AIRBORNE THERMAL INFRARED SURVEY
SUMMER 1977
ST. LUCIE PLANT
QUARTER II FLIGHT
March 10-11, 1977

Prepared for

FLORIDA POWER & LIGHT COMPANY
P.O. Box 013100
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9 December 1977

Prepared by

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SECTION I

REGULATORY PURPOSE

The thermal infrared surveys performed by Texas Instruments for Florida Power & Light Company (FPL) are designed to demonstrate compliance with the requirements of the facility NPDES Permit and the facility Environmental Technical Specifications. The specific regulatory requirements are as follows:

- NPDES Permit FL0002208 Special Conditions B., b., sentence 1 and 2.

  The discharge into the Atlantic Ocean shall not cause a temperature rise in excess of 0.8°C (1.5°F) above ambient surface temperature outside a 162 hectacres (400 acre) zone of mixing during the months of June through September, nor 2.2°C (4°F) rise during the remaining months. In addition, the surface temperature conditions within the zone of mixing will not exceed a rise of 3.1°C (5.5°F) over ambient temperature nor a maximum temperature of 33.9°C (93°F) as an instantaneous maximum at any point.

- St. Lucie Unit No. 1 Technical Specifications, Appendix B, Limiting Conditions, 2.1.1, Specification, paragraph 1.

  The thermal discharge of St. Lucie Unit No. 1 into the Atlantic Ocean shall be limited to a maximum release temperature of 111°F and shall not cause a temperature rise in excess of 1.5°F above ambient surface temperature outside a 400 acre zone of mixing during the months of June through September, nor a 4°F rise during the remaining months. In addition, the surface temperature conditions within the zone of mixing shall not exceed a rise of 5.5°F over ambient temperature nor a maximum temperature of 93°F as an instantaneous maximum at any point.

In accordance with the last sentence of the St. Lucie plant NPDES Permit, Special Conditions B., b., FPL submitted to the EPA Regional Administrator on November 21, 1974, a proposed thermal monitoring program to satisfy the NPDES Permit and Environmental Technical Specifications monitoring requirements, which included the surface area temperature limitation. The thermal infrared survey performed for FPL and reported in this document complies with all the regulatory and monitoring program criteria relating to

the thermal infrared imagery requirements. In addition, the four required flight patterns were to be performed approximately on a quarterly basis in order to obtain a representation of seasonal effects due to wind, temperature and currents on the St. Lucie plant plume. The four flights are to be represented in separate reports as Quarter I through Quarter IV Flights.*

*Environmental Technical Specifications, St. Lucie Plant Unit No. 1 Technical Specifications, Appendix B,3.1.A.6.

SECTION II

FACILITY DESCRIPTION

A. PLANT LOCATION

The plant is located on Hutchinson Island in St. Lucie County, about halfway between the cities of Fort Pierce and Stuart on the east coast of Florida (see Figure II-1). The site is approximately 120 highway miles north of Miami, 225 miles south of Jacksonville and 150 miles east of Tampa. Lake Okeechobee is approximately 35 miles to the southwest.

Hutchinson Island is approximately 22 miles long by 1 mile wide at its maximum width. The Atlantic Ocean lies to the east, and the Indian River separates the island from the mainland to the west. Indian River is not a river in the usual sense. It is a long, thin, tidal lagoon stretching down the southeastern coast of Florida between the mainland and a series of offshore islands. The river is approximately 7200 feet wide at the plant site.

Hutchinson Island is generally flat. Much of it consists of swamp covered with dense vegetation characteristic of Florida coastal mangrove swamps. From the ocean shore the land rises slightly in a dune or ridge to approximately 15 feet above mean low water.

The plant is located on 1132 acres near the midpoint of the island. The plant occupies approximately 300 acres adjacent to Big Mud Creek, an inlet off the Indian River, and across State Road A-1-A from the ocean shore.

B. GENERATING UNIT DESCRIPTION

St. Lucie Unit No. 1 is a nuclear unit of pressurized water design. The reactor heat from the reactor's primary system coolant loops is transferred to a secondary coolant system in two steam generators. Here,

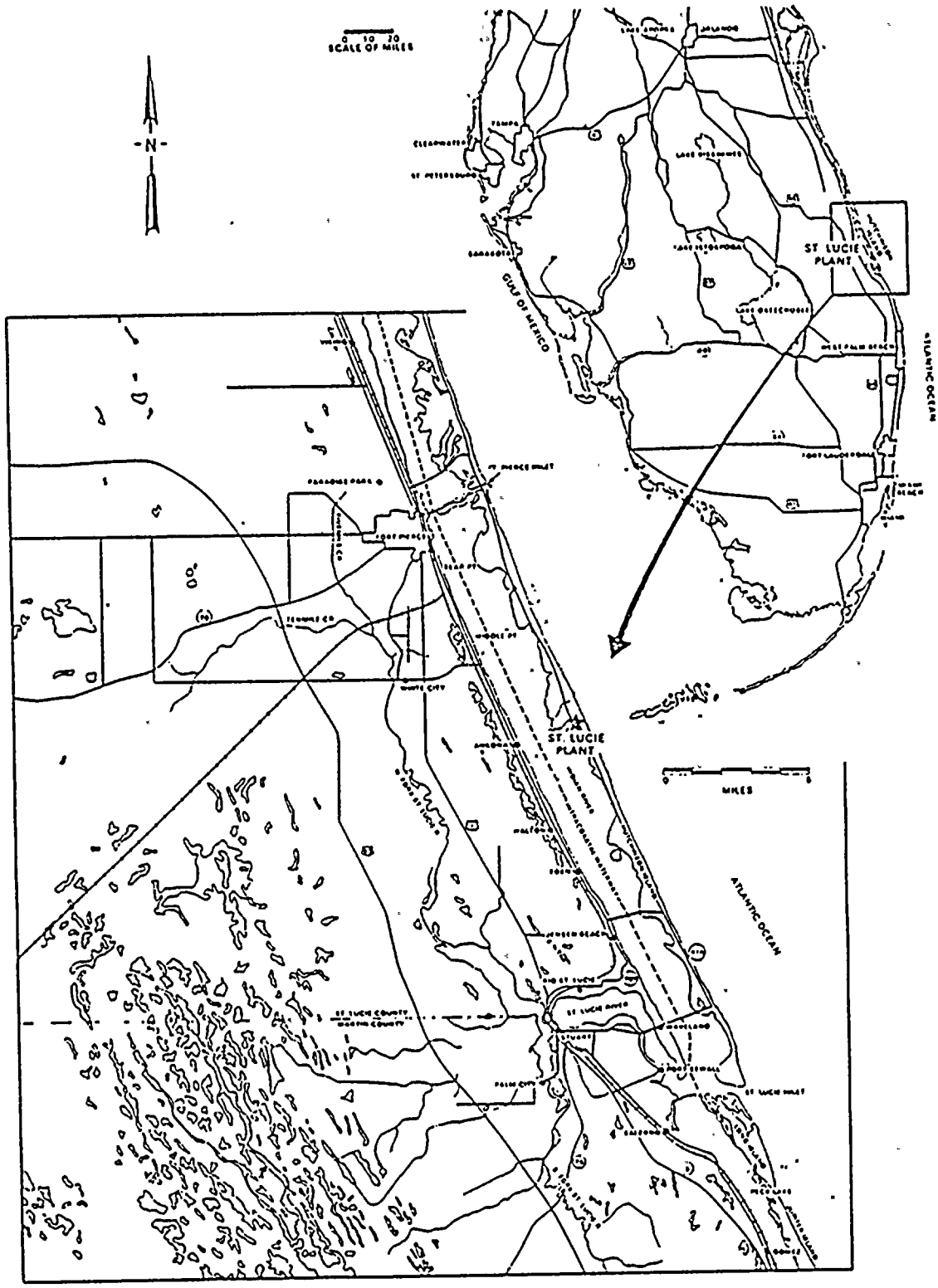


Figure II-1. Site Location Map

the water in the secondary system is converted to steam to drive the turbine-generator; the secondary coolant steam is condensed back to water in a condenser cooled by water from the Atlantic Ocean.

C. COOLING WATER SYSTEM CHARACTERISTICS

The condenser cooling water system is a once-through system with intake and discharge in the Atlantic Ocean. Design flow is 530,000 gpm (1180 cfs) with a maximum and normal temperature rise across the condenser of 24°F. The major components of the system include (1) two intake lines, (2) one discharge line, (3) an intake canal, and (4) a discharge canal. Figure II-2 presents a general plan view of the system.

The intake is located 1200 feet offshore and about 2400 feet south of the discharge structure. As shown in Figure II-2, the top of the intake is situated approximately 8 feet below the water surface at mean low water. Horizontal intake velocities will approach 1 fps.

From the ocean intake point, water is drawn through two buried pipelines (ID 10.5 feet) at 6 fps to the intake canal. This 300-foot wide canal begins 450 feet west of the shoreline and carries the cooling water some 5000 feet to the plant intake structure at approximately 0.3 to 0.5 fps.

The plant intake structure consists of four bays, each containing one coarse screen, traveling screen and circulating water pump. Approach velocities to each bay will be less than 1 fps. From this structure the water flows through a buried pipeline to the condenser at about 7 fps.

The heated water leaving the condenser flows through a buried pipeline for 500 feet to the discharge canal. This open canal is 200 feet wide and extends approximately 1735 feet to a point 400 feet west of the shoreline. There, the discharged water is carried in a 12-foot diameter concrete pipe buried under the beach and ocean floor out to the ocean discharge structure, located 1200 feet out from the shoreline.

The ocean discharge sructure, shown in Figure II-2, consists of a short transition section and a Y-type, high-velocity jet discharge; each port will be 7.5-feet in diameter. Ocean depth at the discharge point is -18 feet (MLW). The centerline of the discharge ports is ~30 feet below the water surface. Exit velocity of the discharge water from each port is ~13 fps. The design is a high-momentum type, which produces a relatively high degree of entrainment of ambient water, thus enhancing the diluting characteristics of the outfall.

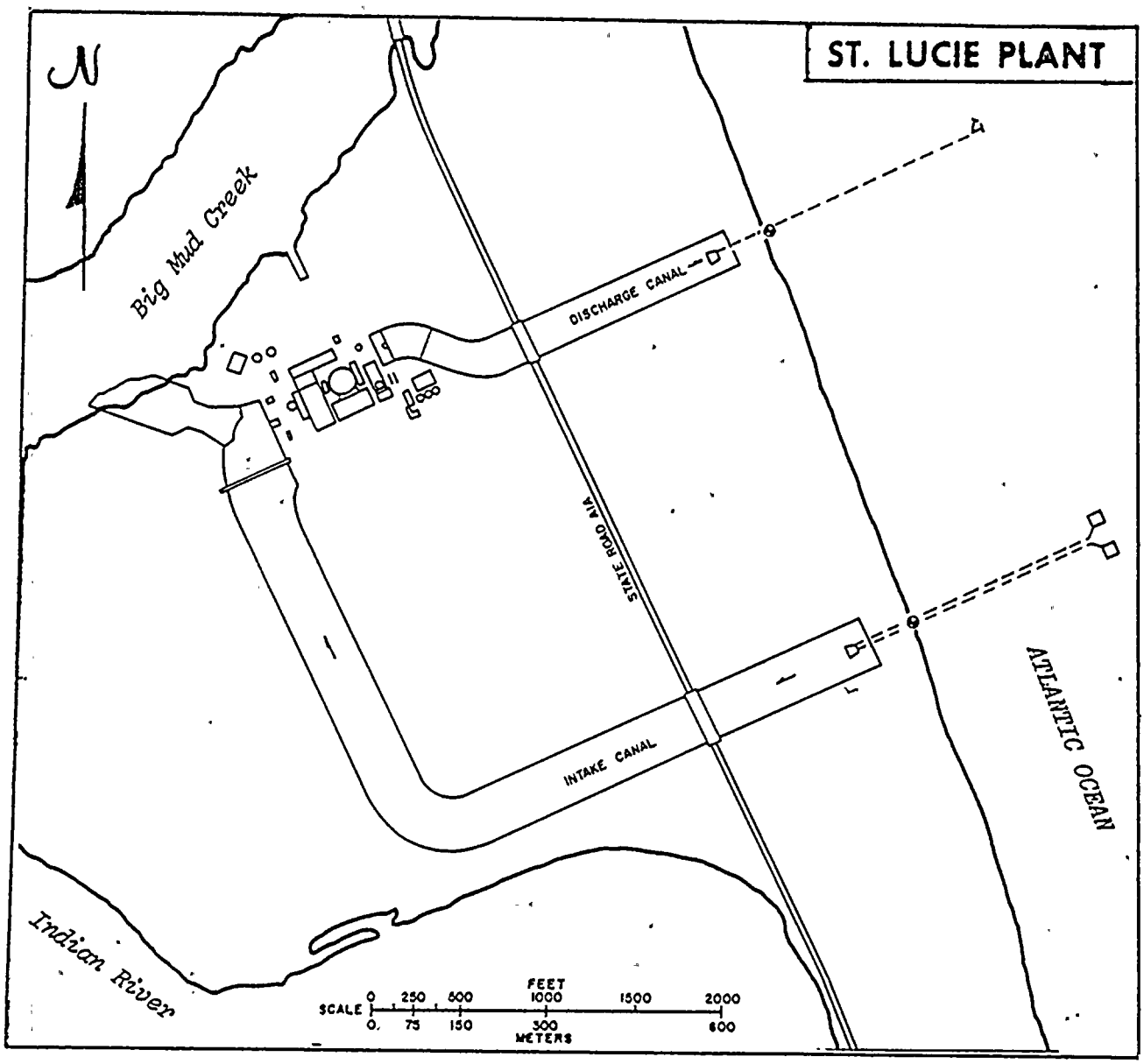


Figure II-2. Plant Intake and Discharge System

SECTION III

GENERAL INTRODUCTION TO THERMAL INFRARED IMAGERY TECHNIQUES

A. INTRODUCTION

Thermal infrared imagery in the 8- to 14-micrometer portion of the electromagnetic spectrum was collected in the Atlantic Ocean area of the St. Lucie Plant intake and discharge. The survey provided surface thermal data compiled from more than 1,000,000 points per square mile.

All plume data were taken within 1 minute, allowing illustration of the thermal mixing pattern and other areas of warm water in a near-synoptic manner. Ambient surface temperatures were observed by ground personnel during the period of airborne data collection and used for the purpose of calibrating the computer-printed temperature maps.

Surface thermal data were developed into a series of computer-printed maps; each computer map of the discharge area was then optically changed to a scale of either 1 inch = 500 feet or 1 inch = 1200 feet with an overlay map of the discharge presented at a scale of either 1 inch = 500 feet or 1 inch = 1200 feet. Additionally, computer printouts of enlarged areas, included in Appendix B, were used for calibration purposes.

B. DATA COLLECTION

Infrared imagery was produced by a series of scan lines perpendicular to the flight direction and was similar in appearance to strip photography. Relative radiometric temperature differences were represented by the imaged grey tones as illustrated in Plates IV-1 through IV-11. Light tones, as they appeared on the positive print of infrared imagery, represented higher radiometric temperatures. Dark image tones corresponded to lower radiometric temperatures.

