CIRCULATION AND BENTHIC CHARACTERIZATION STUDIES ESCAMBIA BAY, FLORIDA

Environmental Protection Agency
Water Quality Office
Southeast Water Laboratory
Technical Services Program
Athens, Georgia

February 1971

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INTRODUCTION

The "Effects of Pollution on Water Quality - Escambia River and Bay, Florida"(1) were investigated during a period of low Escambia River discharge (1,068 cfs) in September and October, 1969. The tidal circulation and bottom sediment characteristics of the bay were reported. Further circulation and more extensive sediment characterization studies were made in June, 1970, at much higher river flows (59,533 cfs). This report presents these results and compares them with those of the 1969 study.

FINDINGS

Both studies show that Escambia Bay sediments are highly organic and tidal circulation in Upper Escambia Bay is poor. Because of these conditions, sediment disturbances--such as result from dredging--can cause severe oxygen depletion. Massive fish kills could result.

Escambia Bay circulation is generally counterclockwise at both low and high Escambia River flows (1,068 and 59,533 cfs). Water flows out from the west portion of the bay; saline water intrudes on the eastern side. Fresh-water flushing is more significant than saline water circulation exchange when river discharge exceeds the mean annual discharge. The Escambia River flows southeastward into the bay, creating a large eddy current counterclockwise to the north, which impedes tidal exchange in Upper Escambia Bay. During low-flow periods, the small creeks in the extreme northern end of the bay do not discharge a sufficient amount of fresh water to flush the area, and persistent pollutants are effectively trapped.

The piling--primarily unused and unnecessary piling--of the Louisville and Nashville Railroad Company bridge restricts circulation between Upper and Lower Escambia Bay.

Organic carbon content of bay sediment ranges from 2.3 to 5.0%. Sediment containing more than 3.0% organic carbon covers 46% of the upper bay. These results agree with the previous study.

About 40% of the upper bay sediment contains more than 0.2% total organic nitrogen; 35% of the same area contains more than 0.03% phosphorus. Total oxygen demand (TOD) of sediments ranged from 25 to 100 g/kg (dry weight). Thirty percent of upper bay sediment TOD exceeds 100 g/kg.

Unconsolidated sediment depth ranged from less than two to greater than six feet. About one-third of the upper bay is covered with unconsolidated sediment greater than six feet deep.

The benthic characterization study also shows counterclockwise bay circulation. The benthic study suggests that wastes discharged along the eastern shore of the bay (from American Cyanamid and Escambia Chemical companies) are generally swept northwestward and deposited along with wastes from Monsanto and Container Corporation in the central and western portions of the upper and lower bay.

RECOMMENDATIONS

1. Recommendations Numbers 1 and 2 of the 1970 Federal-State Enforcement Conference(2) which deal with adequate treatment and/or complete removal of Escambia Bay waste sources should be implemented at the earliest date in order to eliminate the continued buildup of organic sediment deposits in Escambia Bay.
2. The prohibition on construction and control of maintenance dredging, Enforcement Conference Recommendation Number 4, should be extended until the artificial buildup of organic sediment deposits ceases and these deposits stabilize. Spoil from all dredging--now and in the future--should be deposited on diked upland locations.
3. Modification of the Louisville and Nashville Railroad trestle, Enforcement Conference Recommendation Number 5, should include removal of unused and unnecessary bridge piling and old construction debris. This should minimize any effect the bridge has on bay circulation.

PHYSIOGRAPHY

Gemorphology

Escambia Bay is one of the northeast branches of Pensacola Bay (see foldout map). It is a relatively shallow body of water, ranging from one to 20 feet deep, averaging eight feet at mean low water (M.L.W.). Water depth increases from the northern end southward to the mouth, a distance of 11 miles.

The Escambia River enters the bay along the western shore approximately 2½ miles south of the head of the bay. Marshy wetlands and small creeks characterize the north end of the bay. The principal physiographic features of the eastern shore include Mulatto Bayou, located across the bay and south of the Escambia River mouth, and Indian and Trout Bayous, located just south of mid-bay. The bay is approximately two miles wide from its extreme northern portion to the Escambia River. The bay width increases to 3½ miles just below the Escambia River, decreases to approximately two miles between Lora and Live Oaks points, then increases relatively uniformly to its maximum of 5½ miles at the mouth. The surface area of the bay is 24,300 acres (1.02×10^9 square feet) and the volume is 194,400 acre-feet (8.47×10^9 cubic feet), both at M.L.W.

The principal man-made features of the bay include: The U. S. Highway 90 bridge, which crosses the bay at the extreme northern end; the L&N Railroad bridge, which crosses the bay between Lora and Live Oaks points; and the I. S. Highway 10 bridge, which crosses the bay just south of the L&N Railroad bridge. A 100-foot wide navigation channel, maintained at a depth of ten feet (M.L.W.), traverses the bay from north to south.

For the purpose of this report, the bay will be artifically divided into Upper Escambia Bay--that portion of the bay north of the L&N Railroad bridge--and Lower Escambia Bay. Upper Escambia Bay has a surface area of 7,000 acres (3.05×10^8 square feet), a volume of 35,000 acre-feet (1.52×10^9 cubic feet), and a mean depth of five feet, all at M.L.W. The lower bay has a surface area of 17,300 acres (7.54×10^8 square feet), a volume of 159,400 acre-feet (6.94×10^9 cubic feet), and a mean depth of nine feet, all at M.L.W.

Hydrology

The principal fresh-water input to Escambia Bay is the Escambia River. The Escambia River is 91.8 miles long and drains 4,200 square miles of southeastern Alabama and northwestern Florida. The majority of the drainage basin in in Alabama and is characterized by hilly terrain with many perennial streams.

The furthest downstream measurement of discharge is the U. S. Geological Survey gaging station at river mile 48.8 near Century, Florida. The drainage basin area above the gage is 3,817 square miles. Based on a 30-year record at this station, the maximum recorded river flow is 77,200 cfs, and the minimum is 596 cfs. The seven-day minimum flow with a recurrence interval of ten years is 785 cfs. Table I shows the mean monthly flows for the water years 1951-1966. The mean annual discharge for the period of record was 5,460 cfs(3, 4, 5).

The Escambia River discharge during the studies of September, 1969, and June, 1970, is shown in Table II. Allowing for a four-day time of travel (1) from Century, Florida, to Escambia Bay, the average discharge during the study periods was 1,068 cfs and 59,533 cfs respectively.

Table I

ESCAMBIA RIVER NEAR CENTURY, FLORIDA

MONTHLY MEAN DISCHARGE

1951-1966 Water Years

cfs

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	ANNUAL
Maximum	12,970	21,160	19,630	26,960	16,160	8,910	7,022	6,143	6,037	8,735	6,971	24,600	26,960
Mean	6,045	9,197	10,409	11,420	5,044	3,211	3,187	2,539	2,651	2,743	2,477	5,434	5,460
Minimum	1,895	3,588	1,783	2,995	1,556	1,256	1,365	939	708	666	1,033	1,157	666

Table II

ESCAMBIA RIVER DISCHARGE NEAR CENTURY, FLORIDA

September 1969 and June 1970 Studies

DATE	MEAN DAILY DISCHARGE cfs
Sept. 1969	
17	932
18	914
19	914
20	1,030
21	1,260
22	3,960
23	9,130
24	11,600
25	11,500
June 1970	
1	18,300
2	26,600
3	37,600
4	56,800
5	65,700
6	56,100
7	51,200
8	49,900
9	51,000
10	52,800
11	49,800

Provisional discharge
NOTE: Data supplied by the USDI, Geological Survey, Tallahassee, Florida.

Library

Tidal Considerations and Flushing Characteristics

Tides in the Pensacola Bay system are of the mixed type with generally one high and one low tide daily. Escambia Bay has a tidal range of 1.5 feet at Lora Point, which is larger than the 1.1-foot tidal range at the entrance to Pensacola Bay(6). During the September, 1969, and June, 1970, studies, a tide gage was located at McMillan's Fish Camp (see foldout map) to record relative tide heights, which are shown in Figures 1 and 2.

The tidal prism is one of the flushing parameters of an estuary, defined as the mass of water exchanged on an average tidal cycle. The tidal prism of Escambia Bay is 36,450 acre-feet (1.59×10^9 cubic feet). compared to a total bay volume of 194,400 acre-feet (8.47×10^9 cubic feet). Therefore, 18.8% of the bay volume is exchanged every tidal cycle due to tidal considerations only. Another flushing parameter is the displacement time, defined as the time required to fill, or displace completely, the volume of an estuary with the incoming fresh water. The displacement time for Escambia Bay as a whole is 18.0 days; for Upper Escambia Bay alone it is 3.2 days (both based on the mean annual river discharge).

Climatology

The mean annual temperature for the Pensacola area is 68°F, and the average rainfall is 63 inches. Monthly temperatures and rainfall variations for Pensacola, which influence circulation patterns in Escambia Bay, are shown in Table III(7).

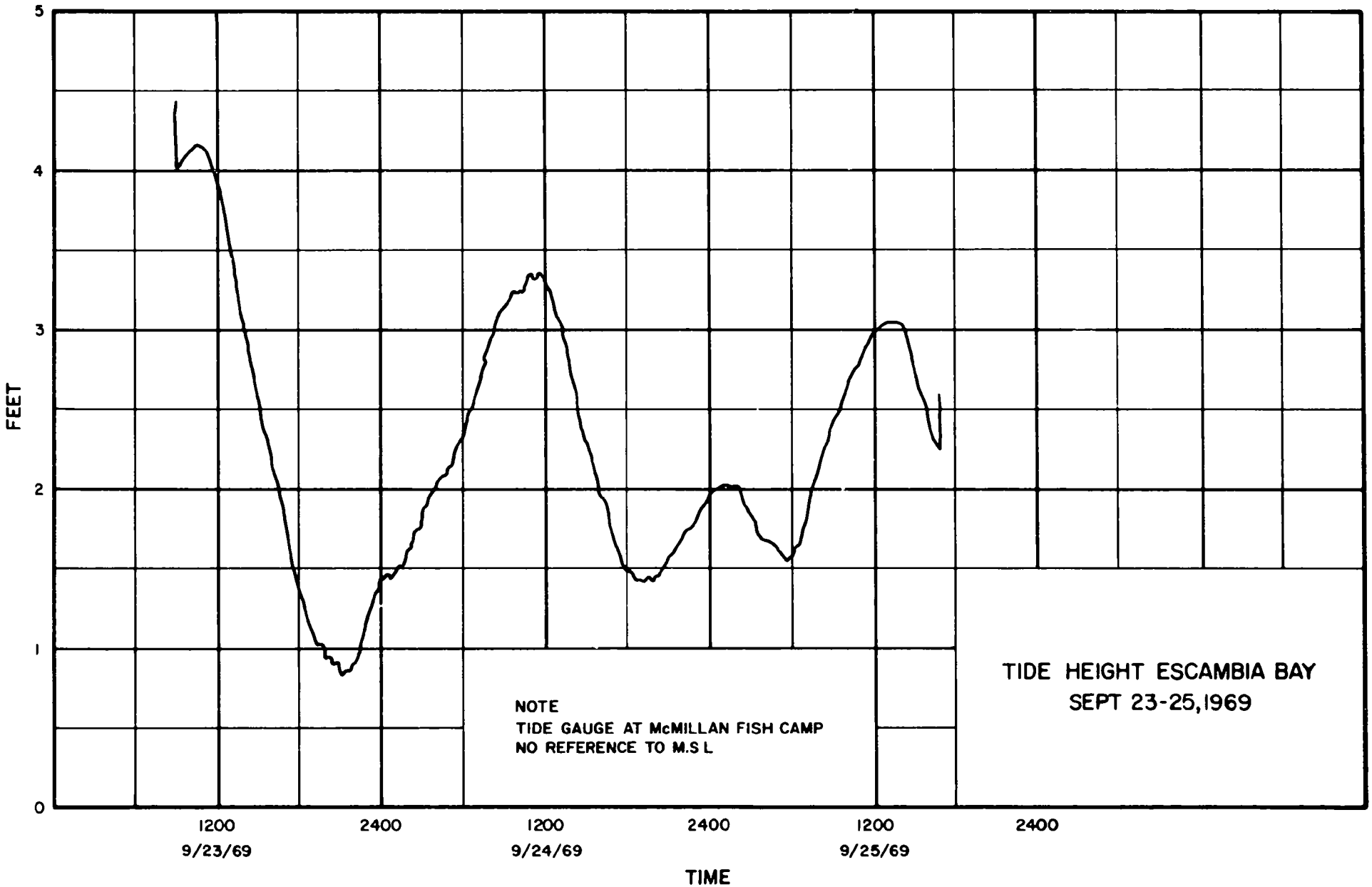

5
4
3
2
1
0
FEET
1200
9/23/69
2400
1200
9/24/69
2400
1200
9/25/69
2400
TIME
NOTE
TIDE GAUGE AT McMILLAN FISH CAMP
NO REFERENCE TO M.S L
TIDE HEIGHT ESCAMBIA BAY
SEPT 23-25,1969

