stage

TABLE 3
GROUND AND WATER SURFACE ELEVATIONS (FT - NGVD)
BAYOU AUX CARPES
JANUARY 1985

Transect	Swamp/Marsh Left Ground	Water	Δ	Swamp/Marsh Right Ground	Water	Δ
A	1.53	1.60	0.07	1.60	1.63	0.03
	1.27	1.60	0.33	1.65	1.67	0.02
				1.61	1.67	0.06
B	1.49	--*		1.28	1.73	0.45
	1.54	1.59	0.05	1.27	1.73	0.46
C	1.05	1.53	0.48	1.02	1.65	0.63
	1.00	1.54	0.54	1.12	1.69	0.57
D				0.44	0.97	0.53
				1.04	--*	
E				1.32	--*	
				0.66	1.00	0.34
F	1.60	1.80	0.20	1.19	1.99	0.80
				1.56	--*	
G	1.51	--*				
	0.57	1.42	0.85			

Total of 22 Ground Observations

Maximum	1.65
Mean	1.24
Minimum	0.44

Total of 17 Water Observation

Maximum	1.80
Mean	1.54
Minimum	0.00

*Water level below ground surface

$\bar{X} = 0.37'$

If Add Areas not Inundated $\bar{X} = 0.29'$

TABLE 4
WATER CHEMISTRY-CHLORIDES (mg/L) and SALINITY (ppt)
BAYOU AUX CARPES
JANUARY 1985

STATION	DATE	TIME	CL	STATION	DATE	TIME	CL	Sal (ppt)
10	1/17	1045	130	2	1/20	1200	250	0.5
		1145	140	5	1/23	0800	260	0.5
		1345	170	7	1/20	1230	220	0.4
		1445	180	9	1/20	0800	430	0.8
		1545	190	10a	1/20	1330	300	0.6
		1645	210	10 soil	1/19	1535	800	1.5
		1745	220	11	1/20	1400	49	0.1
		1845	240					
		1945	240					
		2045	250					
		2145	210					
		2245	110					
		2345	110					
	1/18	0045	130					
		0295	70					
		0345	70					
		1330	280					
		1430	290					
		1530	300					
		1630	290					
		1730	220					
		1830	100					
		1930	110					
		2030	250					
		2130	290					
		2230	260					
		2330	150					
	1/19	0030	140					
		0130	70					
		0230	54					
		0330	51					
		0430	52					
		0530	54					
		0630	65					
		0730	77					
		0830	130					
		0930	200					

TABLE 5
WATER CHEMISTRY (mg/L)
BAYOU AUX CARPES
JANUARY 1985

STATION	DATE	TIME	NH_3-N	NO_2-NO_3-N	Org. N	T-P	TOC
1	1/17	1100	0.22	<0.05	0.78	0.11	14
1	1/18	1205	0.33	<0.05	0.87	0.11	14
1	1/19	1415	0.50	<0.05	0.90	0.14	17
2	1/17	1100	0.07	<0.05	0.93	0.10	12
2	1/18	1210	0.16	<0.05	0.79	0.10	15
2	1/19	1410	0.37	<0.05	1.23	0.15	19
3	1/17	1115	0.50	0.76	0.50	0.36	11
3	1/18	1200	0.26	0.65	0.72	0.34	12
3	1/19	1405	0.24	0.57	0.68	0.34	12
4	1/17	1120	0.20	0.94	1.00	0.38	11
4	1/18	1155	0.26	0.35	0.84	0.37	15
4	1/19	1400	0.14	0.25	0.84	0.36	14
5	1/17	1640	0.18	<0.05	0.60	0.22	15
5	1/18	1135	<0.05	<0.05	0.80	0.16	14
5	1/19	1420	0.09	<0.05	0.76	0.20	15
5-A	1/17	1135	<0.05	<0.05	0.72	0.14	14
5-A	1/18	1135	0.12	<0.05	0.80	0.14	14
5-A	1/19	1430	0.55	<0.05	0.25	0.18	15
6	1/17	1206	0.14	0.35	0.96	0.34	15
6	1/18	1150	0.18	0.16	0.82	0.33	15
6	1/19	1500	0.09	0.24	0.90	0.33	14
7	1/17	1315	0.12	<0.05	3.58	0.37	44
7	1/18	1230	0.12	<0.05	1.58	0.14	22
7	1/19	1335	0.08	<0.05	0.92	0.13	21
9	1/17	1300	0.23	0.24	1.07	0.30	15
9	1/18	1215	0.22	0.14	1.08	0.20	21
9	1/19	1350	0.19	0.09	0.91	0.18	18
10	1/17	1330	0.20	<0.05	1.20	0.64	11
10	1/18	1315	0.08	<0.05	1.12	0.50	13
10	1/19	1300	0.10	<0.05	0.40	0.26	12
11	1/17	1330	0.62	1.4	0.48	0.56	8.4
11	1/18	1320	0.63	1.4	0.17	0.56	8.0

TABLE 5 (continued)

STATION	DATE	TIME	NH_3-N	NO_2-NO_3-N	Org. N	T-P	TOC
10	1/17	1040	0.19	1.1	0.71	0.48	14
		1140	0.19	1.2	0.72	0.43	12
		1240	0.19	0.99	0.72	0.36	11
		1340	0.19	0.94	0.80	0.39	12
		1440	0.20	0.82	0.80	0.38	13
		1540	0.20	0.74	0.97	0.42	13
		1640	0.20	0.65	1.10	0.41	14
		1740	0.20	0.60	0.90	0.34	13
		2340	0.46	1.0	0.74	0.50	12
	1/18	0040	0.43	0.97	0.87	0.53	11
		0140	0.50	1.1	0.90	0.55	10
		0240	0.60	1.3	0.80	0.30	9
		0340	0.60	1.3	0.80	0.56	8.3
		0440	0.62	1.2	0.68	0.56	8.6
		0540	0.55	1.2	0.85	0.52	9
		0640	0.36	0.92	0.84	0.46	12
		0740	0.21	0.58	0.89	0.36	14
		0840	0.43	0.94	0.87	0.48	11.5
		0940	0.18	0.50	0.92	0.40	16
		1040	0.17	0.47	0.93	0.34	15
		1300	0.22	0.43	0.88	0.34	17
		1400	0.13	0.39	1.67	0.80	23
		1500	0.16	0.36	0.94	0.32	16
		1600	0.13	0.38	0.85	0.35	14
		1700	0.38	0.89	0.82	0.42	11
		1900	0.45	1.0	0.75	0.5	8.7
		2000	0.24	0.58	0.96	0.39	14
		2100	0.15	0.37	1.05	0.37	16
		2200	0.24	0.64	0.96	0.42	14

Table 6. Sediment pesticides (µg/kg, dry wt.), Bayou Aux Carpes. January 1985.

Compound	Sta. 2	Sta. 3	Sta. 4	Sta. 7	Sta. 8	Sta. 10a	Sta. 10	Sta. 11
Aldrin	80U	60U	20U	100U	20U	200U	200U	10U
Heptachlor	80U	60U	20U	100U	20U	200U	200U	10U
Heptachlor Epoxide	80U	60U	20U	100U	20U	200U	200U	10U
Alpha-BHC	80U	60U	20U	100U	20U	200U	200U	10U
Beta-BHC	80U	60U	20U	100U	20U	200U	200U	10U
Gamma-BHC (Lindane)	80U	60U	20U	100U	20U	200U	200U	10U
Delta-BHC	80U	60U	20U	100U	20U	200U	200U	10U
Endosulfan I (Alpha)	200U	70U	30U	200U	40U	40U	30U	20U
Dieldrin	200U	70U	30U	200U	40U	40U	30U	20U
4,4'-DDT (P,P'-DDT)	700U	200U	60U	300U	80U	100U	70U	40U
4,4'-DDE (P,P'-DDE)	700U	200U	60U	300U	80U	100U	70U	40U
4,4'-DDD (P,P'-DDD)	700U	200U	60U	300U	80U	100U	70U	40U
Endrin	700U	200U	60U	300U	80U	100U	70U	40U
Endosulfan II (Beta)	700U	200U	60U	300U	80U	100U	70U	40U
Endosulfan Sulfate	1000U	400U	100U	500U	100U	100U	100U	60U
Chlordane (Tech, Mixture)	800U	300U	100U	800U	200U	200U	200U	100U
PCB-1242 (Aroclor 1242)	800U	500U	200U	1000U	300U	1000U	2000U	100U
PCB-1254 (Aroclor 1254)	6000U	2000U	600U	3000U	800U	1000U	700U	500U
PCB-1221 (Aroclor 1221)	800U	600U	200U	1000U	300U	1000U	2000U	100U
PCB-1232 (Aroclor 1232)	800U	600U	200U	1000U	300U	1000U	2000U	100U
PCB-1248 (Aroclor 1248)	800U	600U	200U	1000U	300U	1000U	2000U	100U
PCB-1260 (Aroclor 1016)	6000U	2000U	600U	3000U	800U	1000U	700U	500U
PCB-1016 (Aroclor 1016)	800U	500U	200U	1000U	300U	1000U	2000U	100U
Toxaphene	10000U	4000U	1000U	9000U	2000U	2000U	2000U	900U
Endrin Aldehyde	1000U	400U	100U	500U	100U	100U	100U	60U
Methoxychlor	700U	400U	100U	1000U	200U	100U	200U	80U
Moisutre %	90	90	75	70	88	76	78	67

U - Material was analyzed for but not detected. The reported concentration is the minimum detection limit.

Table 7. Benthic Macroinvertebrates, Qualitative Collections, Bayou aux Carpes, Louisiana, January 1985.

Organism	Forested Swamp Sta. 2	Forested Swamp Sta. 7	Marsh Sta. 8	Marsh Sta. 10	Canal Sta. 4
DIPTERA					
Glyptotendipes sp.					X
Ablabesmyia peleensis		X			
Polypedilum prob. illinoense		X			
Goeldichironomus holoprasinus			X		
Chironomus plumosus group			X		
Tanypus neopunctipennis				X	
EPHEMEROPTERA					
Siphlonuridae (damaged)					X
ODONATA					
Miathyria marcella	X				
Pachydiplax longipennis	X				
Coryphaeschna ingens	X				
Anomalagrion sp.	X				
Nasiaeschna sp.					X
Boyeria vinosa		X			
Anax amazili			X		
Enallagma sp.		X	X		X
Ischnura sp.		X	X		X
HEMIPTERA					
Ranatra sp.					X
CRUSTACEA					
Hyalella azteca	X	X	X	X	X
Gammarus sp.					X
Asellus sp.	X	X	X	X	X
Lirceus sp.			X	X	
Astacidae	X	X			
Astacidae, prob. Cambarellinae		X			
Palaemonetes kadiakensis				X	X
Callinectes sapidus				X	X
Uca sp.					X
BIVALVIA					
Musculium sp.		X			X
GASTROPODA					
Physella prob. heterostropha pomila	X	X	X	X	X
Stagnicola sp.		X			
Menetus sp.		X			
Fossaria sp.				X	
Laevapex sp.	X	X		X	
TOTAL TAXA	9	14	9	9	14

Table 8. Fish Collected, Bayou Aux Carpes, Louisiana, January 1985.

Orgamism	Forested Swamp Sta. 2	Forested Swamp Sta. 7	Marsh Sta. 10	Canal Sta. 4
Clupeidae				
Dorosoma cepedianum		X		
Engraulidae				
Anchoa mitchilli*		X		
Cyprinodontidae				
Fundulus cingulatus			X	
Poecilidae				
Gambusia affinis	X		X	X
Heterandria formosa	X	X	X	X
Poecilia latipinna			X	
Centrarchidae				
Elassoma zonatum	X		X	X
Lepomis punctatus				X
L. sp.		X		
TOTAL TAXA	3	4	5	4