A Texas Instruments RS-310D airborne infrared scanning system was used to collect the thermal infrared data over the St. Lucie plant. This

system recorded data in the 8- to 14-micrometer portion of the electromagnetic spectrum, and temperature reference sources were located within the field-of-view of the scanner system to allow temperature calibration of the image tones for map compilation.

At the start of each scan, the detector was focused first on a hot calibrated radiation source and then on a cold calibrated source. These two sources thus provided verification of calibration of temperature and system gain on each scan line. To aid in analyzing data, the two radiation sources usually were set near the highest and lowest radiation expected from the water to be measured.

As a further aid to produce clear, usable data from these scans, the detector voltage was digitized each 1/2000 radian of scan angle (0.0286). The resulting computer tape had one scan line per record on the tape with 1890 points digitized on that tape for each record (scan line). The digitized information, which included the calibration sources, was recorded on a special high-speed digital tape recorder. This is a special tape not directly usable on a standard computer due to its format and its high packing density. Therefore, the areas of interest were copied from the special tape onto a standard computer tape (9 track 800 BPI) by slowing the special tape to 1/16 of original speed and employing programs in a TI 980 computer used especially for this purpose.

A map was formed by printing a series of scan lines (computer records) along a computer page. Each digitized point was a measure of the radiation from the surface as modified by the atmosphere between the surface and the scanner. Since infrared radiation would not pass through water, the radiation power was a function of the surface only; no radiation came from below the surface.

Other involved factors were:

1) Radiation efficiency of water

2) Angle of water surface to the scanner

3) Difference between temperature of surface molecules and temperature of water 1 to 6 inches below the surface, where it can be measured by a thermometer.

4) Atmospheric loss or absorption

5) Difference in atmospheric path length.

Factor 1) was small, about 0.98 percent, and was calibrated out through use of ground measurements. Factor 2) was also small and was averaged out in the computer; it was seen as $\pm 0.3^{\circ}F$ when looking at waves. Factor 3) was small but was also calibrated out through use of ground temperature measurements.

Factor 4) was variable, depending on water vapor, water droplets in the air, and temperature of the droplets; most could be calibrated out through use of ground measurements. Factor 5) was a function of scan angle and was small for the 30° off-axis scan angles used in the calibrated scanner, therefore no correction was made for this factor.

C. CALIBRATION

It was possible to have sufficiently calibrated information by using only the calibrated sources and flying one extremely low pass along with the normal higher pass. However, when possible, final calibration of the data was done by using water bodies in the areas of measurement as hot and cold calibration sources. At the St. Lucie plant site, the intake and discharge canals provided two sources for this calibration.

For final calibration, three areas were used: the intake canal, the discharge canal, and an area of ocean outside the influence of the hot water discharge canal. Where possible, this ocean area was chosen in the vicinity of the intake structure. A computer printout was made of each of these three areas, and 400 digitized elements were averaged to obtain the average value of the radiation number received in that area. Using average radiation numbers derived for the inlet canal, discharge canal and ocean

area, the computer read from the computer tape and printed out a map of surface water temperature over the entire area covered by the tape. Using the mathematics of the scanner, aircraft height, and aircraft speed, the map was scaled to fit existing maps.

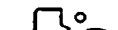
D. PROCESSING TECHNIQUES AND DATA PRESENTATION FORMAT

The recorded airborne thermal infrared data were prepared in two formats: qualitative image presentations and quantitative isothermal maps.

The qualitative data included in this report illustrates the qualitative, near-synoptic view of surface-temperature variations of the survey area depicted as image tones. These grey-tone maps have some panoramic distortion on the sides, making a scale change-out on the sides of the "heat picture."

The plane's altitude was used to determine the computer's printout for the temperature point areas from a linear relationship with the mapping scales. To make a computer printout of temperature, flight data was sampled along the x direction (across flight path) and along the y direction (along flight path) in a ratio of samples to produce the same map scale in both x and y directions. At the same time, the panoramic distortion was removed in the x direction. The resulting map was reasonably distortion- free. Such a map can then be enlarged or compressed optically to any desired scale. Isotherm lines are drawn directly on the printed temperature map and an isotherm line map traced off of these lines.

The digital number of radiation for each point was multiplied by a scale factor that produced a scale of numbers in degrees Fahrenheit or Centigrade as desired. An offset number was then applied to make one of the areas printout as the zero reference. It was easier to visualize a plume if it was referenced against a zero background rather than printing the actual temperature as read from a thermometer. The scaling factor used to produce Fahrenheight degrees and the offset factor to produce a zero reference area in the printout were derived from a calibration printout of enlarged areas



which show the intake canal, discharge canal, and a reference ocean area. This calibration printout was adjusted to follow closely the delta temperatures as measured in the canals from the ground.

SECTION IV

RESULTS

FLIGHT PASS 3/10/77, TIME 12:41

This flight pass was taken with a wind of 4 mph from a direction of 140° with the resulting surface plume widening outward (probably caused by momentum) in the direction of the outlet nozzles; spreading northward (probably caused by the wind) parallel to the shore. For reasons still unknown, the far field of the plume splits. This plume configuration compared well with the winter flight (Quarter I), but in an opposite flown direction. (See Quarter I report.) Plate IV-1 is a grey-toned image illustrating the surface plume.

The following parameters were measured during the overflight:

Ambient air temperature over land 78.6°F

Ambient ocean temperature 70°F

Tide @ 13:00 +2.5 feet

Discharge canal elevation 10.68 feet above MLW

Plant delta T (inlet to outlet of plant) 23.44°F

Discharge flow 509,000 gpm

Reactor power 98.41 percent

Gross power generated 826 megawatts

Intake canal temperature (taken at east end of canal) 67.5°F

Discharge canal temperature (taken at 300 feet from east end of canal) 90.40°F

Temperature difference between canals 22.9°F

Calibration: The ground measurements showed a temperature differential of 22.9°F between canals. The calibration printout showed a differential of 22.5°F between canals. The printout showed the intake canal surface to be 1.8°F warmer than the surface ambient temperature of the ocean (Attachment A).

SUMMARY OF FINDINGS

Temperature distributions measured offshore at the St. Lucie plant are presented on Plate IV-2 and Attachment B.

The maximum surface temperature within the plume was 75.0°F, (5.0°F above ambient) covering an area of 0.2 acre, and the areal extent of the 5°F isotherm was about 75 feet in diameter. The 1.5°F isotherm was shown to cover a large area from 350 to 397 acres which was probably due to the effects of the northward directional wind. The 1.5°F isotherm line appeared to intersect with other warm water along the shore about 1.4 miles north of the discharge canal. The combined 1.5°F area of the plume and the other water was ~397 acres. Each temperature point on the printout (Attachment B) was ~0.093 acres.

Temperature isotherms and their respective areas for various temperatures above ambient (ΔT) are listed as follows:

ΔT Isotherm (°F)	Area (acres)
5.0	0.2
4.0	2.4
3.0	9.7
2.0	159.0
1.5	350-397

FLIGHT PASS 3/11/77, TIME 07:42

The objective of this flight pass was to obtain surface temperature data affected by low tidal conditions. Morning clouds limited the altitude of the flight to 1000 feet, therefore, limiting the width of coverage to approximately 900 feet. This was the only flight pass available for analysis of the low tidal condition. Plate IV-3 is a grey-toned image illustrating the surface plume at low tide.

The following parameters were measured during the overflight:

Wind 2 mph from 140°

Ambient air temperature over land 70.9°F

Ambient ocean temperature 70°F

Tide @ 07:03 +0.3 feet

Discharge canal elevation 6.6 feet above MLW

Plant delta T (inlet to outlet of plant) 23.0°F

Discharge flow 509,000 gpm

Reactor power at 99.42 percent

Gross power generated 830 megawatts

Intake canal temperature (taken at east end of canal) 68.8°F

Discharge canal temperature (taken at 300 feet from end of canal) 91.9°F

Temperature difference between canals 23.1°F

Calibration: The ground measurements showed a differential between canals of 23.1°F. The calibration printout showed a differential of 22.4°F between the average temperature of the intake canal and discharge canal (Attachment C).

SUMMARY OF FINDINGS

Temperature distribution measured offshore of the St. Lucie plant are presented in Plate IV-4 and Attachment D. The maximum surface temperature measured within the plume was 76.0°F (6.0°F above ambient). The areal extent of the 6.0°F temperature ΔT isotherm covered an area of 0.1 acre. Due to the low cloud layer and the low altitude flight pass, about one-half of the plume could not be adequately recorded. The computer printout (attachment D) has been rerun to reflect a high altitude pass. The 1.5°F isotherm could not be totally measured, but the 1.5°F surface area that had been recorded showed an area about 90 acres. It has been estimated that the 1.5°F isotherm area contained approximately one half of the total surface area and including that the total area could be between 180 to 200 acres.

Temperature isotherms and their respective areas for various temperatures above ambient (ΔT) are listed as follows:

ΔT Isotherm ($^{\circ}F$)	Area (acres)
6.0	0.1
5.0	0.2
4.0	5.4
3.0	21.1
2.0	23.0
1.5	200 (estimated)

FLIGHT PASS 3/11/77, TIME 13:41

This flight pass shows both the Indian River area behind the plant and the Atlantic Ocean in front of the plant at mid-day. The pass covered the essential portion of the plume and both the intake canal and discharge canal used for calibration. Plate IV-5 is a grey-toned image of the mid-day flight pass.

The following parameters were measured during the overflight:

Wind 4 mph from 140°

Ambient air temperature over land $78.6^{\circ}F$

Ambient ocean temperature $70^{\circ}F$

Tide @ 13:00 +2.5 feet

Discharge canal elevation 10.68 feet above MLW

Plant delta T (inlet to outlet of plant) $23.44^{\circ}F$

Discharge flow 509,000 gpm

Reactor power at 98.41 percent

Gross power generated 826 megawatt

Intake canal temperature (taken at east end of canal) $68.97^{\circ}F$

Discharge canal temperature (taken at 300 feet from ed of canal) $92.1^{\circ}F$

Temperature differences between canals $23.1^{\circ}F$

Calibration: The ground measurements showed a differential between canals of 23.1°F. The calibration printout showed a differential of 23.3°F between the average temperature of the intake canal and discharge canal (Attachment E).

SUMMARY OF FINDINGS

Temperature distributions measured offshore of the St. Lucie plant are presented in Plate IV-6 and Attachment F. The maximum surface temperature measured within the plume was 74.0°F (4.0°F above ambient) and covering an area of 0.1 acre. The flight pass did not include the entire plume, so the total 1.5°F isotherm area (~350 acres) could not be computed accurately. The 1.5°F isotherm of the plume also extended into another mass of warm surface water. Thus, the extent of the 1.5°F plume isotherm cannot be separated or accurately computed once the masses begin to mix. The 1.5°F plume isotherm was estimated from the printout of an area of 230 acres with a total 1.5°F isotherm area estimated to be less than 350 acres.

Temperature isotherms and their respective areas for various temperature above ambient (ΔT) are listed as follows:

ΔT Isotherm (°F)	Area (acres)
4.0	0.1
3.0	5.9
2.0	120.2
1.5	350.0 (estimated)

FLIGHT PASS 3/11/77, TIME 16:23

This flight pass consisted of a coverage along the coast from the Ft. Pierce Inlet south to the Martin County line. The flight pass was approximately 12 miles long. The station area and both end segments were converted to computer tapes for isothermal printouts. Plate IV-7 is the grey-toned image of the flight pass.

The following parameters were measured during the overflight:

Wind 8 mph at 130°

Ambient air temperature over land 76.2°F

Ambient ocean temperature 70°F

Tide @ +0.5 feet

Discharge canal elevation 9.42 feet above MLW

Plant delta T (inlet to outlet of plant) 23.46°F

Discharge flow 509,000 gpm

Reactor power at 98.55 percent

Gross power generated 825 megawatts

Intake canal temperature (taken at east end of canal) 69.41°F

Discharge canal temperature (taken at 300 feet from end of canal) 92.93°F

Temperature differences between canals 23.52°F

Calibration: The flight pass data of 16:31 was used to calibrate the 16:23 pass. The ground measurements showed a differential between canals of 23.5°F. The calibration printout which is included as Attachment G shows a temperature differential between the canals of 23.8°F.

SUMMARY OF FINDINGS

Temperature distributions found offshore of the St. Lucie plant, the end segments of the Ft. Pierce Inlet, and the south of the plant are presented as Plate IV-8, 9, and 10 respectively and Attachment H, I, and J respectively. The maximum surface temperature measured within the plume was 72°F (2°F above ambient), but the 1.5°F isotherm could not be computed completely due to a mass of warm water which was present and mixed with the plume. An estimated area of the plume 1.5°F isotherm was 250 acres. The surface temperature of the ambient ocean increased at the south end of the plant as the mass of warm water approached the coastline. The warmest surface temperature measured was 75°F, 5°F greater than the ambient temperature measured at the plant area. The mass of warm water which was mixing with the plant plume, appeared to be part of the Gulf Stream.

Temperature isotherms and their respective areas for various temperatures above ambient (ΔT) are listed as follows:

ΔT Isotherm (°F)	Area (acres)
2.0	16.5
1.5	250 (estimated)

FLIGHT PASS 3/11/77, TIME 16:31

This flight pass shows the plume temperature from the St. Lucie plant and the warm mass of surface temperatures that appears to relate to the Gulf Stream. Plate IV-11 is a grey-toned image of the flight pass. The parameters measured during the overflight are listed as follows:

Wind 8 mph at 130°

Ambient air temperature over land 76.2°F

Ambient ocean temperature 70°F

Tide @ +0.5 feet

Discharge canal elevation 9.42 feet above MLW

Plant delta T (inlet to outlet of plant) 23.46°F

Discharge flow 509,000 gpm

Ractor power at 98.55 percent

Gross power generated 825 megawatts

Intake canal temperature (taken at east end of canal) 69.41°F

Discharge canal temperature (taken at 300 feet from end of canal) 92.93°F

Temperature differences between canal 23.52°F

Calibration: The ground measurements showed a temperature differential between canals of 23.5°F. The calibration printout showed a temperature differential between the canals of 23.8°F. The calibration printout is included as Attachment G.

SUMMARY OF FINDINGS

Temperature distributions measured offshore of the St. Lucie plant are presented in Plate IV-12 and Attachment K. The maximum surface temperature measure within the plume was 73°F (3°F above ambient), covering an area of 1.3 acres. The 1.5°F isotherm area could not be measured in its entirety since the area extended beyond the measured coverage. The 1.5°F isotherm area covered by the computer printout was 70 acres. It appeared that only a 10 to 20 percent additional area would remain at the 1.5°F isotherm if the entire plume could have been measured.