FIGURE 1

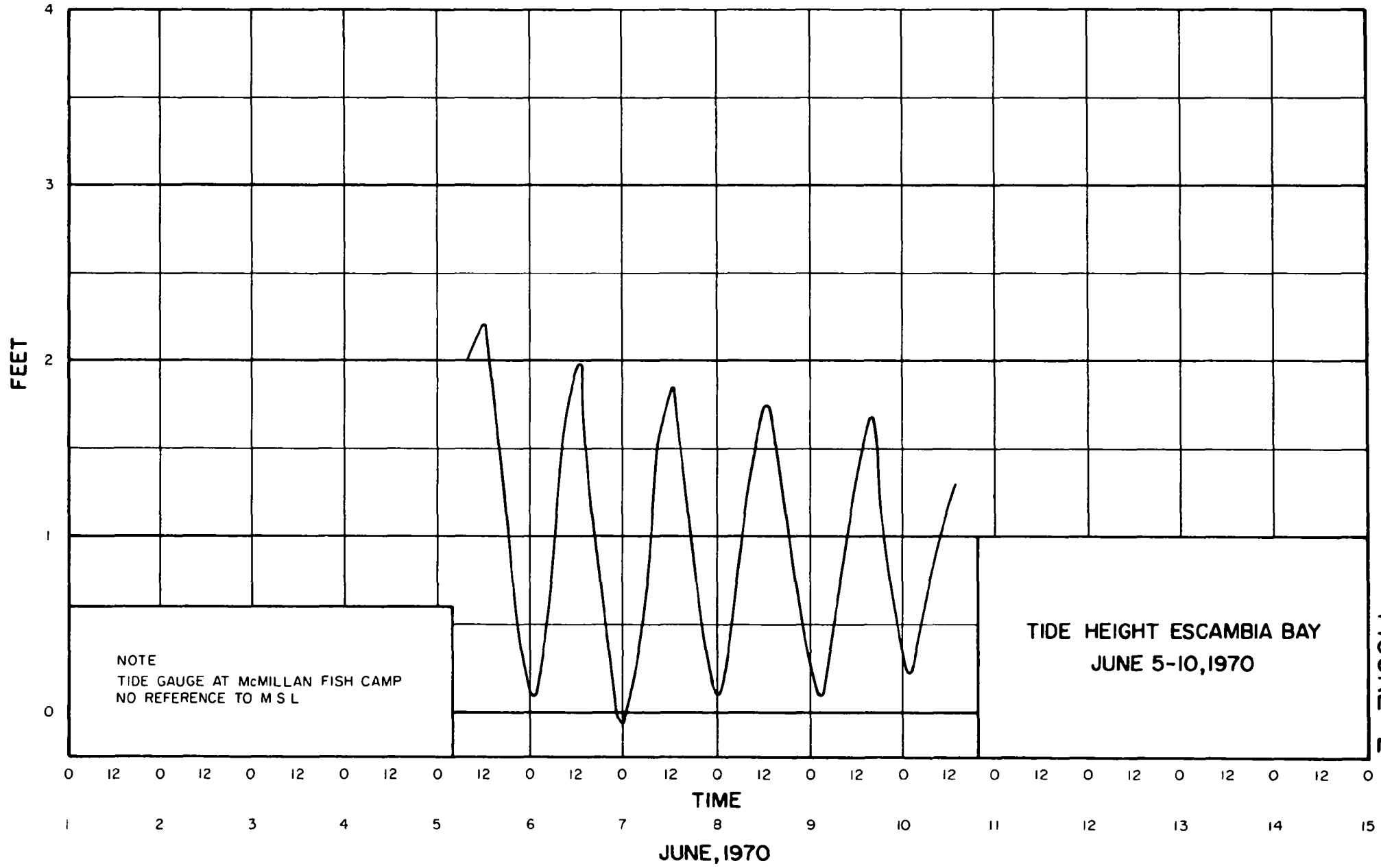

FEET
4
3
2
1
0
NOTE
TIDE GAUGE AT McMILLAN FISH CAMP
NO REFERENCE TO M S L
TIDE HEIGHT ESCAMBIA BAY
JUNE 5-10,1970
0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0 12 0
TIME
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
JUNE, 1970

FIGURE 2

Table III

MEAN TEMPERATURE AND RAINFALL DATA

Pensacola Airport Weather Station

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	ANNUAL
Temp. ^{o}F	53.5	56.1	61.0	67.9	75.5	81.1	81.7	81.5	78.2	70.4	59.5	54.3	68.4
Rainfall (inches)	4.22	4.25	6.04	5.25	4.56	5.43	8.02	6.97	7.69	2.98	3.24	4.22	62.9

Mean values represent 30-year average for period 1931-1960.

CIRCULATION

Dispersion and advection of freshwater into an estuary can be measured through the use of chloride data. The major factors affecting chloride concentrations in an estuary are: advection caused by freshwater input, and turbulent diffusion caused by tidal and wind action. The principal source of freshwater to Escambia Bay is the Escambia River. The effects of Escambia River discharge on the dispersion and advection patterns in the bay can be seen from chloride isopleths traced from synoptic chloride data.

Circulation Studies at High Escambia River Discharge (59,533 cfs)

The predominate circulation patterns in Escambia Bay for high discharge are illustrated in Figures 3 and 4. These current patterns were derived from synoptic sampling at thirty-three sampling stations in Escambia Bay during the period June 8-10, 1970. Advection during this study caused by the discharge of the Escambia River (which was near the historical peak of 77,200 cfs of April 5, 1960) was more important than dispersive or tidal forces. As a consequence, the waters of Upper Escambia Bay were essentially fresh (chloride range: 4-143 mg/l) and distinct chloride gradients necessary for accurate interpretation of current patterns were not present. However, a general picture of the upper bay circulation patterns was obtained.

During flood tide some freshwater from the Escambia River spread over the surface of the upper bay (Figure 3). Most of the freshwater moved down the bay, west of the bay centerline, approximately paralleling

FIGURE 3

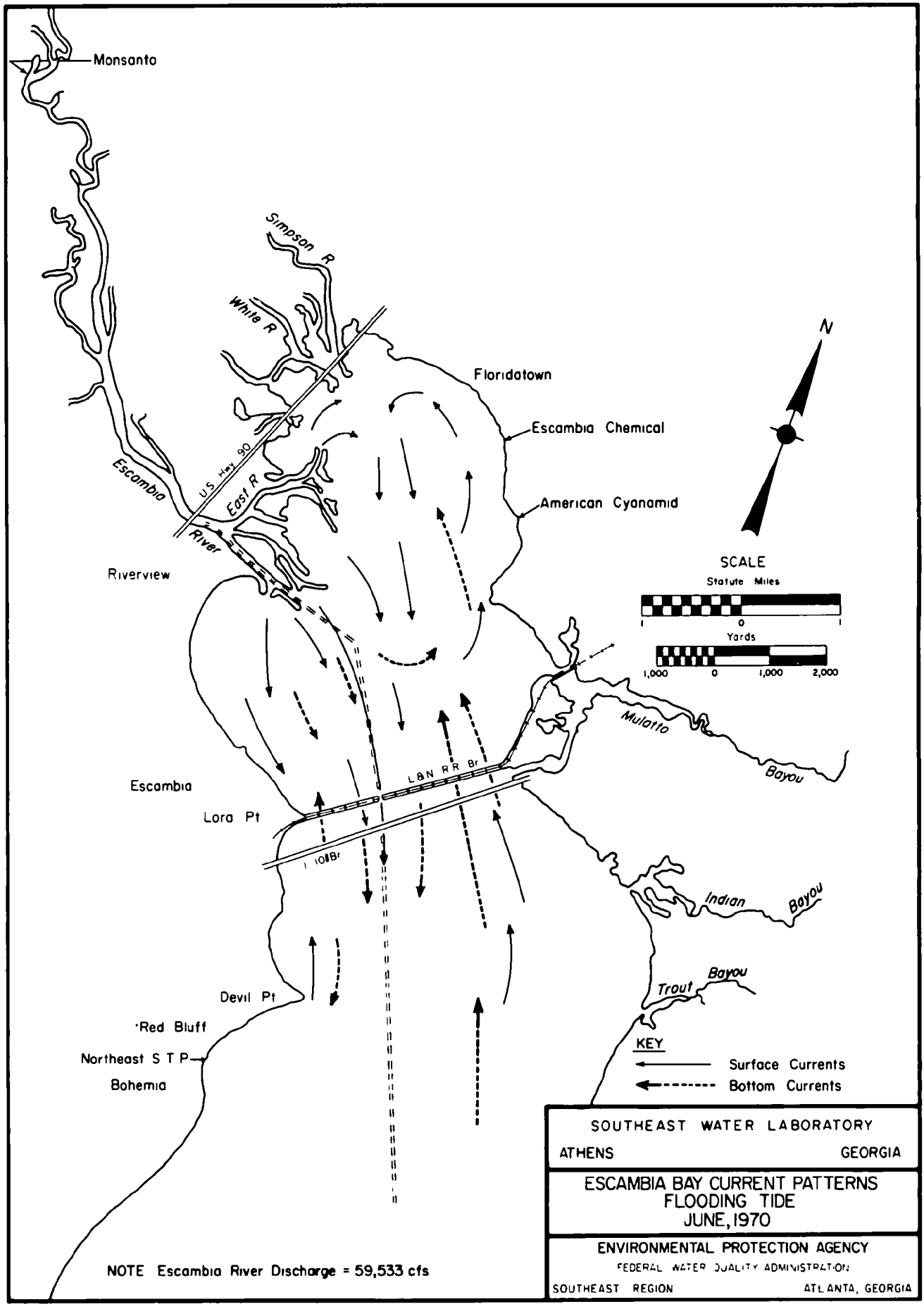
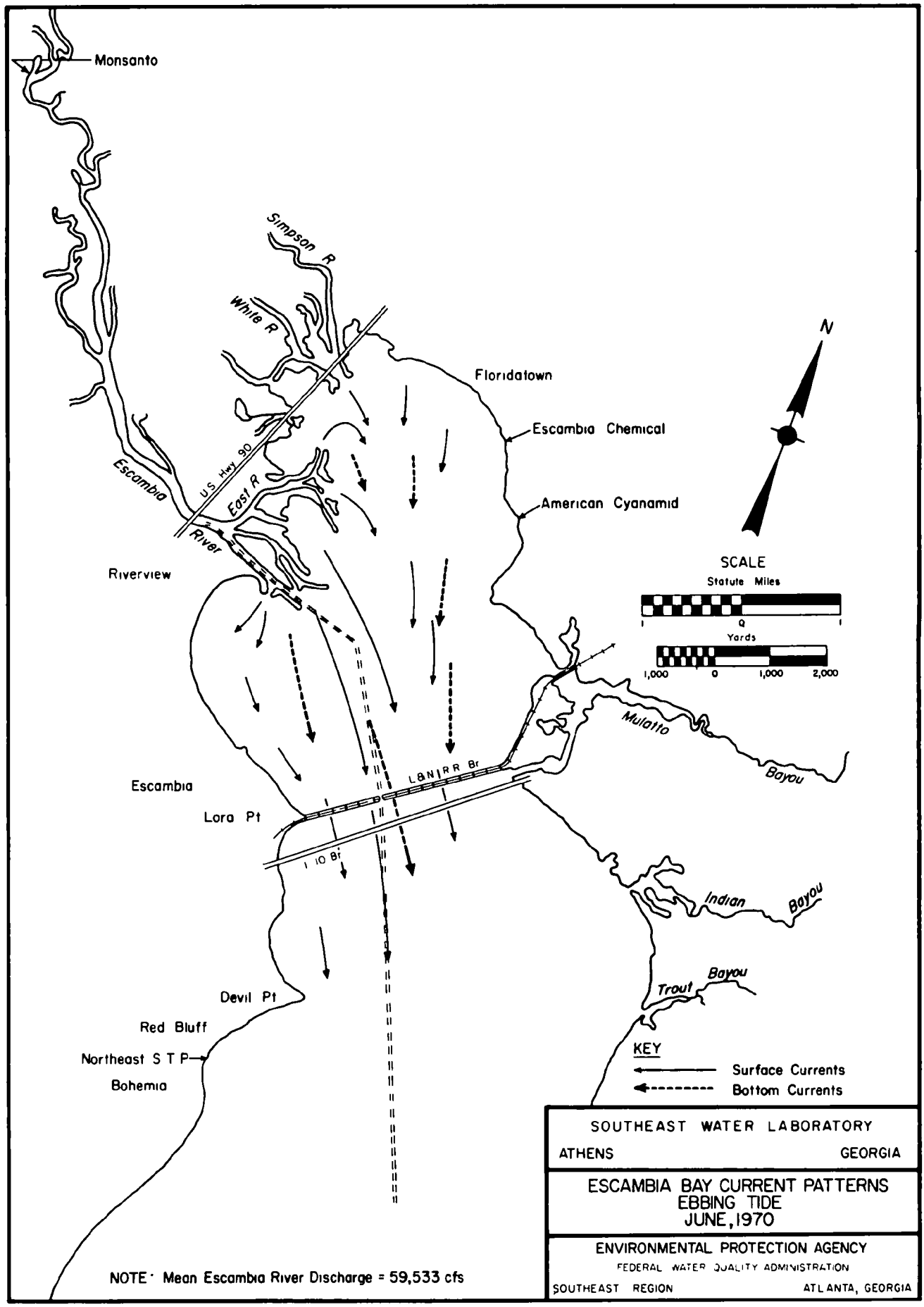

Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
U.S. Hwy 90
East R
River
Riverview
N
SCALE
Statute Miles
1 0 1
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
L&N R R Br
Escambia
Lora Pt
I 10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
KEY
Surface Currents
Bottom Currents
NOTE Escambia River Discharge = 59,533 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY CURRENT PATTERNS
FLOODING TIDE
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