*Estuarine species

FIGURE 1
SITE LOCATION
BAYOU AUX CARPES
JANUARY 1985

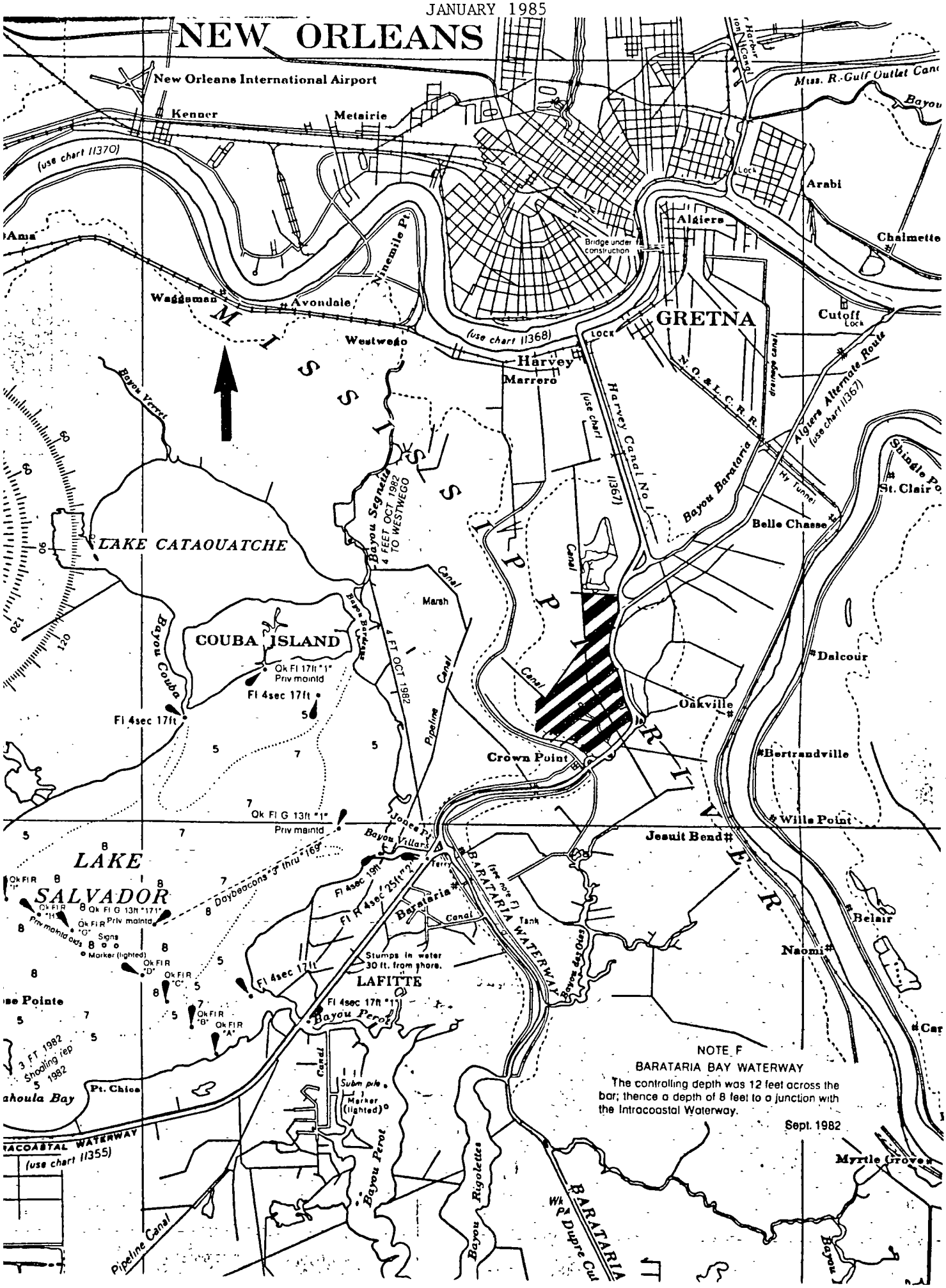


FIGURE 2
BAYOU AUX CARPES
JEFFERSON PARISH, LOUISIANA

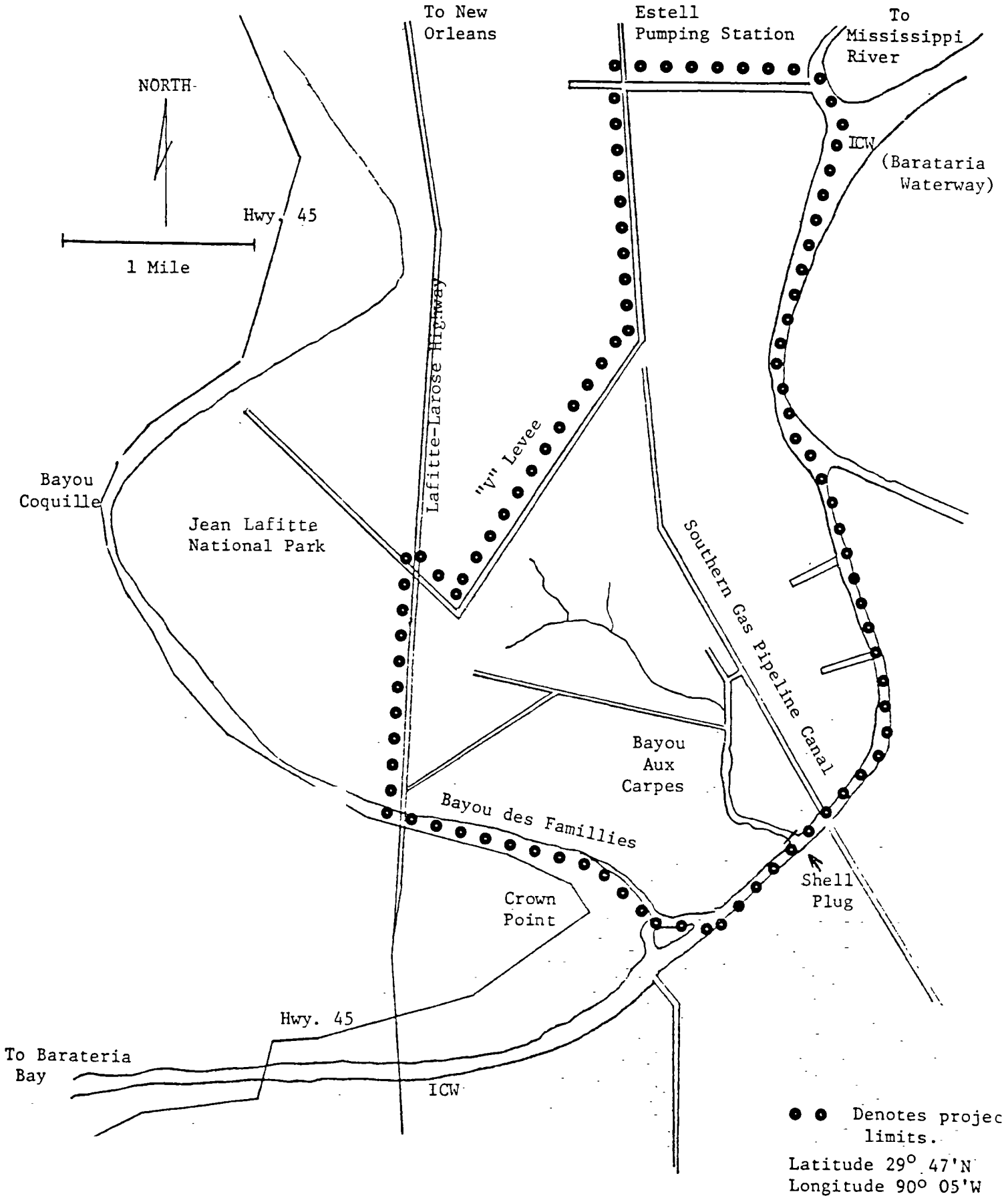


FIGURE 3
HYDROGRAPHIC MONITORING LOCATIONS
BAYOU AUX CARPES
JANUARY 1985

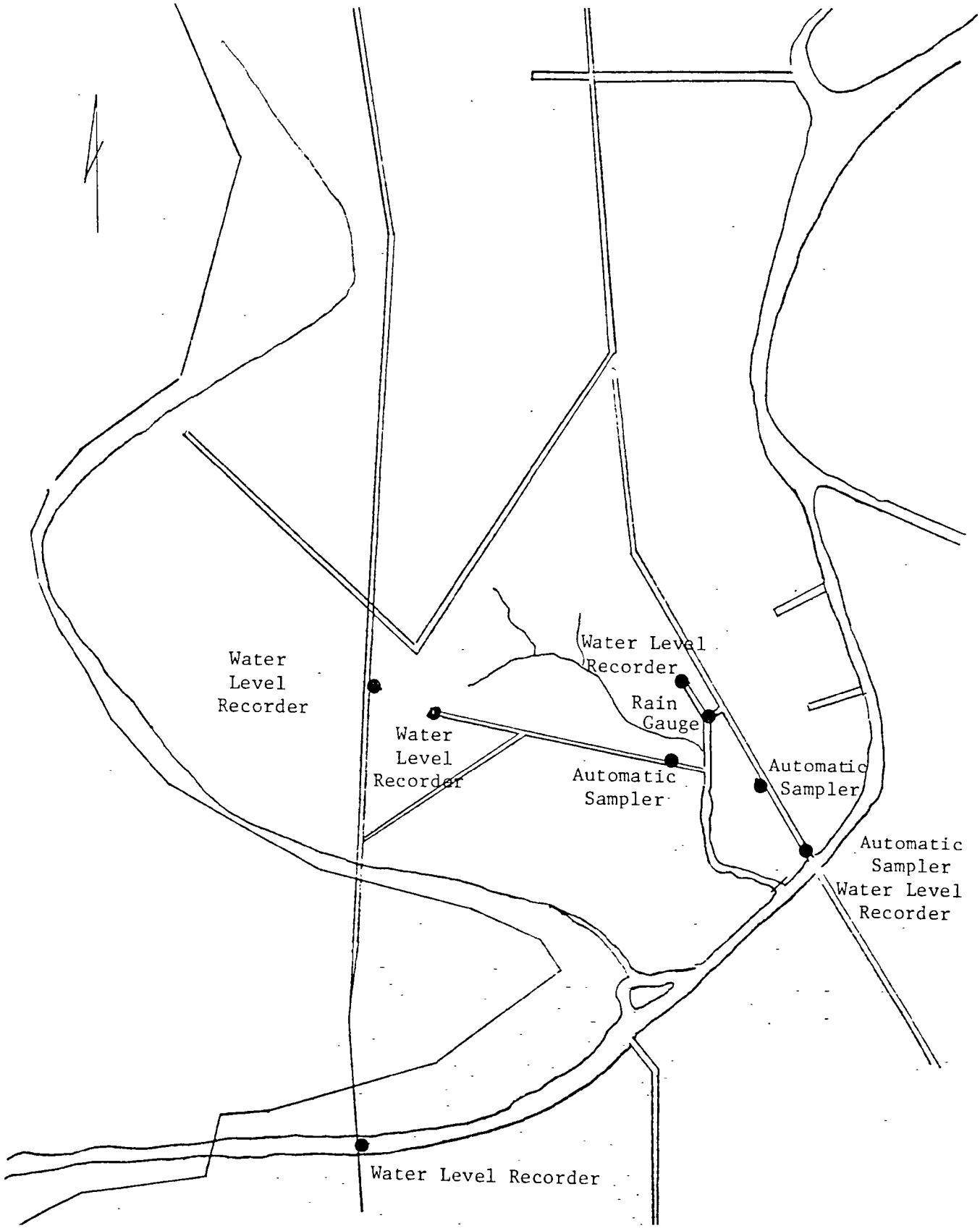


FIGURE 4.
Stations for water quality sampling,
Bayou Aux Carpes Study
January, 1985

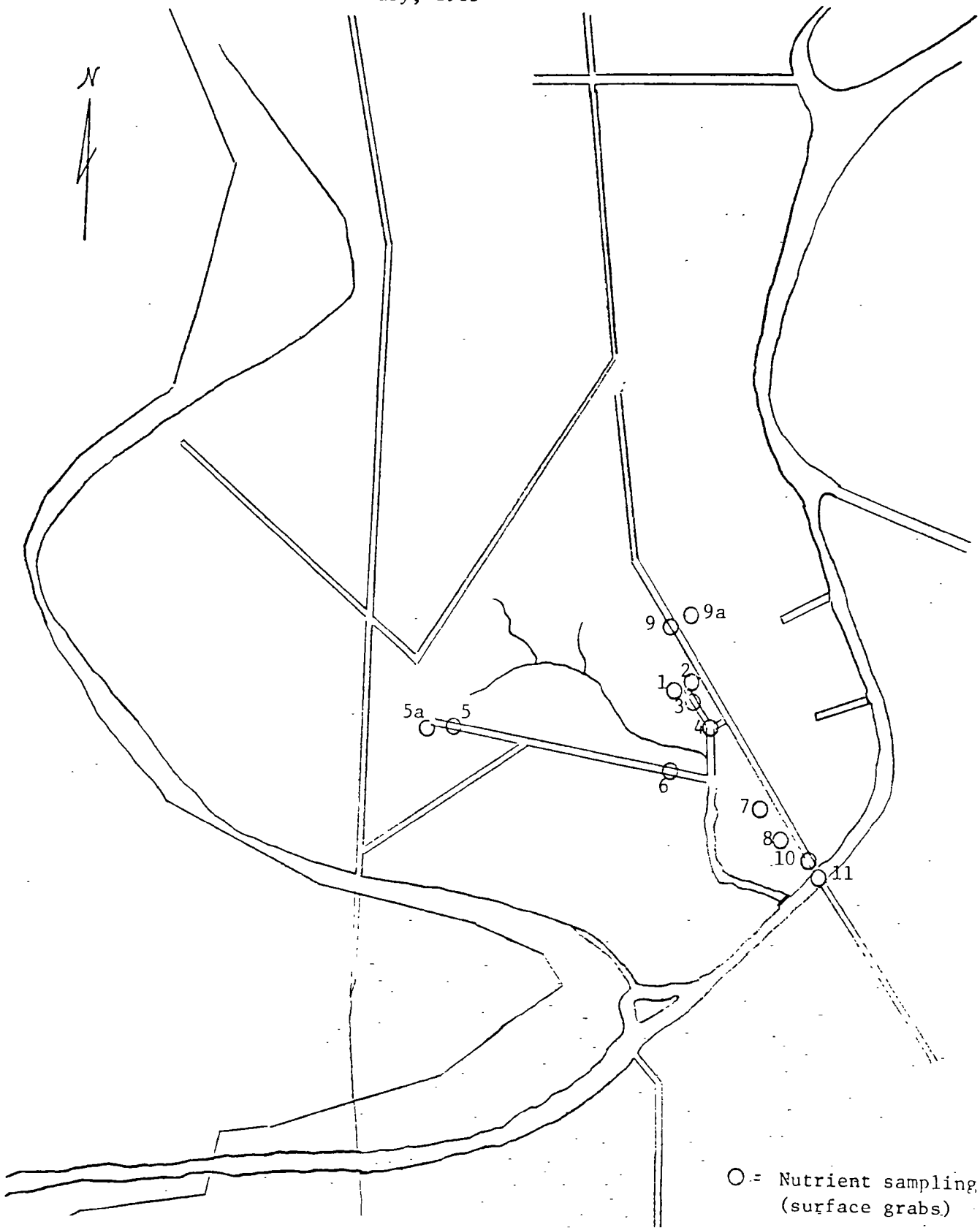


FIGURE 5.
Station for biological sampling,
Bayou Aux Carpes Study
January, 1985

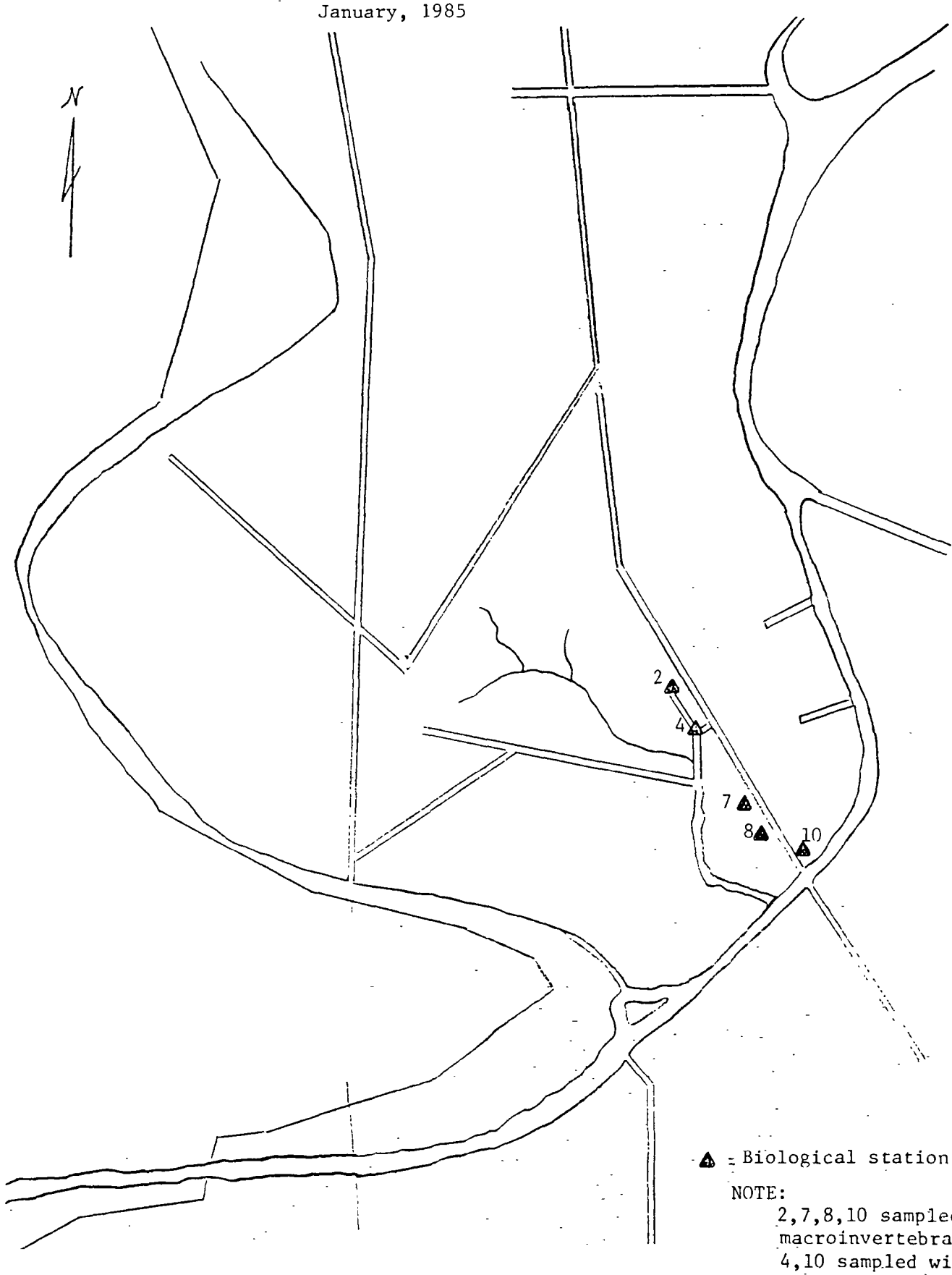


FIGURE 6
WATER LEVELS
BAYOU AUX CARPES
JANUARY 16-20, 1985

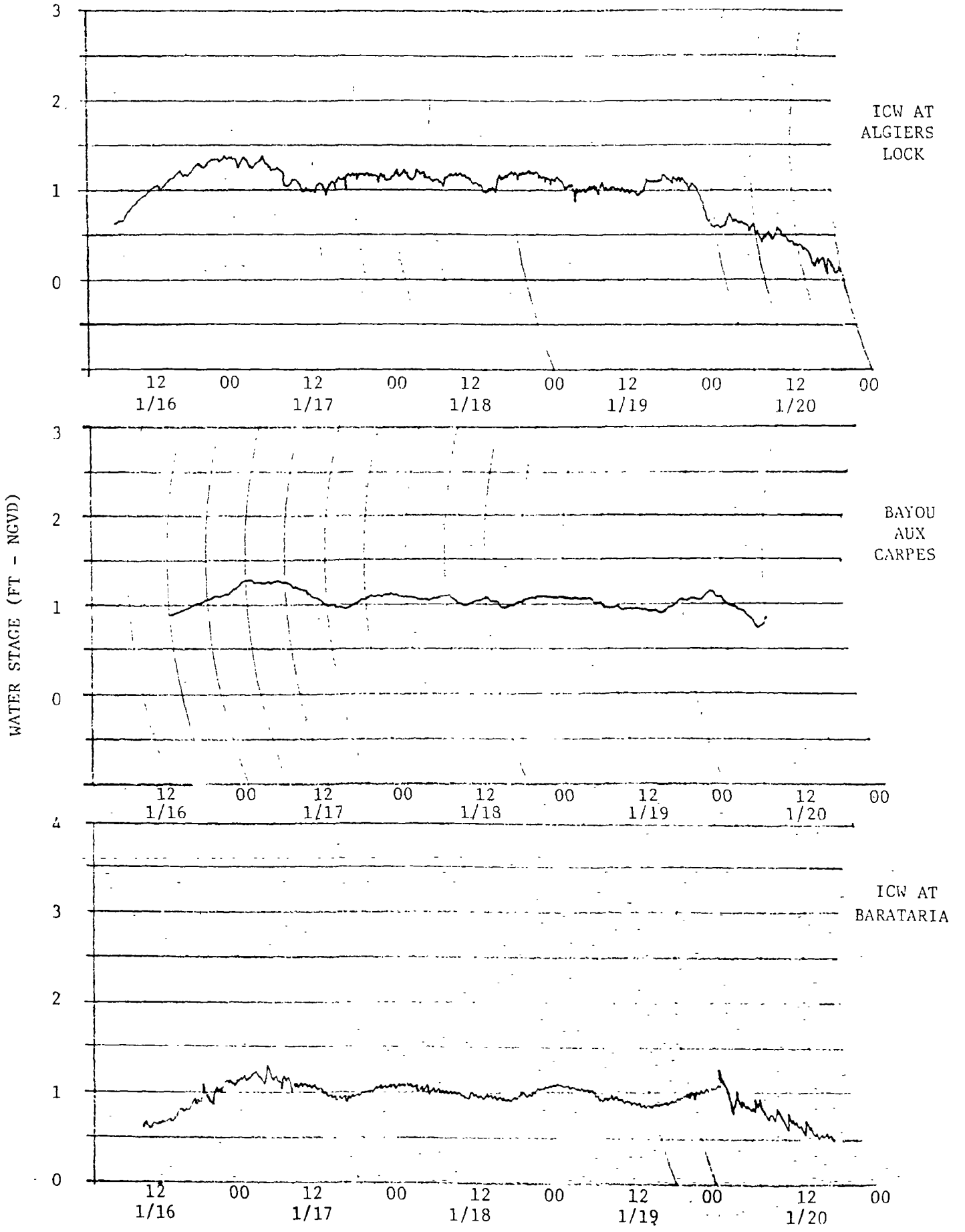


FIGURE 7
DAILY WATER LEVEL RECORDINGS AT 0800 HOURS. COE AT ALGIERS AND BARATARTIA STAGING STATIONS, 1984 BAYOU AUX CARPES, LOUISIANA