Temperature isotherms and their respective areas for various temperatures above ambient (ΔT) are listed as follows:

ΔT Isotherm (°F)	Area (acres)
3.0	3.6
2.0	27.4
1.5	84 (estimated)

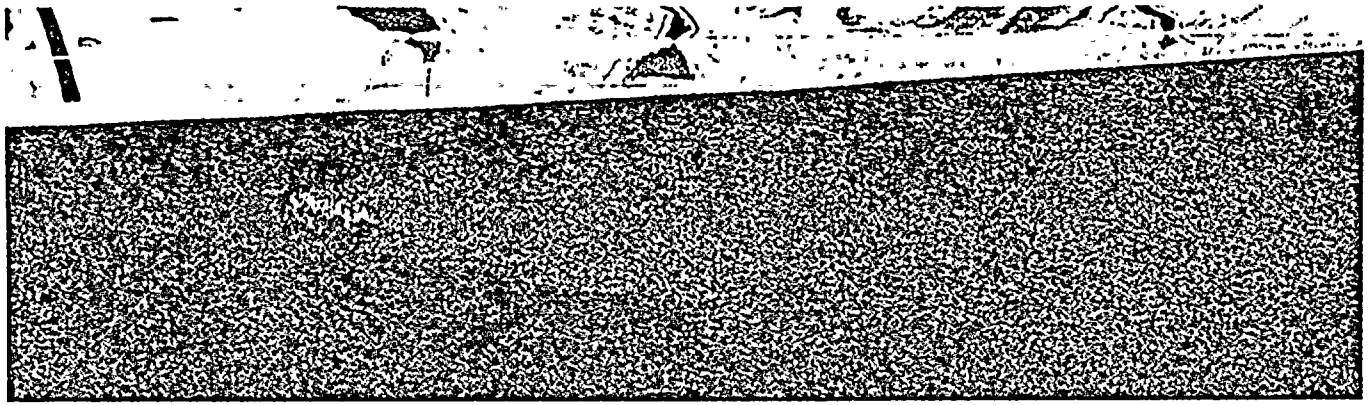
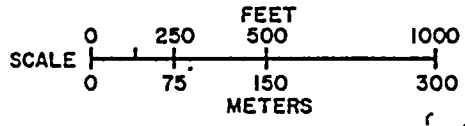


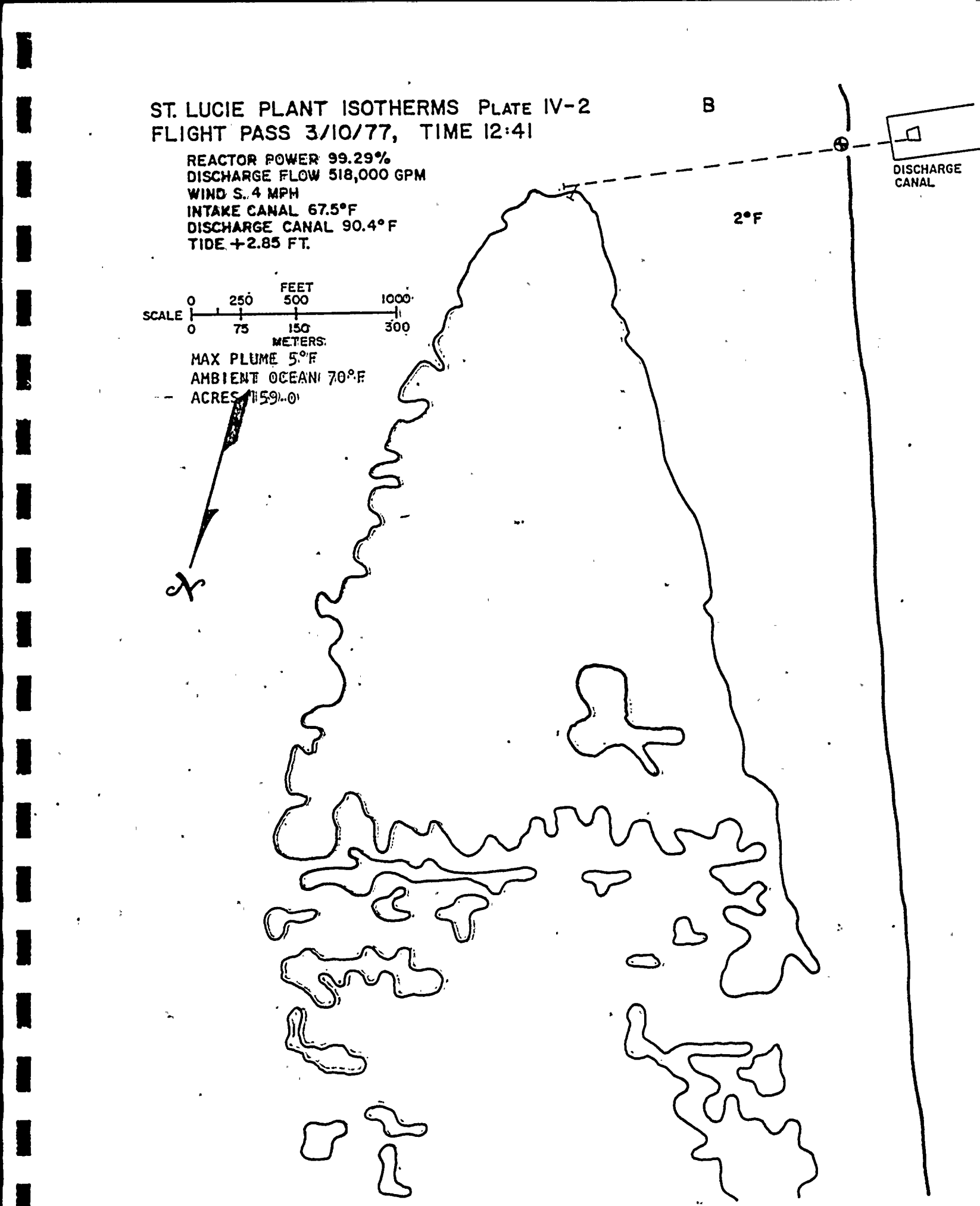
Plate IV-1. Flight Pass, 3/10/77, Time 12:41

Plate IV-2. Isotherms, Flight Pass 3/10/77, Time 12:41

ST. LUCIE PLANT ISOTHERMS PLATE IV-2 A
FLIGHT PASS 3/10/77, TIME 12:41

REACTOR POWER 99.29%
DISCHARGE FLOW 518,000 GPM
WIND S. 4 MPH
INTAKE CANAL 67.5°F
DISCHARGE CANAL 90.4°F
TIDE +2.85 FT.
MAX. PLUME 5°F
AMBIENT OCEAN 70°F

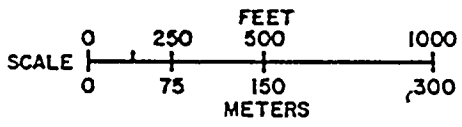



ST. LUCIE PLANT ISOTHERMS PLATE IV-2
FLIGHT PASS 3/10/77, TIME 12:41
B
REACTOR POWER 99.29%
DISCHARGE FLOW 518,000 GPM
WIND S. 4 MPH
INTAKE CANAL 67.5°F
DISCHARGE CANAL 90.4° F
TIDE +2.85 FT.
FEET
SCALE 0 250 500 1000
0 75 150 300
METERS
MAX PLUME 5°F
AMBIENT OCEAN 70°F
ACRES 159.0
2°F
DISCHARGE CANAL
N

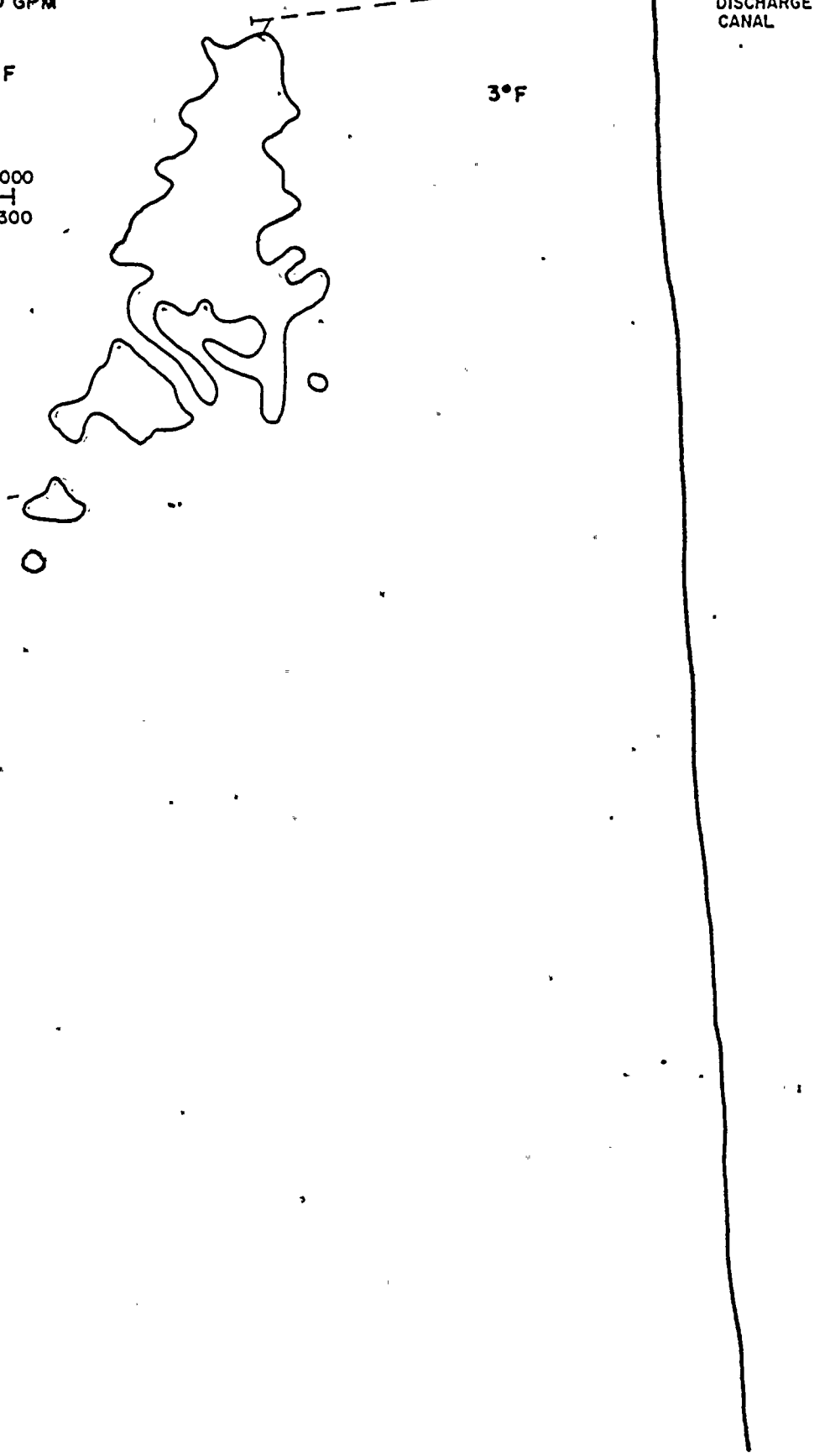
ST. LUCIE PLANT ISOTHERMS PLATE IV-2 C

FLIGHT PASS 3/10/77, TIME 12:41

REACTOR POWER 99.29%
DISCHARGE FLOW 518,000 GPM
WIND S. 4 MPH
INTAKE CANAL 67.5°F
DISCHARGE CANAL 90.4° F
TIDE +2.85 FT.

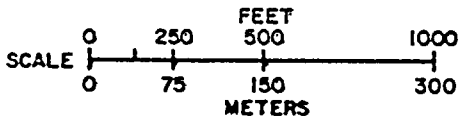


MAX PLUME 5°F
AMBIENT OCEAN 70°F
ACRES 9.7

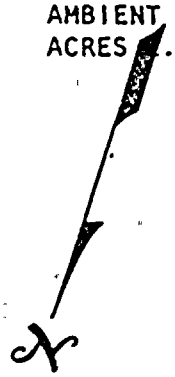


ST. LUCIE PLANT ISOTHERMS PLATE IV-2
FLIGHT PASS 3/10/77, TIME 12:41

REACTOR POWER 99.29%
DISCHARGE FLOW 518,000 GPM
WIND S. 4 MPH
INTAKE CANAL 67.5°F
DISCHARGE CANAL 90.4° F
TIDE +2.85 FT.

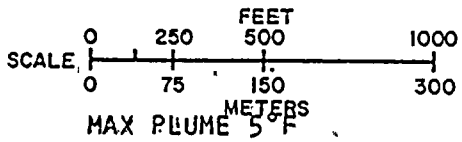


MAX PLUME 5°F
AMBIENT OCEAN 70°F
ACRES .4



ST. LUCIE PLANT ISOTHERMS PLATE IV-2
FLIGHT PASS 3/10/77, TIME 12:41

REACTOR POWER 99.29%
DISCHARGE FLOW 518,000 GPM
WIND S. 4 MPH
INTAKE CANAL 67.5°F
DISCHARGE CANAL 90.4°F
TIDE +2.85 FT.



