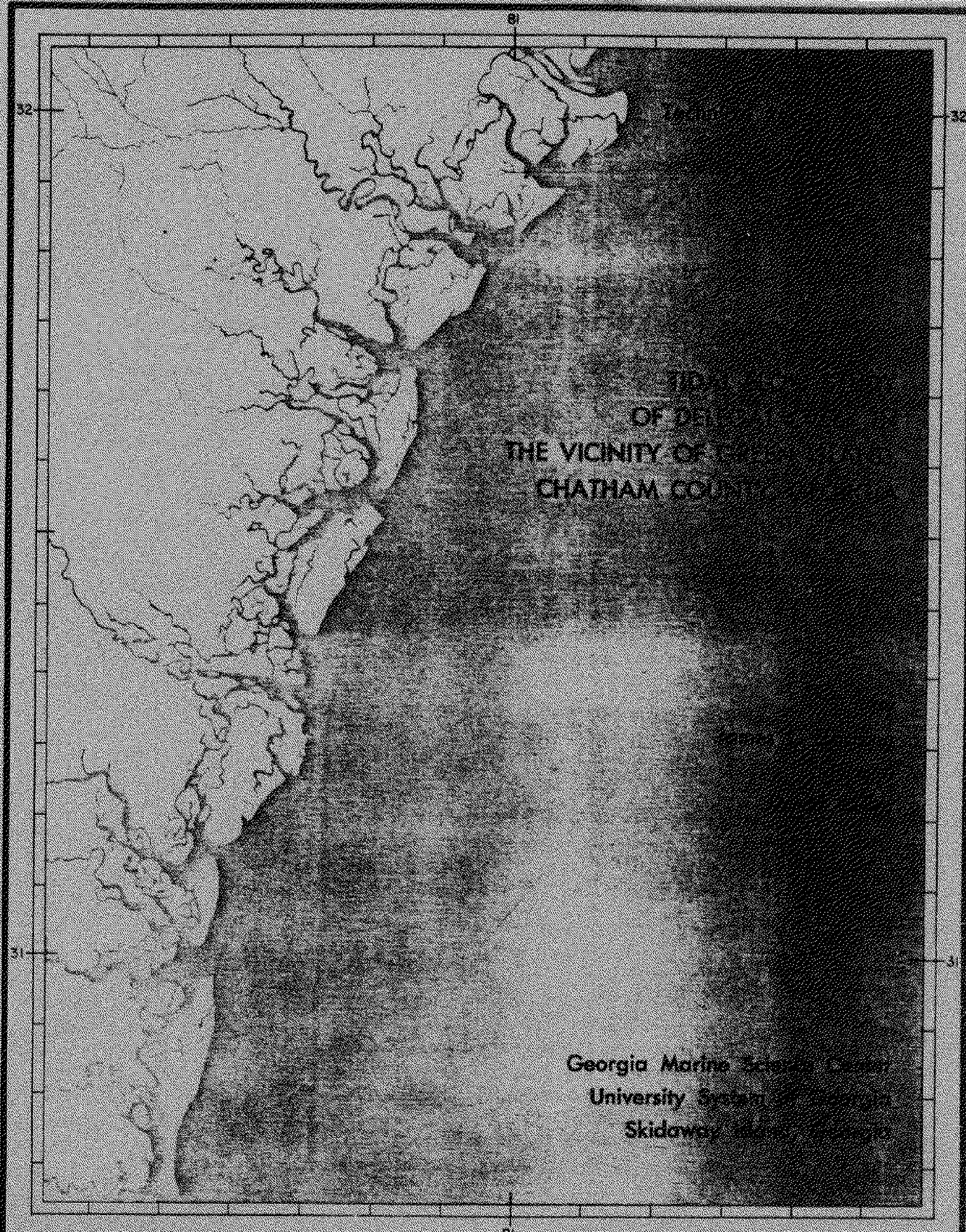

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TIDAL FLOW STUDY

of

DELEGAL CREEK IN THE VICINITY

of

GREEN ISLAND, CHATHAM COUNTY, GEORGIA

by

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and
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I. Introduction

A. History of Project

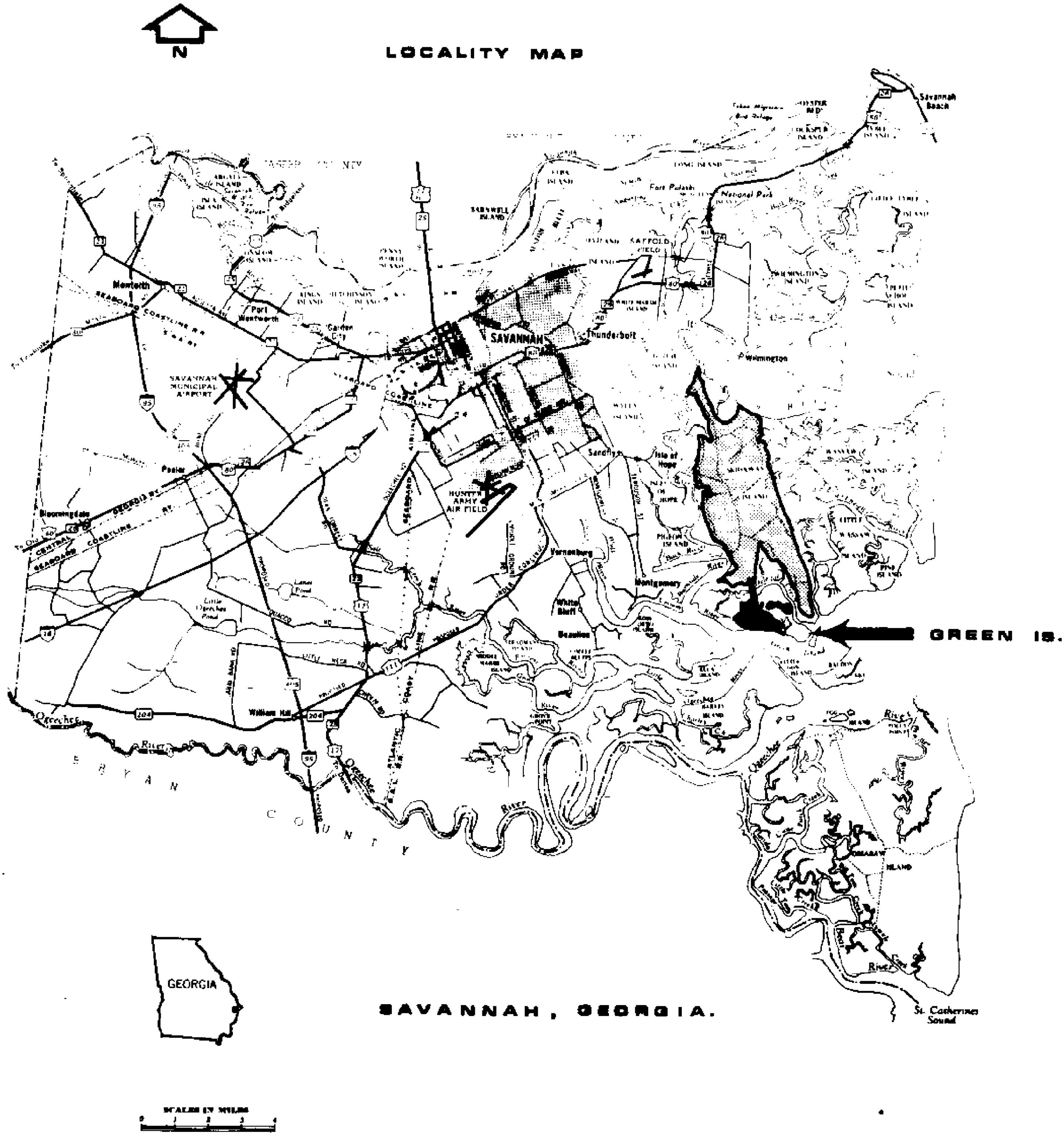
In late August, 1971, Mr. William Breen, of Breen Associates called on Dr. David Menzel, Director of the Skidaway Institute of Oceanography, to solicit advice in studying the tidal flow pattern in Delegal Creek between Green and Skidaway Islands. Mr. Breen was representing clients who are desirous of constructing a bridge-causeway connecting the two islands for a real estate development project.

A conference ensued between Mr. Breen, Drs. Menzel and Windom of the Skidaway Institute and Dr. Harding of the Marine Extension Program at Skidaway, in which it was suggested that by using a water soluble dye augmented by aerial surveillance it may be possible to trace the general pattern of water flow.