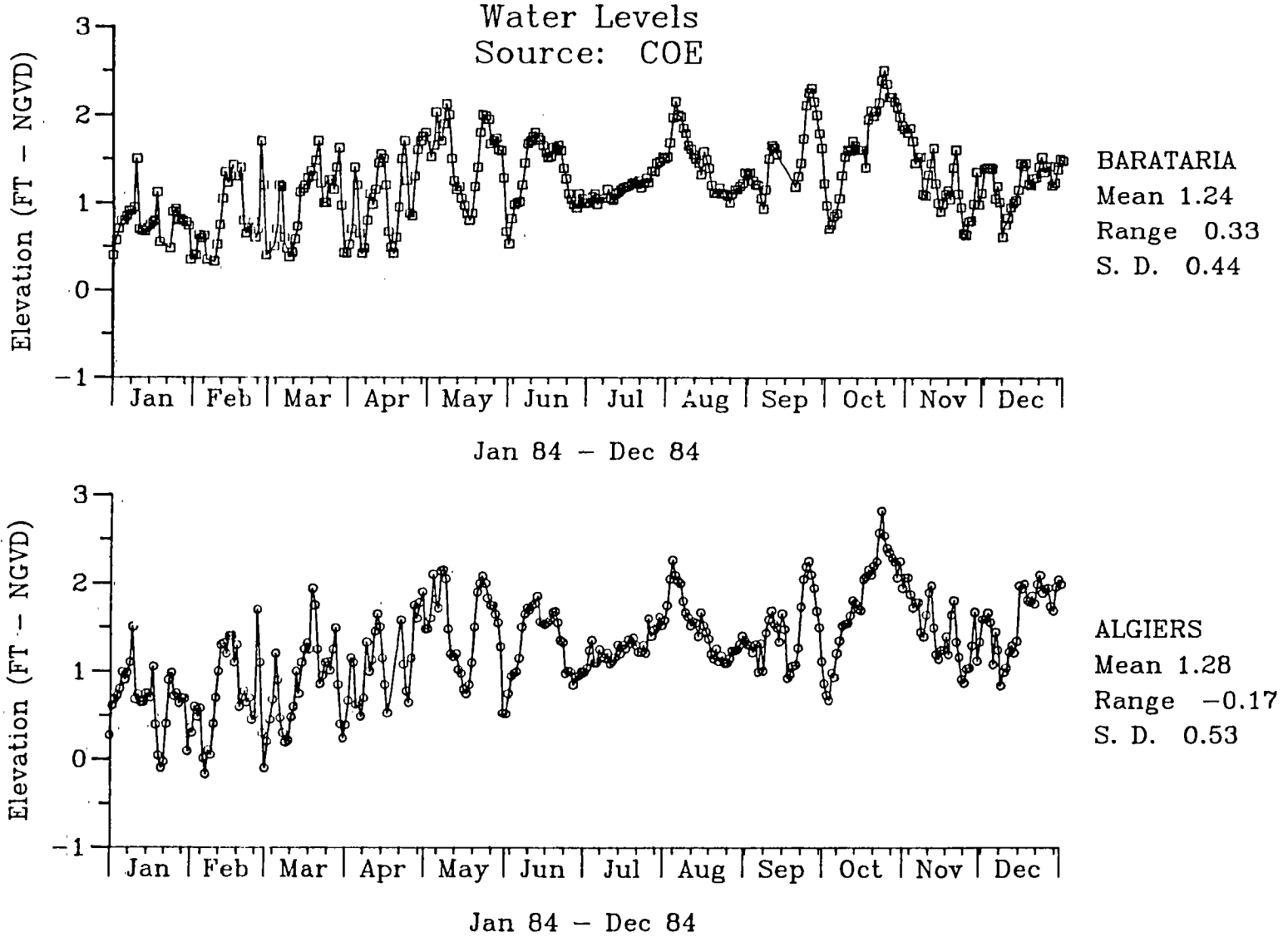
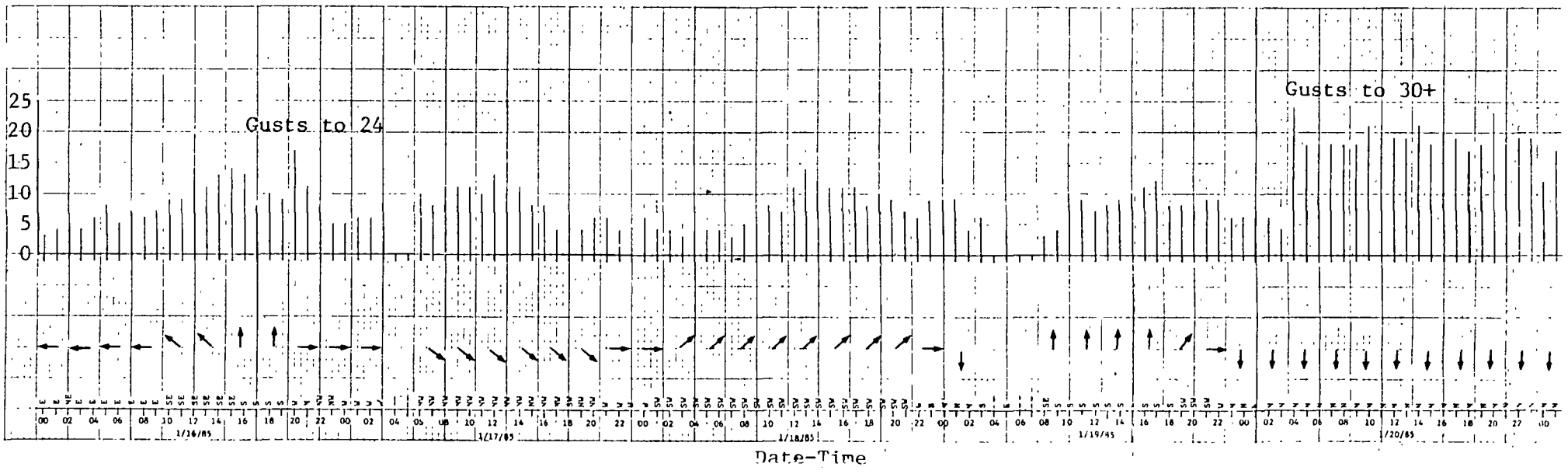