MAX PLUME 5°F
AMBIENT OCEAN 70°F
ACRE 0.2

E

DISCHARGE CANAL

7

0

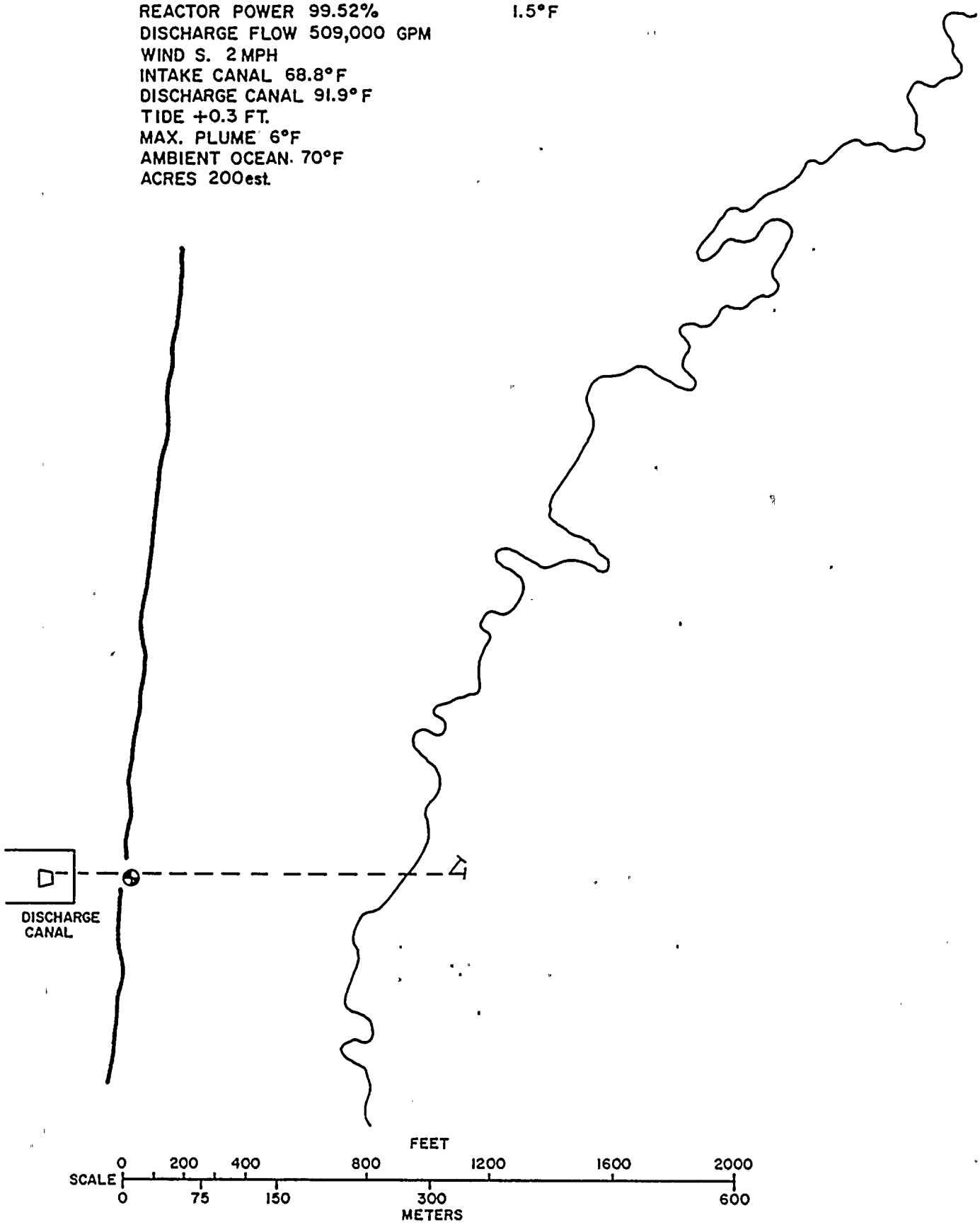
5°F

Plate IV-3. Flight Pass, 3/11/77, Time 07:42

Plate IV-4. Isotherms, Flight Pass, 3/11/77, Time 07:42

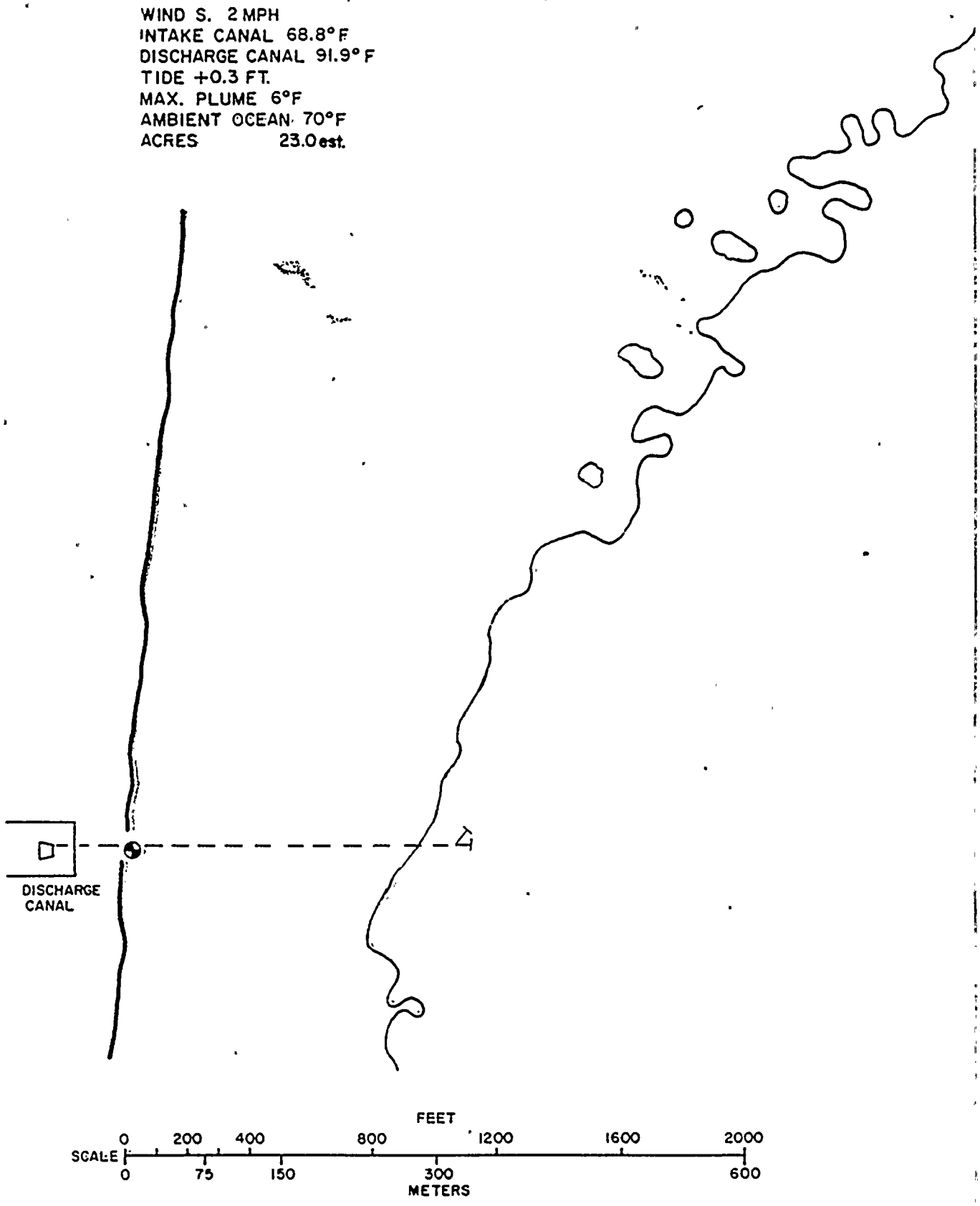
ST. LUCIE PLANT ISOTHERMS PLATE IV-4 A
FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8°F
DISCHARGE CANAL 91.9°F
TIDE +0.3 FT.
MAX. PLUME 6°F
AMBIENT OCEAN. 70°F
ACRES 200 est.



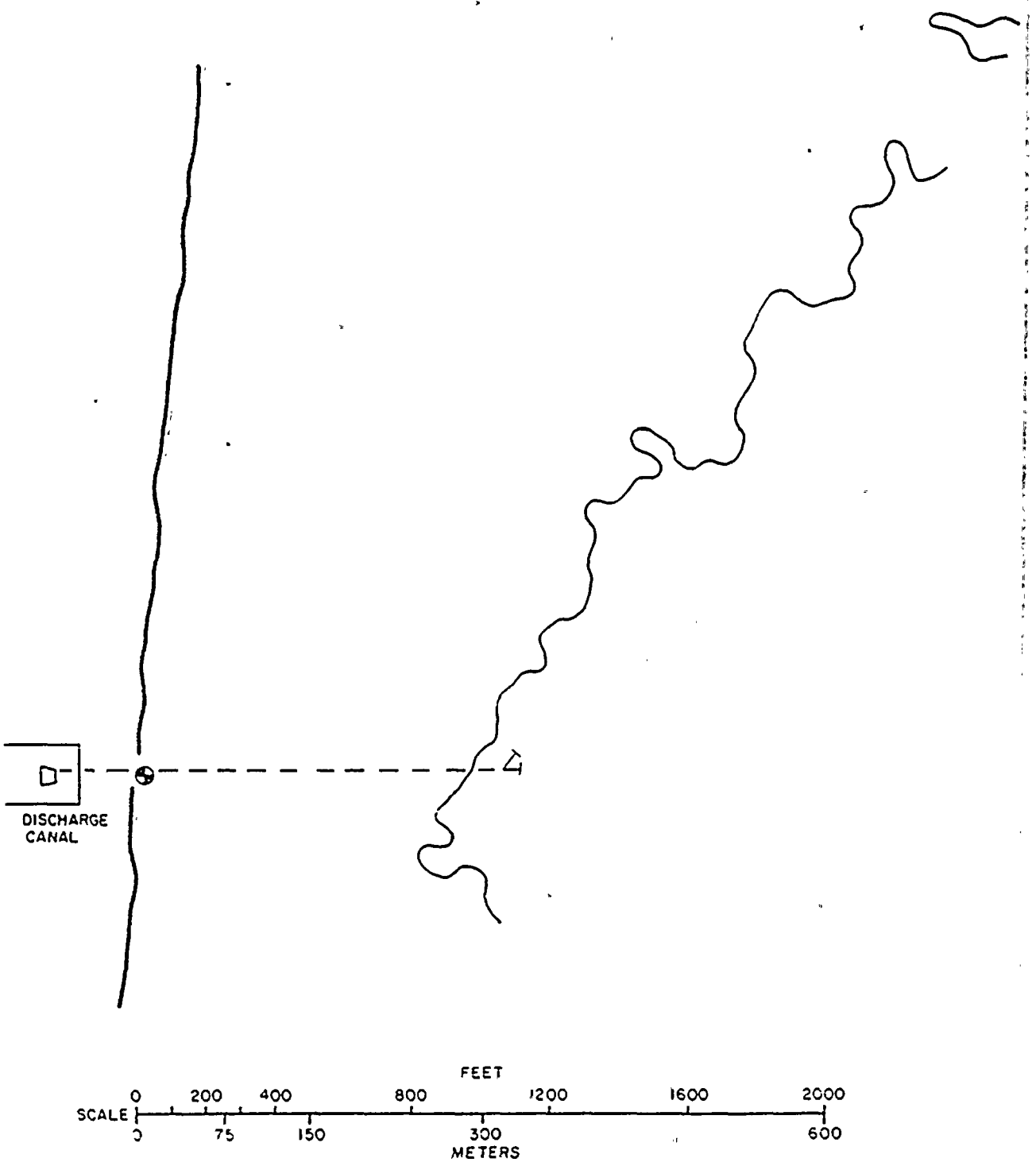
ST. LUCIE PLANT ISOTHERMS PLATE IV-4 B
FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8°F
DISCHARGE CANAL 91.9°F
TIDE +0.3 FT.
MAX. PLUME 6°F
AMBIENT OCEAN 70°F
ACRES 23.0 est.



ST. LUCIE PLANT ISOTHERMS PLATE IV-4 C
FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8°F
DISCHARGE CANAL 91.9°F
TIDE +0.3 FT.
MAX. PLUME 6°F
AMBIENT OCEAN 70°F
ACRES 21.1 est.

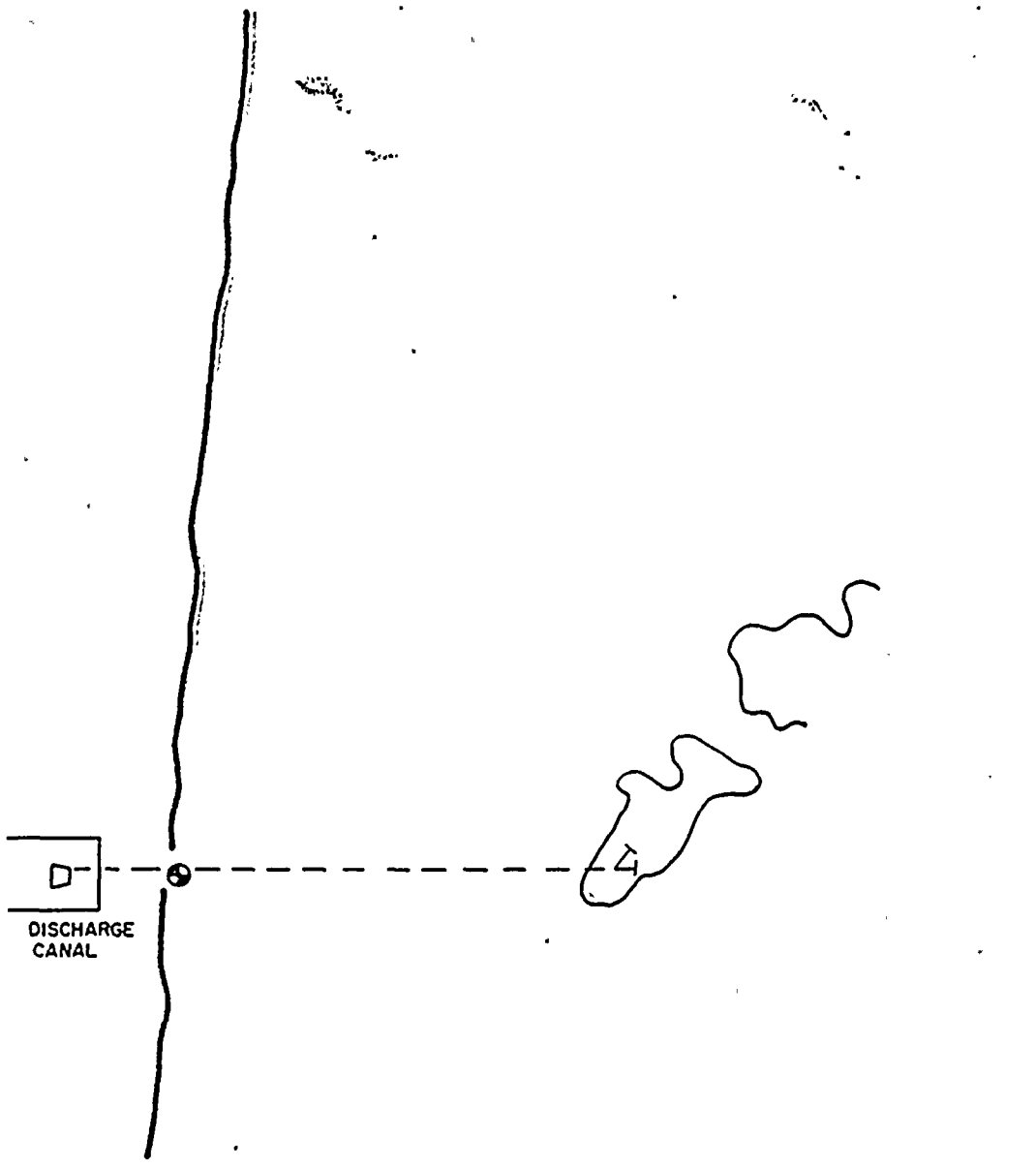


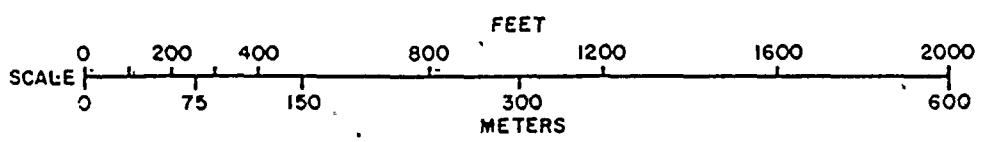
ST. LUCIE PLANT ISOTHERMS PLATE IV-4 D

FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8° F
DISCHARGE CANAL 91.9° F
TIDE +0.3 FT.
MAX. PLUME 6°F
AMBIENT OCEAN 70°F
ACRES 5.4 est.