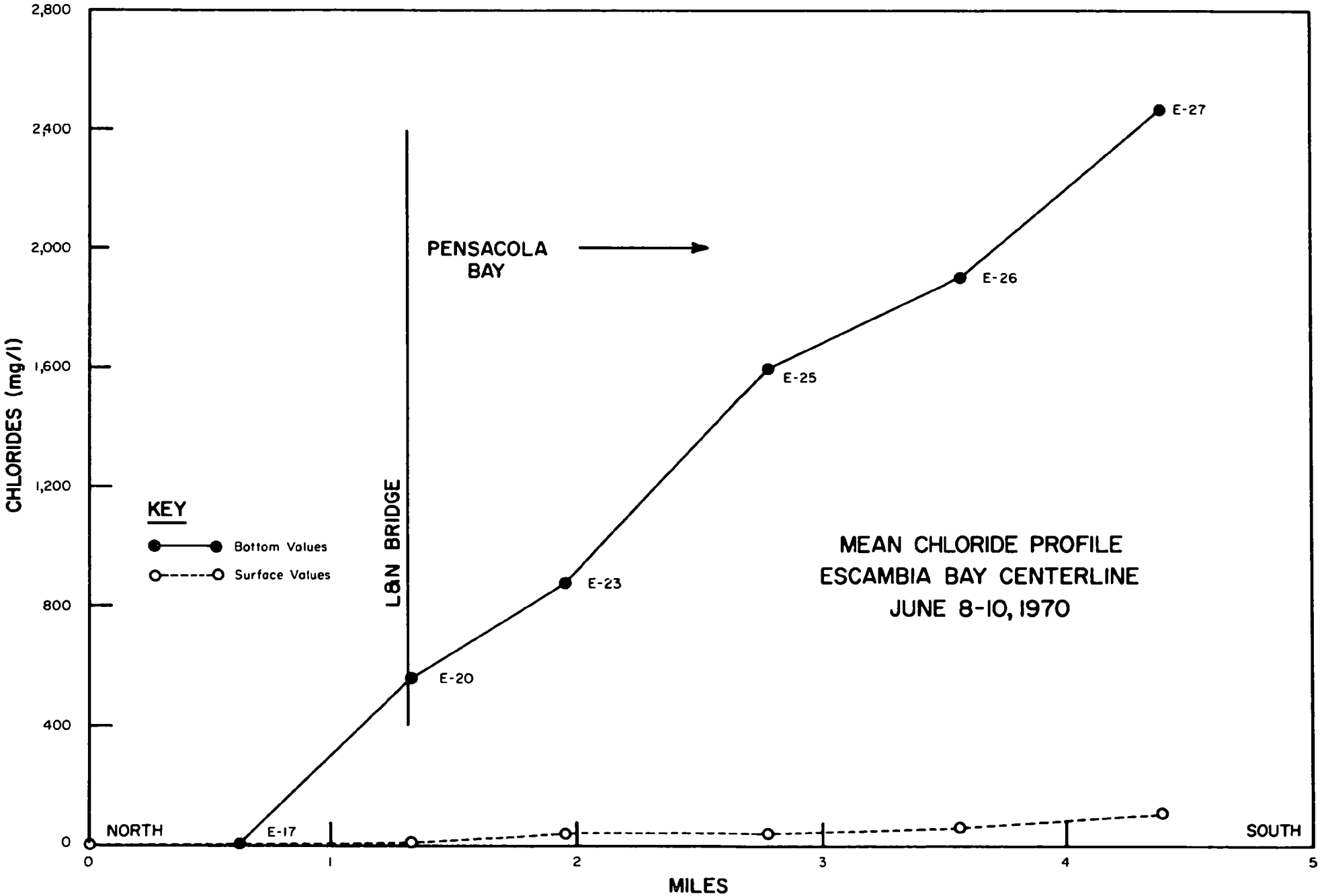
FIGURE 4


Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
U.S. Hwy 90
East R
River
Riverview
N
SCALE
Statute Miles
1 0 1
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
Escambia
Lora Pt
L&N RR Br
I 10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
KEY
Surface Currents
Bottom Currents
NOTE: Mean Escambia River Discharge = 59,533 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY CURRENT PATTERNS
EBBING TIDE
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

the navigation channel. The highest chloride values in the upper bay were found near the eastern shore in the vicinity of Mulatto Bayou. Some saline water moved up the eastern shore, apparently creating the counterclockwise surface eddy shown in the northeast quadrant of the upper bay. This eddy and the movement of the unusually large freshwater mass down the bay apparently trapped saline water in Mulatto Bayou. The principal movement of saline water took place on the bottom, moved up the eastern side of the bay as shown, and undoubtedly contributed to the eddy.

Figure 4 shows the predominate current patterns of the ebb tidal cycle. The bulk of the freshwater moved down the western half of the bay more or less parallel to the navigation channel. The highest upper bay chloride concentrations were found off the mouth of Mulatto Bayou indicating that circulation near Mulatto Bayou is poor.

The mean centerline chloride profile, Figure 5, illustrates the extent of the very low chloride concentrations which were present in the upper bay. Bottom chloride concentrations increased just south of the L&N railroad bridge. This increase could have been caused by the L&N railroad bridge hindering freshwater flushing, and blocking the inflow of saline Pensacola Bay water. However, it is just as likely, that the saline water did not intrude into the upper bay because of the sheer volume of freshwater being discharged from the Escambia River, or the chloride increase could have resulted from a combination of both conditions.



MEAN CHLORIDE PROFILE
ESCAMBIA BAY CENTERLINE
JUNE 8-10, 1970

FIGURE 5

The lateral chloride profiles for the east and west sides of the bay, Figure 6, also illustrate the freshwater nature of the upper bay and the increase in chloride concentration just south of the L&N railroad bridge. These lateral profiles indicate the intrusion of more saline water along the eastern shore.

Circulation Studies at Low Escambia River Discharge (1068 cfs)

Chloride samples were collected 12 times synoptically at 28 sampling stations in Escambia Bay during the period September 23-25, 1969. The results of the 1969 study are described in detail in the report on that study (1) and are summarized below.

During flood tide, freshwater from the Escambia River dispersed over the upper bay toward the western shoreline (Figure 7). Saline water from Pensacola Bay moved northward along the eastern shore bottom, impeded freshwater flushing, and pushed the freshwater into the relatively stagnant marshy wetlands that characterize the northern part of the Bay in the vicinity of the U.S. 90 highway bridge. Poor circulation in this area was indicated by little variation in chloride concentration over tidal cycles.

During ebb tide, freshwater flowed south through a narrow zone on the surface, generally to the west of the bay centerline, and dispersed very little (Figure 8). Saline water receded along the bottom, primarily along the eastern shore.

The net outflow of water from the bay was generally along the western portion with intrusion of salt water on the eastern side, indicating a counterclockwise circulation pattern. Very little flushing

FIGURE 6

EAST & WEST ESCAMBIA BAY
LONGITUDINAL CHLORIDE PROFILES
JUNE 8-10, 1970

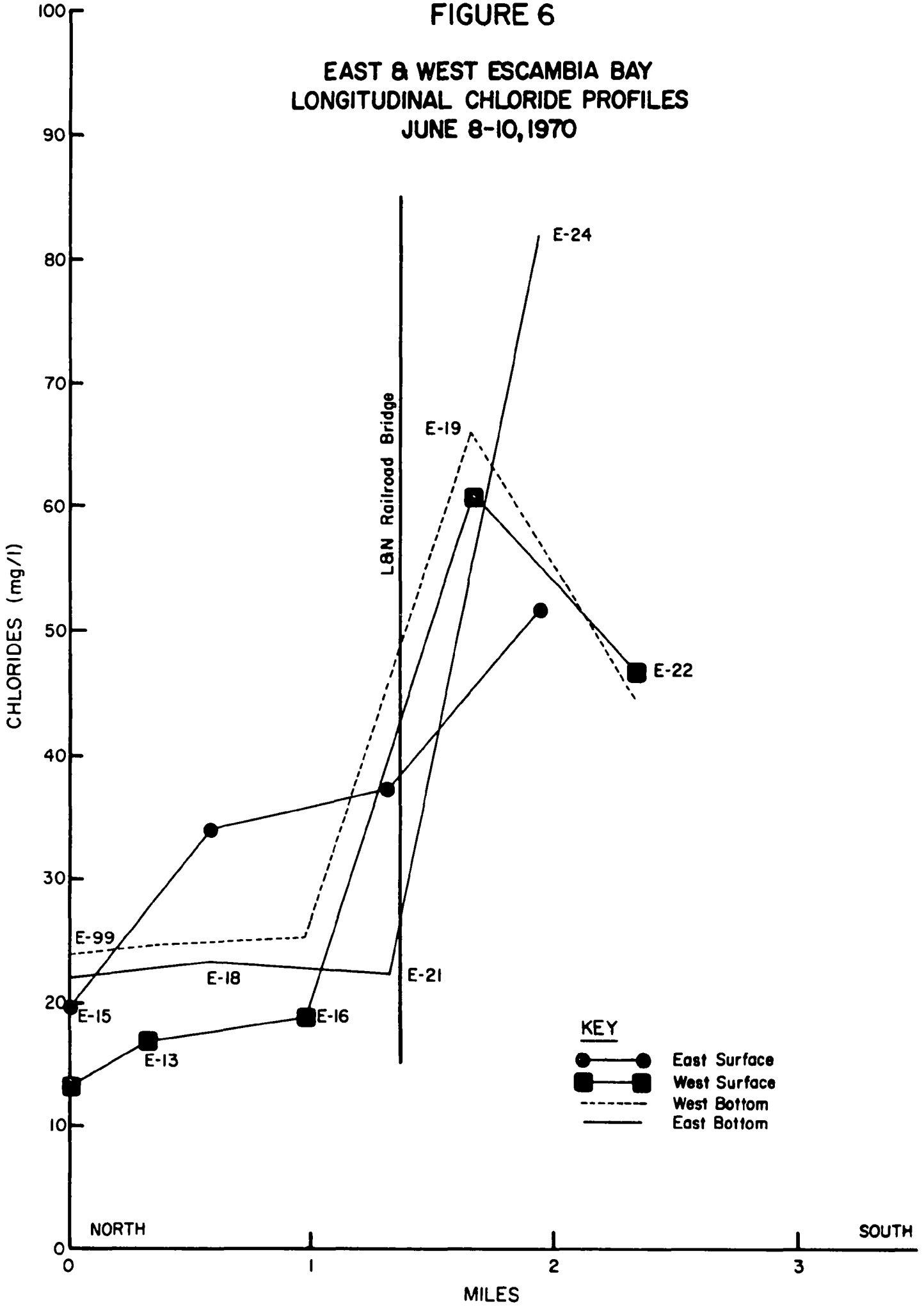
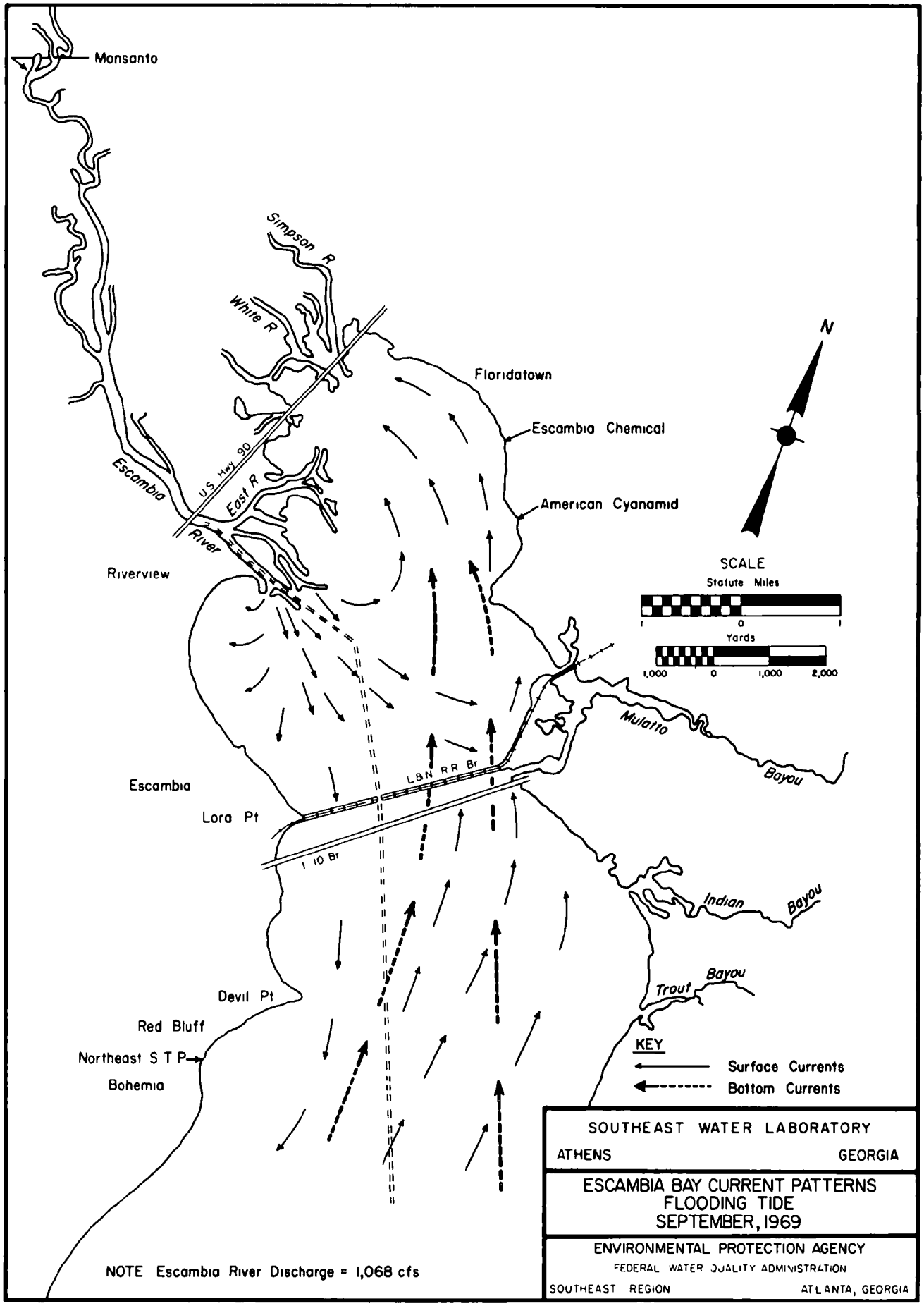