In subsequent correspondence and discussions, it was decided that personnel of the Marine Extension Program would help perform this study, as the information gained could be helpful in building the data base necessary for understanding the hydrology of Georgia's salt marshes.

During September and October, 1971, several site visits were made to the Delegal Creek - Green Island area.

LOCALITY MAP



SAVANNAH, GEORGIA.

FIG. 1.

Also, during this same period, conferences were held with Dr. Frederick Marland at the University of Georgia Marine Institute at Sapelo Island, whose interest and advice were helpful during the planning stage.

November 5, 1971 was chosen as the date on which to perform the dye study.

B. Description of the Area

The study area consisted of Delegal Creek and its drainage basin which separate Skidaway and Green Islands. (See Figure 1). Delegal Creek flows into Green Island Sound which constitutes the upper reaches of Ossabaw Sound. Hence, Delegal Creek is indirectly connected to the open sea, and as such, owes almost its entire water budget (exclusive of fresh-water precipitation) to tidal circulation.

In order to fully comprehend the effects of the placement of a connecting causeway-bridge between the two islands, it is first necessary to establish the nature of this tidal flow.

C. Test Procedures

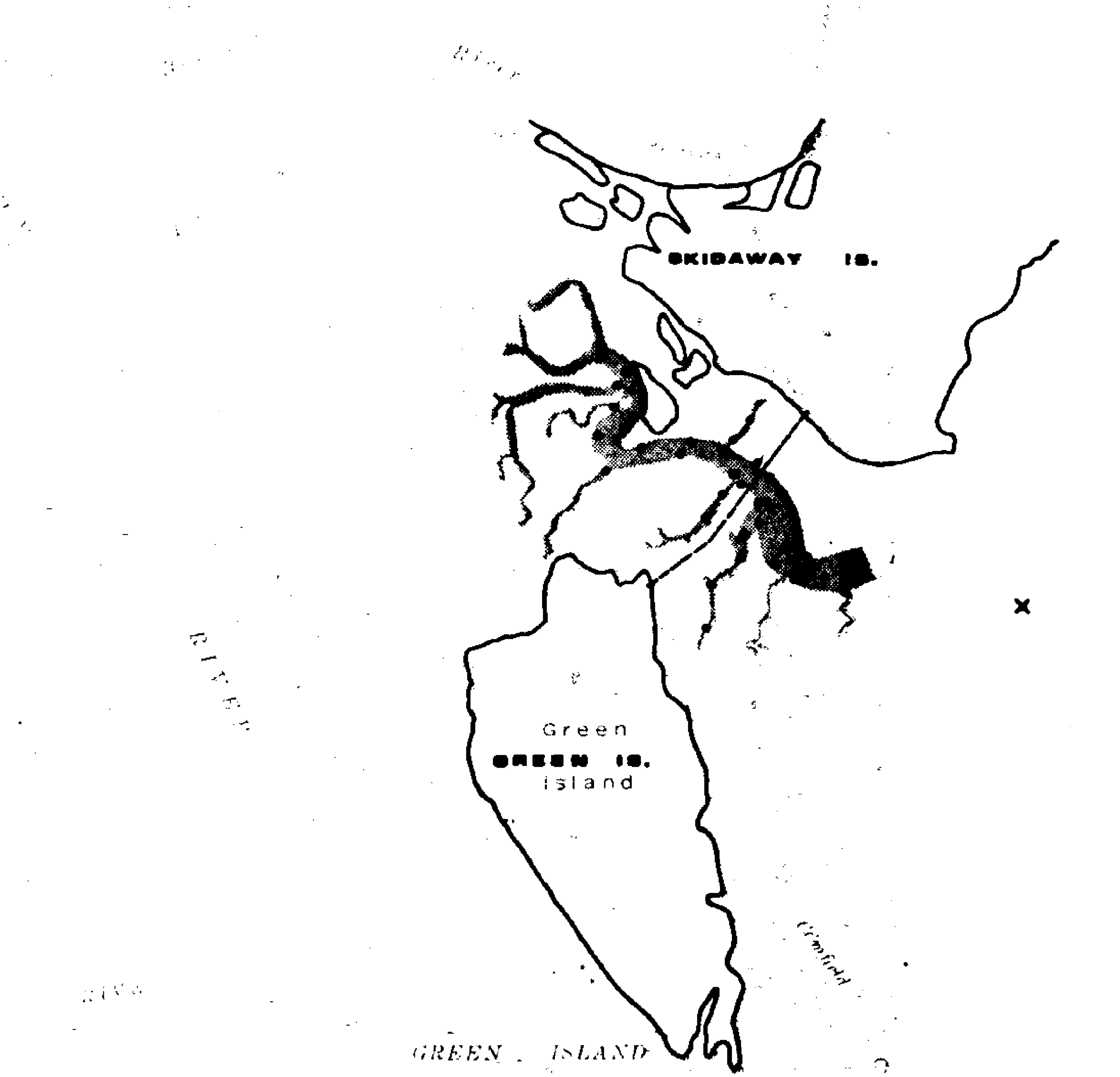
The use of dyes in surface-water hydrology has been practiced by the U.S. Geological Survey for a number of years.

The specific dye selected for the Green Island study was Rhodamine WT-Solution 20%. This is a clear, very dark red aqueous solution with a specific gravity of 1.19 $\pm$ 0.02 at 20°C. It was developed by the DuPont Corporation in response to the need for a dye which would exhibit high tinctorial strength and with a low tendency to stain silt and other suspended matter.

The dye, in four 50-pound containers, was delivered to Skidaway Institute on November 4th, and was subsequently decanted and diluted into 5-gallon plastic carboys for ease in handling.

It was deemed essential to plant the dye in the water as near as possible to the beginning of flood tide on November 5th. A high tide of 9.2 feet was expected at 1100 hours. The Marine Extension personnel left Skidaway the afternoon of the 4th and spent the night at anchor in Delegal Creek, using the R/V Golden Isles as a quarter boat. Arrangements were made to effect a rendezvous with a helicopter furnished by Breen Associates in the early morning hours of November 5th.

At 0600 on the 5th, James Harding and David Miller of the Marine Extension Program departed the quarter boat in a Boston Whaler to commence placing the dye in the water. Figure II shows the points at which the dye was poured into the tidal water.



------ ℄ OF PROPOSED CROSSING

• DYE DROP STATIONS, NOV. 6, 1971

X ANCHORAGE OF R/V GOLDEN ISLES

FIG. 6.

As will be discussed in later sections of this report, it was held imperative that the dye be dispensed in three principal areas: (1) into the two creeks on opposite sides of the centerline for the proposed causeway; (2) into the marsh adjacent to the southern end of Skidaway Island, again in proximity to the proposed centerline; and (3) into the drainage basin of Delegal Creek west of the proposed crossing.

All primary dye drops were made prior to the arrival of the helicopter at 0840 at which time aerial photographic coverage began. Secondary drops were made at many of the same points after rendezvous with the aircraft and up until 1045 hours on approximately maximum flood tide.

II. General Remarks

That portion of the Delegal Creek watershed which was the object of investigation is characterized by a well-defined dendritic drainage system. This is true of the basin west of the proposed causeway as well as on a micro-scale on the peninsula adjacent to Green Island.

In order to place the numerous streams of this network in perspective, it is advisable to adhere to the quantitative terminology of Strahler (1964), where the smallest tributaries are designated first-order streams.

Where two first-order channels join, a second-order channel segment is formed; and so forth. Based on this descriptive terminology, Delegal Creek is a fourth-order stream, and the principal trunk segment.

Any drainage basin, tidal or otherwise, is an open system which maintains its energy budget through boundaries and is dependent upon the uniform transformation of this energy to maintain operation. Although the transformation of energy may be uniform, the tidal marshes are subjected to a unique type of unsteady flow, where velocity changes in magnitude but not necessarily direction with respect to time.

Tideland hydrography, in general, is well understood, with complicating factors usually being localized. Tidal flows in estuaries are the result of tide-producing forces at the mouth of the estuary (Ippen 1966). The tidal oscillations at the mouth and the exchange of water through the entrance temporarily store sea water in the estuary during high tide and drain it seaward during low tide. The volume of water thus exchanged is known as the tidal prism, which, according to Ippen (op. cit.) varies only with tidal amplitude.

Tides are waves; but they are waves with typical periods of 12 hours and 25 minutes (43,000 seconds) and a wavelength equal to half the circumference of the earth or about 12,600 miles (Pattullo 1966).

Because of the extreme length of the period, the wavelength is usually much larger than the length of any given estuary. The water displacement is horizontal along the channel axis and the wave shape is adequately described by harmonics (Ippen 1966). In other words, the tidal water does not enter the estuary as a wave front, but fills the tidal streams first parallel to their axes, and under conditions of excess amplitude, may fill them to overflow stage, whereupon the marsh may flood. Drainage takes place by a reverse process.