4° F

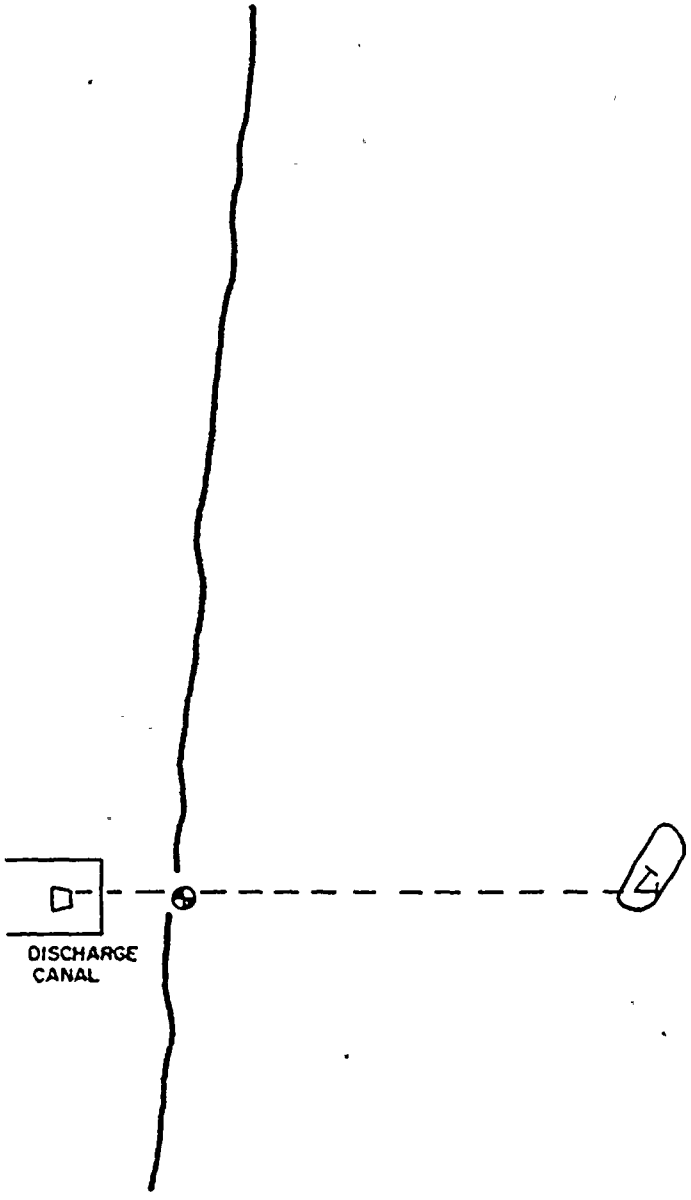


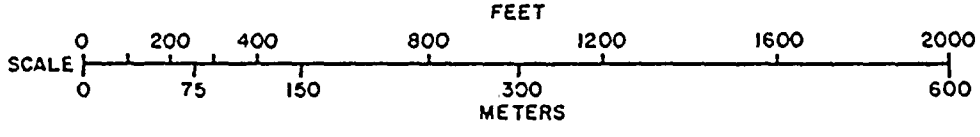


ST. LUCIE PLANT ISOTHERMS PLATE IV-4 E

FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8° F
DISCHARGE CANAL 91.9° F 5°F
TIDE +0.3 FT.
MAX. PLUME 6°F
AMBIENT OCEAN 70°F
ACRES 0.2

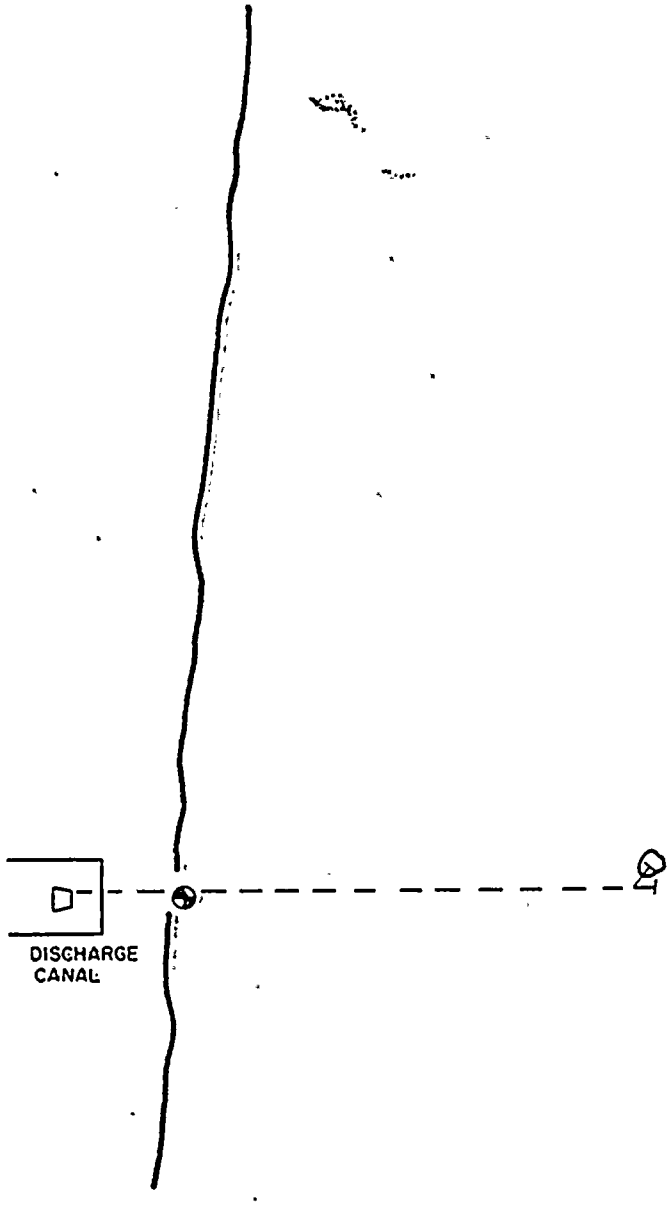


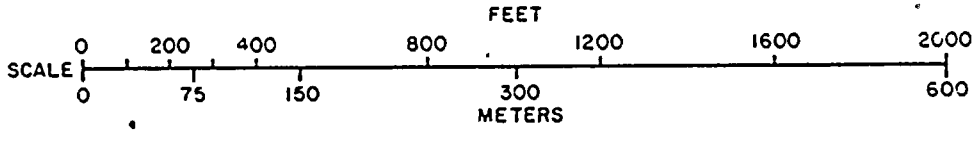


ST. LUCIE PLANT ISOTHERMS PLATE IV-4 F

FLIGHT PASS 3/11/77, TIME 07:42

REACTOR POWER 99.52%
DISCHARGE FLOW 509,000 GPM
WIND S. 2 MPH
INTAKE CANAL 68.8°F
DISCHARGE CANAL 91.9°F
TIDE +0.3 FT.
MAX. PLUME 6°F — 6°F
AMBIENT OCEAN 70°F
ACRES — 0.1





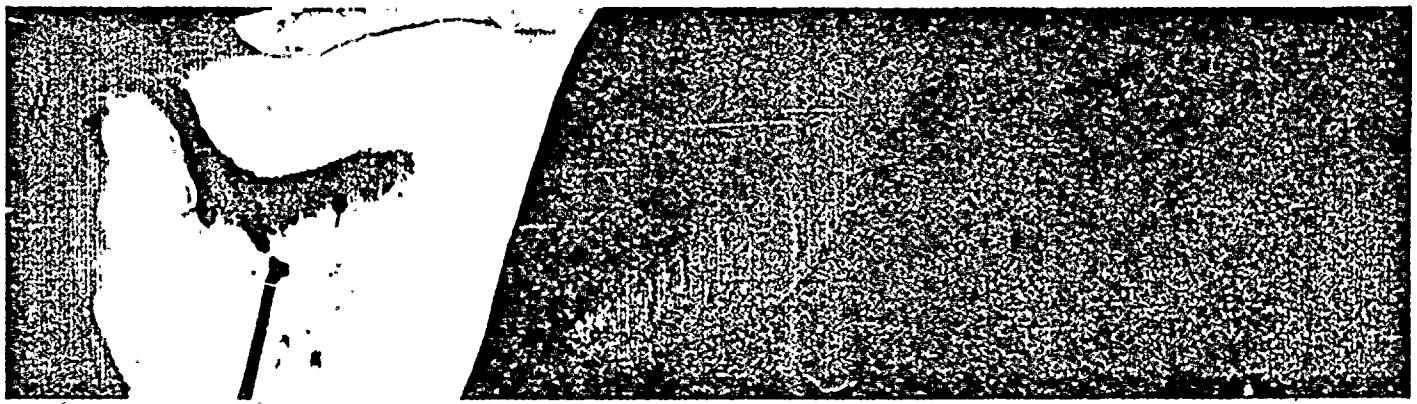
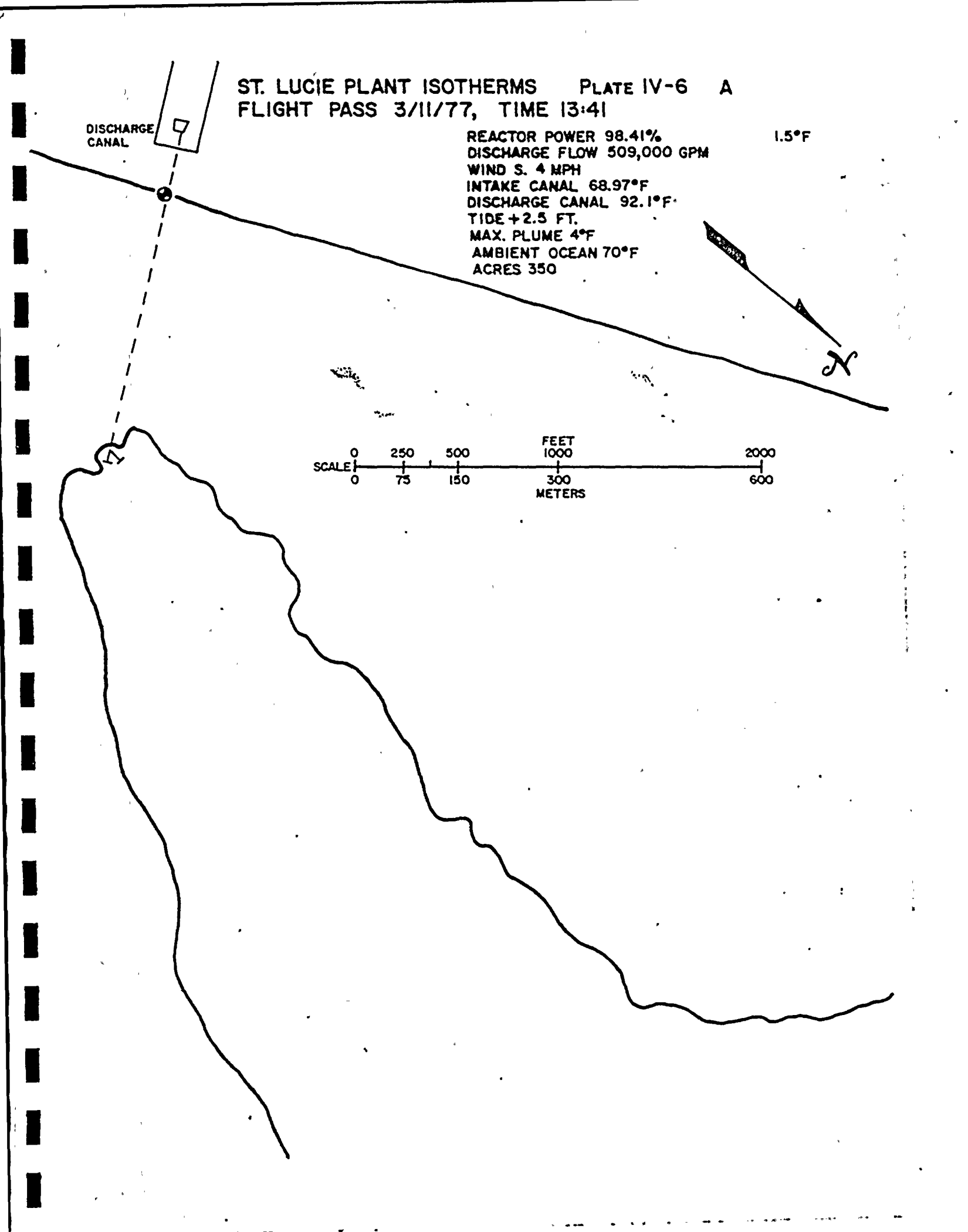
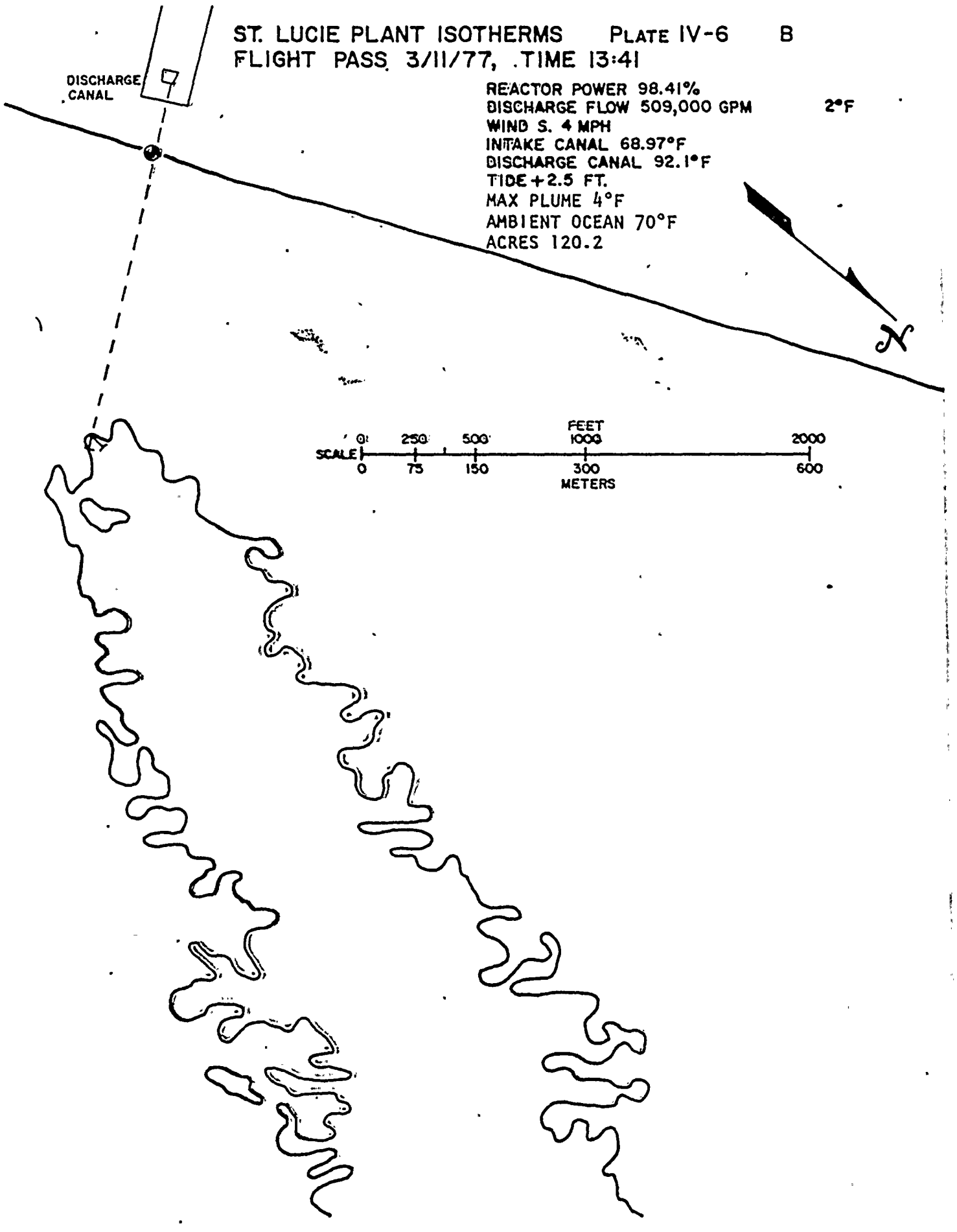
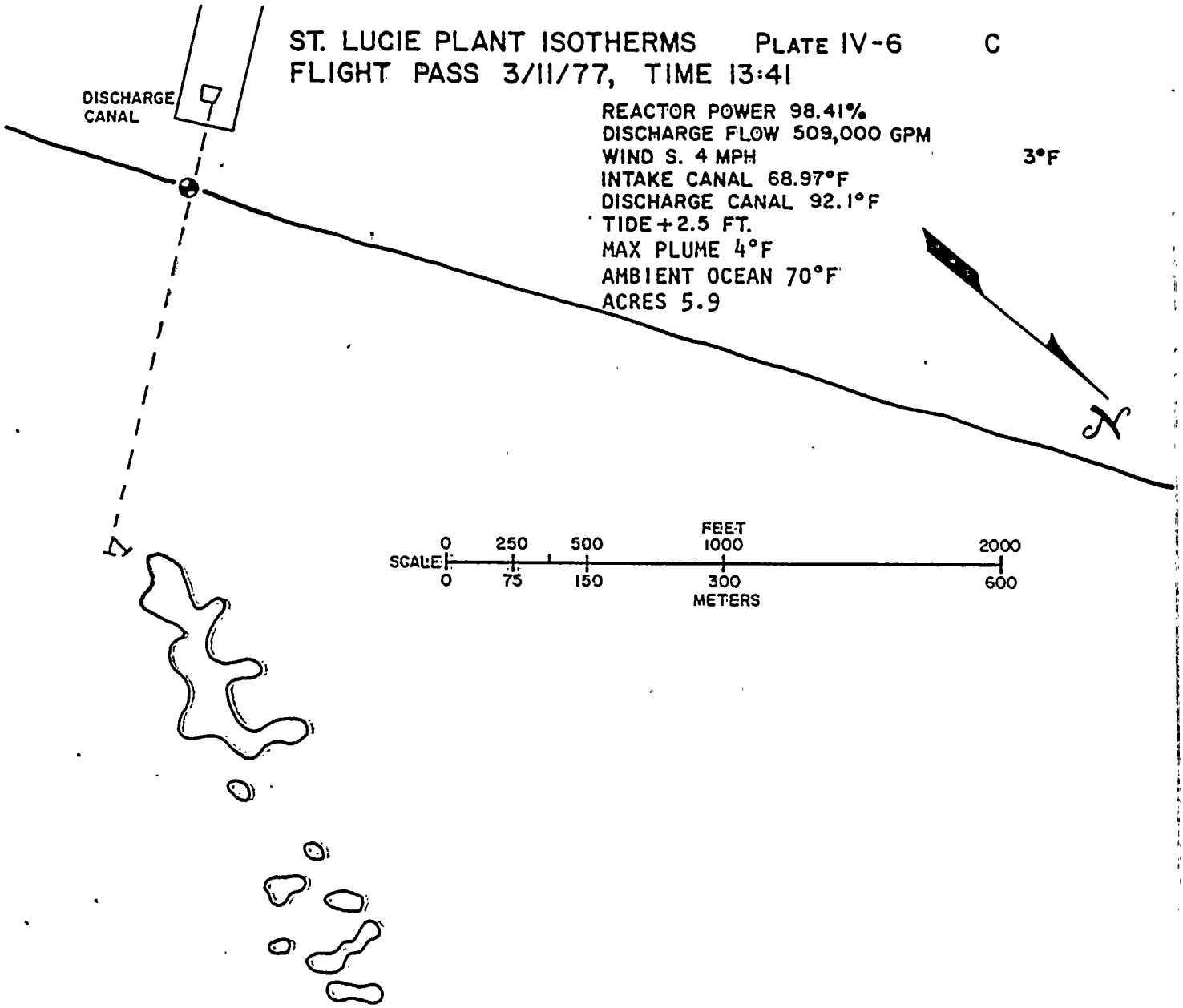