FIGURE 7


Monsanto
Simpson R
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Escambia Chemical
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Escambia
U S Hwy 90
East R
River
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Bottom Currents
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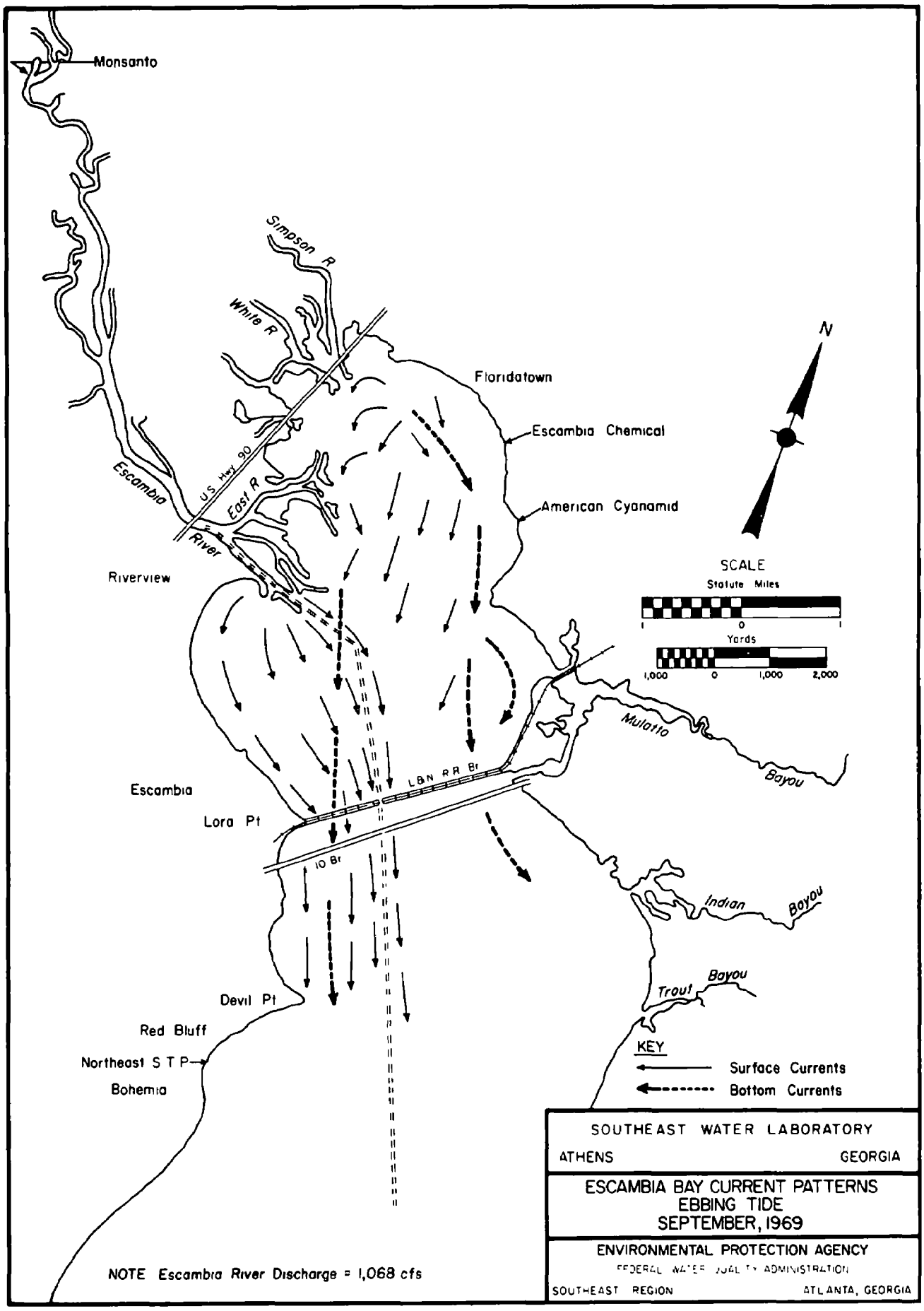
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY CURRENT PATTERNS
FLOODING TIDE
SEPTEMBER, 1969
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 8


Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
U.S. Hwy 90
East R
River
Riverview
N
SCALE
Statute Miles
1 0 1
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
L&N R R Br
Escambia
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10 Br
Indian
Bayou
Trout
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EBBING TIDE
SEPTEMBER, 1969
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

occurred above the mouth of the Escambia River in the northern marsh flats.

Low chloride concentrations found during the September 1969 study on the northeast side of the upper bay, north of the L&N railroad bridge (Figure 9), indicated that freshwater in the upper bay was unable to disperse to the lower bay at a significant rate. The hypothesis was proposed that the closely spaced piling of the L&N railroad bridge may contribute to restricted circulation between Upper and Lower Escambia Bay. It was postulated, therefore, that the wastes discharged above the trestle (all sources except the northeast sewage treatment plant) would remain in this section of the bay and exercise an organic demand for a long period of time.

L&N Railroad Bridge

To assess more accurately the effect of the L&N trestle on the circulation patterns of the bay, a measurement of the cross-sectional area of Escambia Bay affected by the trestle was made on June 8, 1970. The number of visible piles in the cross-section were counted and a fathometer trace of the bay cross-section immediately adjacent to the trestle was made.

Piles supporting the trestle were counted in addition to those which had been replaced but which still remained in the bay. A total of 1,149 piles with an average diameter of 12 inches were observed. This represents 1,149 square feet per foot of water depth lost because of the cross-sectional area of the piles.

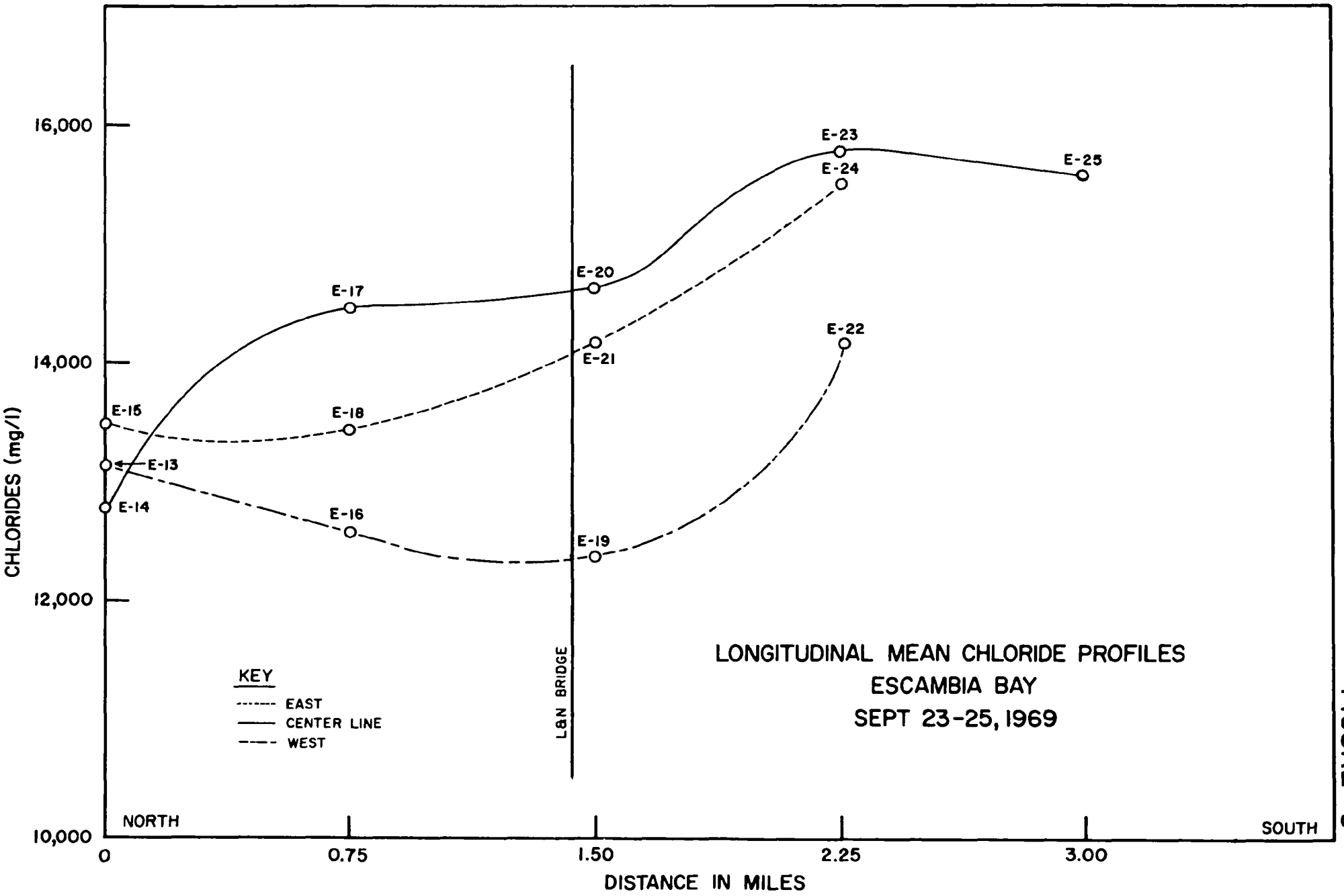

16,000
14,000
12,000
10,000
CHLORIDES (mg/l)
0
0.75
1.50
2.25
3.00
DISTANCE IN MILES
NORTH
SOUTH
L&N BRIDGE
E-13
E-14
E-15
E-16
E-17
E-18
E-19
E-20
E-21
E-22
E-23
E-24
E-25
KEY
EAST
CENTER LINE
WEST
LONGITUDINAL MEAN CHLORIDE PROFILES
ESCAMBIA BAY
SEPT 23-25, 1969

FIGURE 9

A fathometer trace was made immediately adjacent (within ten feet) and parallel to the south side of the trestle, within 0.2 feet of high water slack. The gross cross-sectional area of the bay at this tidal condition was 77,668 square feet, with a mean depth in the cross-section of 7.2 feet. For these conditions, 10.6% of the bay cross-section is obstructed by trestle pilings (Figure 10).

The tidal range for the cycle in which the cross-sectional measurements were made was 1.64 feet as monitored by a portable water level recorder. Tidal ranges for the period June 5-10 varied from 1.47 to 2.08 feet. In order to illustrate the effect of rising and falling tides on cross-section blockage, an arbitrary tide cycle range of 1.9 feet was picked from the tide chart. For this tidal range, an additional 0.3 feet of water was present in the bay at high water slack and 1.6 feet less at low water slack. Under these conditions, 10.6% of the cross-section was blocked for both tidal conditions. Examination of the cross-section reveals that the relative percentage blocked would not be materially changed unless water depths in the bay were decreased more than six feet--an unlikely event except under hurricane conditions.

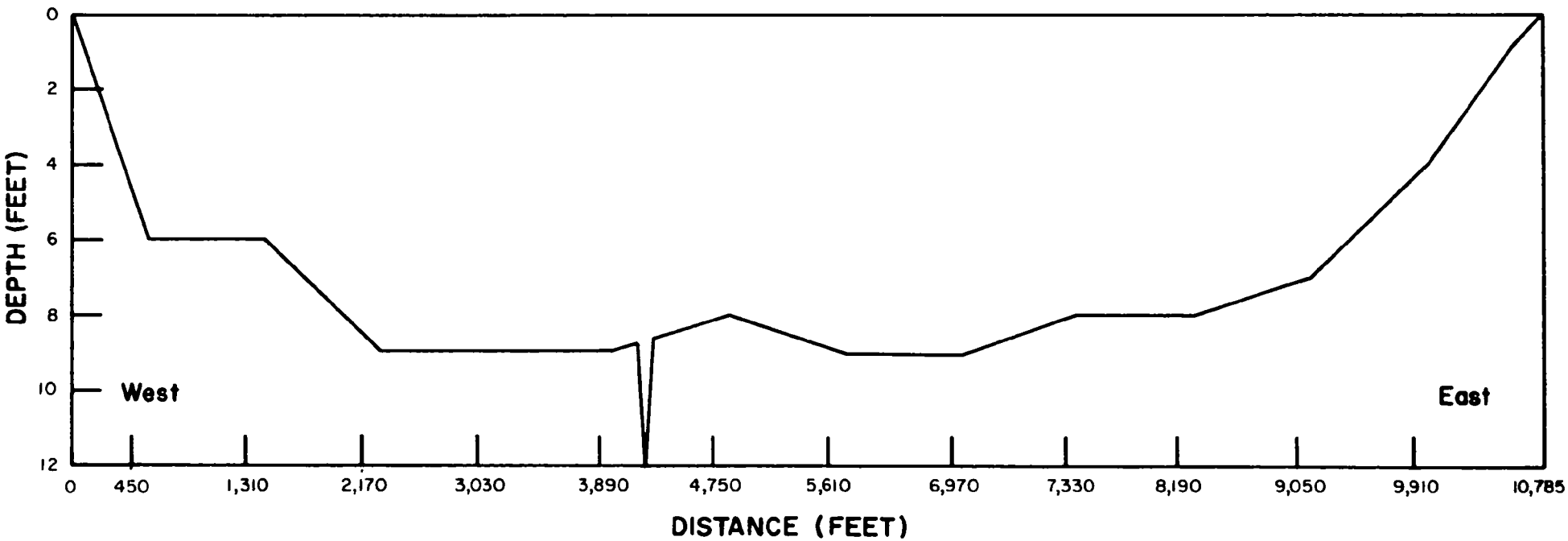
Since only visible piles were counted, it is possible that piling and/or obstructions below the water line could significantly affect the percentage of the cross-section blocked. In view of this fact, the actual cross-section blockage may be greater than 10.6%.