FIGURE 8
WIND SPEED AND DIRECTION
MOISANT INTERNATIONAL AIRPORT
NEW ORLEANS, LA
JANUARY 1985



47150
47155
1MILE

FIGURE 9
RAINFALL
BAYOU AUX CARPES
JANUARY 1985

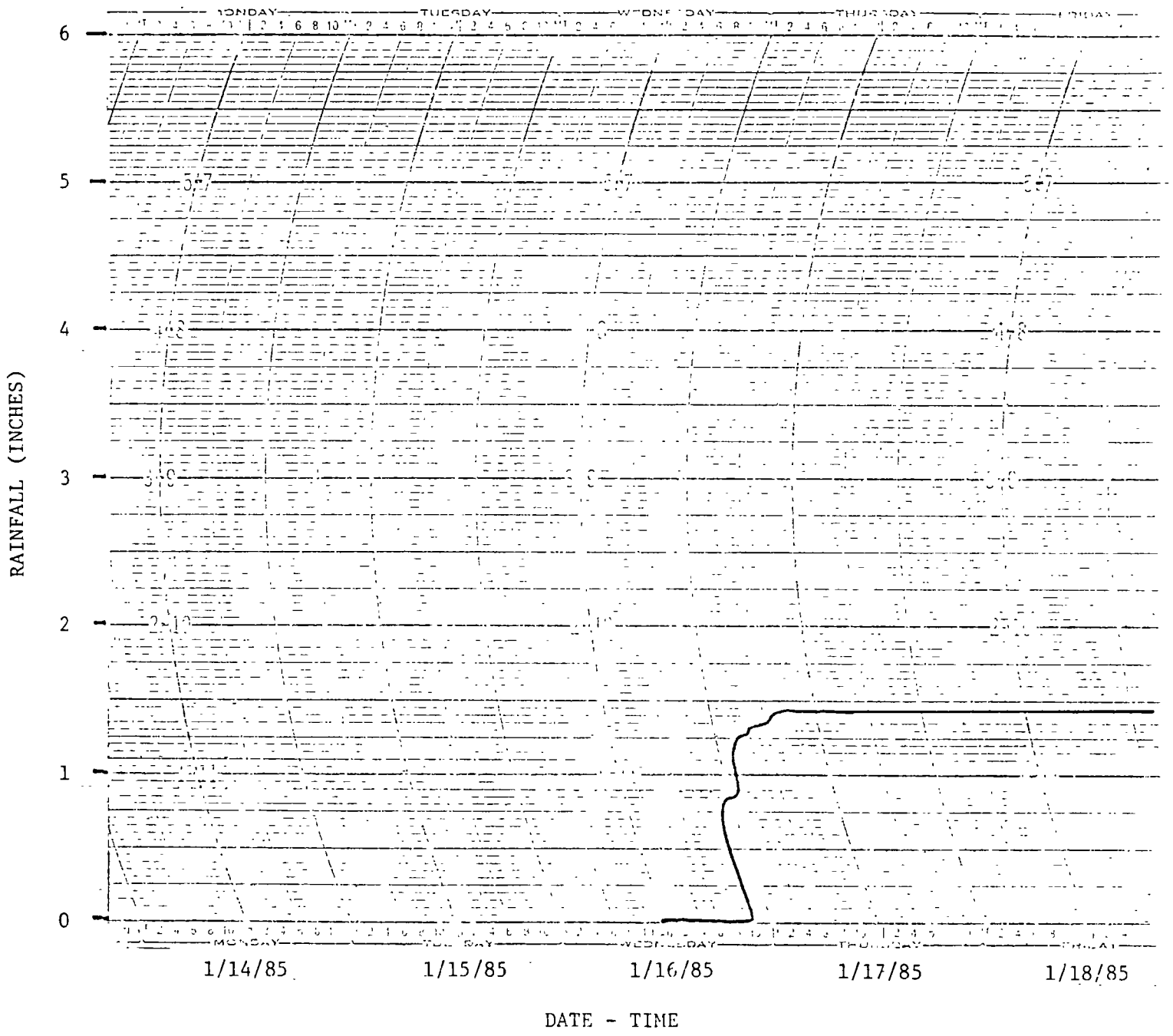


FIGURE 10
WATER LEVEL
EAST BORROW DITCH
LAFITTE/LAROSE HWY.
BAYOU AUX CARPES
JANUARY 1985

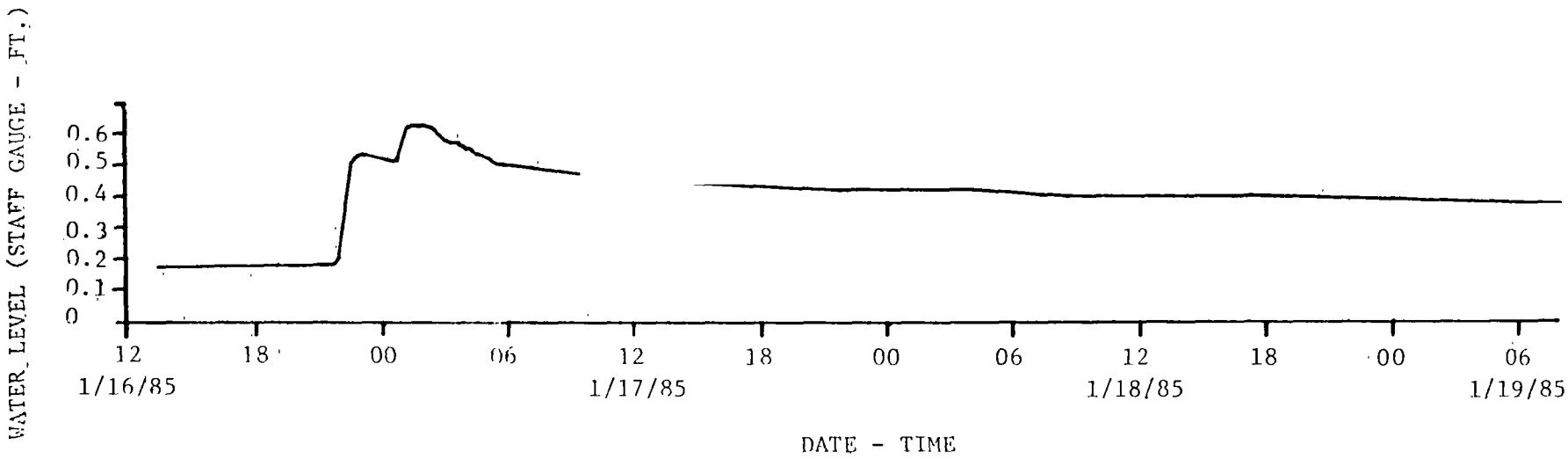


FIGURE 11
WATER LEVEL COMPARISON ON 1/16/85
BAYOU AUX CARPES
JANUARY, 1985

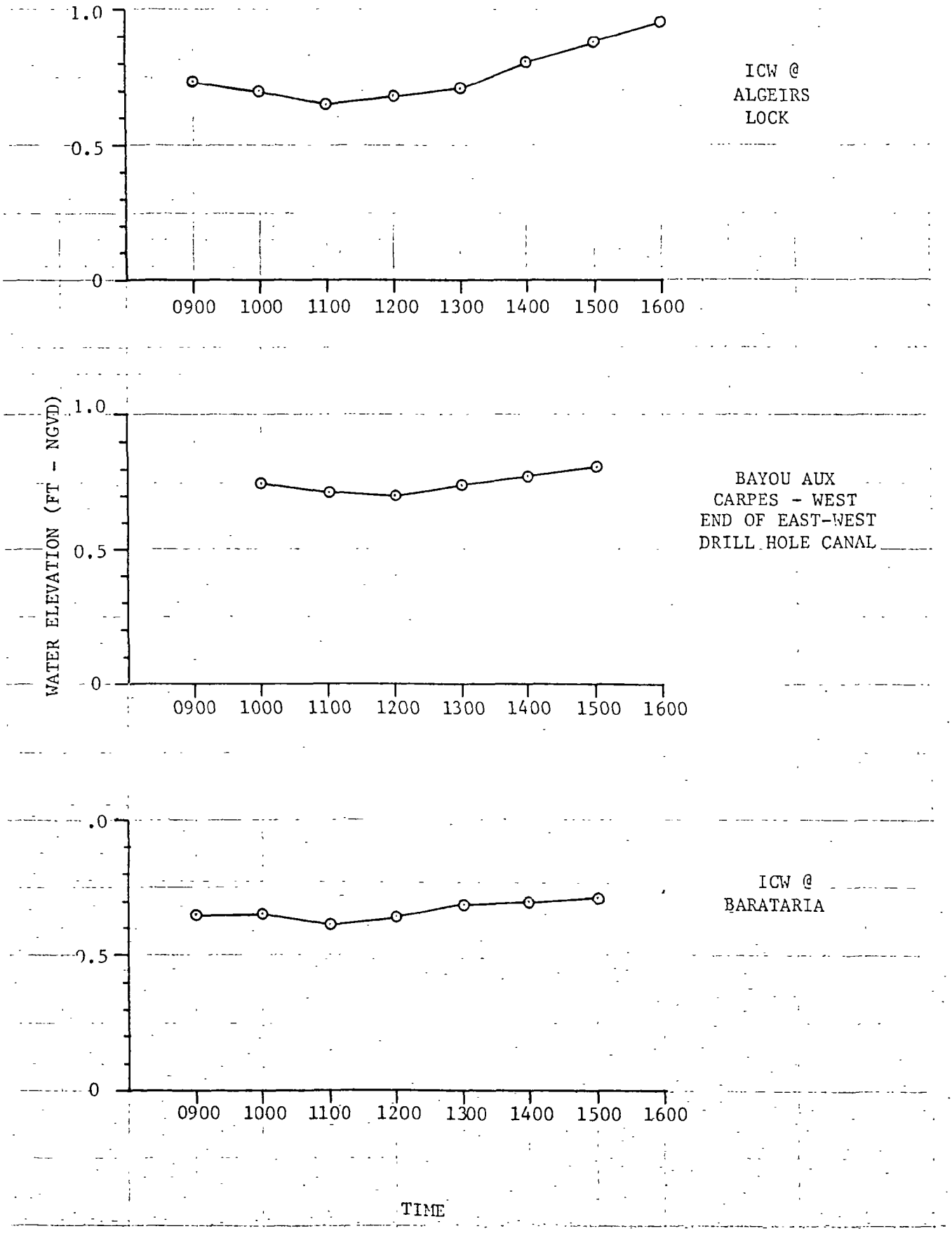


FIGURE 12
GROUND SURFACE TRANSECTS
BAYOU AUX CARPES
JANUARY 1985

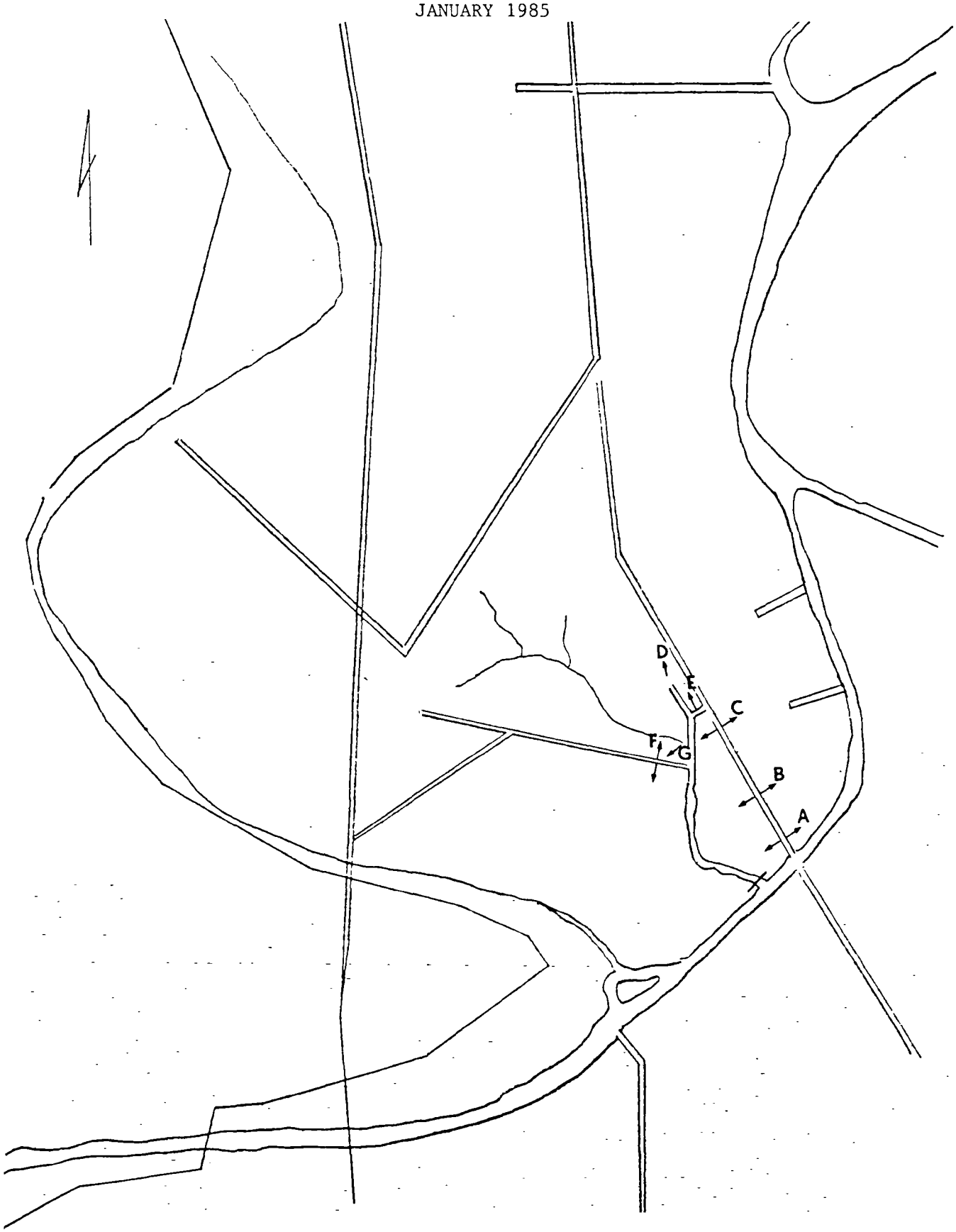


FIGURE 13

FREQUENCY OF DAILY WATER LEVELS FOR 1984 AT THE COE ALGIERS AND BARATARIA STAGING STATIONS.
BAYOU AUX CARPES, LOUISIANA

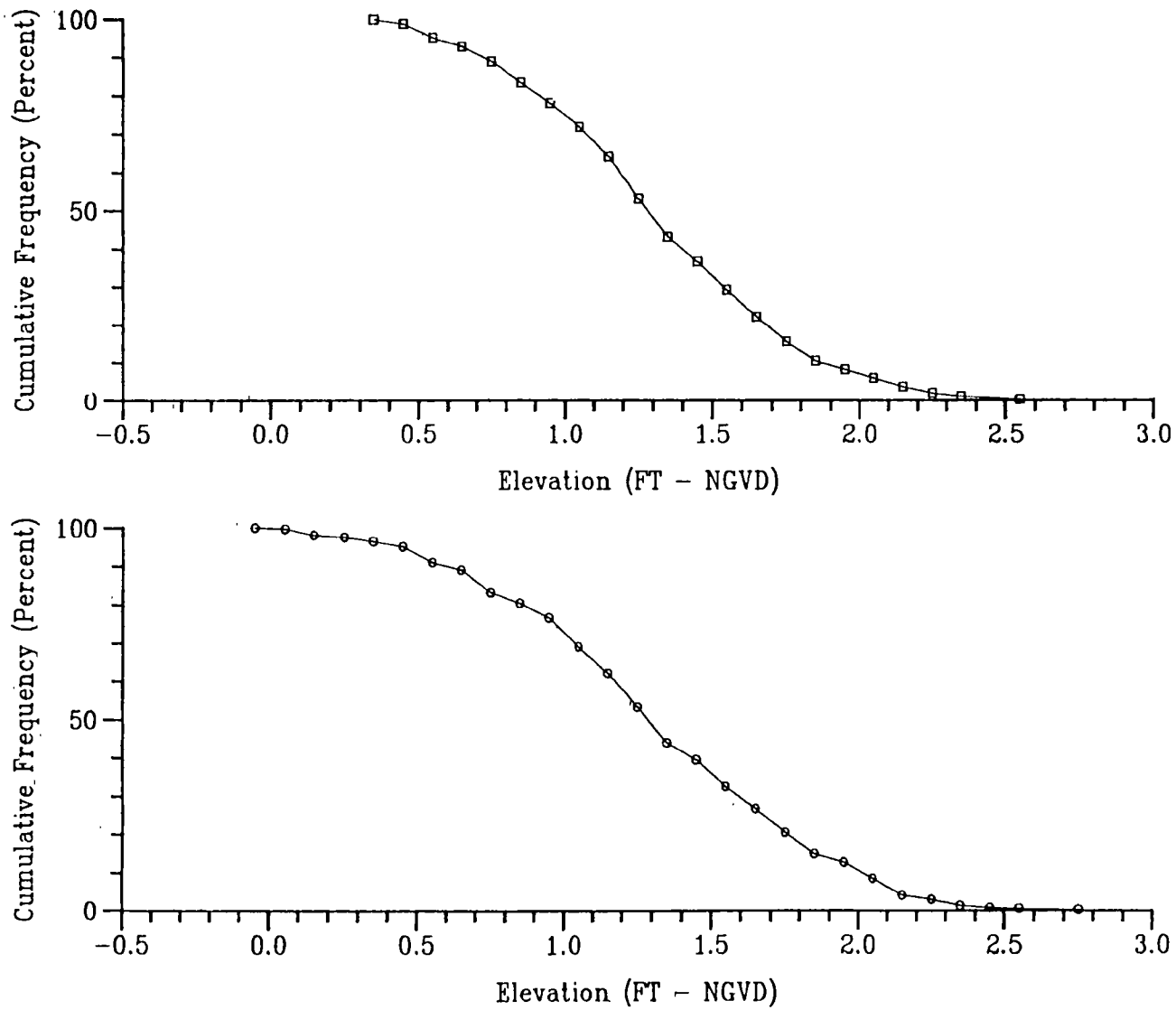


FIGURE 14
WATER LEVELS, CHLORIDES AND DYE TRACER
SNGP CANAL AT JCT. WITH ICW