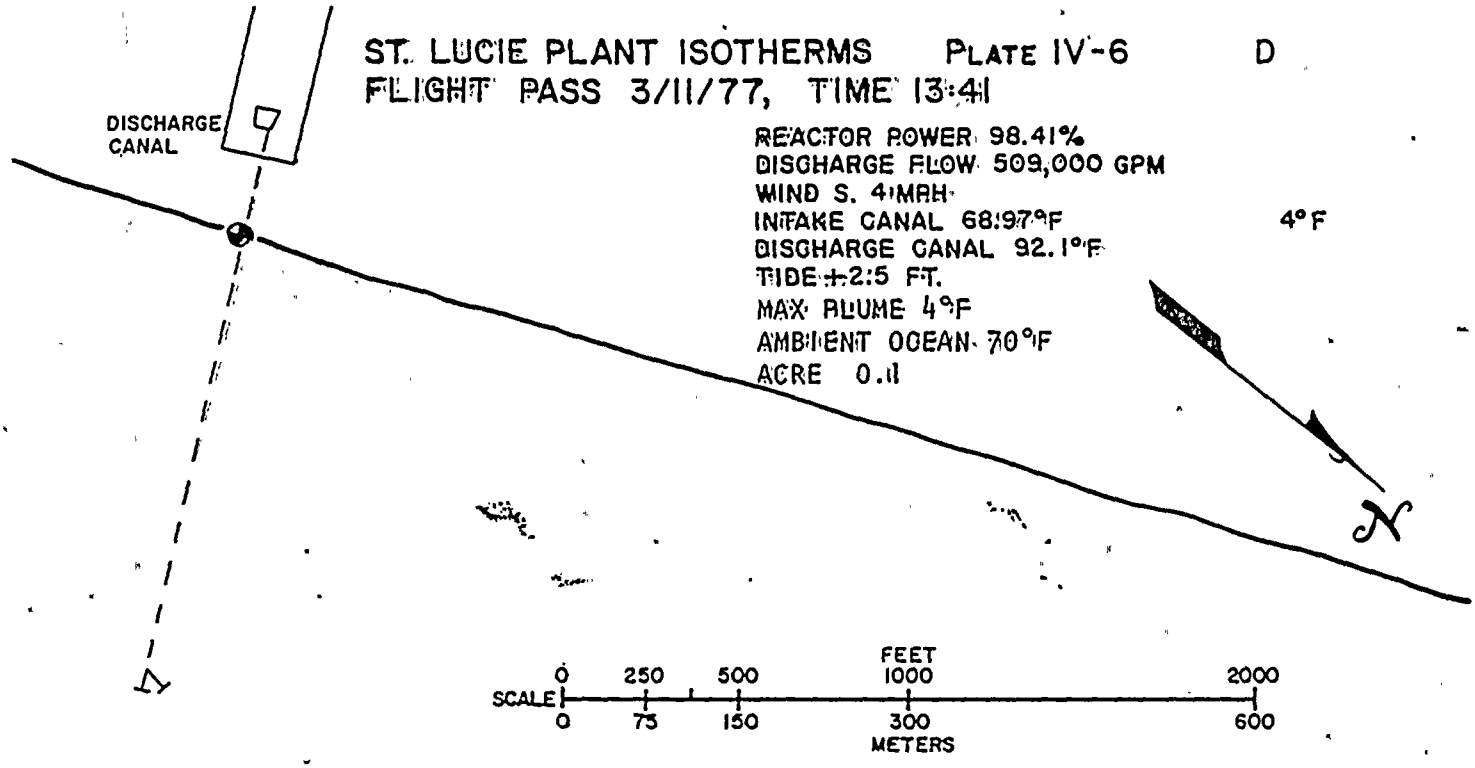
Plate IV-5. Flight Pass, 3/11/77, Time 13:41

Plate IV-6. Isotherms, Flight Pass, 3/11/77, Time 13:41


ST. LUCIE PLANT ISOTHERMS PLATE IV-6 A
FLIGHT PASS 3/11/77, TIME 13:41
DISCHARGE CANAL
REACTOR POWER 98.41%
DISCHARGE FLOW 509,000 GPM
WIND S. 4 MPH
INTAKE CANAL 68.97°F
DISCHARGE CANAL 92.1°F
TIDE +2.5 FT.
MAX. PLUME 4°F
AMBIENT OCEAN 70°F
ACRES 350
1.5°F
N
SCALE
0 250 500 FEET 1000 2000
0 75 150 300 METERS 600


ST. LUCIE PLANT ISOTHERMS PLATE IV-6 B
FLIGHT PASS 3/11/77, TIME 13:41
REACTOR POWER 98.41%
DISCHARGE FLOW 509,000 GPM
WIND S. 4 MPH
INTAKE CANAL 68.97°F
DISCHARGE CANAL 92.1°F
TIDE +2.5 FT.
MAX PLUME 4°F
AMBIENT OCEAN 70°F
ACRES 120.2
DISCHARGE CANAL
2°F
N
SCALE
0
250
500
FEET
1000
2000
0
75
150
300
METERS
600


ST. LUCIE PLANT ISOTHERMS PLATE IV-6 C
FLIGHT PASS 3/11/77, TIME 13:41
DISCHARGE CANAL
REACTOR POWER 98.41%
DISCHARGE FLOW 509,000 GPM
WIND S. 4 MPH
INTAKE CANAL 68.97°F
DISCHARGE CANAL 92.1°F
TIDE +2.5 FT.
MAX PLUME 4°F
AMBIENT OCEAN 70°F
ACRES 5.9
3°F
N
SCALE
FEET
0 250 500 1000 2000
0 75 150 300 600
METERS


ST. LUCIE PLANT ISOTHERMS PLATE IV-6 D
FLIGHT PASS 3/11/77, TIME 13:41
DISCHARGE CANAL
REACTOR POWER 98.41%
DISCHARGE FLOW 509,000 GPM
WIND S. 4 MPH
INTAKE CANAL 68.97°F
DISCHARGE CANAL 92.1°F
TIDE +2.5 FT.
MAX PLUME 4°F
AMBIENT OCEAN 70°F
ACRE 0.11
4° F
N
SCALE
FEET
0 250 500 1000 2000
0 75 150 300 600
METERS

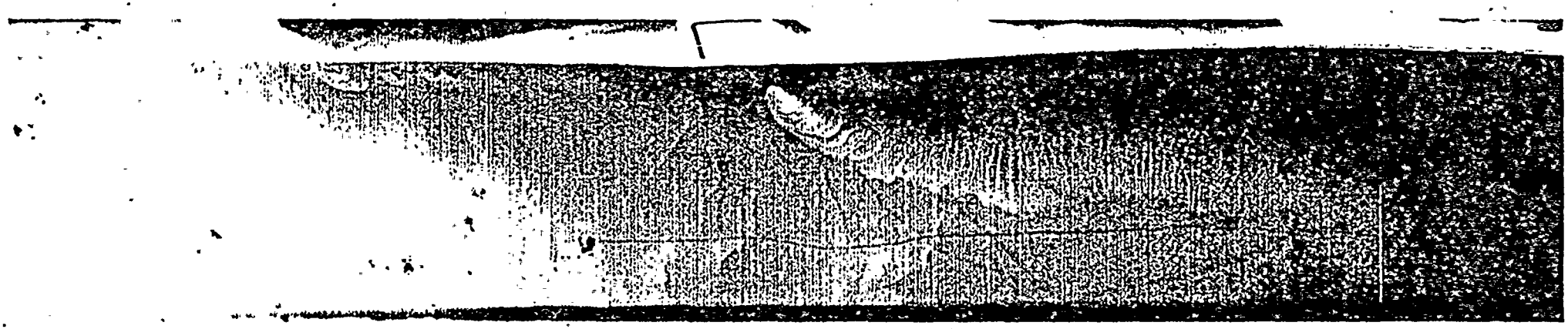
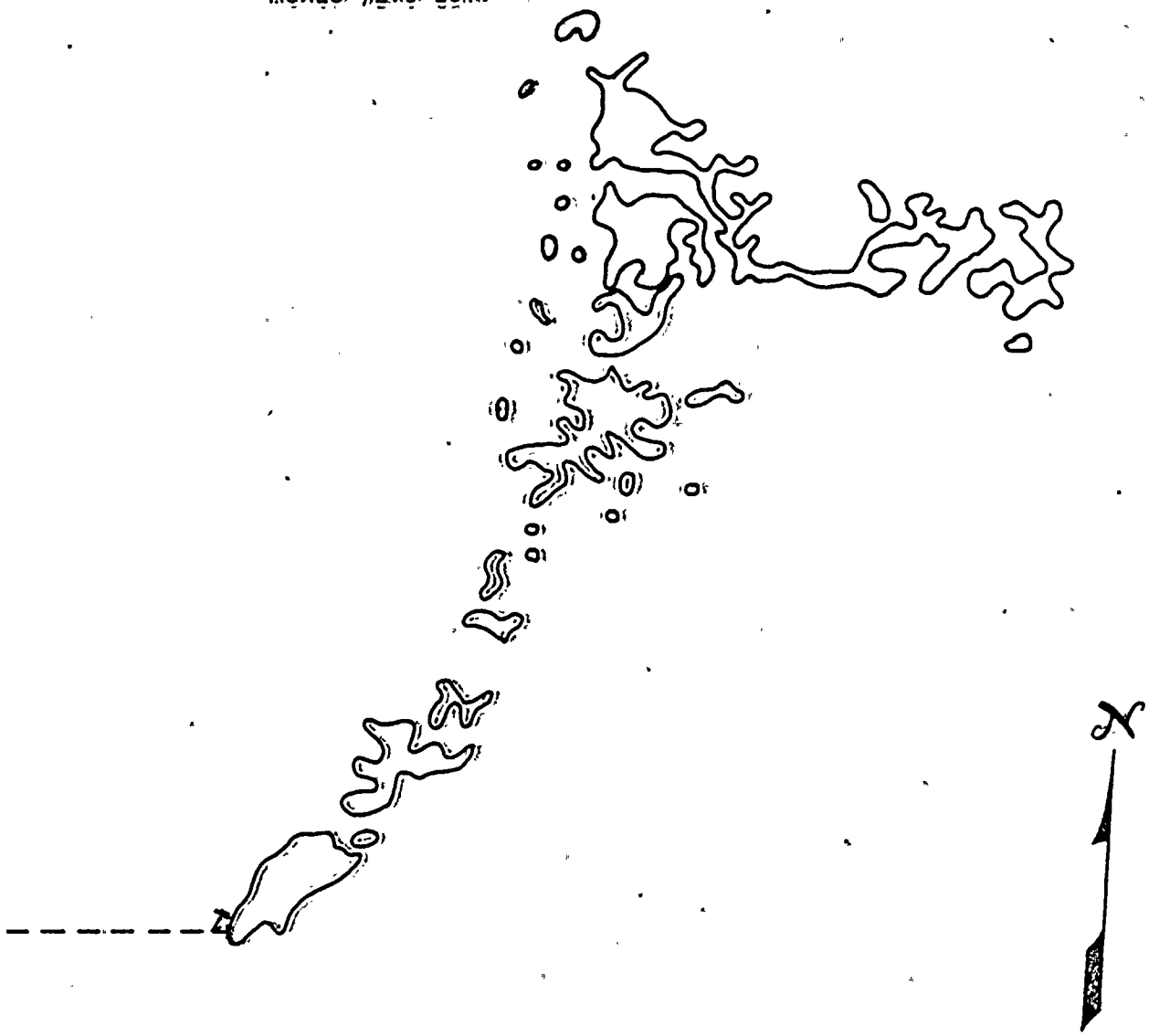


Plate IV-7. Flight Pass. 3/11/77. Time 16:23.