Discussion

Both low and high Escambia River discharge circulation studies indicate a counterclockwise circulation in Escambia Bay. During both

FIGURE 10

ESCAMBIA BAY CROSS SECTION
IMMEDIATELY NORTH OF L&N RAILROAD BRIDGE
JUNE 8, 1970



studies poor circulation was found north of Mulatto Bayou, along the eastern shore of the upper bay. Poor circulation in the northern end of the upper bay near the U.S..90 highway bridge occurred during low but not high river flows because of the quantity of fresh water discharged at high flows from the Escambia River and freshwater bleeding from the marshy area above the bridge.

The areas of poor tidal exchange in the upper bay are caused by the geometry of the bay system and the prevailing counterclockwise circulation. Escambia River discharge flows to the southeast, hindering the tidal exchange of saline water flowing northward into the upper bay, during flood tides. This condition creates a shortcircuiting effect in the upper bay, resulting in poor tidal exchange.

The effect of river discharge on bay circulation may be illustrated through a comparision of the tidal prism concept with the physical displacement time of the bay at high and low river discharge. Escambia Bay normally has one complete tidal cycle per day resulting in tidal exchange of 18.8% (the tidal prism) of the bay volume. Thus assuming complete mixing conditions, 5.3 days would be required to completely flush the bay volume by tidal exchange alone. Physical displacement time at low river flow (1068 cfs) is 92 days, at mean annual discharge (5460 cfs) is 18.0 days and at high river discharge (59,533 cfs) is 1.6 days. Thus as river discharge increases above the mean annual flow, it becomes increasingly important in exchange of bay waters.

The effect of the L&N railroad bridge on bay circulation is not clear-cut. Chloride profiles from the circulation studies show that the L&N railroad trestle causes more backwater at high Escambia River

discharge than at low discharge. However, with 10.6% of the available cross-section blocked, it is doubtful that any appreciable increase in tidal flow would result from the removal of the trestle. The effects of the trestle would be minimized by removing any unnecessary piling and old construction debris as recommended by the Federal-State Enforcement Conference (2).

BENTHIC CHARACTERIZATION

Eighteen Escambia Bay sediment samples were collected and analyzed for organic carbon, total organic nitrogen, total phosphorus, and total oxygen demand. A record was kept of how deep sampling station markers had to be driven in the bottom sediment to achieve firm support. This crude measurement gave depths of unconsolidated sediment from two feet or less to greater than six feet (Figure 11). Approximately one-third of the upper bay was covered with sediment greater than six feet deep.

Sediment Organic Carbon Distribution

Organic carbon (O.C.) concentrations ranged from a high of 5.0% at the confluence of the Escambia and East Rivers near the mouth of the Escambia River (Station E-1), to a low of 2.3% in the southeast section of the upper bay above the L&N railroad bridge off Mulatto Bayou. (See Figure 12 for detailed data.) Organic carbon decreased southward from the highest values in and around the mouth of the Escambia River. Most of the total organic carbon (72.2%) is discharged to Escambia Bay via the Escambia River in which Monsanto and Container Corporation discharge waste. The O.C. content of the upper bay sediment increases southward to 3.5% from 1.5% at the U.S. 90 highway bridge. This increase is undoubtedly caused by the sediment load of the Escambia River and its associated waste sources and the wastes from the American Cyanamid Company. The American Cyanamid Company discharges 26.3% of the total organic carbon to the Escambia Bay system along the eastern shore of the upper bay. Another area of high O.C. (2.5% to greater than 4%) extends

FIGURE 11

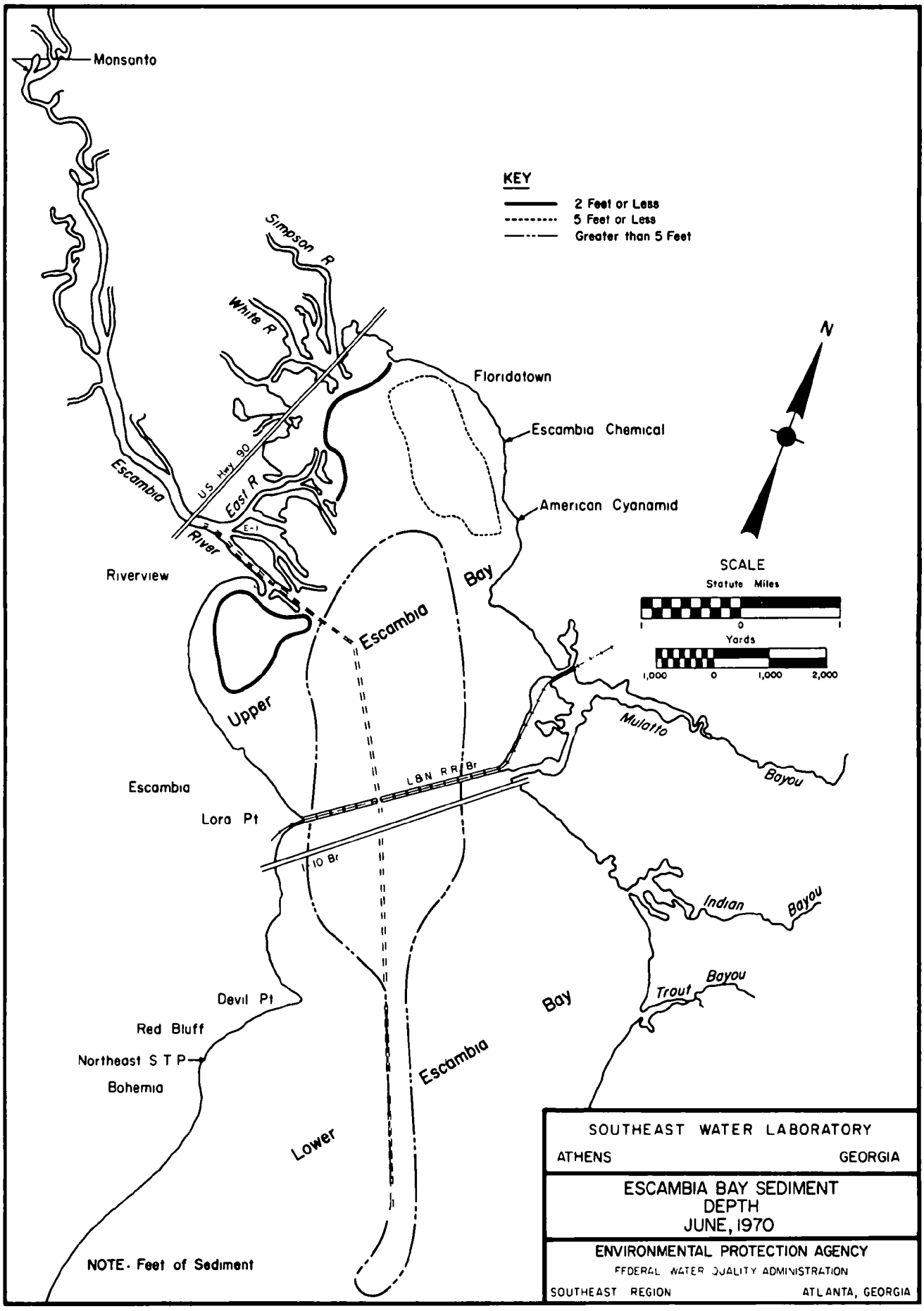
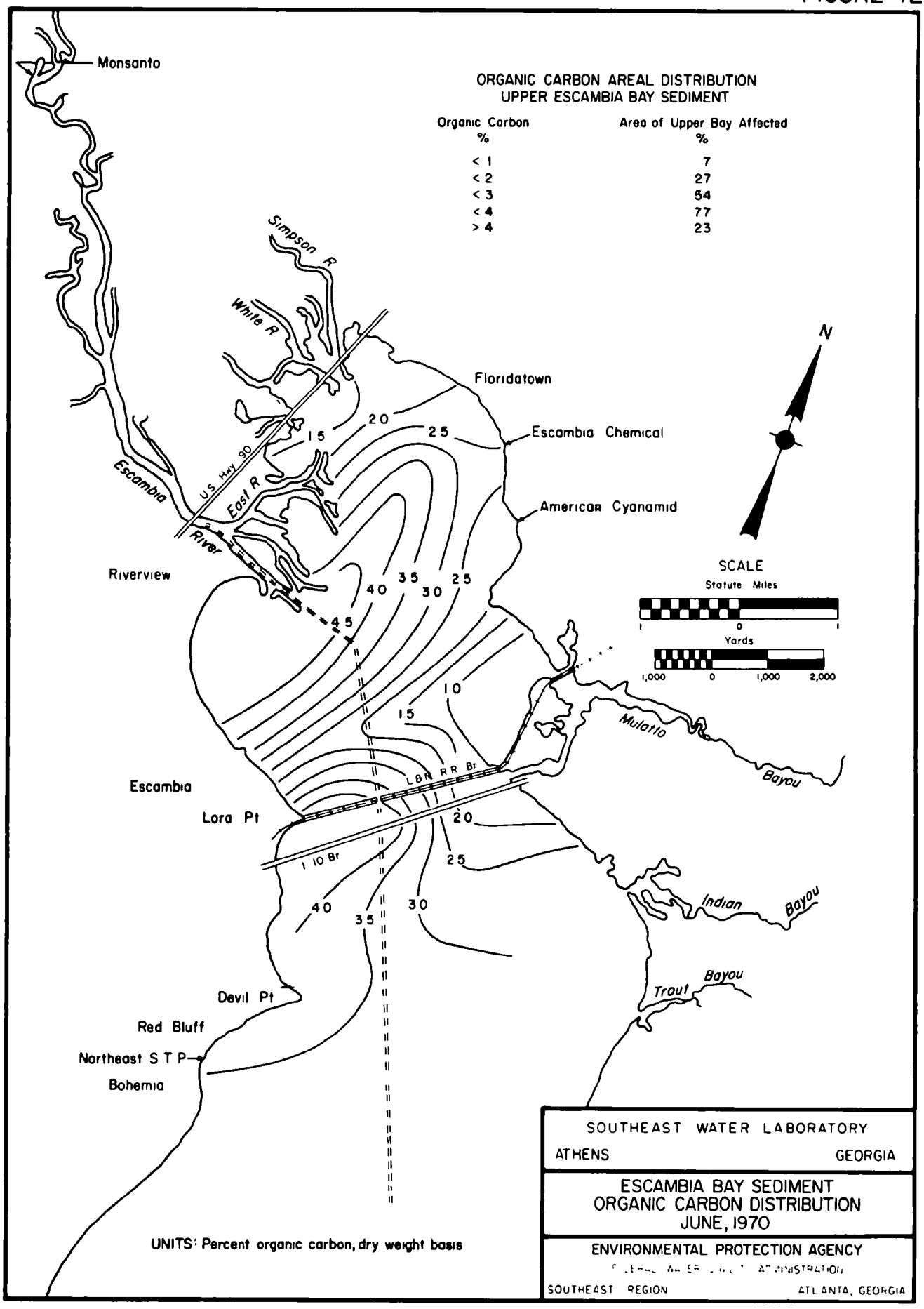

Monsanto
KEY
2 Feet or Less
5 Feet or Less
Greater than 5 Feet
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
N
Escambia
U.S. Hwy 90
East R
River
E-1
Riverview
Bay
Escambia
SCALE
Statute Miles
1
0
1
Yards
1,000
0
1,000
2,000
Upper
Mulatto
Bayou
L&N RR Br
Escambia
Lora Pt
I-10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Bay
Red Bluff
Northeast S T P
Bohemia
Escambia
Lower
NOTE- Feet of Sediment
SOUTHEAST WATER LABORATORY
ATHENS
GEORGIA
ESCAMBIA BAY SEDIMENT
DEPTH
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION
ATLANTA, GEORGIA

FIGURE 12


ORGANIC CARBON AREAL DISTRIBUTION
UPPER ESCAMBIA BAY SEDIMENT
Organic Carbon %
Area of Upper Bay Affected %
< 1 7
< 2 27
< 3 54
< 4 77
> 4 23
Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
US Hwy 90
East R
River
Riverview
N
SCALE
Statute Miles
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
Escambia
Lora Pt
L&N RR Br
I 10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
UNITS: Percent organic carbon, dry weight basis
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY SEDIMENT
ORGANIC CARBON DISTRIBUTION
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
SOUTHEAST REGION ATLANTA, GEORGIA