BAYOU AUX CARPES

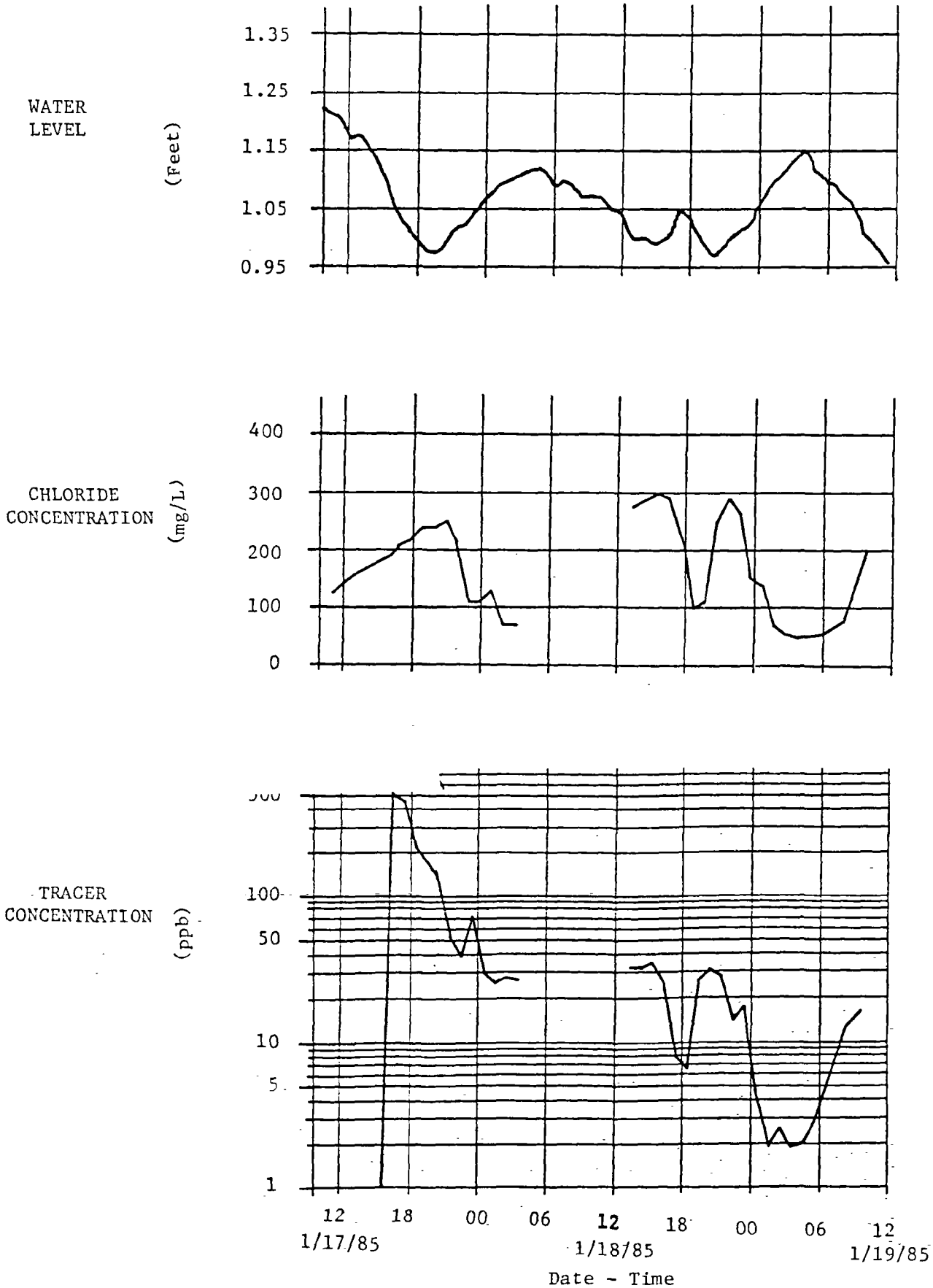


FIGURE 15
DYE TRACER STUDY
BAYOU AUX CARPES
JANUARY, 1985

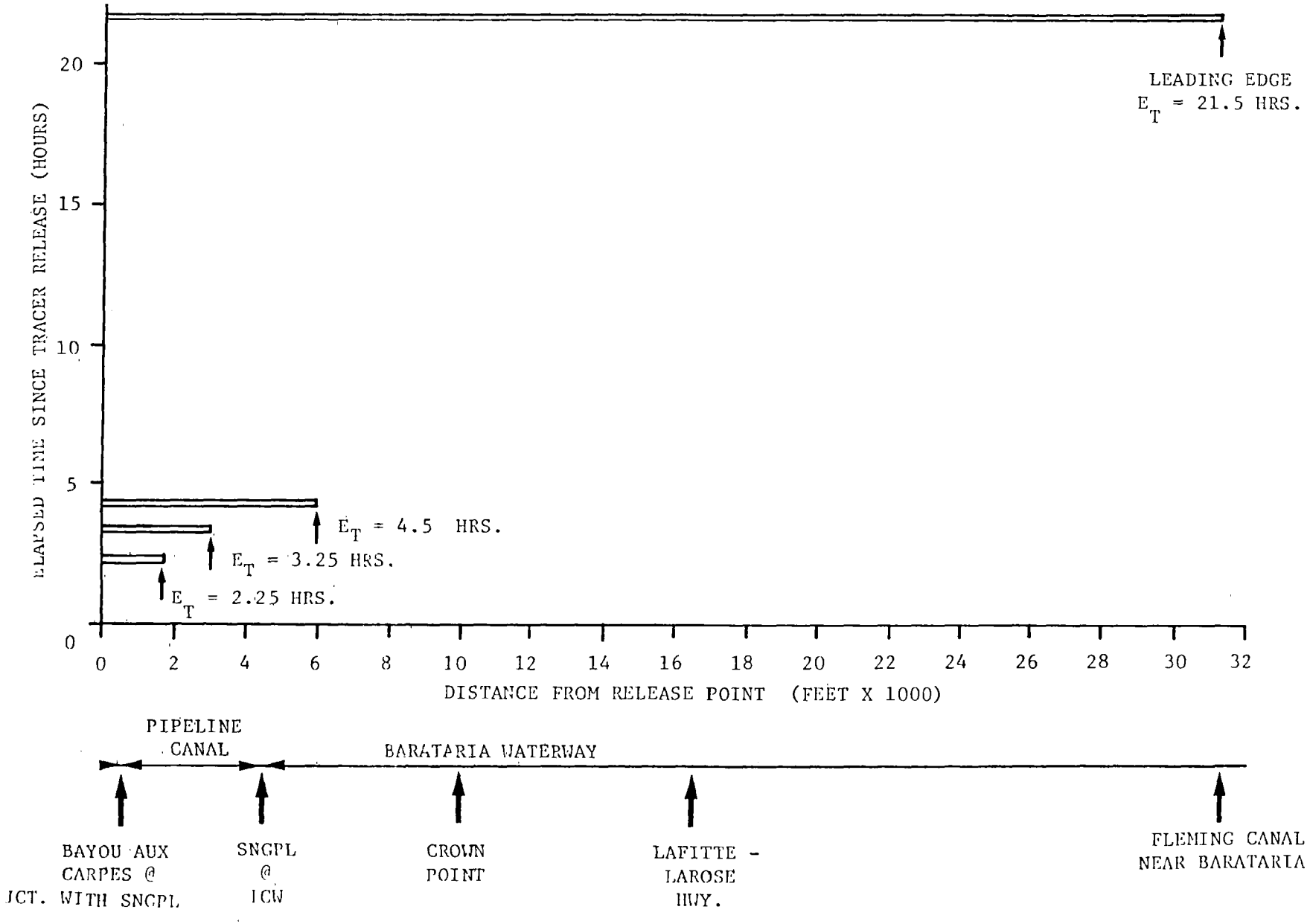


FIGURE 16
WATER LEVELS, TOTAL ORGANIC CARBON AND TOTAL ORGANIC NITROGEN
SNGP CANAL AT JCT. WITH ICW
BAYOU AUX CARPES

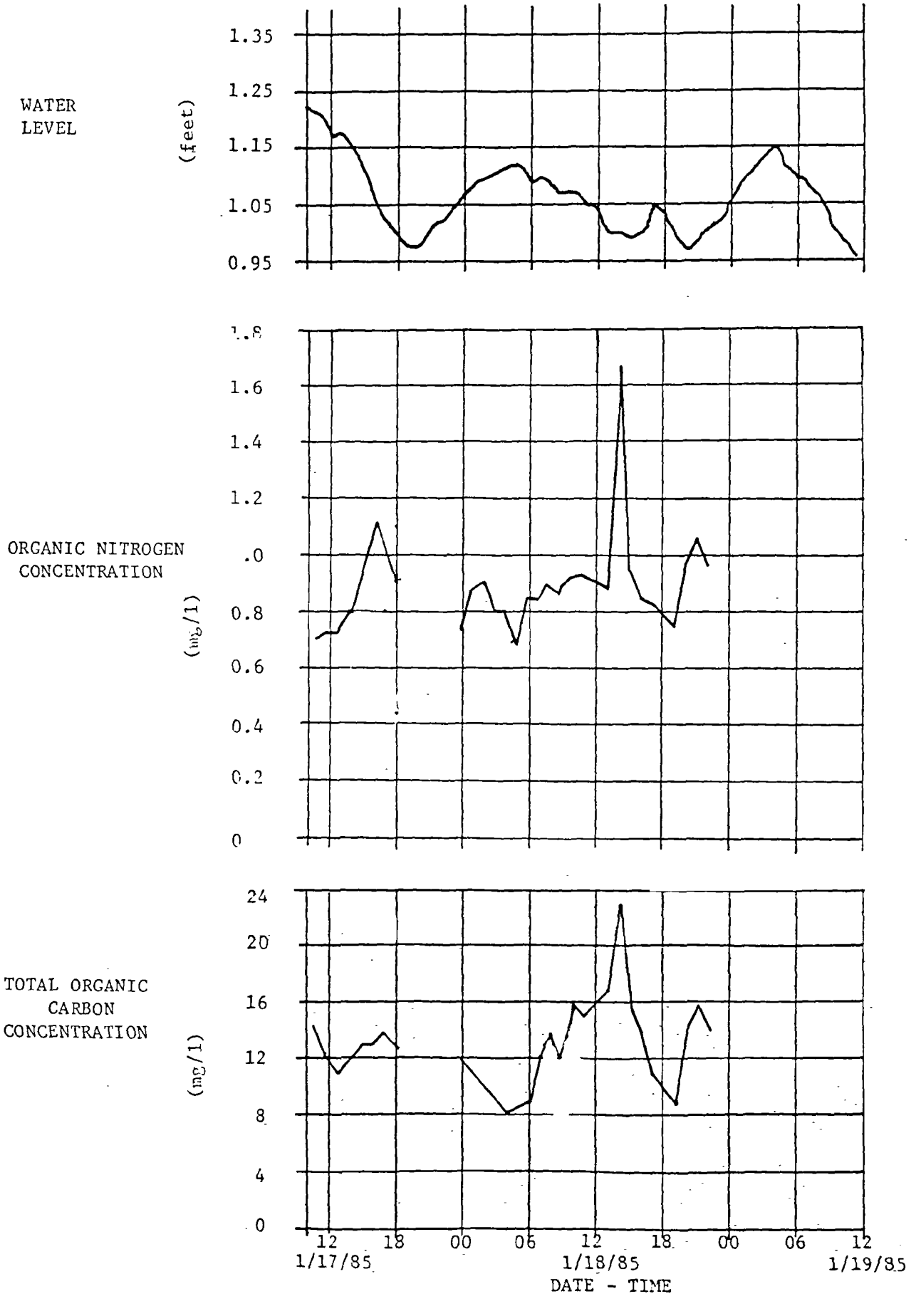


FIGURE 17
WATER LEVELS AND NITROGEN FORMS
SNGP CANAL AT JCT. WITH ICW
BAYOU AUX CARPES

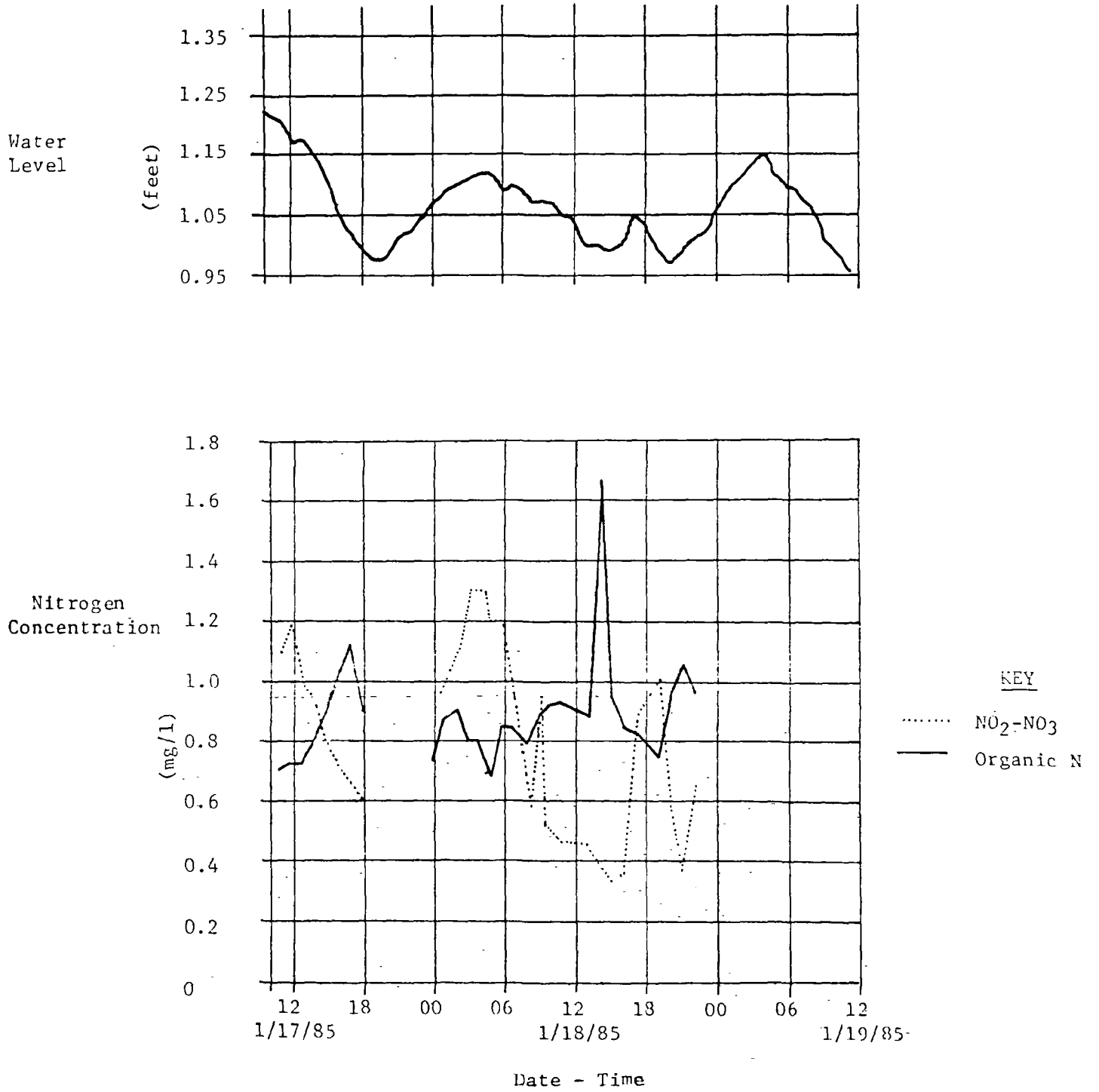


FIGURE 18
NO2-NO3, ORG. N, TOC COMPARISON
BAYOU AUX CARPES
JANUARY, 1985

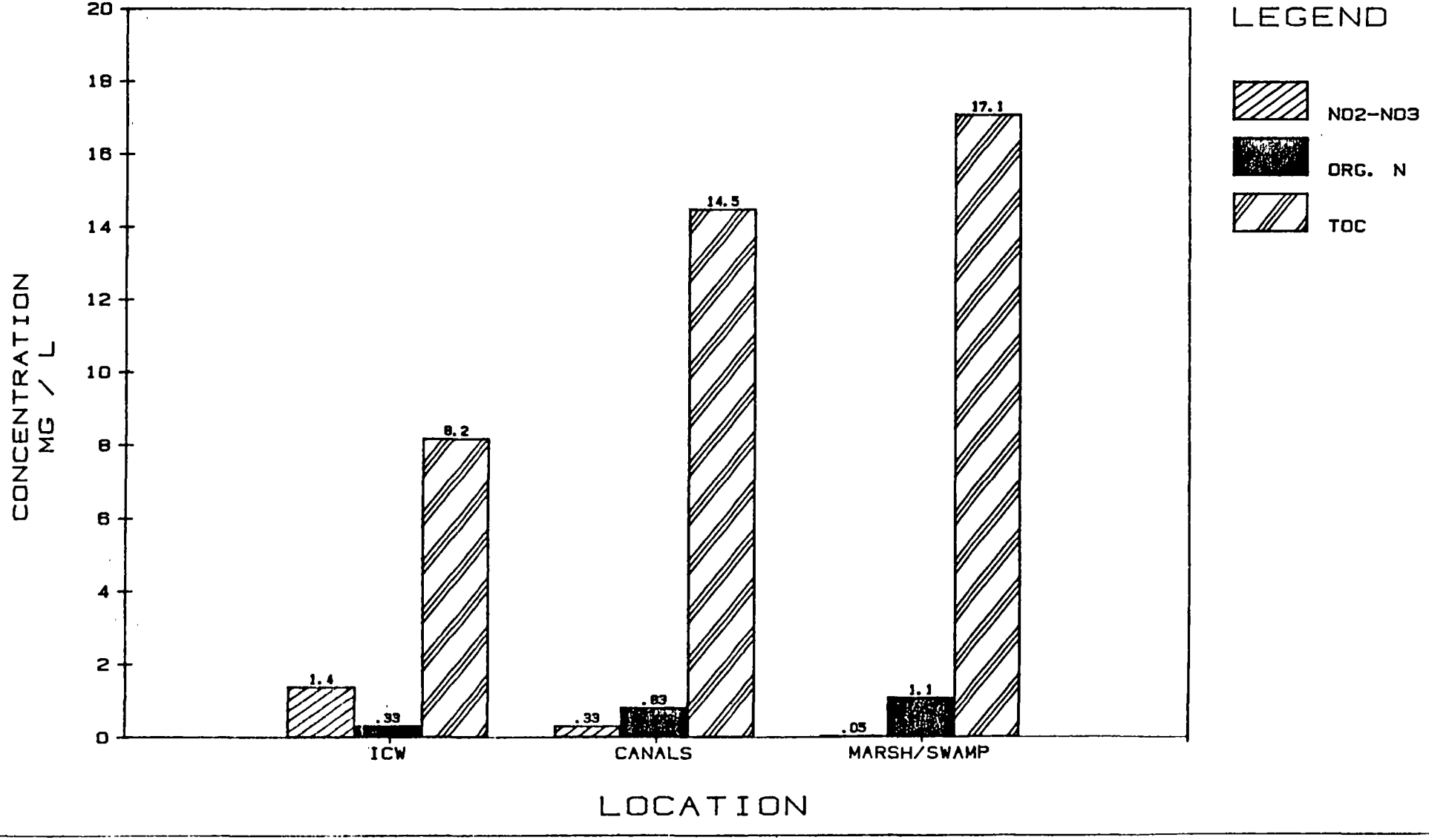
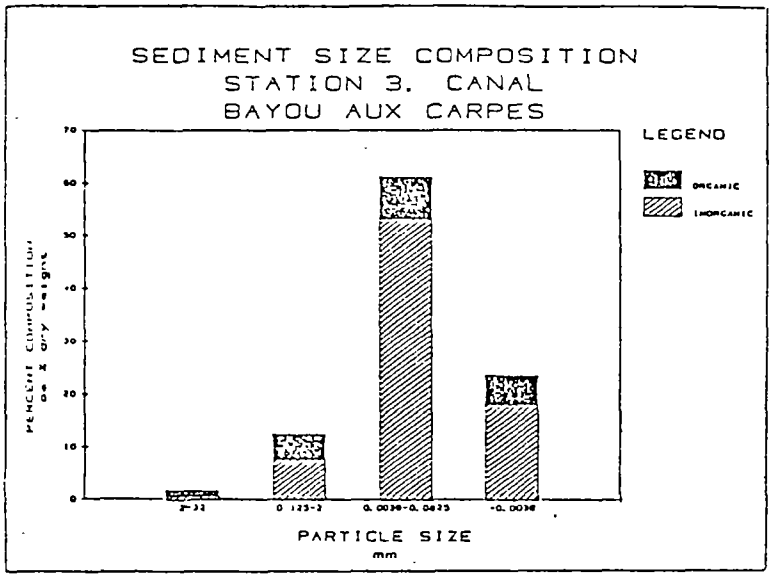
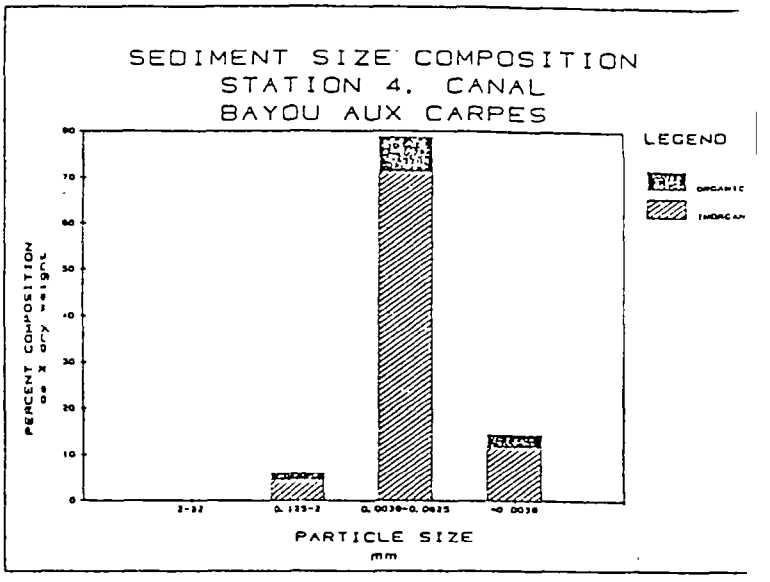
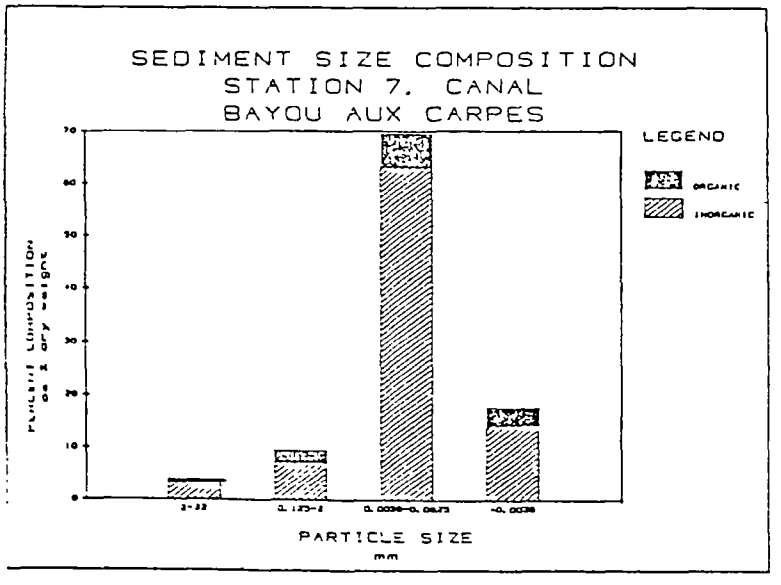


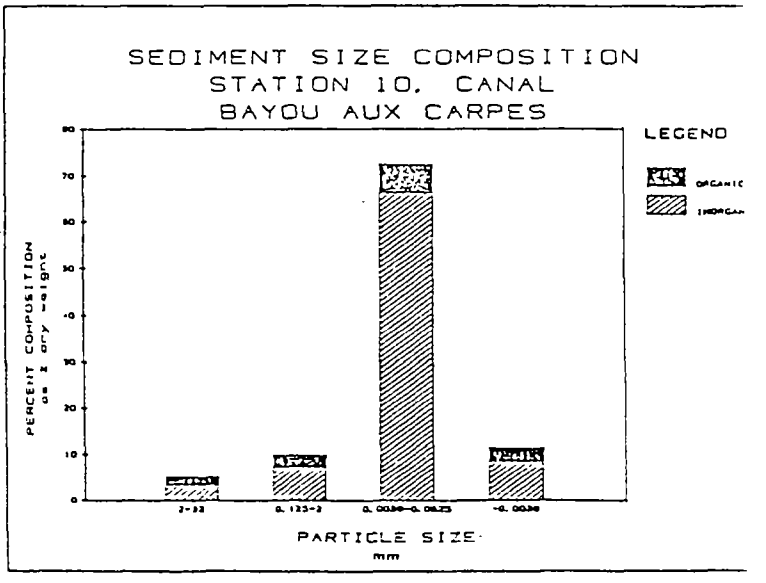
FIGURE 19.

SEDIMENT SIZE COMPOSITION, CANALS AND ICW,
BAYOU AUX CARPES.