ST. LUCIE PLANT ISOTHERMS PLATE IV-8
FLIGHT PASS 3/11/77, TIME 16:23

A

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F.
TIDE +0.5 FT.
MAX PLUME 2°F
AMBIENT OCEAN 70°F
ACRES 72.0 EST.



SCALE
FEET
0 1000 2000
0 300 600
METERS

ST. LUCIE PLANT ISOTHERMS PLATE IV-8
FLIGHT PASS 3/11/77, TIME 16:23

B

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX. PLUME 2°F
AMBIENT OCEAN 70°F
ACRES 16.5

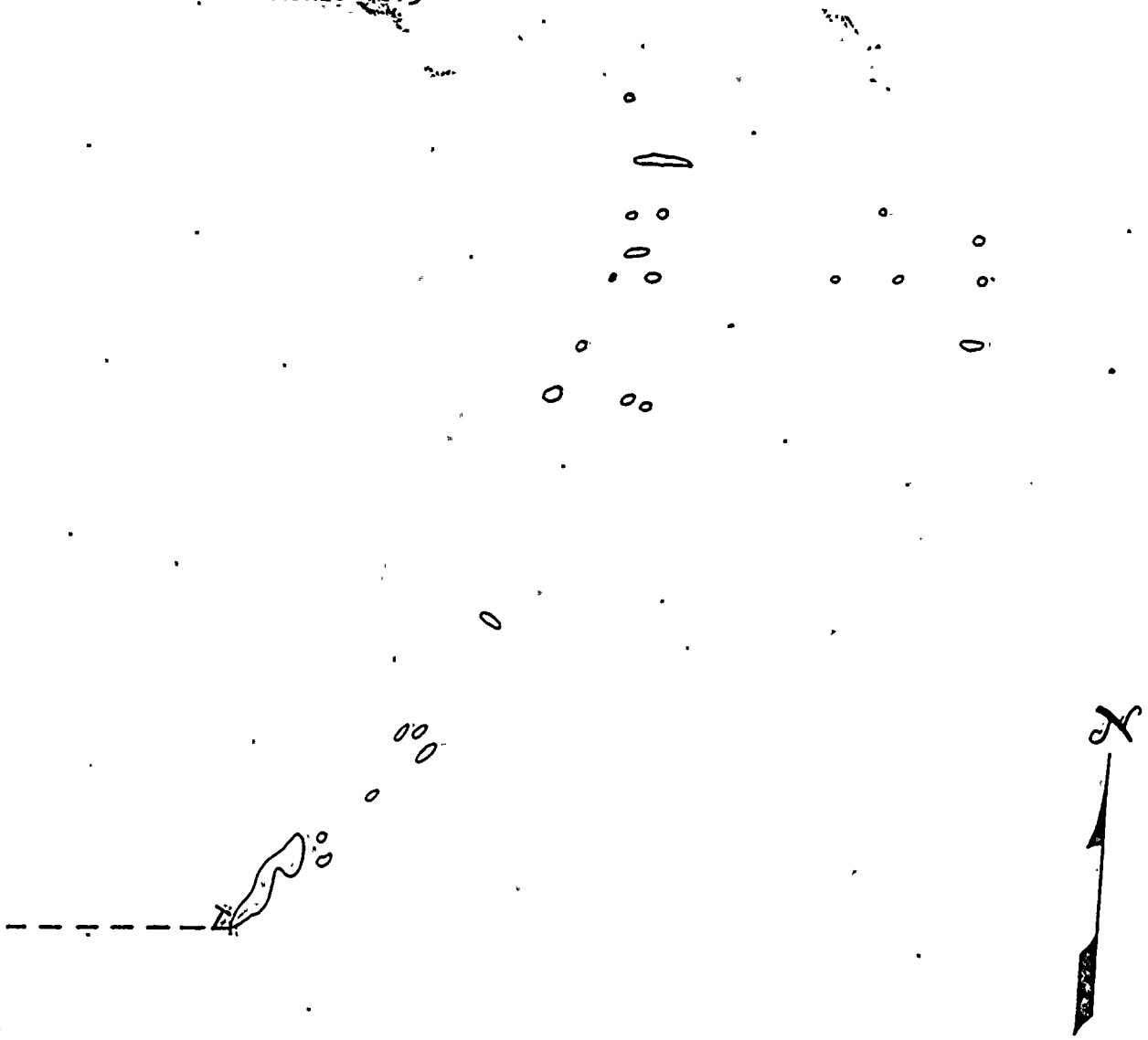


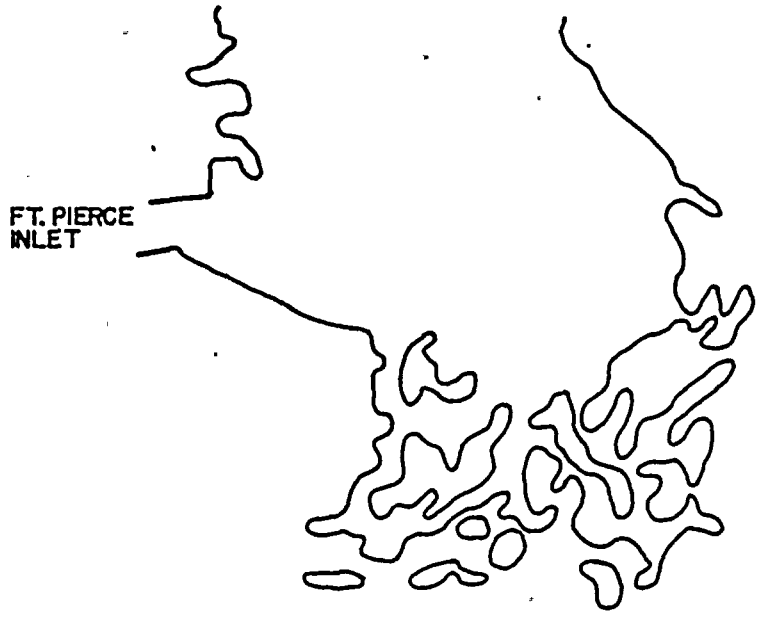
Plate IV-9. Isotherms, Ft. Pierce Inlet, Flight Pass, 3/11/77, Time 16:23

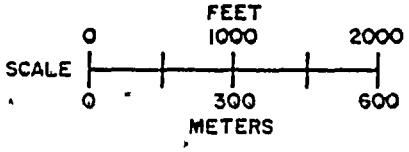
ST. LUCIE PLANT ISOTHERMS PLATE IV-9 A

FLIGHT PASS 3/11/77 TIME 16:23

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93° F
TIDE +0.5 FT.
MAX PLUME -1°F
AMBIENT OCEAN 70°F
ACRES 112.7

-1° F



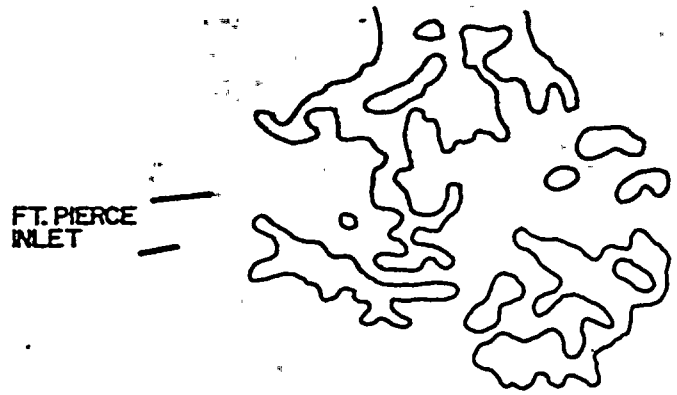


ST. LUCIE PLANT ISOTHERMS PLATE IV-9 B

FLIGHT PASS 3/11/77 TIME 16:23

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME -1°F
AMBIENT OCEAN 70°F
ACRES 36.9

-2°F



N

SCALE 0 FEET 1000 2000
0 300 600
METERS

Plate IV-10. Isotherms, South of St. Lucie Plant, Flight Pass, 3/11/77, Time 16:23

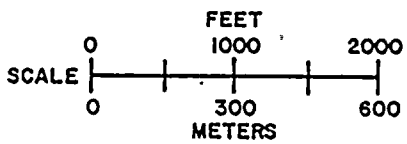
ST. LUCIE PLANT ISOTHERMS PLATE IV-10 A

FLIGHT PASS 3/11/77, TIME 16:23

1.5 MILE SOUTH

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME 4°F
AMBIENT OCEAN 70°F

1°F



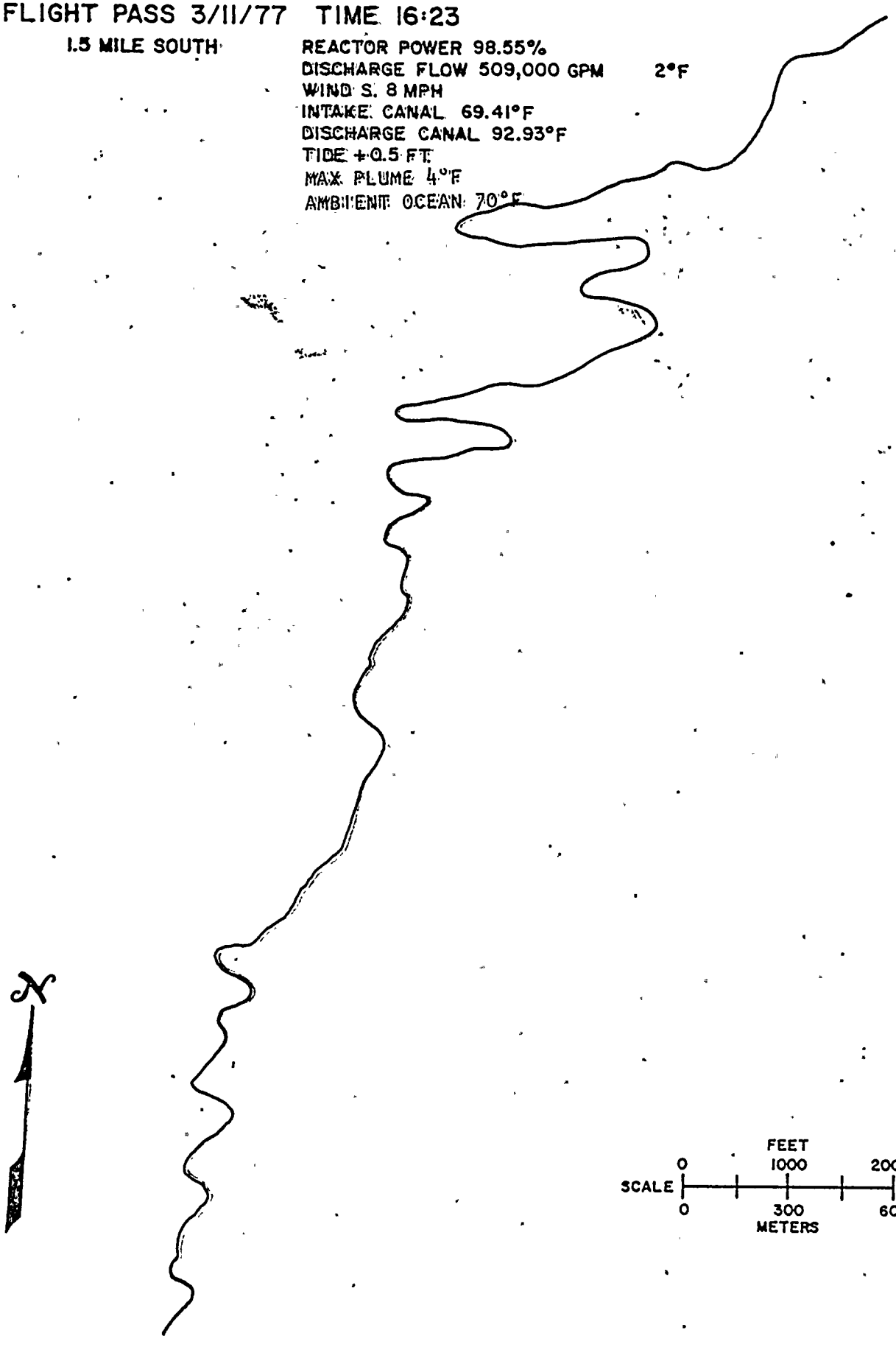
ST. LUCIE PLANT ISOTHERMS PLATE IV-10 B

FLIGHT PASS 3/11/77 TIME 16:23

1.5 MILE SOUTH

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT
MAX PLUME 4°F
AMBIENT OCEAN 70°F