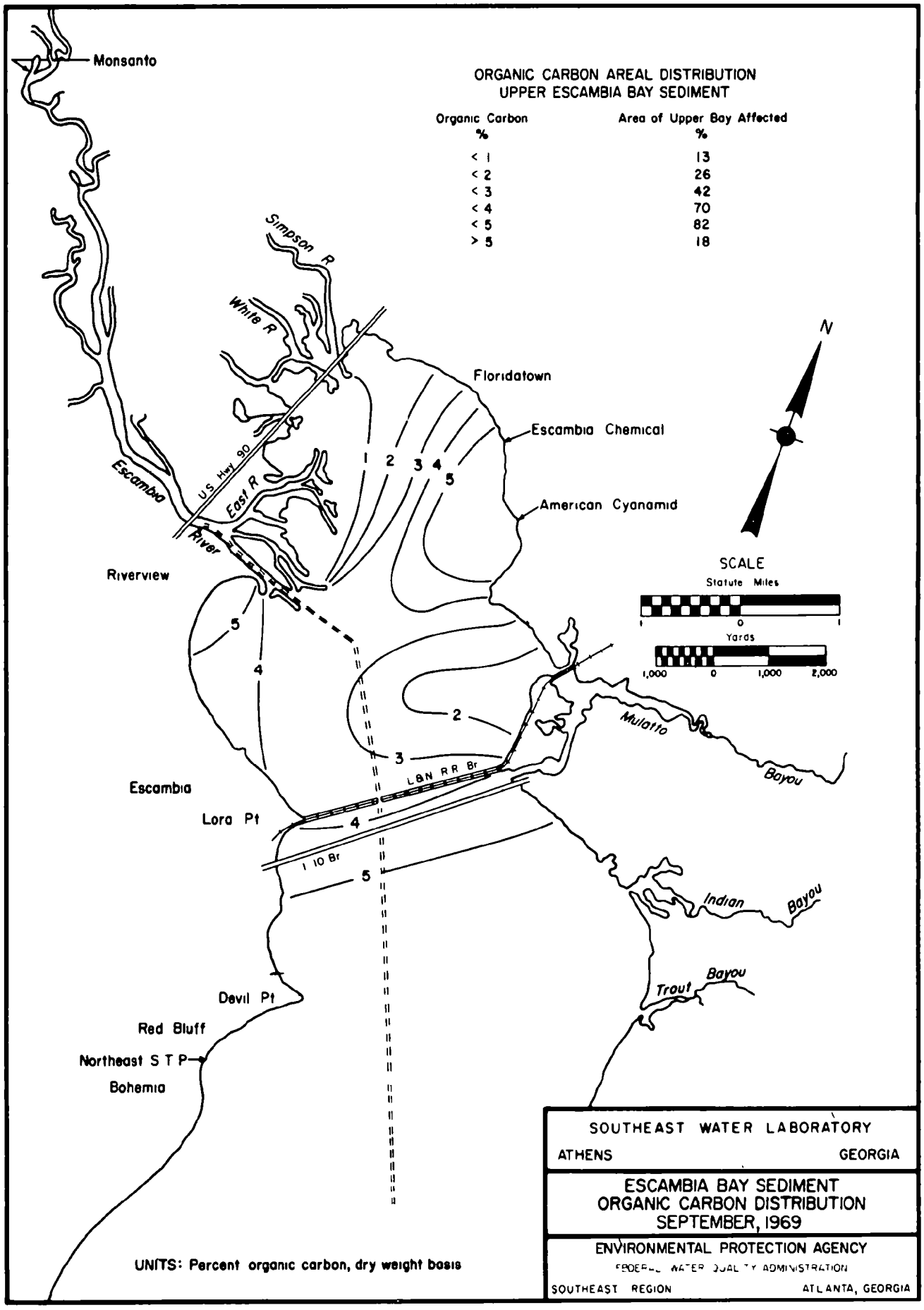
along the western shore from an area south of the L&N railroad bridge to just north of it. The O.C. concentration in this area and in the pocket along the western shore just below and west of the Escambia River are probably caused by poor circulation. A table is included at the top of Figure 12 giving the area of the upper bay covered by various concentrations of O.C. as a percentage of the upper bay area.

During the September 1969 study, sediment samples were collected at ten stations for O.C. analysis (Figure 13). The only major difference in O.C. distributions found in the two studies is that in September 1969 the highest O.C. concentrations were adjacent to the eastern shore of the upper bay near the outfalls of the American Cyanamid and Escambia Chemical companies. Except for this one exception, the two studies show very similar sediment O.C. distributions. For example, during the September 1969 study, sediment with O.C. concentrations greater than 4% was found in 29.5% of the area of the upper bay; during the June 1970 study 22.6% of this area was covered with the same concentration. It is possible that the sediment in the upper bay was rearranged during the period of high discharge of the Escambia River in June. The spatial distribution of O.C. in upper bay sediments in this study are shown at the top of Figure 13.

Sediment Total Organic Nitrogen Distribution

The highest total organic nitrogen (T.O.N.) sediment concentration, 0.27%, was located at Station E-20 in the channel, just below the L&N railroad bridge, and at Station E-1 at the confluence of the Escambia and East Rivers. The lowest concentration, 0.05%, was located off

FIGURE 13


ORGANIC CARBON AREAL DISTRIBUTION
UPPER ESCAMBIA BAY SEDIMENT
Organic Carbon %
Area of Upper Bay Affected %
< 1 13
< 2 26
< 3 42
< 4 70
< 5 82
> 5 18
Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
U.S. Hwy 90
East R
River
Riverview
N
SCALE
Statute Miles
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
L&N RR Br
Escambia
Lora Pt
I 10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
UNITS: Percent organic carbon, dry weight basis
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY SEDIMENT
ORGANIC CARBON DISTRIBUTION
SEPTEMBER, 1969
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

Mulatto Bayour at Station E-18. Sediment total organic nitrogen (Figure 14) decreased from greater than 0.2% at the mouth of the Escambia River to 0.05% southeastward; it decreased from 0.15% in the area of the Escambia Chemical Company to 0.10% northward; and it increased from 0.10% in the area of the U.S. 90 highway bridge to 0.15% southward. The Escambia River contributes 20.6% of the total Kjeldahl nitrogen (T.K.N.) discharged to the bay system. The Escambia and American Cyanamid Chemical Companies, located along the eastern shore of the upper bay, contribute 54.7%. An area of high sediment T.O.N. exists along the western shore of the bay, above the Northeast Sewage Treatment plant and extends from just below Devil Point to just above the L&N railroad bridge. The Northeast Sewage Treatment plant discharges 14.7% of the T.K.N. to the bay system. This area of high sediment nitrogen is probably the result of the sewage treatment plant discharge and poor circulation.

Sediment Total Phosphorus Distribution

The spatial distribution of total phosphorus (Figure 15) is very similar to the O.C. distribution (Figure 12). The highest total phosphorus concentration, 0.085%, was located at the confluence of the Escambia and East rivers at Station E-1; the lowest, 0.005%, was located at Station E-18, just west of Mulatto Bayou. The concentration gradients in the sediment are similar to those of O.C. for the same reasons. A total of 51.7% of the total phosphorus is discharged to the bay via the Escambia River (Monsanto and Container Corporation discharges), 29.1% from the American Cyanamid and Escambia Chemical plants along the eastern

FIGURE 14

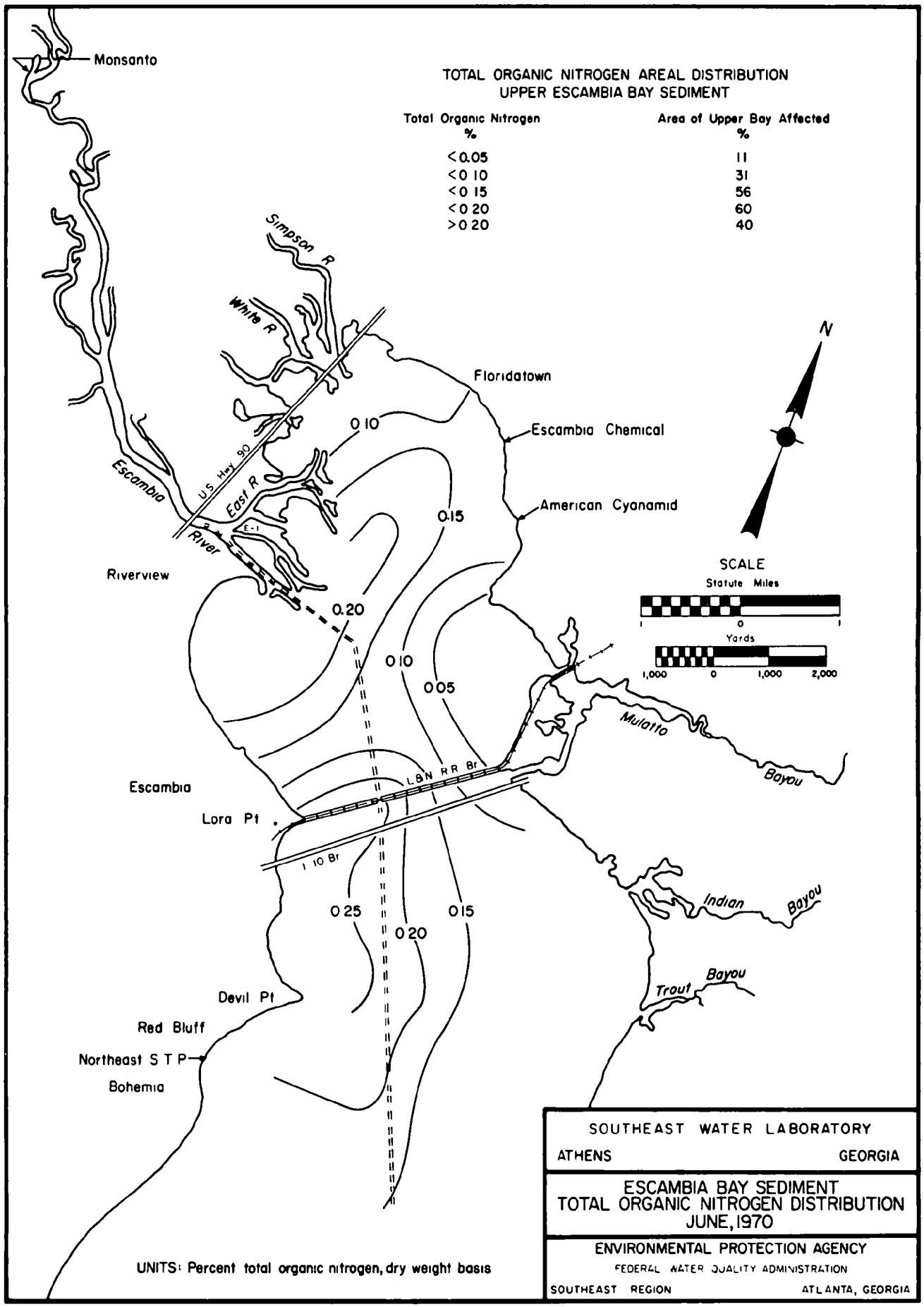
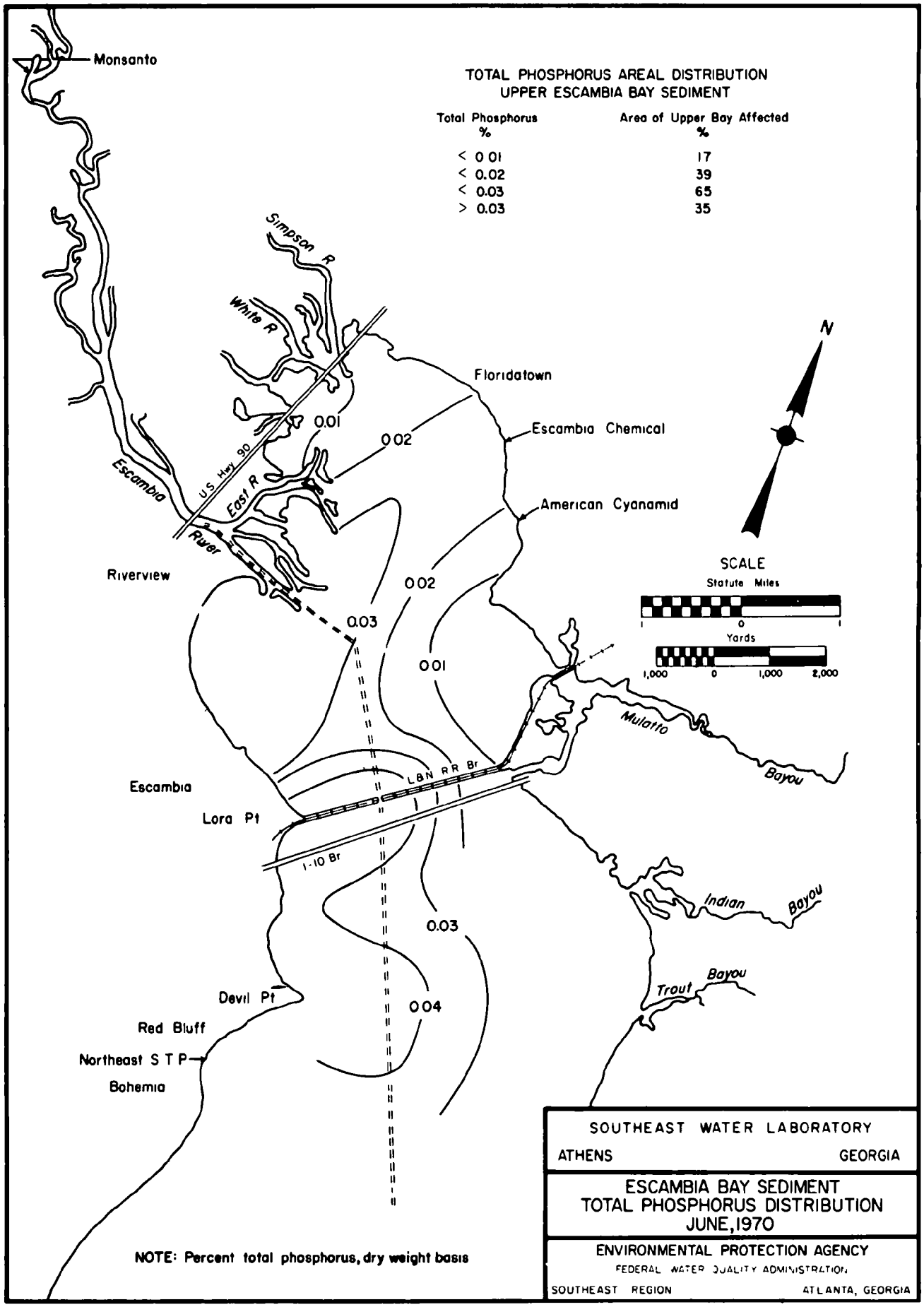