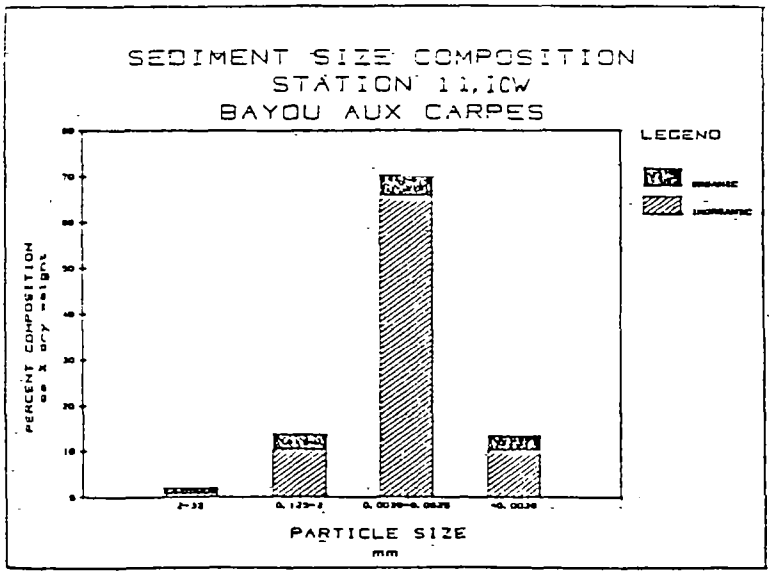
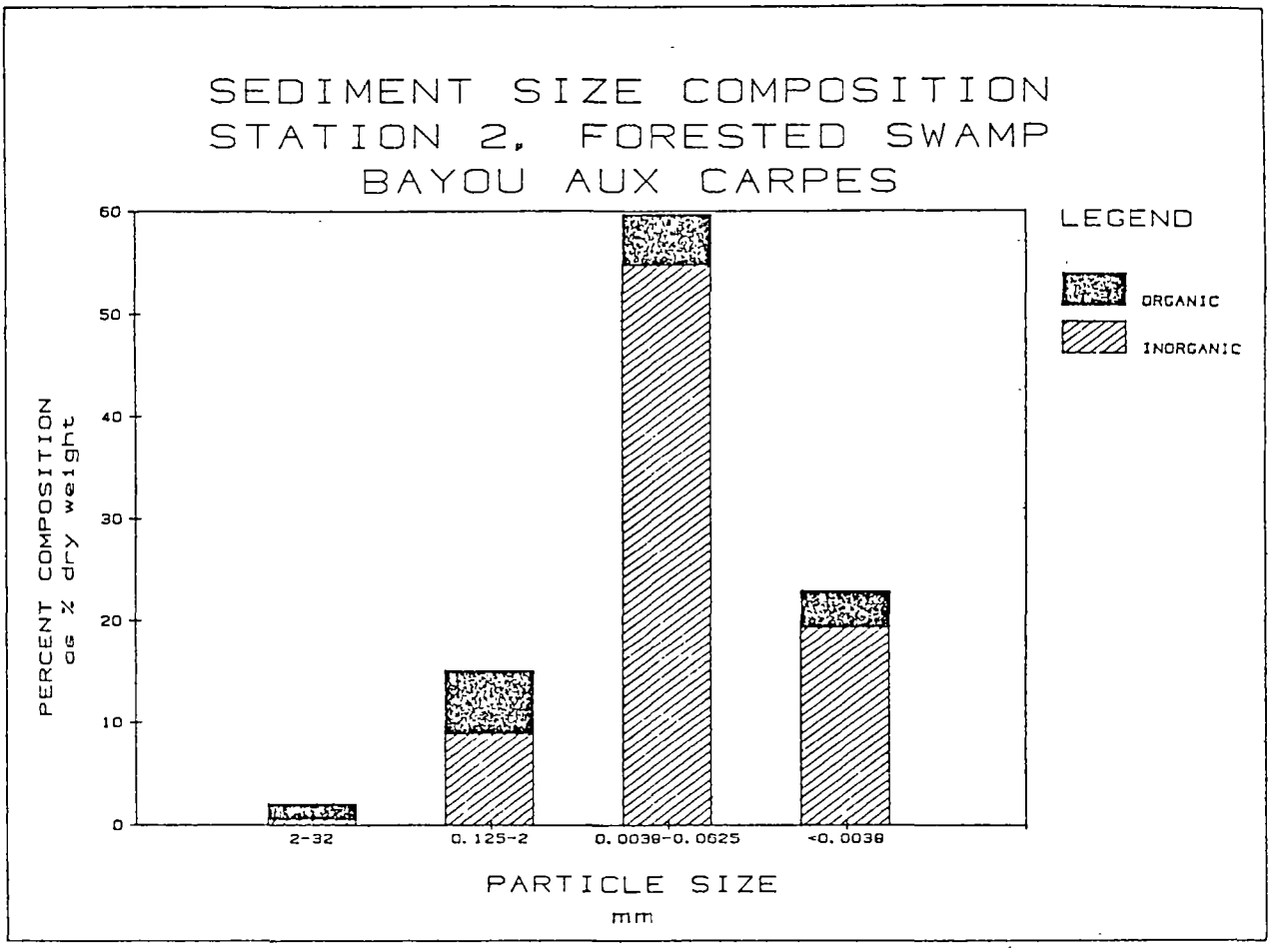


FIGURE 20.
SEDIMENT SIZE COMPOSITION, FORESTED SWAMP AND MARSH,
BAYOU AUX CARPES.



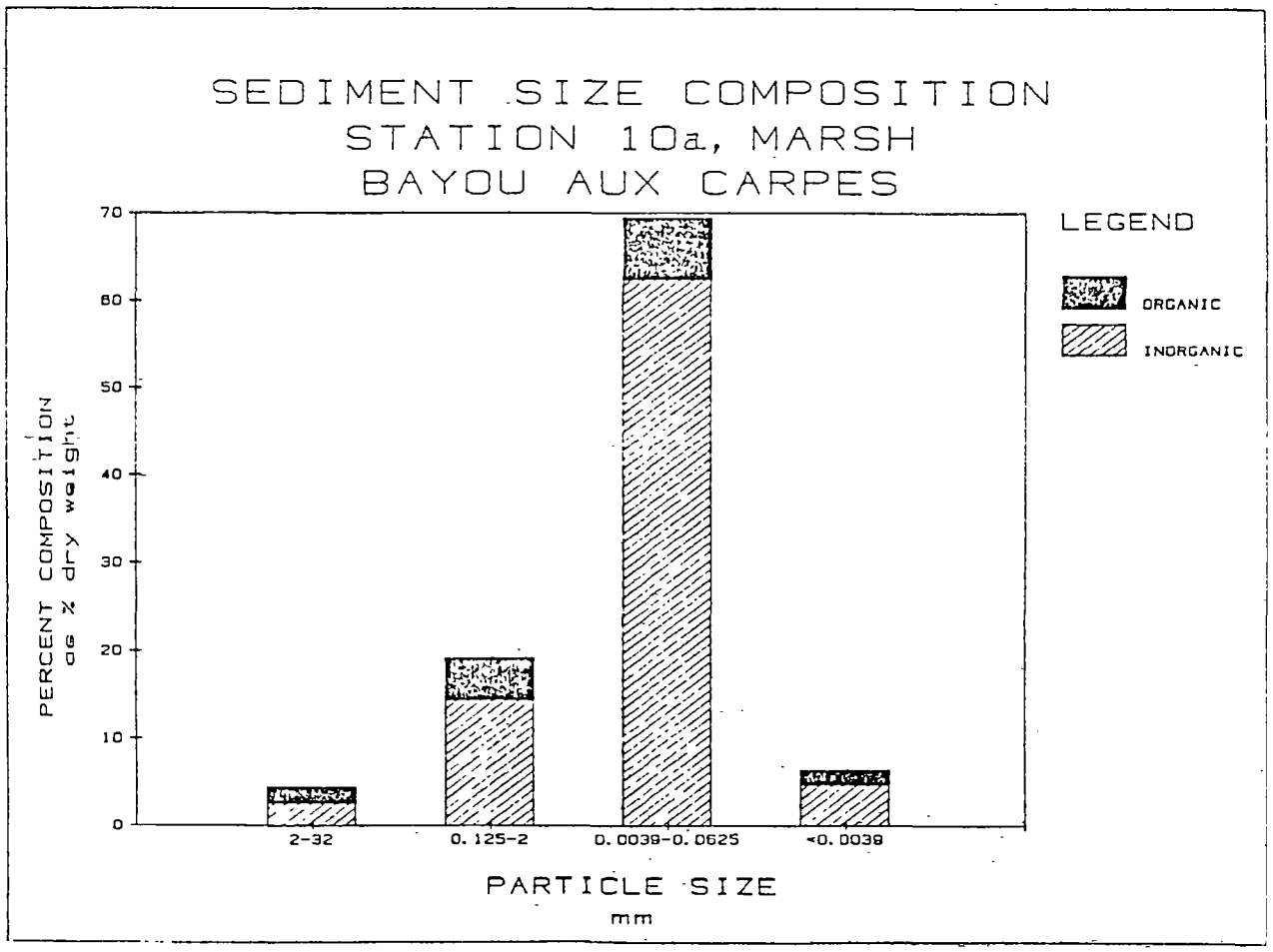
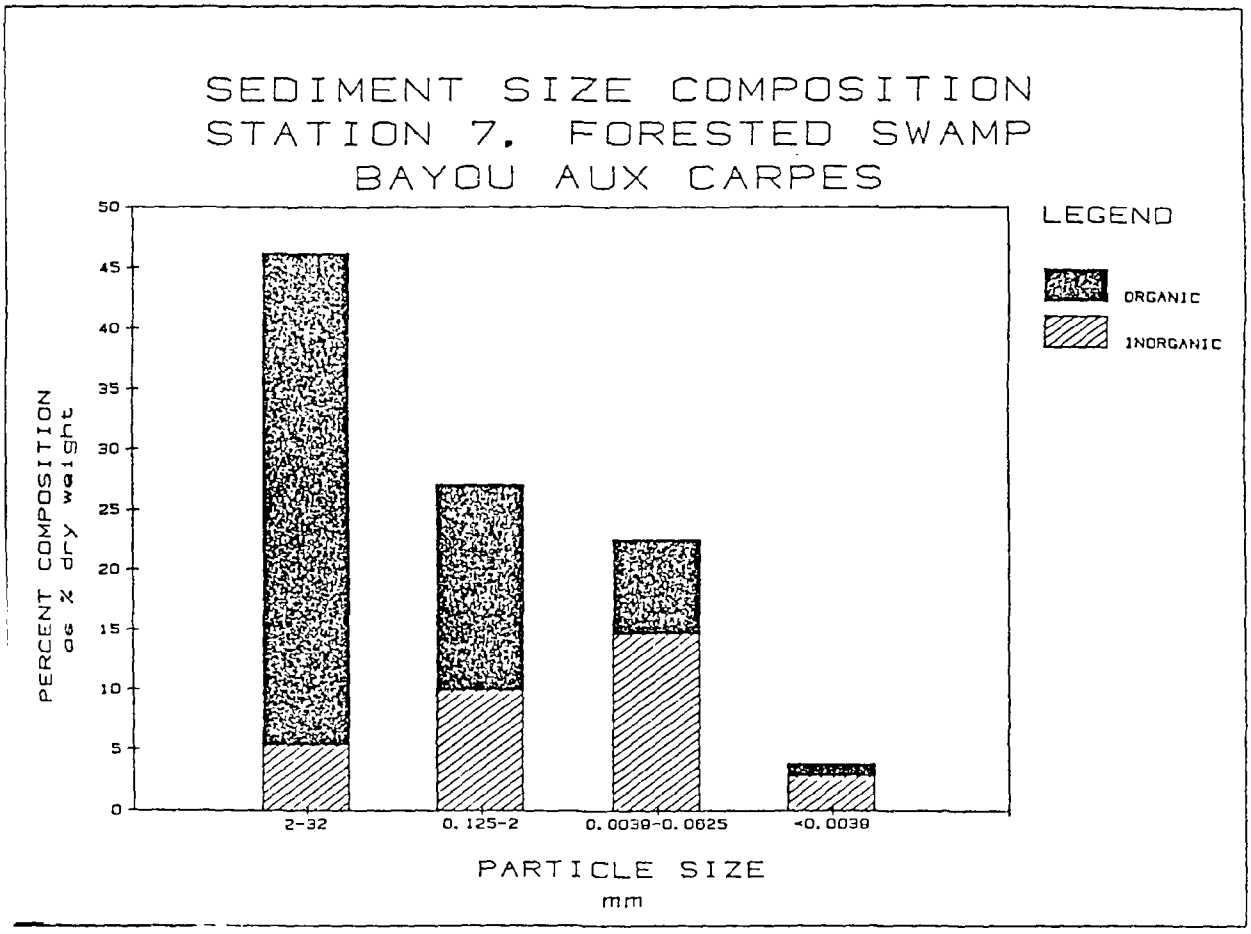


FIGURE 21.
SEDIMENT SIZE COMPOSITION, FORESTED SWAMP AND MARSH,
BAYOU AUX CARPES.