One of the earlier reference works on marshes applicable to the Georgia coast is that of Shaler (1893) in which he described the flow of water on ebbing tide draining into shallow grooves, which as they extend, become deeper and maintain more distinct banks as a result of the additional energy of stream occupancy. As these "grooves" coalesce, the gathered energy is strong enough to cut a channel which extends below the low-tide mark. Shaler also observed that the general surface of the area between these grooves slopes gently towards their margins, thereby enhancing the ebb flow into the groove channels.

In essence, the foregoing remarks are held to be applicable to the hydrologic regime of salt marshes in general and those along the Georgia coast, in particular. Exceptions may exist, but only where a well-developed dendritic drainage pattern does not exist.

III. Discussion of Survey Results

Aerial photographs taken between 0840 and 1530 hours on November 5, 1971 are presented in this section of the report. These hours extend from a time when all dye stations had been made on the initial drops (about 30% into flood stage) to approximately one hour before maximum low tide. The high tide on November 5th was 9.2 feet which was heightened somewhat by a brisk (estimated 12-15 knot) wind out of the North-Northeast. Wind wave action can be noted on some of the photos. While there is no doubt that wind friction at the sea-air interface exercised some control in dye dispersal, the augmentation was <u>into</u> the marsh proper and therefore additive to normal tidal flow direction and velocity. The milky appearance of many of the air photos is probably due to excessive silt and organic matter placed in suspension by wind driven currents.

The salinity of the water in the area was measured at 25 0/00 with a refractive index, T/C = 1.3377. The water temperature was 20.45°C, and the air temperature at 12 noon 59°F (19°C).

Figures 3 and 4 were taken from ground level and 50', respectively and illustrate how the dyed water dispersed into the channels of the marsh. Figure 4 also illustrates the habit of the tall Spartina salt grass and its propensity to grow immediately adjacent to the channels. On air photos taken from higher altitudes, this taller grass (2-3 meters) tends to "etch" the principal tributaries in sharp outline.

As the tidal water rises in Delegal Creek, it enters into the third and second-order streams and hence into the first-order tributaries. These latter constitute the headwaters of the system and are much narrower and shallower than those of higher order. Further, they appear to have termination points, albeit somewhat ill-defined, so that as the momentum of tidal flooding continues, these smaller channels overflow their banks and water spreads over the adjacent marsh.

This same phenomenom continues in the lower reaches of the first-order channels and the upper reaches of the second-order ones with the water spreading laterally due to the overbank flow.

Eventually, however, this lateral movement of the water is arrested by interfering flow patterns, i.e. water still coming in from one principal direction (the third-order streams) and being met by the overflow water. At first, this results in a confused flow pattern, followed by a period of essentially no horizontal movement except that of generally rising water level.

Dye placed in the third and fourth order streams an hour before maximum high tide stayed essentially in place except for movement in the direction of the main current, parallel to the stream axis; it did not penetrate far into the marsh.

Figures 5 through 13 illustrate the sequence of events described above.

The period of slack tide was extremely short; no sooner had this equilibrium as indicated by the lack of movement of the dye patches begun, than the flow began to ebb. The first indication of ebb flow was a slow movement of the dye patches out of the third-order streams and into Delegal Creek. (See Figure 15).

Figure 16 illustrates the conditions about an hour into ebb tide. Many of the first-order tributaries still contain dyed water. Figure 17, about 30 minutes later, shows that even these concentrations have dissipated.

IV. Summary and Conclusions

In summary, it appears that the tidal marsh on either side of Delegal Creek, between Green and Skidaway Islands floods and drains in the manner described previously, where the network of first-order streams comprising the headwaters overflow their banks, with the processing continuing into the lower reaches, etc. until an equilibrium state is reached and the general water level rises.

At ebb tide, the process is essentially reversed. These observations are held to be indicative of near maximum conditions, as the 9.2 foot tide was only 0.5 foot below the average yearly highest tide for the years 1936 - 1961 (Wiegel 1964).

Insofar as the basin west of the proposed crossing is concerned, all the flow is carried in and out by the main channel segment (Delegal Creek) and its third-order tributaries. The proposed bridge-causeway should have no deleterious effects on this area as long as the flow of the main channel is not constricted in any way.

The dendritic network of channels in the area is a manifestation of tidal ebb and flow over the years. In order to maintain these channels, and hence the nourishment of the marsh ecosystem, the energy flow maintaining the channel network needs to be protected. This protection must be extended to the fourth, third, and second-order streams. As for the first-order streams, those tiny (and hence fragile) tributaries need be mapped and studied in detail. Although the most fragile, they may be the first to re-adjust to a new flow pattern, as their channels are less well-entrenched.

Figure 18 shows the area at about mid-ebb. The small boat is hove to on the proposed centerline. As proposed, it crosses an important second-order stream. An alternate route, offset to the west would miss this channel.

Indeed, as Figures 19 and 20 illustrate, there appears to be a natural divide, between second-order streams coming into the marsh from either side of the proposed centerline.

Again, by referring to Figure 18, a second alternate should be given consideration. Although dependent upon property holdings, etc. it appears to offer some merit, as such a route would miss low areas adjacent to both islands where the center-line as presently proposed crosses.

These alternate routes are suggestions. It is not the intent of this report to make engineering recommendations, but rather to elucidate the nature of the water flow patterns.

To reiterate, the fourth-order stream (Delegal Creek) must suffer no constriction. The third-order streams are also important and also must not be constricted in any fashion. The second-order streams must be protected as much as possible, either by bridging or with culverts, and the first-order streams should be carefully mapped and plotted prior to route selection.