TOTAL ORGANIC NITROGEN AREAL DISTRIBUTION
UPPER ESCAMBIA BAY SEDIMENT
Total Organic Nitrogen %
Area of Upper Bay Affected %
<0.05 11
<0 10 31
<0 15 56
<0 20 60
>0 20 40
Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
U.S. Hwy 90
East R
River
E-1
Riverview
0 10
0.15
0.20
0 10
0 05
N
SCALE
Statute Miles
1 0 1
Yards
1,000 0 1,000 2,000
Mulatto
Bayou
L&N RR Br
Escambia
Lora Pt
I 10 Br
0 25
0 20
0 15
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
UNITS: Percent total organic nitrogen, dry weight basis
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY SEDIMENT
TOTAL ORGANIC NITROGEN DISTRIBUTION
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 15


TOTAL PHOSPHORUS AREAL DISTRIBUTION
UPPER ESCAMBIA BAY SEDIMENT
Total Phosphorus %
Area of Upper Bay Affected %
< 0.01 17
< 0.02 39
< 0.03 65
> 0.03 35
Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia
East R
U.S. Hwy 90
River
Riverview
0.01
0.02
0.03
0.04
N
SCALE
Statute Miles
Yards
1,000
0
1,000
2,000
Mulatto
Bayou
L&N RR Br
Escambia
Lora Pt
I-10 Br
Indian
Bayou
Trout
Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
NOTE: Percent total phosphorus, dry weight basis
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY SEDIMENT
TOTAL PHOSPHORUS DISTRIBUTION
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

shore, and 19.2% from the Northeast Sewage Treatment plant in the lower bay along the western shore.

Sediment Total Oxygen Demand Distribution

The spatial distribution of total oxygen demand (T.O.D.) in Escambia Bay sediment (Figure 16) is almost a carbon copy of the O.C. and T.O.N. distributions. T.O.D. is based on a theoretical calculation in which the organic carbon is assumed to be oxidized to carbon dioxide and the organic nitrogen to nitrate according to the following stochiometric equation: TOD = 2.67 C + 4.75 N (8). This theoretical calculation may be used as an indication of the oxygen demanding properties of a waste or sediment material.

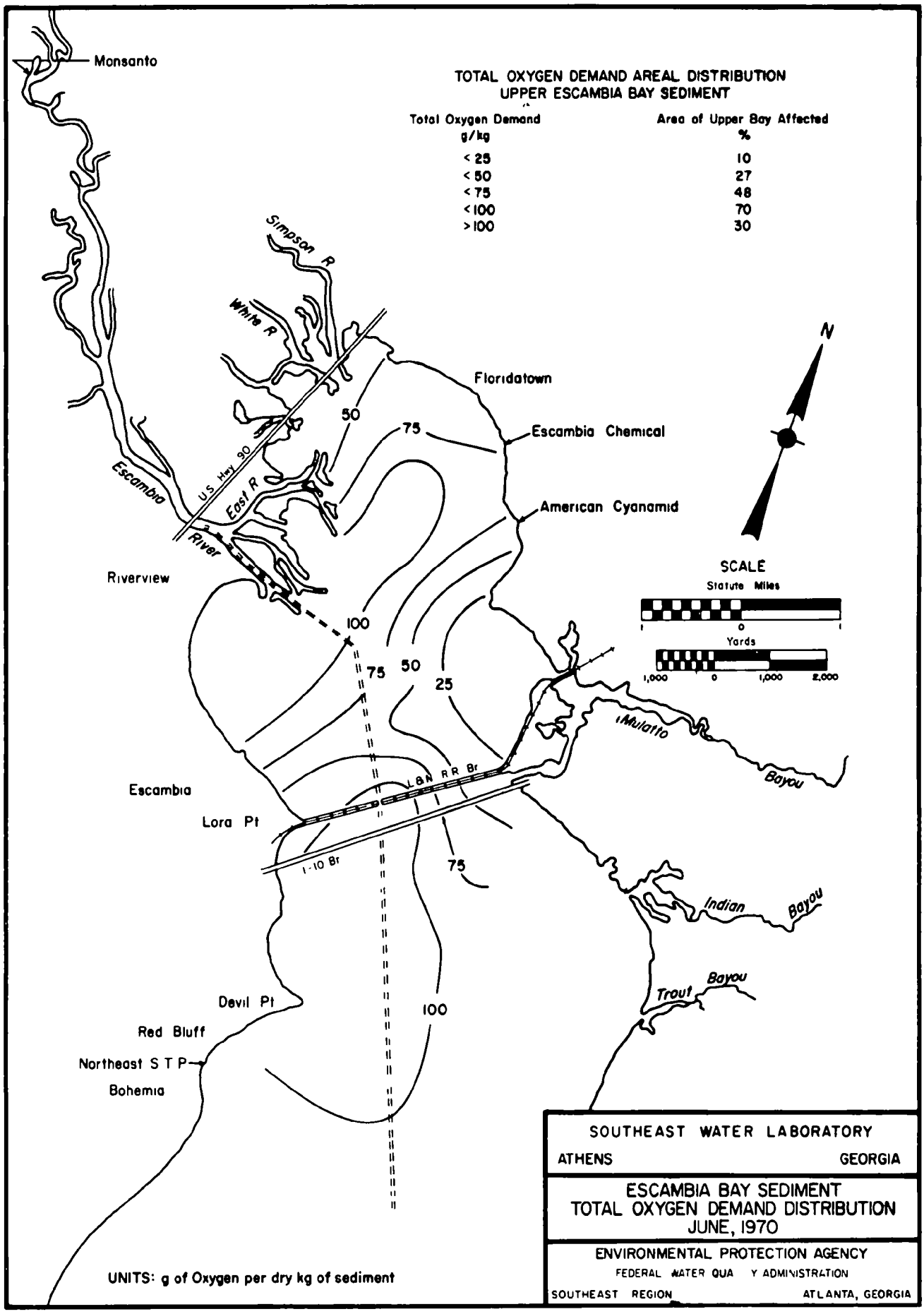
The T.O.D. spatial distribution in the upper bay is shown in a table at the top of Figure 16. A T.O.D. concentration of 100g O_2/dry KG of sediment means that theoretically 100 grams of oxygen would be required to completely oxidize (stabilize) 1 kilogram of sediment material.

Discussion

The organic sediment of Escambia Bay serves as a reservoir of nitrogenous, phosphatic, and carbonaceous material for the aquatic organisms of the bay. However, the immediate concern is the devastating effect that this material in the sediment could have on the oxygen resources of the bay should it become resuspended through dredging, or other means, and exert its potential oxygen demand.

The sediment of lowest organic carbon content was located along the eastern shore of the upper bay off Mulatto Bayou; the sediment

FIGURE 16


TOTAL OXYGEN DEMAND AREAL DISTRIBUTION
UPPER ESCAMBIA BAY SEDIMENT
Total Oxygen Demand g/kg
Area of Upper Bay Affected %
< 25 10
< 50 27
< 75 48
< 100 70
> 100 30
Monsanto
Simpson R
White R
Floridatown
Escambia Chemical
American Cyanamid
Escambia River
U.S. Hwy 90
East R
Riverview
Escambia
Lora Pt
L&N RR Br
I-10 Br
Mulatto Bayou
Indian Bayou
Trout Bayou
Devil Pt
Red Bluff
Northeast S T P
Bohemia
50
75
100
25
N
SCALE
Statute Miles
Yards
1,000
0
1,000
2,000
UNITS: g of Oxygen per dry kg of sediment
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
ESCAMBIA BAY SEDIMENT
TOTAL OXYGEN DEMAND DISTRIBUTION
JUNE, 1970
ENVIRONMENTAL PROTECTION AGENCY
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

highest in organic carbon content was located off the mouth of the Escambia River and west of center of the upper and lower bays. The location and character of these sediment deposits support the chloride circulation study conclusions regarding the counter-clockwise nature of bay circulation. The wastes discharged along the eastern shore (American Cyanamid and Escambia Chemical) are swept westward and are deposited along with wastes (primarily those from Monsanto and Container Corporation) and the sediment load from the Escambia River in the central and western portions of the upper and lower bays.

Library Copy

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APPENDICES

APPENDICES

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II	Sampling Procedures and Analytical Methods	24
III	Chloride Data Summary	28,29
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V	Sampling Station Locations	31,32

APPENDIX I

PROJECT PERSONNEL

Escambia Bay Study
June 8-10, 1970

Name	Title
M. D. Lair	Sanitary Engineer
Dennis T. Cafaro	Sanitary Engineer
L. W. Olinger	Sanitary Engineer
P. L. Wagner	Sanitary Engineer
T. Bennett	Project Chemist
R. T. Wilkerson	Technician
R. A. Wiemert	Technician
H. C. Vick	Technician
M. R. Weldon	Aquatic Biologist
C. M. Swinford	Technician
T. P. Gallagher	Sanitary Engineer

APPENDIX II

SAMPLING PROCEDURES AND ANALYTICAL METHODS

Escambia Bay Study

June 8-10, 1970

1) PROCEDURES

The Escambia Bay field survey was conducted from noon on June 8 to noon on June 10, 1970. Thirty-five sampling stations were located in the field by compass-bearing techniques. Twenty-eight of these stations, E-1 through E-28, were used on the previous Escambia Bay study. These sampling stations are shown on the fold-out map at the rear of this report and the geographic locations are given in Appendix V.

a) Chloride Circulation Study

Chloride sampling runs were made every four hours around the clock for a total of 12 complete runs.

Samples were collected with Kemmerer samplers at one foot below the surface (surface sample), one foot above the bottom (bottom sample) and at mid-depth according to the following schedule:

Water Depth	Sampling Depth
0-3 feet	mid-depth
3-6 feet	surface and bottom
over 6 feet	surface, mid-depth and bottom

Samples were collected in plastic bottles and returned to the Southeast Water Laboratory for analysis.

Samples were collected at 33 locations. One station was located at the confluence of the Escambia and East Rivers (E-1), two in Mulatto Bayou (M-1 and M-2), 20 in upper Escambia Bay (E-2 through E-18, E-36, E-59 and E-99) and 10 in the lower Escambia Bay (E-19 through E-28).

b) Sediment Characterization

Eighteen sediment samples were collected from Escambia Bay for chemical characterization during the study. These samples were collected on the chloride sampling runs as time permitted. Samples were collected at the following sample locations: E-1, E-2, E-3, E-6, E-7, E-9, E-10, E-13, E-15, E-16, E-18, E-20, E-22, E-24, E-25, E-27, EB-1, EB-2.

Sediment samples were collected with a Peterson dredge, stored in plastic containers and returned to the Southeast Water Laboratory for analysis. The samples were analyzed for organic carbon, organic nitrogen and total phosphorus.

2) ANALYTICAL METHODS

a) Circulation Study

Chloride

Reference: Automated Ferricyanide Method, FWQA Methods for Chemical Analysis of Water and Wastes, November 1969.

Thiocyanante ion is liberated from mercuric thiocyanate by sequestering mercury with chloride ion to form unionized mercuric chloride. In the presence of ferric ion, the liberated thiocyanate forms highly colored ferric thiocyanate, whose concentration (color) is proportional to the original chloride concentration.

b) Sediment Characterization Study

- Pre-treatment

All sediment samples were oven dried overnight at 103°C. The samples were then ground and aliquot portions were used for chemical analysis.

- Chemical Oxygen Demand (COD)

Reference: Chemical Oxygen Demand Method, FWQA Methods for Chemical Analysis of Water and Wastes, November 1969.

Organic materials are oxidized by potassium dichromate solution in 50% sulfuric acid. The excess dichromate is titrated with standard ferrous ammonium sulfate using ferroin indicator. The amount of dichromate used in the oxidation is proportional to the amount of organic and oxidizable inorganic matter in the sample.

- Total Organic Nitrogen (TON)

References: Bottom Sediments, Chemistry Laboratory Manual, Great Lakes Region, FWQA, 1969. Automated Alkaline Hypochlorite Dried Procedure for Phosphorus, FWQA, Methods for Chemical Analysis of Water and Wastes, November 1969.

Sediment samples were manually digested by the referenced Great Lakes procedure and distilled. The ammonia was determined by the automated alkaline hypochlorite procedure.

- Total Phosphorus

References: Automated Ascorbic Acid Method, FWQA, Methods for Chemical Analysis of Water and Wastes, November 1969. Dried sediment samples were manually digested with acid persulfate.

Phosphorus is reacted with ammonium molybdate complex. This complex

is reduced to an intensely blue colored complex by ascorbic acid. The color is proportional to the phosphorus concentration.