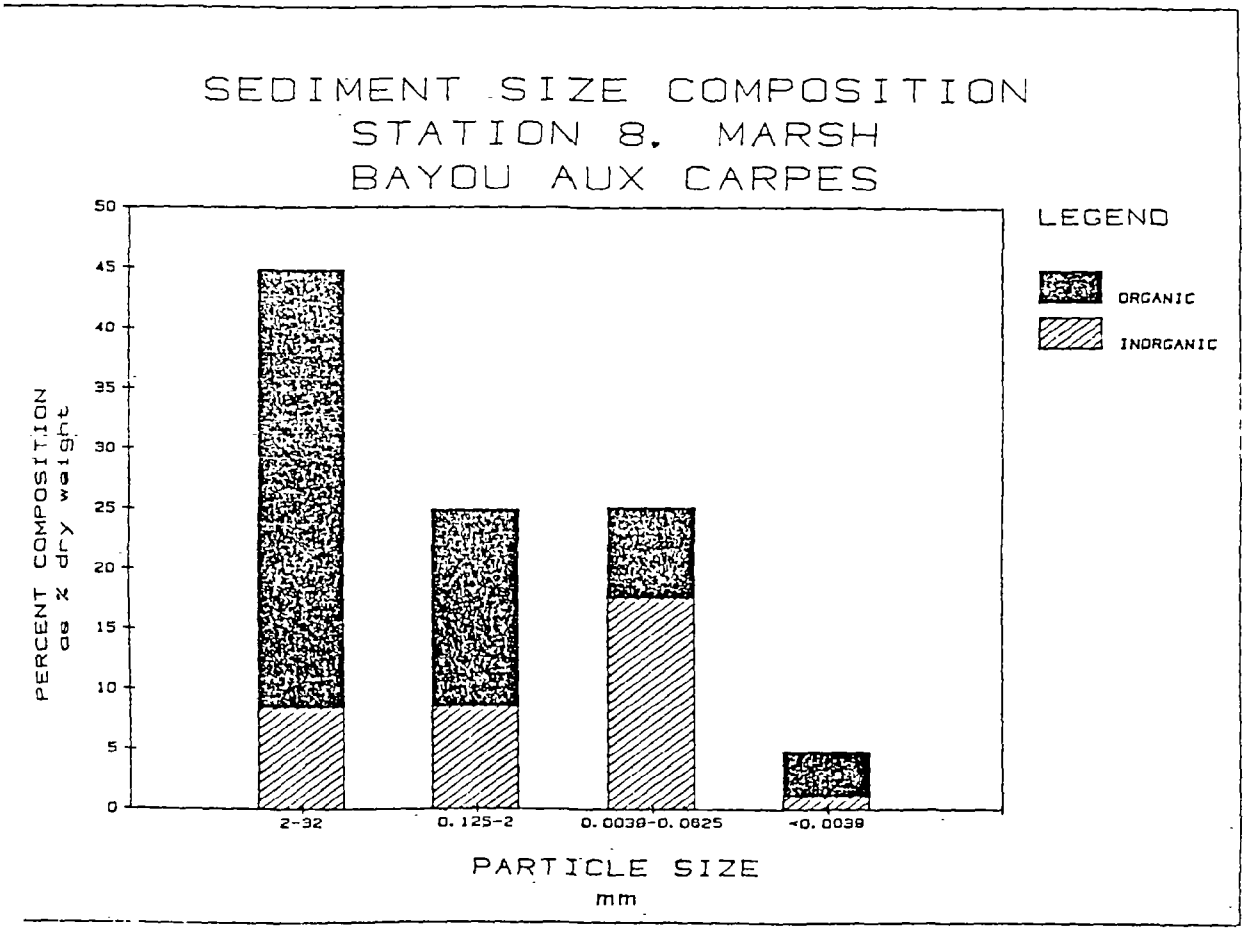


FIGURE 22
SEDIMENT METALS mg/kg [dry wt.]
BAYOU AUX CARPES
JANUARY, 1985

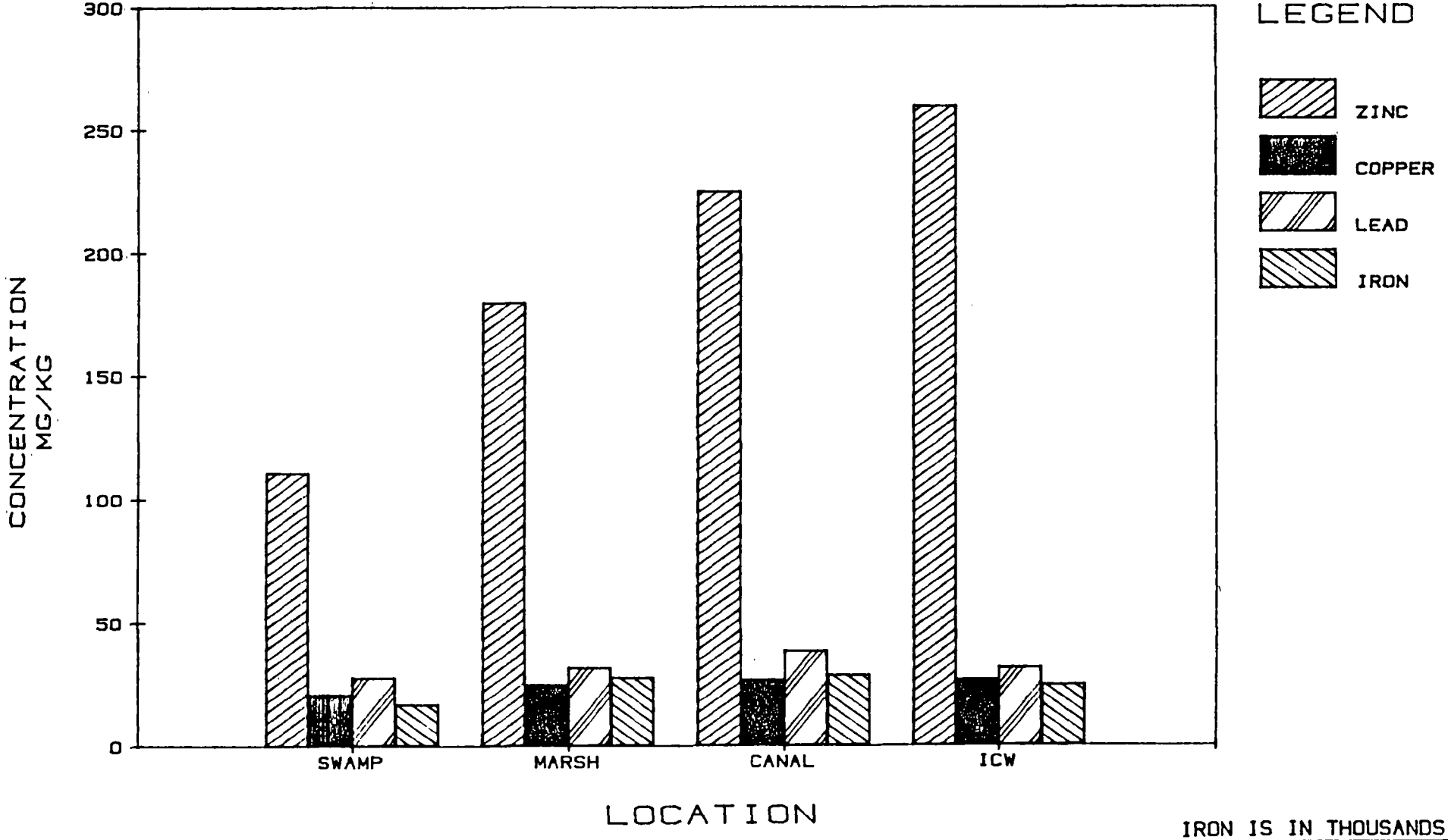
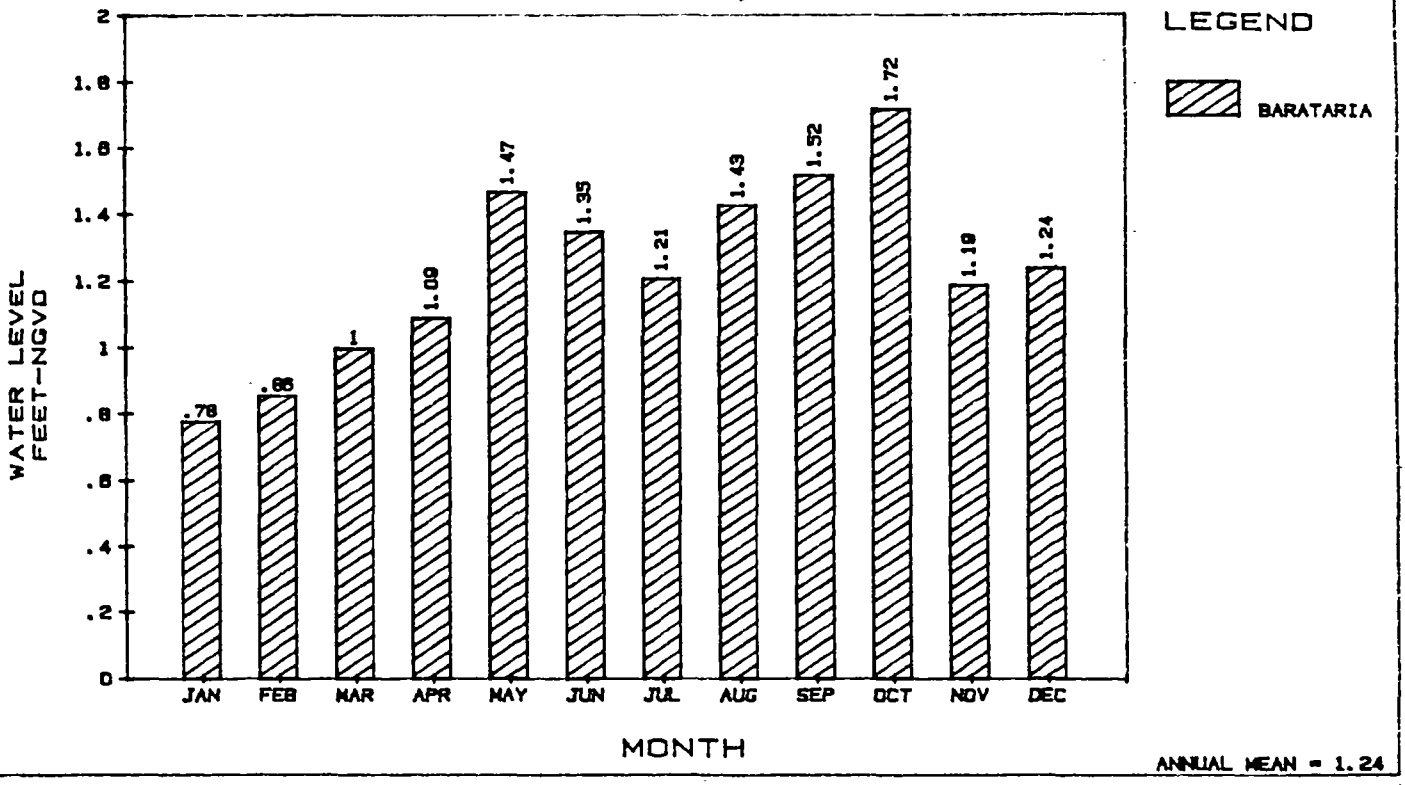


FIGURE 23
SEASONAL DISTRIBUTION
WATER LEVELS AT BARATARIA
JAN - DEC. 1984



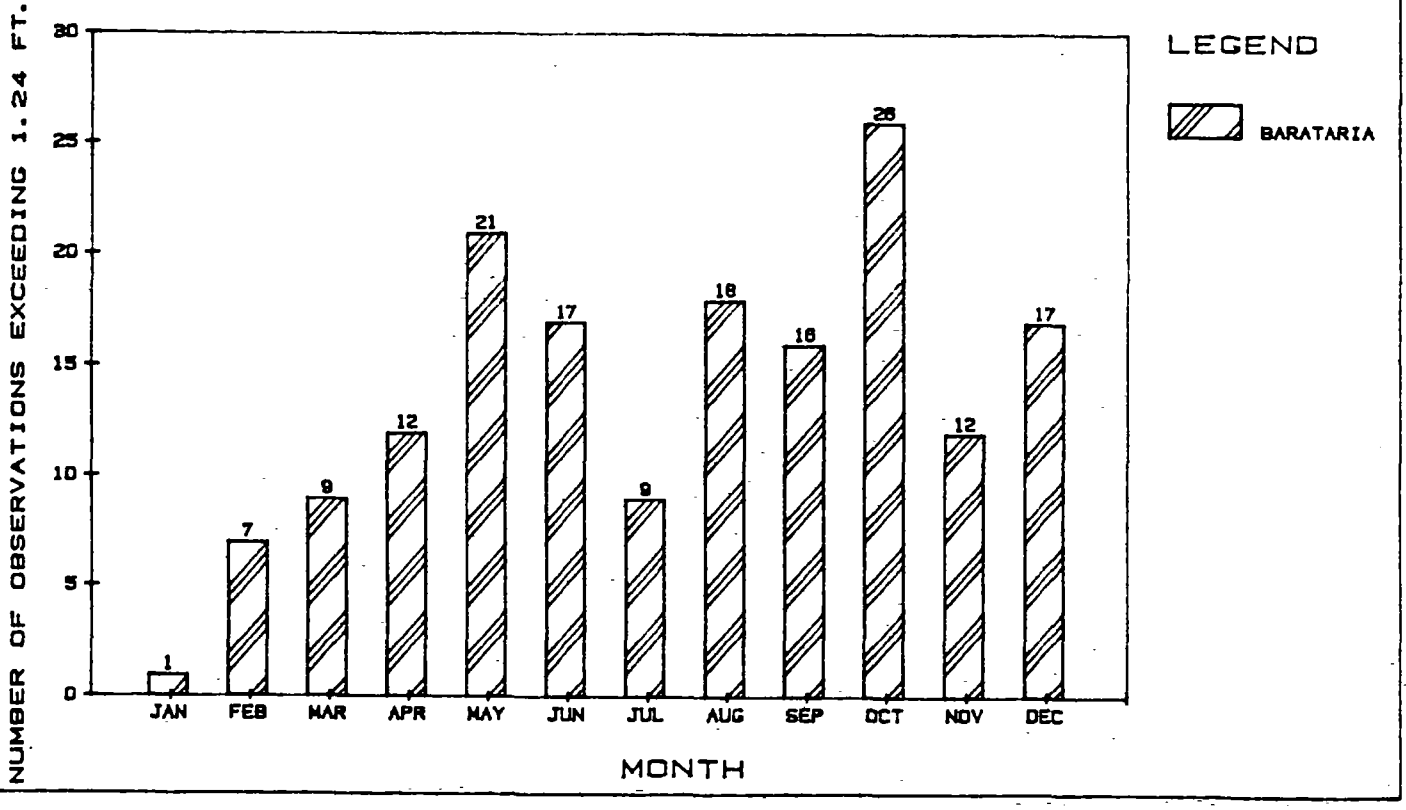
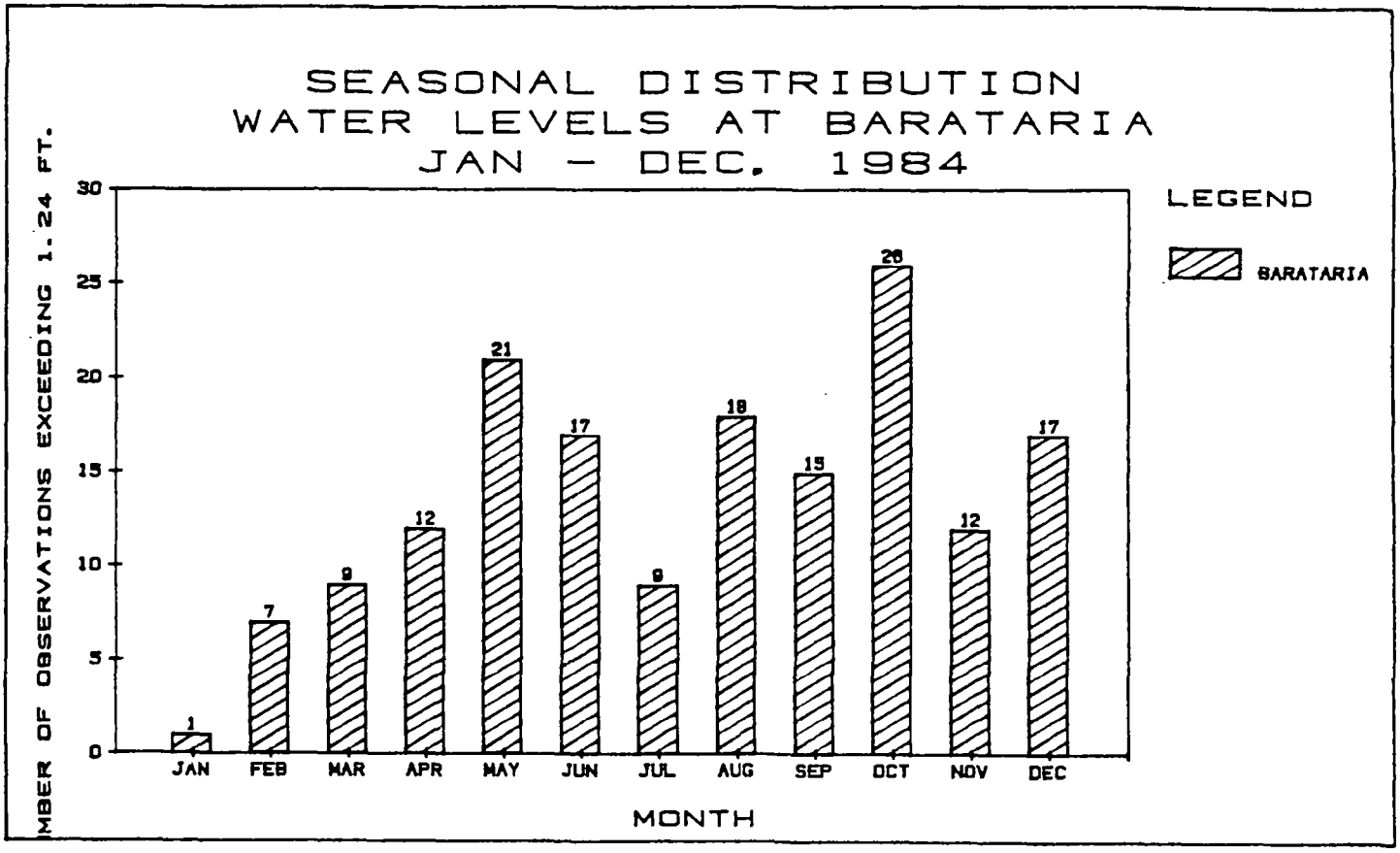


Figure 24


SEASONAL DISTRIBUTION
WATER LEVELS AT BARATARIA
JAN - DEC. 1984
NUMBER OF OBSERVATIONS EXCEEDING 1.24 FT.
30
25
20
15
10
5
0
1
7
9
12
21
17
9
18
15
26
12
17
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
LEGEND
BARATARIA