FIG. 3 GROUND LEVEL

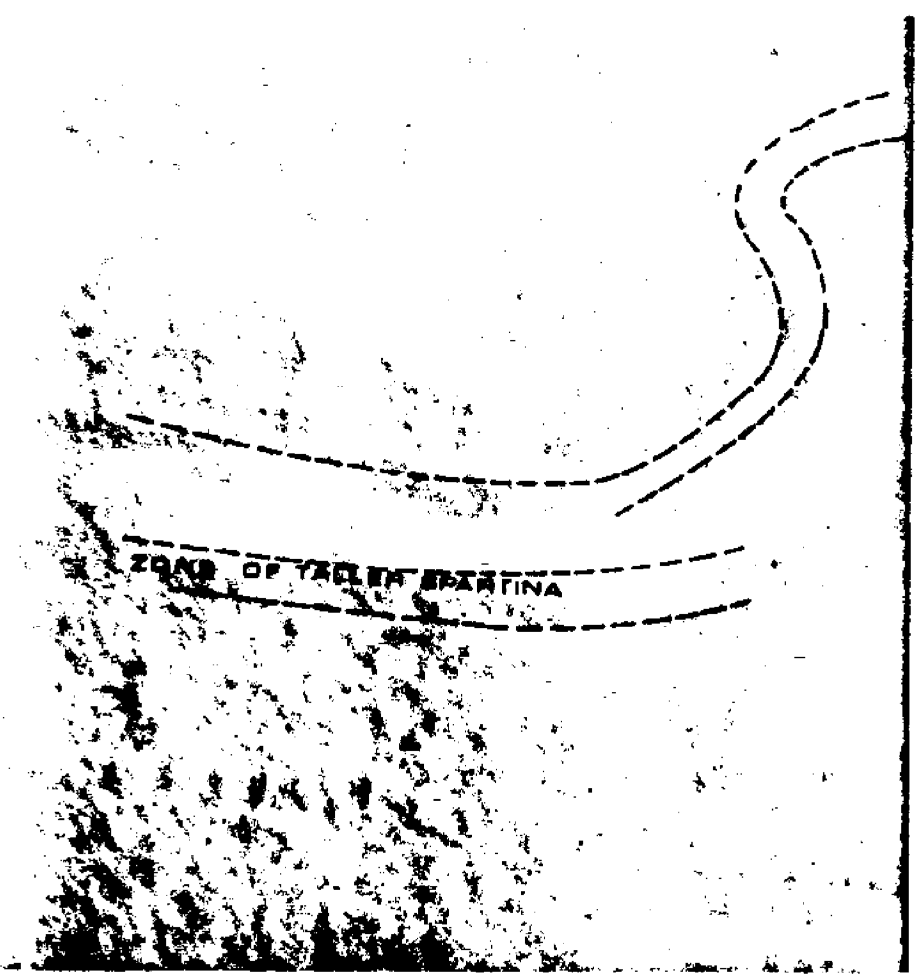


FIG. 4 50' ALTITUDE

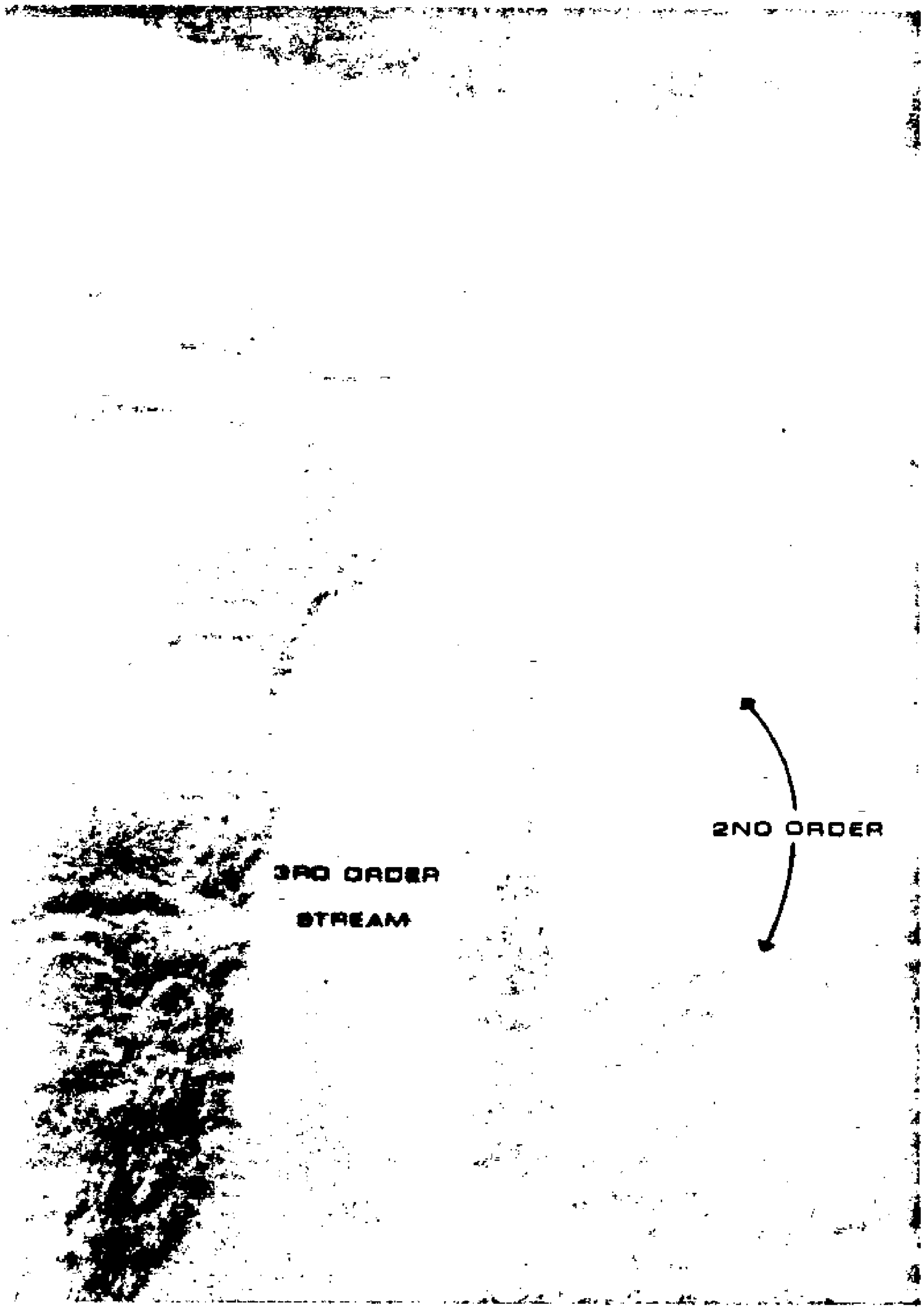


FIG. 6 DYE DROP STATION IN 3RD ORDER STREAM TO EAST OF PROPOSED ℄. NOTE WIND WAVE-CURRENT EFFECT IN MID-CHANNEL. TALL LEVEE-TYPE SPARTINA AND ENTRY OF DYE INTO 2ND ORDER CHANNELS.

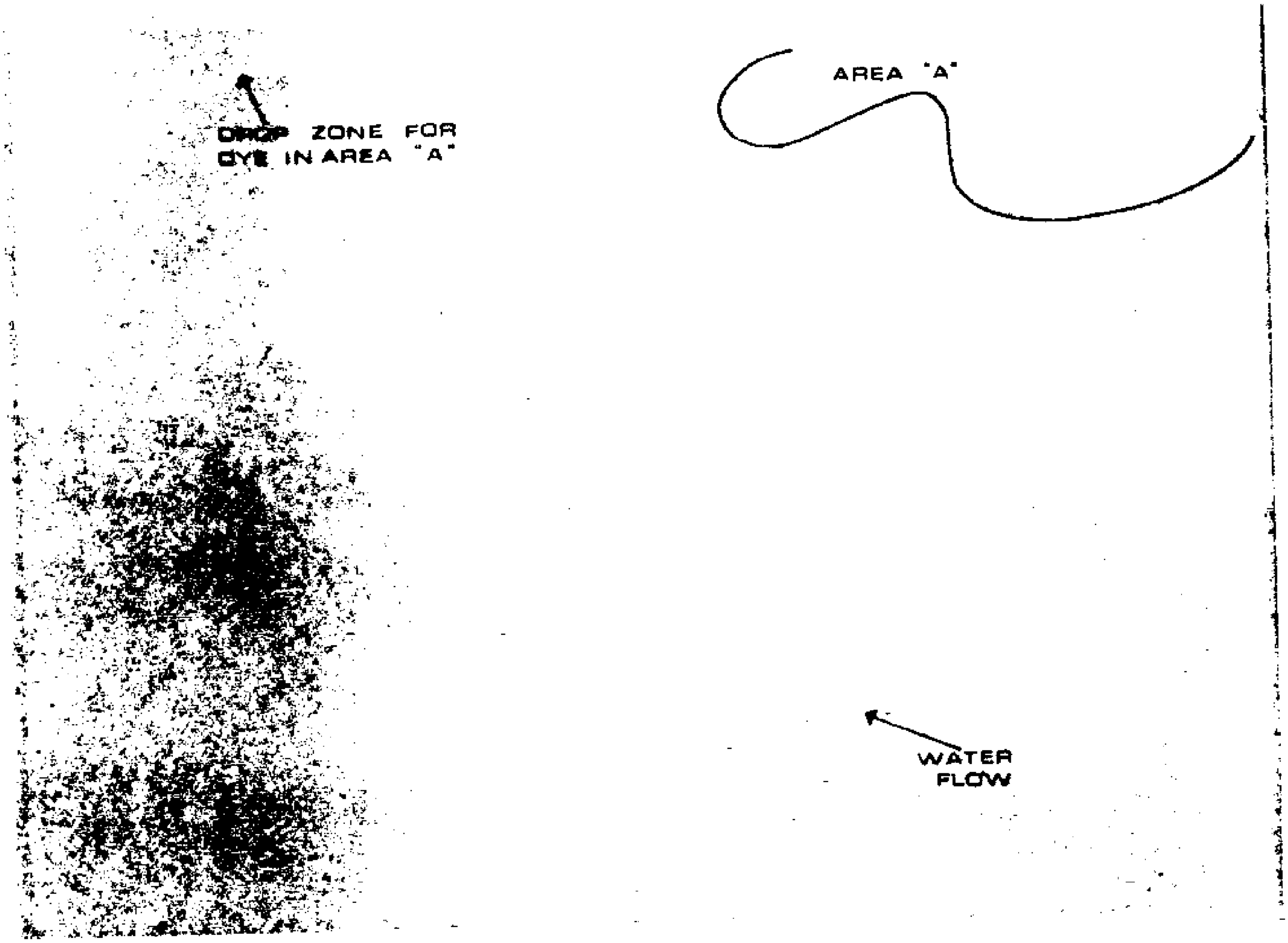


FIG. 8 ANOTHER DYE STATION IN A 3RD ORDER STREAM ON FLOOD TIDE. NOTE COLORATION IN AREA "A", WHERE 2ND AND 1ST ORDER STREAMS ARE RECEIVING DYED WATER.

FIG. 7 NETWORK OF 1ST ORDER STREAMS IN BEGINNING OF OUTFLOW CONDITION. DYE DROP AREA WAS TO THE LOWER LEFT, OUTSIDE OF PICTURE AREA.