APPENDIX III

CHLORIDE DATA SUMMARY JUNE 8-10, 1970

Run	Date June 1970	Beg. Time of Run	End. Time of Run	Depth*	E-1	E-2	E-3	E-4	E-5	E-6	E-7	E-8	E-9	E-10	E-11	E-12	E-13	E-14	E-15	E-16	E-17
					CHLORIDE CONCENTRATIONS (mg/l)																
1	8	1325	1530	S	<10	11	11	14	12	11	12	11	10	11	13	10	23	11	11	13	15
				M	<10	-	-	-	-	11	-	-	11	12	-	-	20	11	-	18	16
				B	<10	11	15	30	12	14	44	12	45	23	19	28	34	16	20	39	17
2	8	1655	1950	S	10	10	10	23	10	12	21	17	12	11	29	26	18	13	27	19	17
				M	10	-	-	-	-	-	-	-	24	11	-	-	28	17	-	-	-
				B	10	10	11	12	12	18	23	26	27	18	48	33	58	20	30	45	18
3	8-9	2140	0105	S	10	10	-	68	-	11	54	21	11	16	-	24	20	30	19	18	16
				M	10	-	11	-	12	-	-	-	-	-	36	-	-	12	-	-	-
				B	10	12	-	30	-	13	56	22	14	14	-	22	33	14	20	-	16
4	9	0135	0335	S	6	-	-	-	-	11	17	-	10	18	32	24	16	16	-	23	12
				M	6	7	7	16	9	-	-	13	-	19	-	-	-	-	22	-	-
				B	12	-	-	-	-	12	17	-	12	19	35	28	14	16	-	27	12
5	9	0502	0612	S	5	-	-	-	-	12	18	-	10	13	-	25	12	12	-	22	10
				M	5	7	8	15	7	-	-	12	-	-	42	-	-	-	23	-	-
				B	9	-	-	-	-	14	19	-	11	14	-	25	12	13	-	23	12
6	9	0835	0949	S	5	-	-	-	-	11	45	-	10	13	-	25	14	9	-	24	10
				M	5	7	9	17	8	-	-	14	-	-	47	-	-	-	21	-	13
				B	5	-	-	-	-	13	29	-	11	13	-	29	15	13	-	24	14
7	9	1300	1505	S	<10	-	12	23	12	12	25	11	18	11	19	31	16	12	11	27	12
				M	10	17	-	-	-	12	-	-	-	-	-	-	-	13	-	-	-
				B	10	-	12	25	13	19	101	13	14	13	26	20	37	17	24	26	12
8	9	1645	1815	S	10	-	-	28	-	11	49	13	15	12	32	15	18	12	22	16	14
				M	10	12	11	-	10	11	-	-	18	-	-	-	-	13	-	-	-
				B	12	-	-	49	-	19	28	16	25	18	68	22	21	52	24	15	15
9	9	2130	2335	S	<10	-	-	-	-	12	-	15	13	14	28	15	24	20	22	14	24
				M	<10	10	32	125	15	12	73	-	13	14	-	-	-	-	-	-	-
				B	<10	-	-	-	-	12	-	14	12	16	56	26	24	17	22	15	23
10	10	0100	0215	S	5	-	-	-	-	13	43	18	9	45	-	18	13	17	-	12	15
				M	5	8	8	85	6	-	-	-	-	-	39	-	-	-	19	-	14
				B	5	-	-	-	-	13	16	17	9	16	-	24	15	17	-	28	18
11	10	0505	0618	S	5	-	-	-	-	30	-	18	8	29	-	22	13	11	-	19	11
				M	6	7	7	27	16	-	26	-	-	-	30	-	-	-	19	-	11
				B	5	-	-	-	-	13	-	12	10	17	-	26	12	12	-	24	12
12	10	0838	1035	S	5	-	-	-	-	10	-	13	9	26	-	25	20	11	-	17	11
				M	4	7	7	26	13	-	38	-	-	-	29	-	-	-	21	-	12
				B	5	-	-	-	-	12	-	20	10	18	-	40	19	12	-	17	12

*Surface samples were taken at one foot depth - bottom samples one foot from the bottom.

APPENDIX III (contd)

CHLORIDE DATA SUMMARY JUNE 8-10, 1970

Run	Date June 1970	Beg. Time of Run	End. Time of Run	Depth*	E-18	E-19	E-20	E-21	E-22	E-23	E-24	E-25	E-26	E-27	E-28	E-36	E-59	E-99	M-1	M-2
					CHLORIDE CONCENTRATION (mg/l)															
1	8	1325	1530	S	15	74	-	17	28	38	222	19	96	278	218	10	10	10	49	247
				M	15	72	83	25	30	81	450	40	330	415	760	12	-	-	-	247
				B	20	71	5800	42	31	6100	560	6000	6700	5750	8700	13	10	13	72	234
2	8	1655	1950	S	21	35	72	19	92	88	65	189	135	211	390	11	11	19	153	194
				M	-	-	93	-	100	104	-	253	170	243	420	-	-	-	-	-
				B	30	35	320	21	84	725	118	4400	5250	4950	4300	12	12	137	240	210
3	8-9	2140	0105	S	23		16	19		224	36	64	66	193	88	11	-	-	-	-
				M	-	-	22	-	-	210	-	283	111	149	115	-	12	11	160	-
				B	20	-	62	19	-	300	37	550	1550	258	2300	11	-	-	-	-
4	9	0135	0335	S	21	52	10	16	44	19	26	22	73	34	72	11	-	-	-	-
				M	-	-	12	-	-	22	-	20	112	35	112	-	7	14	-	-
				B	22	52	11	16	57	145	26	120	390	690	6650	12	-	-	-	-
5	9	0502	0612	S	23	58	<10	238	38	12	23	23	93	51	54	11	-	-	-	-
				M	-	-	-	-	-	13	-	20	97	50	5200	-	8	15	-	-
				B	24	58	10	22	39	12	24	44	272	1550	-	11	-	-	-	-
6	9	0835	0949	S	22	47	<10	21	31	12	42	21	69	66	66	11	-	-	-	-
				M	-	-	14	-	-	12	-	22	130	264	75	-	6	7	-	-
				B	19	128	465	18	42	1550	27	450	1530	4600	6200	12	-	-	-	-
7	9	1300	1505	S	16	75	12	15	29	12	24	22	58	157	168	12	10	10	57	151
				M	-	-	12	-	30	14	-	34	167	245	310	-	-	-	-	-
				B	32	86	16	20	28	655	31	3750	3600	2850	5500	14	11	18	70	149
8	9	1645	1815	S	14	116	16	20	76	16	24	30	28	113	278	14	12	13	76	167
				M	-	-	16	-	75	18	-	33	32	112	300	-	-	-	-	-
				B	13	95	15	23	50	42	28	3400	1850	3550	7400	14	13	15	76	180
9	9	2130	2335	S	20	49	14	19	46	28	84	27	47	47	73	10	-	<10	-	-
				M	-	-	14	-	-	28	-	27	57	55	82	-	<10	-	-	-
				B	20	47	14	20	46	28	60	46	1090	1490	2450	11	-	<10	-	-
10	10	0100	0215	S	47	50	<10	19	42	11	21	26	27	30	98	11	-	-	-	-
				M	-	-	<10	-	-	19	-	29	28	33	98	-	11	33	-	-
				B	28	51	<10	18	42	-	23	10	290	50	4200	11	-	-	-	-
11	10	0505	0618	S	143	41	10	21	46	10	27	18	74	29	145	9	-	-	75	150
				M	-	-	10	-	-	<10	-	16	139	26	80	-	7	8	-	152
				B	26	40	11	23	46	10	21	400	300	271	4950	10	-	-	-	158
12	10	0838	1035	S	43	76	10	22	40	10	24	14	25	144	142	9	-	-	74	142
				M	-	-	10	-	-	12	-	13	30	96	140	-	7	7	-	150
				B	26	67	12	25	22	12	24	36	182	3550	4150	10	-	-	75	170

*Surface samples were taken at one foot depth - bottom samples one foot from the bottom.

Errata

APPENDIX IV

SEDIMENT ANALYTICAL DATA SUMMARY

Escambia Bay Study

June 8-10, 1970

Station Number	Date (1970)	Chemical Oxygen Demand (mg/kg)	Total Phosphorus (mg/kg)	Total Organic Carbon[1/] (mg/kg)	Total Oxygen Demand[2/] (mg/kg)	Total Organic Nitrogen (mg/kg)
	June					
E-1	9	132,500	850	49,625	146.4	2,695
E-2	10	30,100	85	11,273	32.8	525
E-3	9	49,000	142	18,352	53.1	770
E-6	10	105,000	275	39,326	114.6	1,820
E-7	9	70,200	288	26,292	76.3	1,155
E-9	9	122,500	370	45,880	134.3	2,275
E-10	10	88,000	208	32,959	96.4	1,610
E-13	10	126,100	388	47,228	138.0	2,275
E-15	9	6,200	55	2,322	7.6	292
E-16	9	65,200	288	24,419	71.6	1,242
E-18	9	13,900	50	5,206	15.2	252
E-20	9	125,700	550	47,079	139.8	2,748
E-22	9	110,000	400	41,198	122.8	2,520
E-24	9	66,800	215	25,019	73.8	1,348
E-25	9	92,500	455	34,644	105.6	2,625
E-27	9	89,700	325	33,596	97.8	1,540
EB-1	9	82,200	262	30,787	89.1	1,295
EB-2	9	89,100	362	33,370	98.5	1,820

1/ Calculated stoichiometrically from the chemical oxygen demand analysis from the chemical reaction: $C + O_2 \longrightarrow CO_2$.

2/ Total Oxygen Demand = 2.67 organic carbon + 4.57 organic nitrogen. Reference: Department of Scientific and Industrial Research, "Effects of Polluting Discharges on the Thames Estuary." Water Poll. Res. Tech. Paper No. II, Her Majesty's Stationery Office, London (1964).

APPENDIX IV

SEDIMENT ANALYTICAL DATA SUMMARY

Escambia Bay Study

June 8-10, 1970

Station Number	Date (1970)	Chemical Oxygen Demand (mg/kg)	Total Phosphorus (mg/kg)	Total Organic Carbon[1/] (mg/kg)	Total Oxygen Demand[2/] (g/kg)
	June				
E-1	9	32,500	850	49,625	146.4
E-2	10	30,100	85	11,273	32.8
E-3	9	49,000	142	18,352	53.1
E-6	10	105,000	275	39,326	114.6
E-7	9	70,200	288	26,292	76.3
E-9	9	122,500	370	45,880	134.3
E-10	10	88,000	208	32,959	96.4
E-13	10	126,100	388	47,228	138.0
E-15	9	6,200	55	2,322	7.6
E-16	9	65,200	288	24,419	71.6
E-18	9	13,900	50	5,206	15.2
E-20	9	125,700	550	47,079	139.8
E-22	9	110,000	400	41,198	122.8
E-24	9	66,800	215	25,019	73.8
E-25	9	92,500	455	34,644	105.6
E-27	9	89,700	325	33,596	97.8
EB-1	9	82,200	262	30,787	89.1
EB-2	9	89,100	362	33,370	98.5

1/ Calculated stoichiometrically from the chemical oxygen demand analysis from the chemical reaction: $C + O_2 \longrightarrow CO_2$.

2/ Total Oxygen Demand = 2.67 organic carbon + 4.57 organic nitrogen. Reference: Department of Scientific and Industrial Research, "Effects of Polluting Discharges on the Thames Estuary." Water Poll. Res. Tech. Paper No. II, Her Majesty's Stationery Office, London (1964).

APPENDIX V

SAMPLING STATION LOCATIONS

Escambia Bay Study

June 8-10, 1970

Station Designation	General Location	Geographic Position Latitude	Longitude
E-1	Confluence of Escambia and East Rivers	30° 32' 52"	87° 11' 25"
E-2	Upper Escambia Bay	30° 34' 05"	87° 10' 56"
E-3	"	30° 34' 29"	87° 10' 05"
E-4	"	30° 34' 33"	87° 09' 38"
E-5	"	30° 33' 28"	87° 10' 28"
E-6	"	30° 33' 52"	87° 09' 39"
E-7	"	30° 34' 11"	87° 09' 13"
E-8	"	30° 32' 19"	87° 11' 10"
E-9	"	30° 32' 50"	87° 10' 02"
E-10	"	30° 33' 17"	87° 09' 17"
E-11	"	30° 33' 42"	87° 08' 47"
E-12	"	30° 31' 34"	87° 10' 46"
E-13	"	30° 31' 55"	87° 10' 05"
E-14	"	30° 32' 17"	87° 09' 28"
E-15	"	30° 32' 43"	87° 08' 48"
E-16	"	30° 31' 25"	87° 09' 47"
E-17	"	30° 31' 46"	87° 09' 78"
E-18	"	30° 32' 07"	87° 08' 21"
E-19	Lower Escambia Bay	30° 30' 38"	87° 09' 35"

Station Designation	General Location	Geographic Position Latitude	Geographic Position Longitude
E-20	Lower Escambia Bay	30° 31' 07"	87° 08' 56"
E-21	"	30° 31' 34"	87° 08' 11"
E-22	"	30° 30' 15"	87° 09' 17"
E-23	"	30° 30' 34"	87° 08' 41"
E-24	"	30° 31' 02"	87° 07' 54"
E-25	"	30° 29' 40"	87° 08' 15"
E-26	"	30° 28' 53"	87° 07' 52"
E-27	"	30° 28' 05"	87° 07' 28"
E-28	"	30° 27' 20"	87° 07' 28"
E-36	Upper Escambia Bay	30° 34' 09"	87° 09' 54"
E-59	"	30° 33' 08"	87° 10' 15"
E-99	"	30° 32' 15"	87° 10' 17"
EB-1	Lower Escambia Bay	30° 30' 25"	87° 07' 58"
EB-2	"	30° 28' 26"	87° 08' 46"
M-1	Mulatto Bayou at L&N Railroad Trestle	30° 32' 54"	87° 07' 38"
M-2	Mulatto Bayou	30° 32' 15"	87° 07' 36"

PAGE NOT

AVAILABLE

DIGITALLY