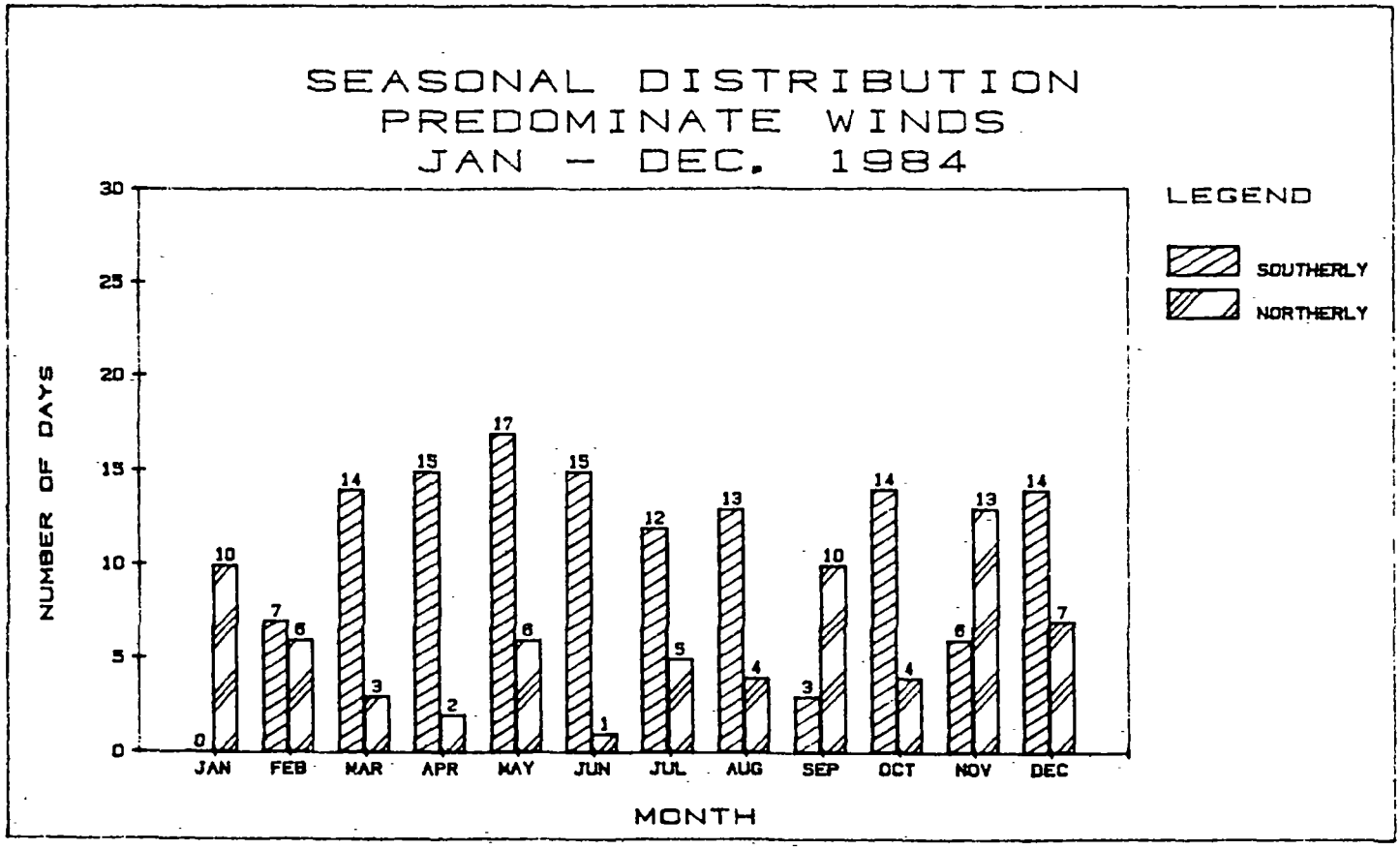
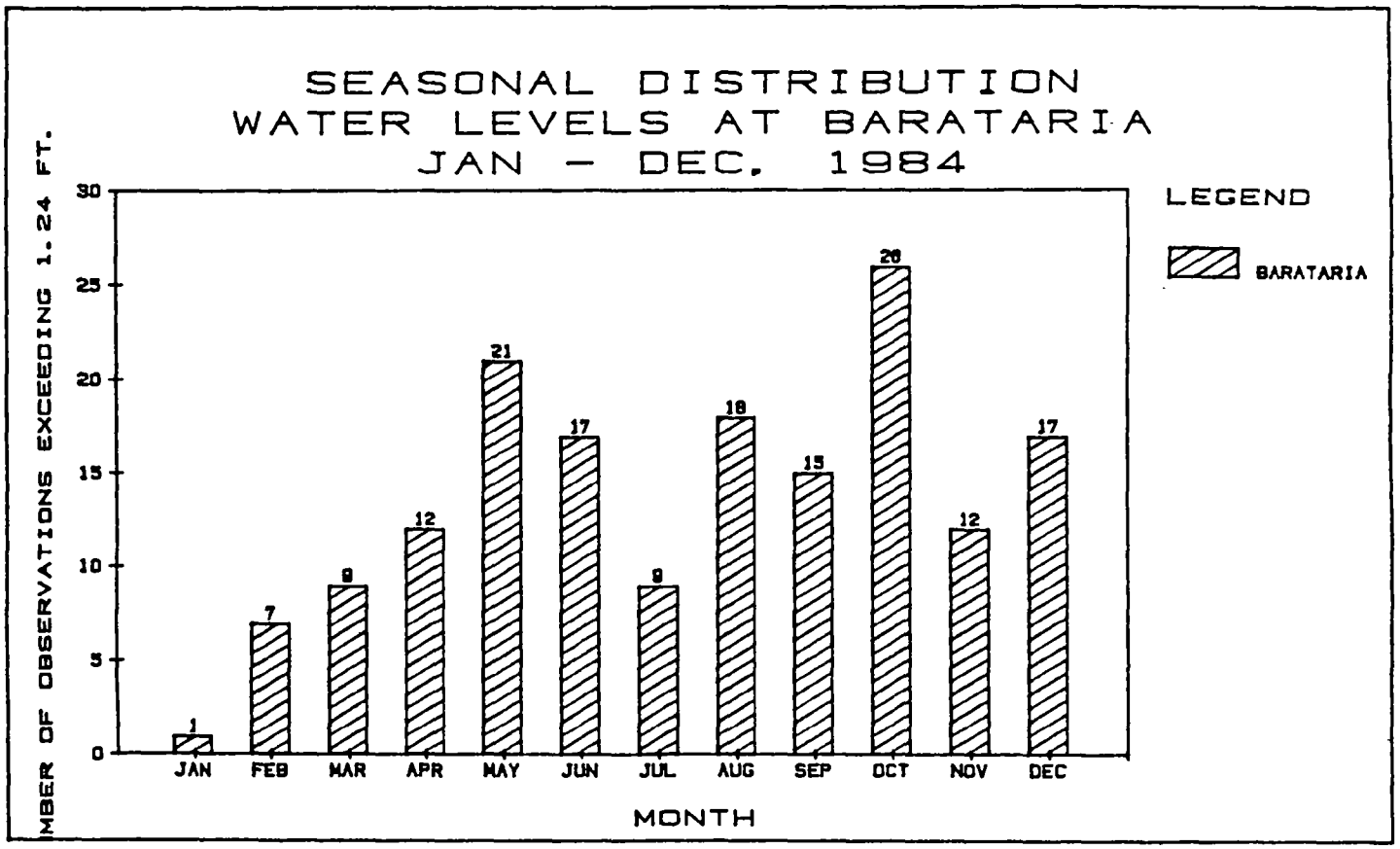
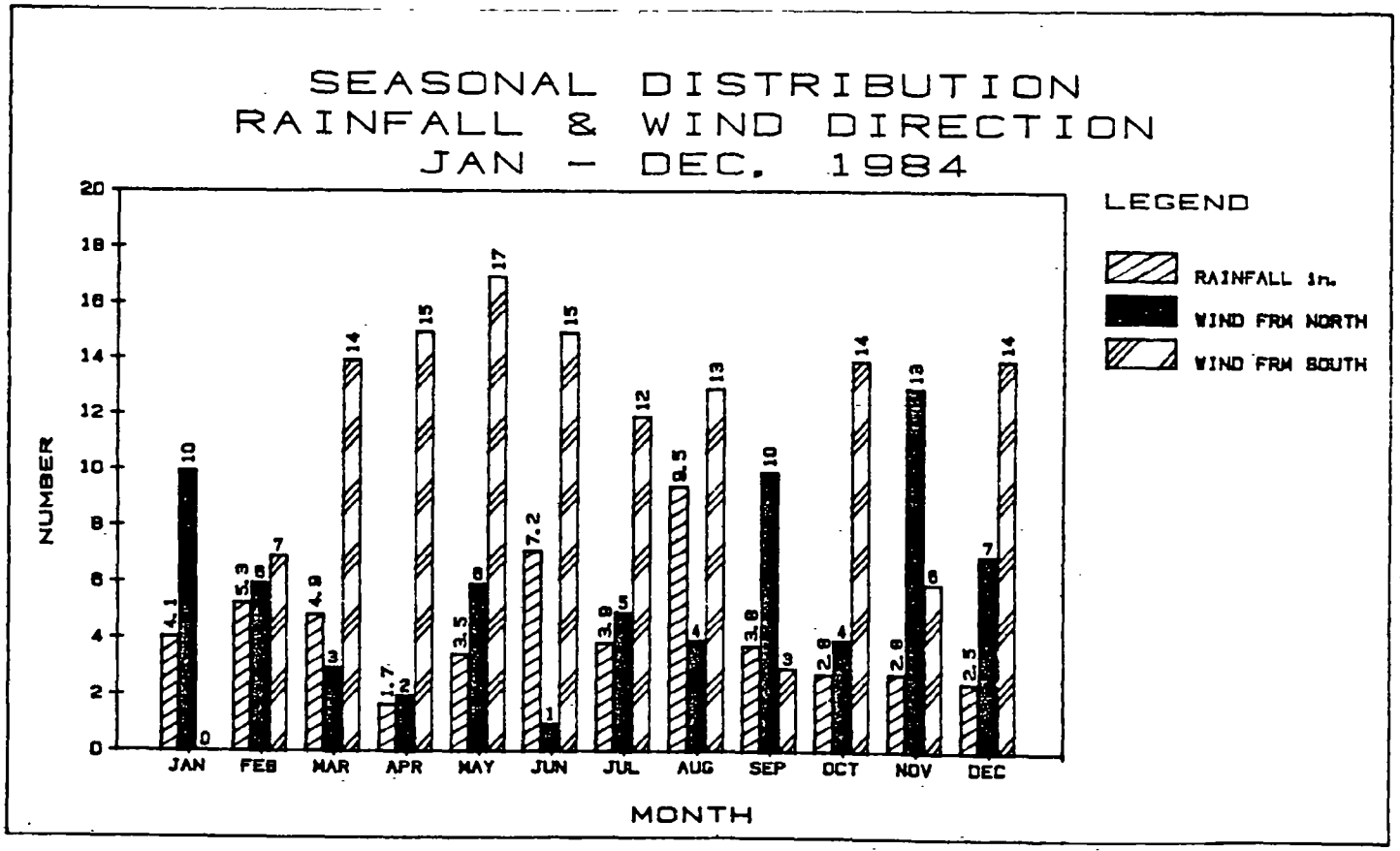

SEASONAL DISTRIBUTION
PREDOMINATE WINDS
JAN - DEC. 1984
NUMBER OF DAYS
30
25
20
15
10
5
0
0
10
7
6
14
3
15
2
17
6
15
1
12
5
13
4
3
10
14
4
6
13
14
7
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
LEGEND
SOUTHERLY
NORTHERLY

Figure 25


SEASONAL DISTRIBUTION
WATER LEVELS AT BARATARIA
JAN - DEC. 1984
MBER OF OBSERVATIONS EXCEEDING 1.24 FT.
30
25
20
15
10
5
0
1
7
9
12
21
17
9
18
15
26
12
17
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
LEGEND
BARATARIA


SEASONAL DISTRIBUTION
RAINFALL & WIND DIRECTION
JAN - DEC. 1984
NUMBER
20
18
16
14
12
10
8
6
4
2
0
4.1
10
0
5.3
6
7
4.9
3
14
1.7
1.2
15
3.5
6
17
7.2
1
15
3.9
5
12
9.5
4
13
3.8
10
3
2.8
4
14
2.8
13
6
2.5
7
14
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
LEGEND
RAINFALL in.
WIND FRM NORTH
WIND FRM SOUTH

APPENDIX A

APPENDIX A

Harvey Canal-Bayou Barataria Levee Project March 31, 1976

See Below

Mr. John C. White
Regional Administrator
EPA Region VI

SUMMARY

As requested, we have surveyed the subject project and offer the following conclusions. The 3,700-acre tract of wetlands, as it presently relates to the subject project, remains a valuable and viable parcel of swamp and marsh area. In view of the value of this resource, we consider Region VI's decision to request use of a floodgate instead of a pumping station as reasonable, appropriate, and justifiable.

ACTION

For your information.

BACKGROUND

At your request, we reviewed the present status of the subject project and determined if existing alterations have impaired the functioning of the 3,700-acre wetlands to the extent that environmental impacts of completing the project (i.e., pumped drainage of the wetlands) would be trivial. The review was completed the week of March 22 and consisted of briefings, a site visit to the project area and surrounding environs, and a review of available documents. The briefings were by Mr. Peter W. Dunsavage of your office and by staff members of the New Orleans District Corps of Engineers office (list of attendees at March 23, 1976, meeting is attached). The site visit was accomplished with the aid of a helicopter. Pertinent documents were provided by the COE staff.

To complete our evaluation, it will be necessary to briefly describe the site and the project as they relate to the Barataria Bay system.

The Site - The Harvey Canal-Bayou Barataria Levee project is an 11,700-acre (18.3-square-mile) tract located near the headwaters of the Barataria Bay system. The 3,700 acres (5.8 square miles) of the project with which we are concerned is predominantly a freshwater system of mainly swamp and some marsh. The site is near sea level, has an imperceptible gradient, and is subject to only a slight tidal influence (0.25 foot).

The Barataria Bay drainage basin, including the 3,700-acre site, is approximately 1,900 square miles and is characterized by distinct parallel zones of vegetation which are noted below.

- Freshwater swamps - Headwaters of the basin featuring swamp forests (cypress, gum, etc.) with salinity less than 1 ppt.

- Freshwater marshes - Immediately seaward of swamps and comprised mainly of herbaceous vegetation with salinity less than 1 ppt; extensive in upper-central portion of basin.

- Intermediate and brackish marshes - Transition zone from fresh to salt marsh with salinity 5 to 10 ppt.

- Salt marsh - Most seaward extension of vegetation (except for scattered mangrove stands near some of the isles) with average salinity near 17 ppt.

From the above it can be seen that these vegetational zones are highly correlated with a specific salinity regime, thus showing that spatial and temporal variation in the salinity gradient is controlled by freshwater runoff from the drainage basin where the annual rainfall averages 60 inches. Reversals of gradient occasionally occur during periods of high runoff from the Mississippi River.

According to the reports reviewed, Louisiana leads all states in the volume of commercial fish and shellfish harvested. Ninety percent of the harvest is of estuarine-dependent species. Barataria Bay, in turn, is described as the singly most productive estuarine area along the Louisiana coast. Reports of the LSU Center for Wetland Resources clearly indicate that Louisiana estuaries owe their high productivity largely to the extensive systems of marshes and swamps at the land-water interface and to the broad, brackish zones where salinity fluctuations are tempered by continuous freshwater inputs from interior storage areas (i.e., the freshwater swamps and marshes).

The Project - The Harvey Canal-Bayou Barataria project involves two distinct subareas:

- An 8,000-acre tract whose levees and pumping stations are installed and operated by local interests.

- A 3,700-acre tract immediately seaward of the 8,000-acre tract which was unleveed and undrained at the beginning of the federal project. For purposes of this discussion, reference to the "federal project" will allude specifically to the 3,700-acre tract.

Construction of initial levees for the "federal project" were completed by the Corps of Engineers in November 1973. Gaps in the levee were left at Bayou Aux Carpes, the Southern Natural Gas pipeline, and a partial opening at Bayou Des Familles. Subsequent to completion of the levee, local interests have completed closure of the Bayou Aux Carpes opening using clam-shell fill. Plans call for reclamation of the 3,700-acre tract by pump drainage via a pumping station to be installed at the Bayou Aux Carpes closure. At present, circulation of water between the 3,700-acre tract and the Intracoastal Waterway is via the Southern Natural Gas pipeline canal.

Importance of Site - Freshwater swamps and marshes in coastal areas perform several critical functions including:

- Efficient producers of organic matter which support an indigenous fauna, and surpluses are exported to fuel downstream systems.
- Serve as freshwater storage and recharge areas which control the rate and timing of freshwater inputs to downstream estuaries, thus maintain a broad zone of salinity gradient throughout the year.
- Support an indigenous flora and fauna which is of direct value to man for recreation, esthetics, sport fishing, and timber production.

Based on observations made during our visit, the 3,700-acre tract is still performing all of the above functions. The Cypress-Tupelo Swamp and the fresh marshes will remain viable as long as they are not drained. It is reasonable to expect that they will continue to produce significant quantities of organic matter to fuel the system. Closure of Bayou Aux Carpes and the reduction of sheet flow from the system has undoubtedly lessened the esport of organic matter to downstream systems; however, the Southern Natural Gas pipeline canal still serves as a major export route of organic material produced in the swamps and marshes. Installation of a floodgate at Bayou Aux Carpes, as recommended by EPA Region VI would provide an additional avenue for export of detritus to downstream systems.

Perhaps the most important function of the freshwater swamps and marshes in the Barataria Bay system is the amelioration of fluctuations in freshwater inputs to the estuary during periodic wet and dry periods. Since the swamp and marsh are intact and connected to the rest of the system via the pipeline canal, this important function is still taking place.

According to reports of the LSU Center for Wetland Resources, the salinity of Barataria Bay is determined by basin runoff and inputs from the Mississippi River. The basin runoff, however, is the major determinant of the salinity gradient and also serves in a buffering capacity to maintain uniform salinity throughout the water year. According to these same reports, the 3,700-acre tract is part of the zone of major freshwater storage for the Barataria Bay system. Loss of such storage areas via drainage increases the amplitude of salinity variations in the brackish zone.

A brief example illustrates the change in freshwater runoff characteristics brought about by pump drainage:

Hydrologic data:

1. Annual rainfall = 60 inches
2. Annual runoff = 20 inches (40 inches consumed by evapotranspiration)
3. Rate of discharge following rainfall = 0.20 inch per day.

Thus:

1. From 2 above, the mean annual runoff rate from 3,700 acres = 8.5 cfs

2. From 3 above, the runoff rate following rainfall = 31.1 cfs

Based on this analysis, it is apparent that the initial 150-cfs pump to be installed will move rainfall at a rate five times greater than the natural system. As pointed out by the Corps, the initial 150-cfs installation will only drain a portion of the area. Larger-capacity pumps will ultimately be installed, thus further increasing the rate of de-watering as compared with the natural system.

Finally, we have no doubt that the existing 3,700 acres of wetlands continues to support an indigenous biota of direct value to man. The present diking of the 3,700 acres of wetlands may have reduced public access to the area; but it fails to eliminate any of the recreational, esthetical, or sport-fishing features of the tract. In addition, the potential timber value of the cypress trees remains as a renewable resource if the area is not drained.

Writers: L:.B. Tebo, Jr., S&A, Region IV
Delbert B. Hicks, S&A, Region IV
Thomas R. Cavinder, S&A, Region IV
Victor W. Lambou, EM&S Lab., Las Vegas

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