FIG. [illegible] DISPERSAL PATTERN OF FIRST DYE DROPS. NOTE CONCENTRATION OF DYED WATER IN HEAD WATERS OF SYSTEM (AREA A), NEAR GREEN ISLAND.

⟶ FLOW DIRECTION

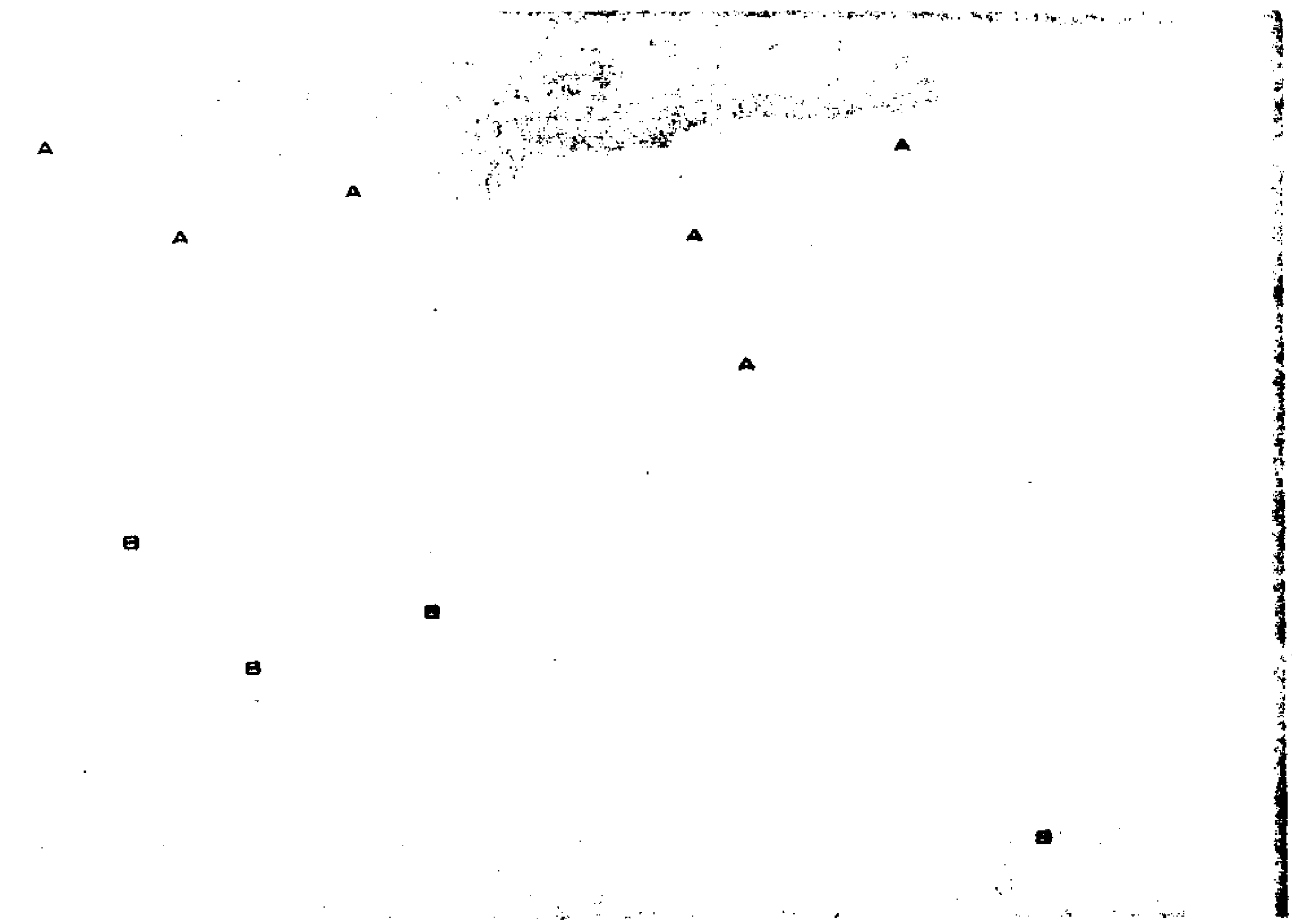


FIG. 9 HEADWATERS (NETWORK OF 1ST ORDER STREAMS) DYED BY FIRST SERIES OF DROPS SPREADING LATERALLY (AREA A). SECOND SERIES OF DYE DROPS COMMENCED (AREA B).

FIG. 10 ZONE ADJACENT TO SKIDAWAY ISLAND AFTER 1ST DYE DROP.

FIG. 11 SAME ZONE FOLLOWING 2ND DYE DROP.

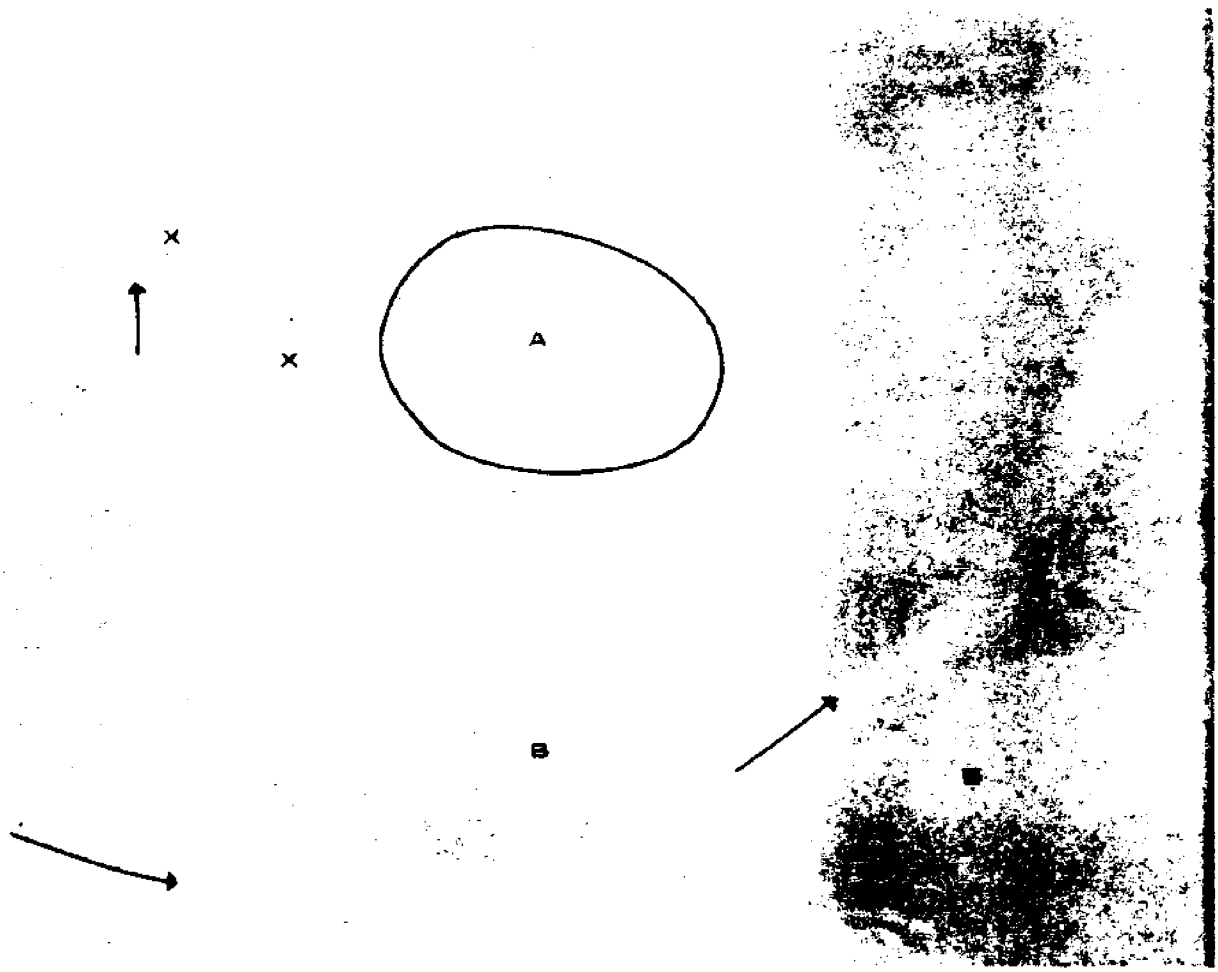


FIG. 12 AFTER 2ND SERIES OF DYE DROPS. NOTE CONFUSED DYE PATTERN IN AREA "A", THOUGHT TO BE DUE TO INTERFERING FLOWS. THIS DYE ORIGINATED FROM POINTS MARKED "X" DURING FIRST SERIES OF DROPS.

DYE FROM SECOND SERIES OF DROPS (B) NOT MOVING IN TO MARSH AS RAPIDLY AS DID 1ST SERIES.

⟶ FLOW DIRECTION

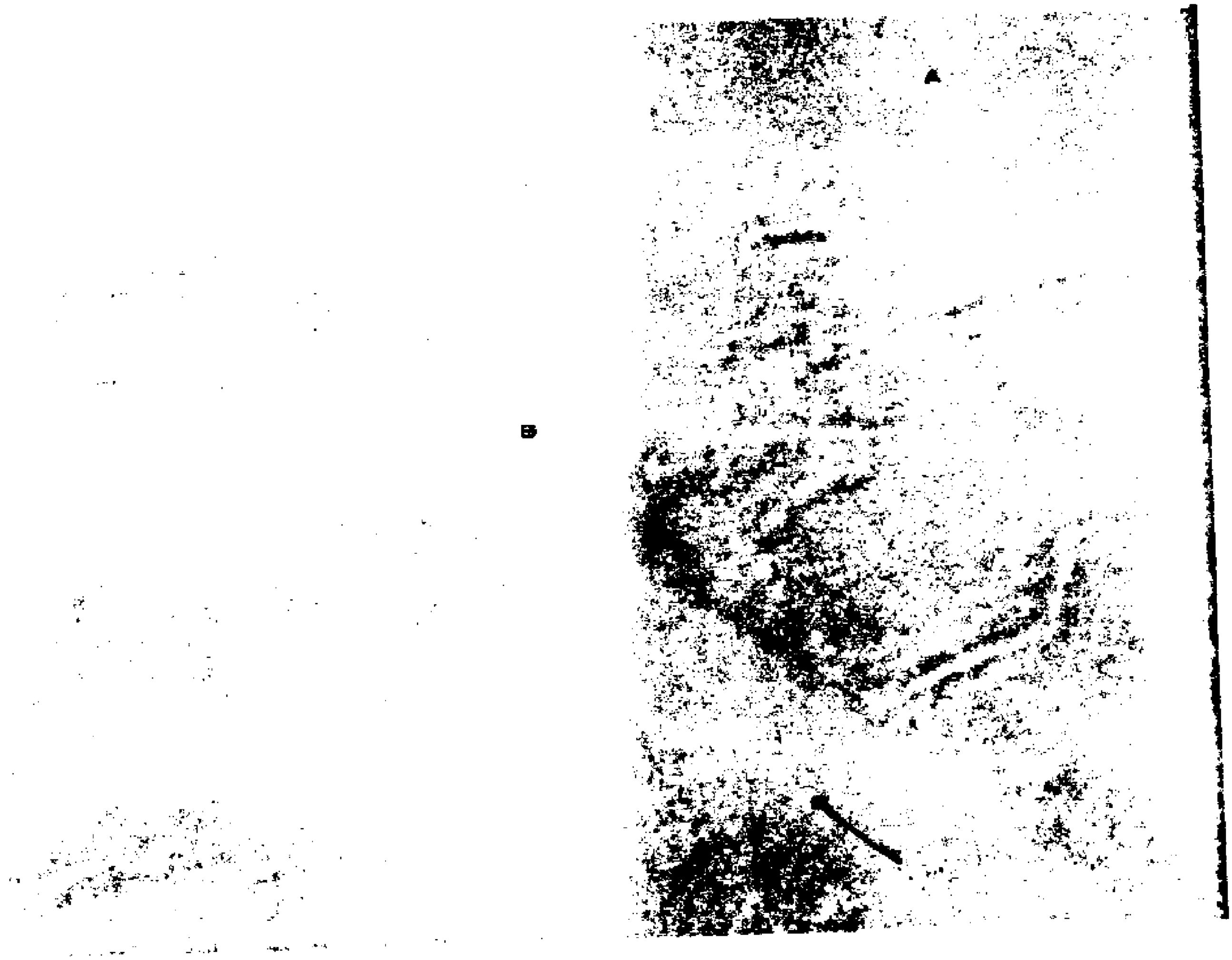


FIG. 13 3RD ORDER STREAM NEAR MAXIMUM FLOOD TIDE. NOTE DYE IN AREA "A" FROM FIRST DROP AND IN CHANNEL (B) FROM SECOND DROP, WHICH IS STAYING IN CHANNEL.

$\longrightarrow$ FLOW

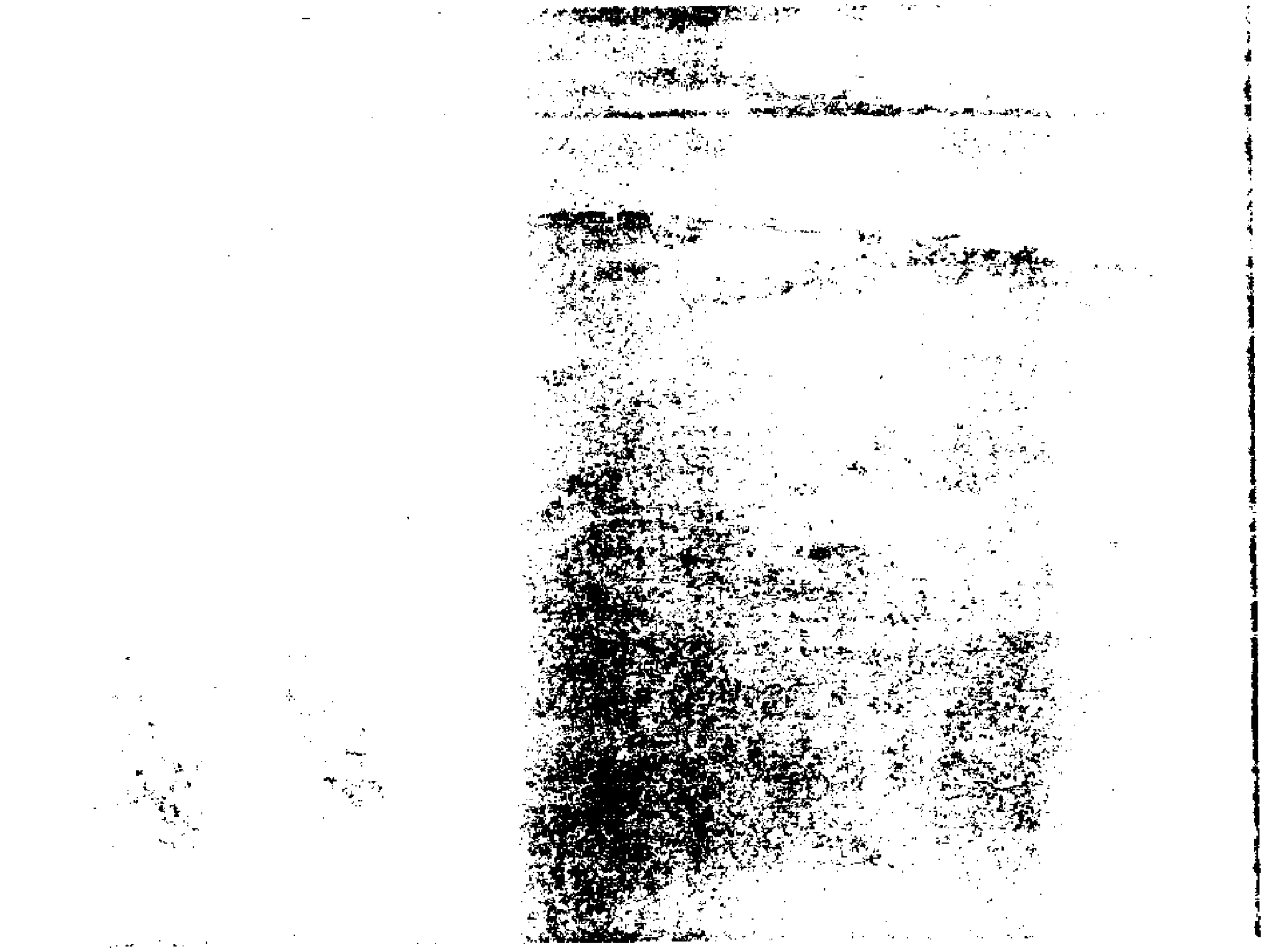


FIG. 14 APPROXIMATE SLACK TIDE.

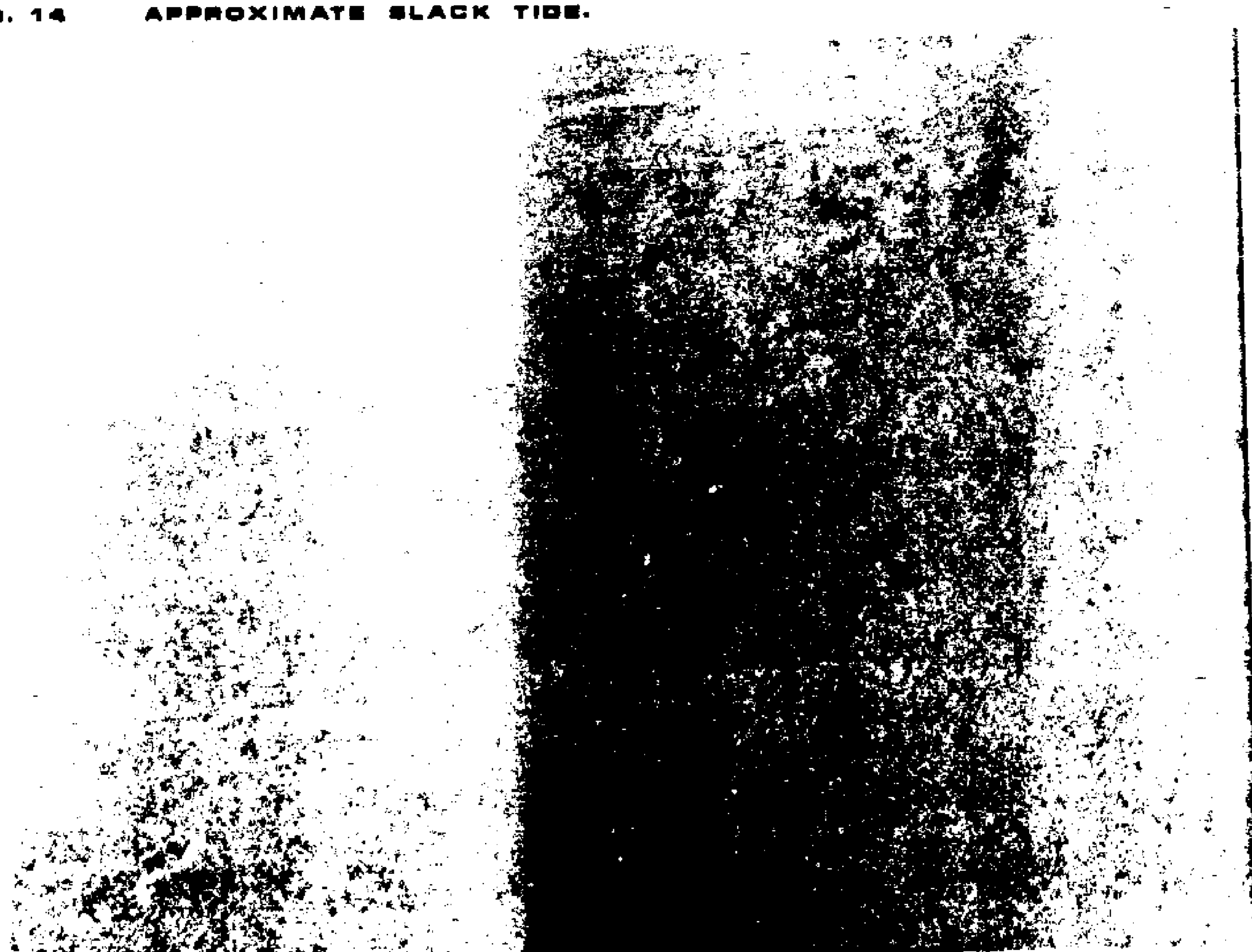


FIG. 15 TIDE BEGINNING TO EBB.

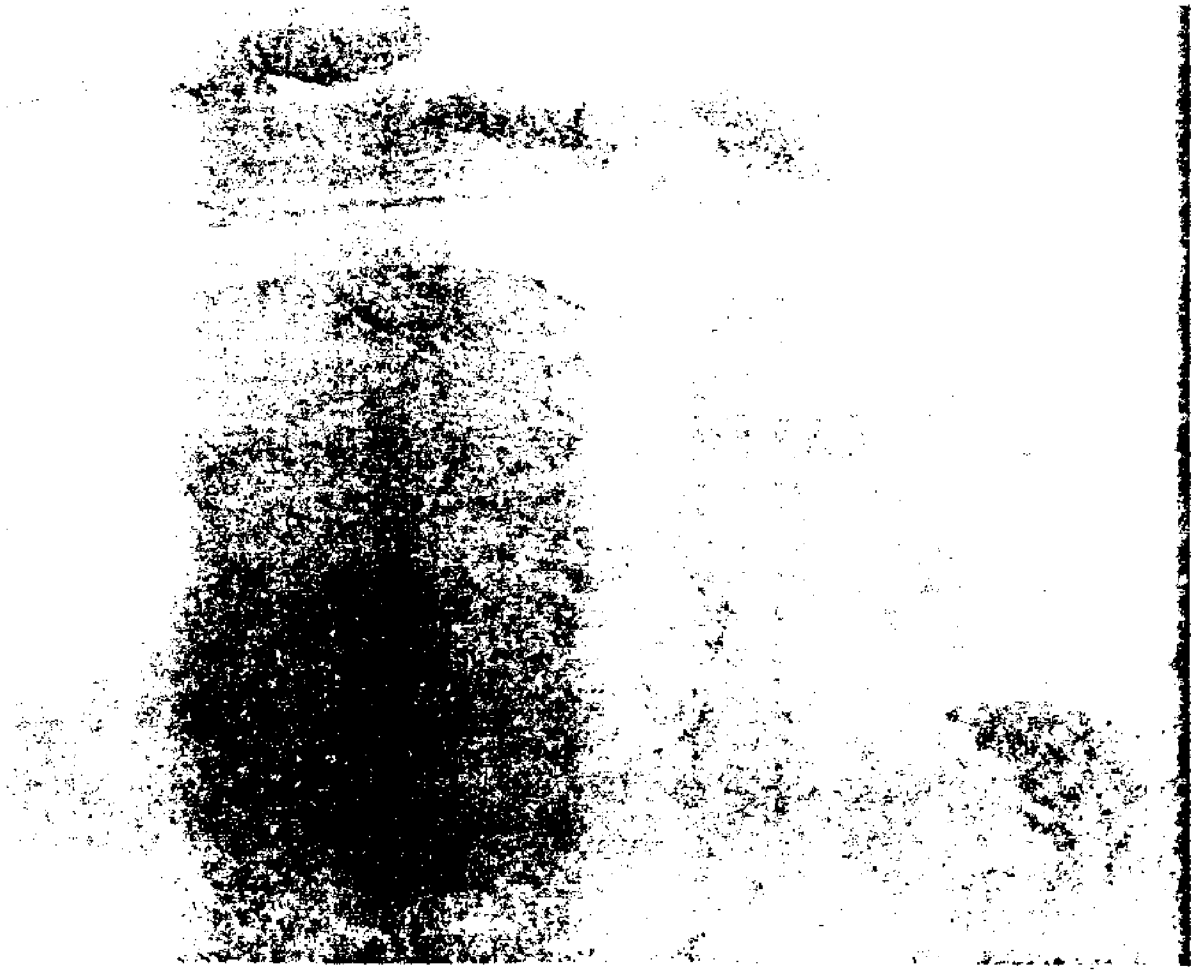


FIG. 16 ONE HOUR INTO EBB FLOW. SMALL BOAT ON PROPOSED ℄.

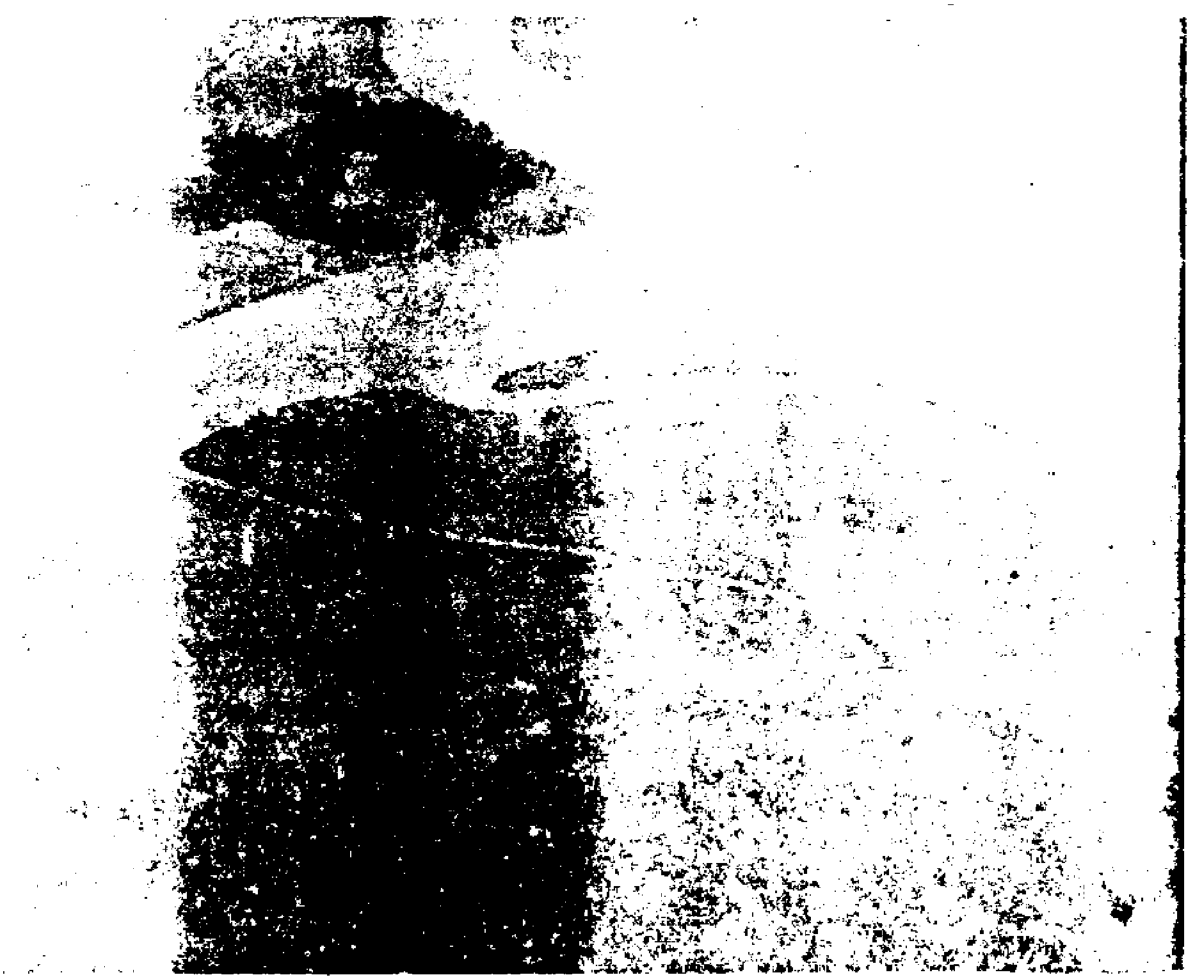


FIG. 17 30 MINUTES LATER.

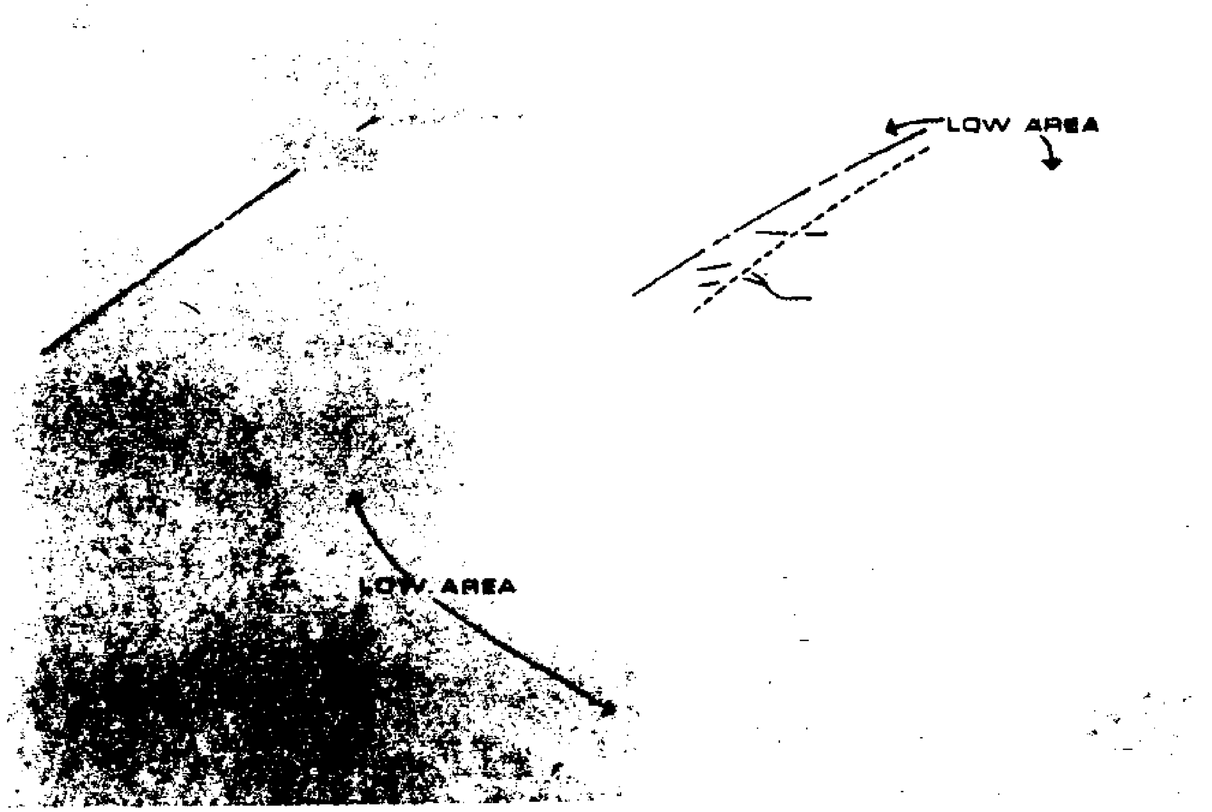


FIG. 15 ---------------- ROUTE AS PROPOSED.

—·—— - POSSIBLE ALTERNATE ROUTES.

FIG. 19 DOTTED LINE ON APPARENT DIVIDE.

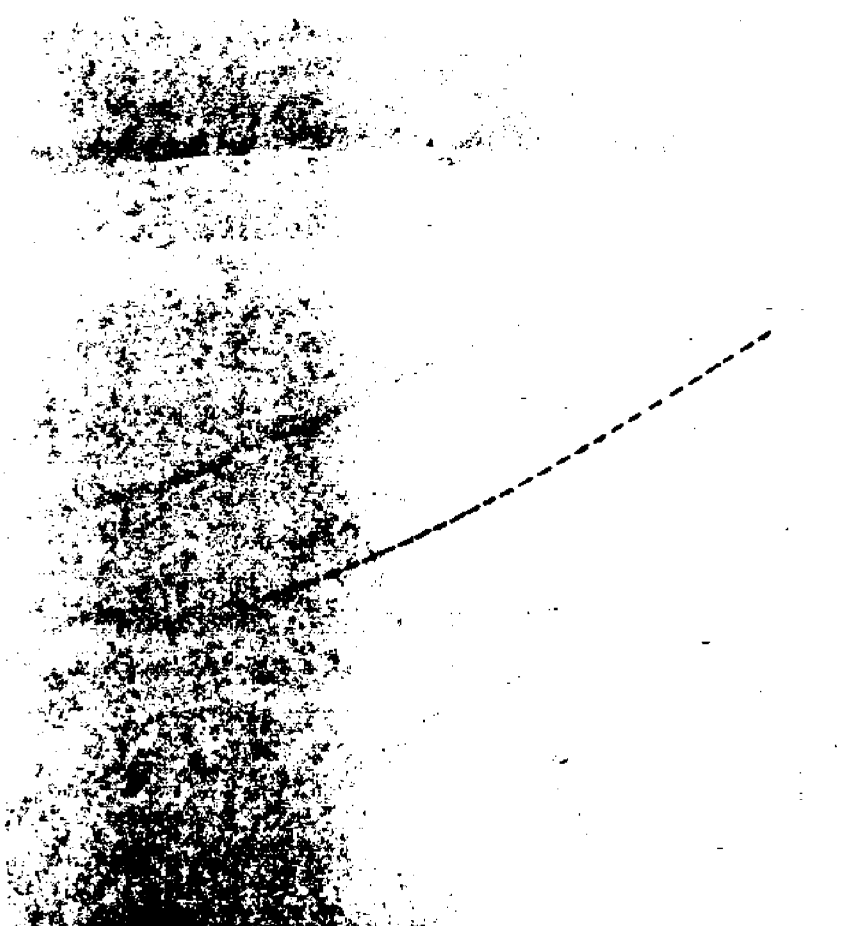


FIG. 20 DOTTED LINE ON APPARENT DIVIDE.

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