2°F



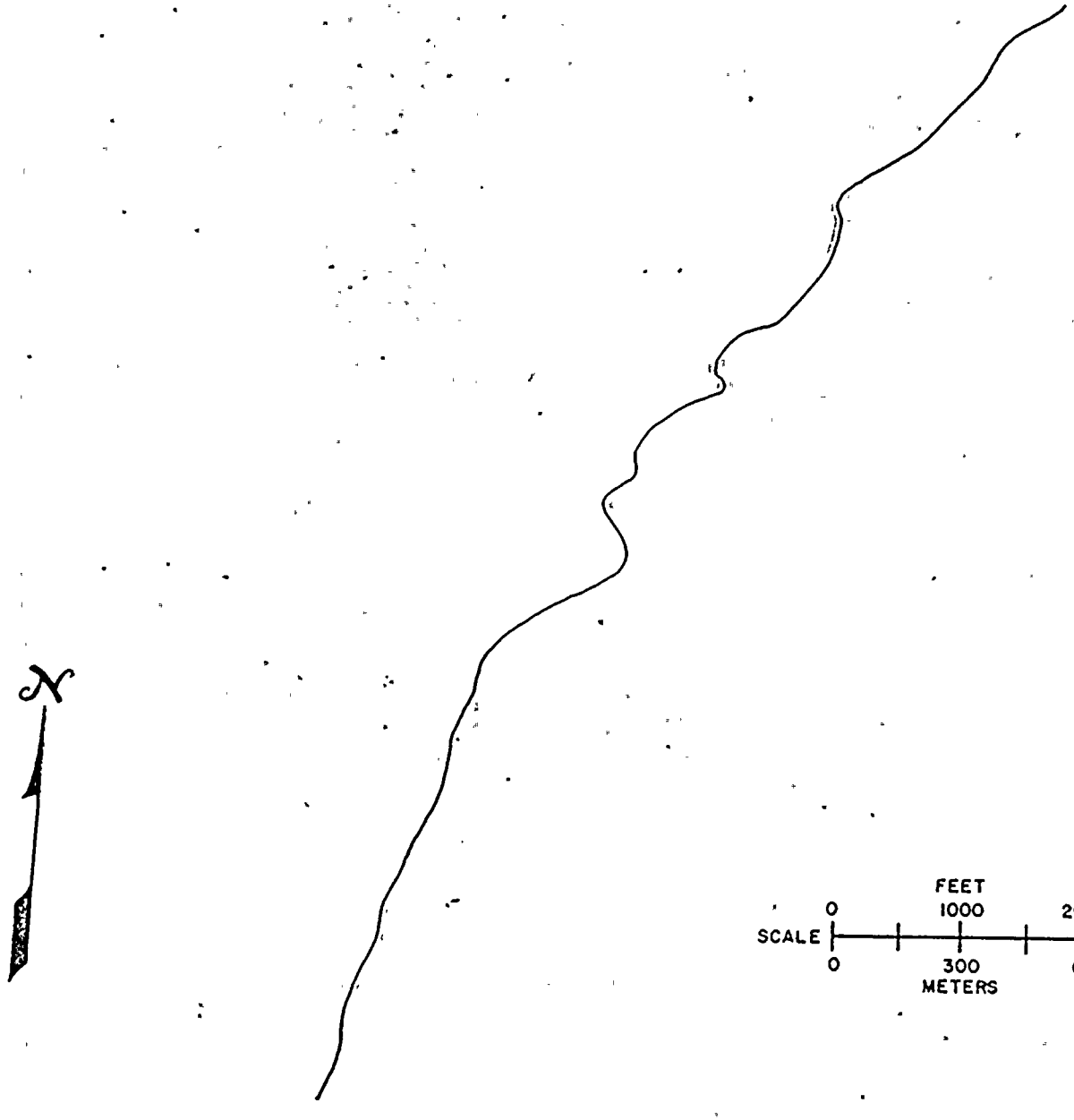
ST. LUCIE PLANT ISOTHERMS PLATE IV-10 C

FLIGHT PASS 3/11/77 TIME 16:23

1.5 MILE SOUTH

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME 4°F
AMBIENT OCEAN 70°F

3°F



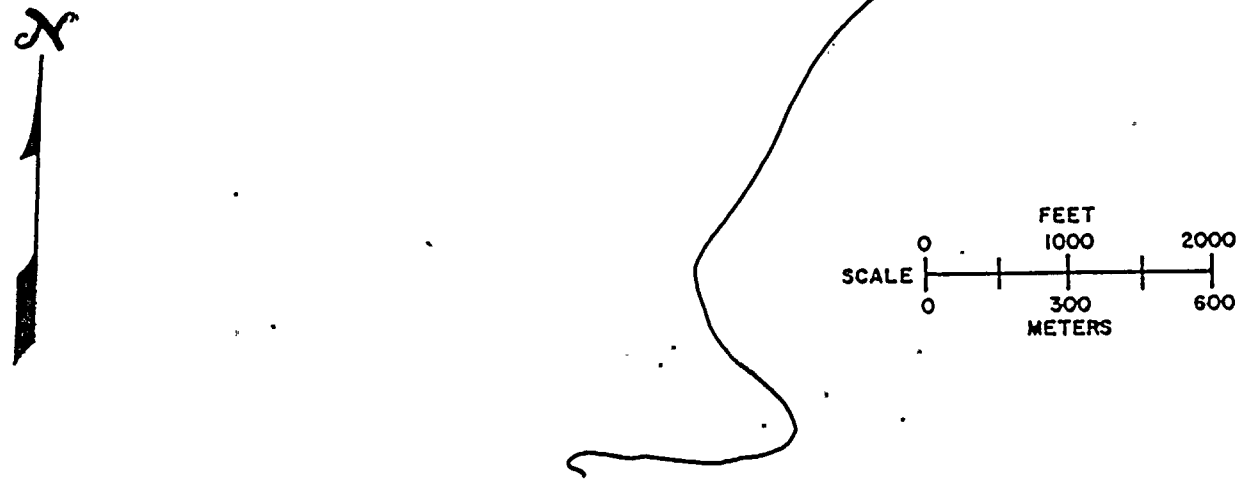
ST. LUCIE PLANT ISOTHERMS PLATE IV-10 D

FLIGHT PASS 3/11/77 TIME 16:23

1.5 MILE SOUTH

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX. PLUME 4°F
AMBIENT OCEAN 70°F

4°F



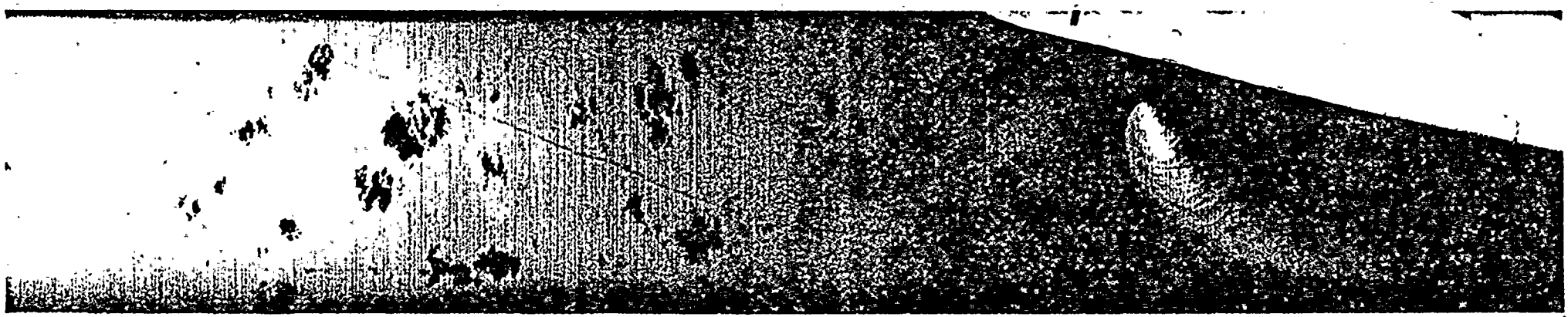


Plate IV-11. Flight Pass, 3/11/77, Time 16:31

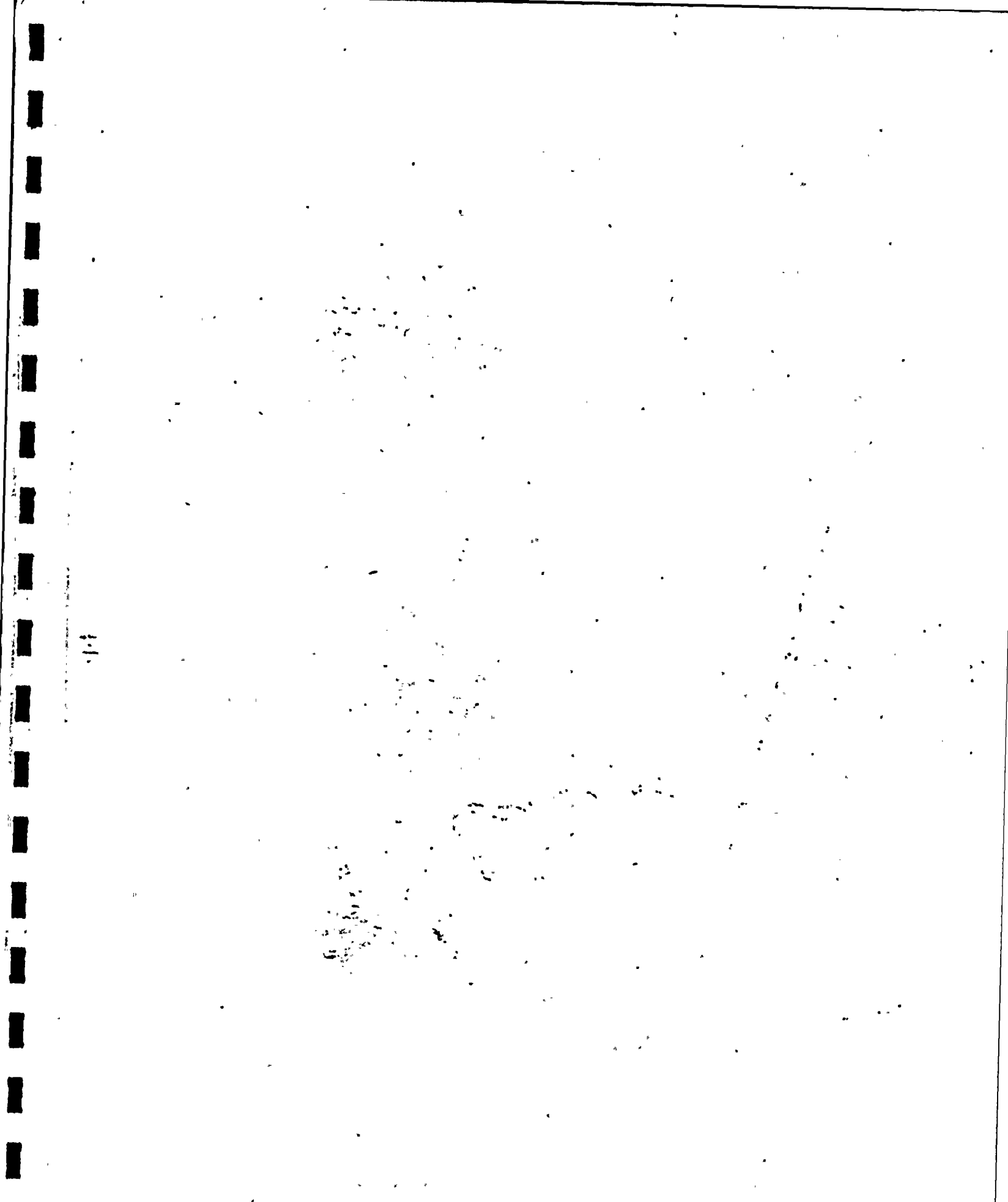
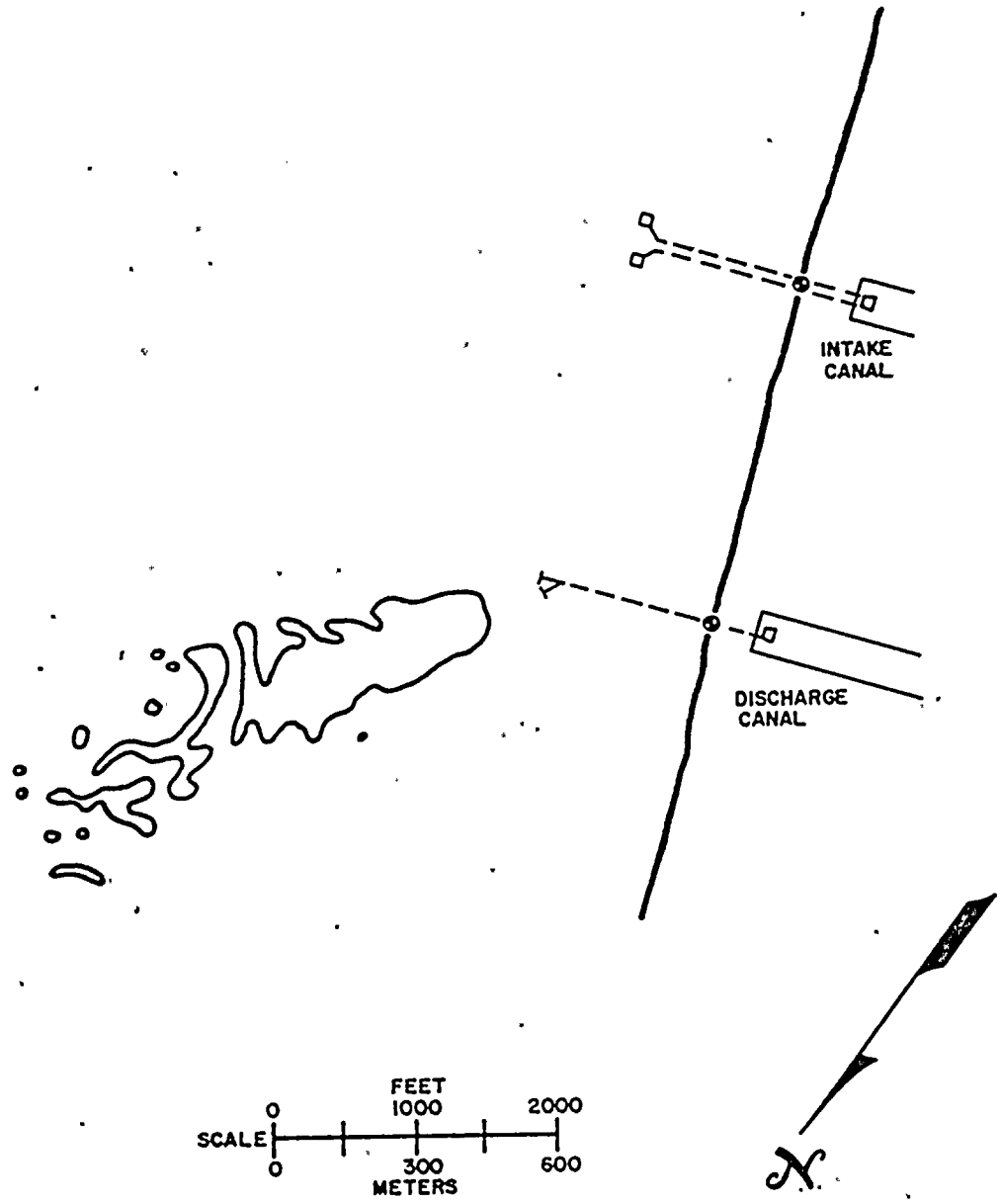


Plate IV-12. Isotherms, Flight Pass, 3/11/77, Time 16:31

ST. LUCIE PLANT ISOTHERMS PLATE IV-12
FLIGHT PASS 3/11/77, TIME 16:31

B

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME 3°F
AMBIENT OCEAN 70°F
ACRES 27.4

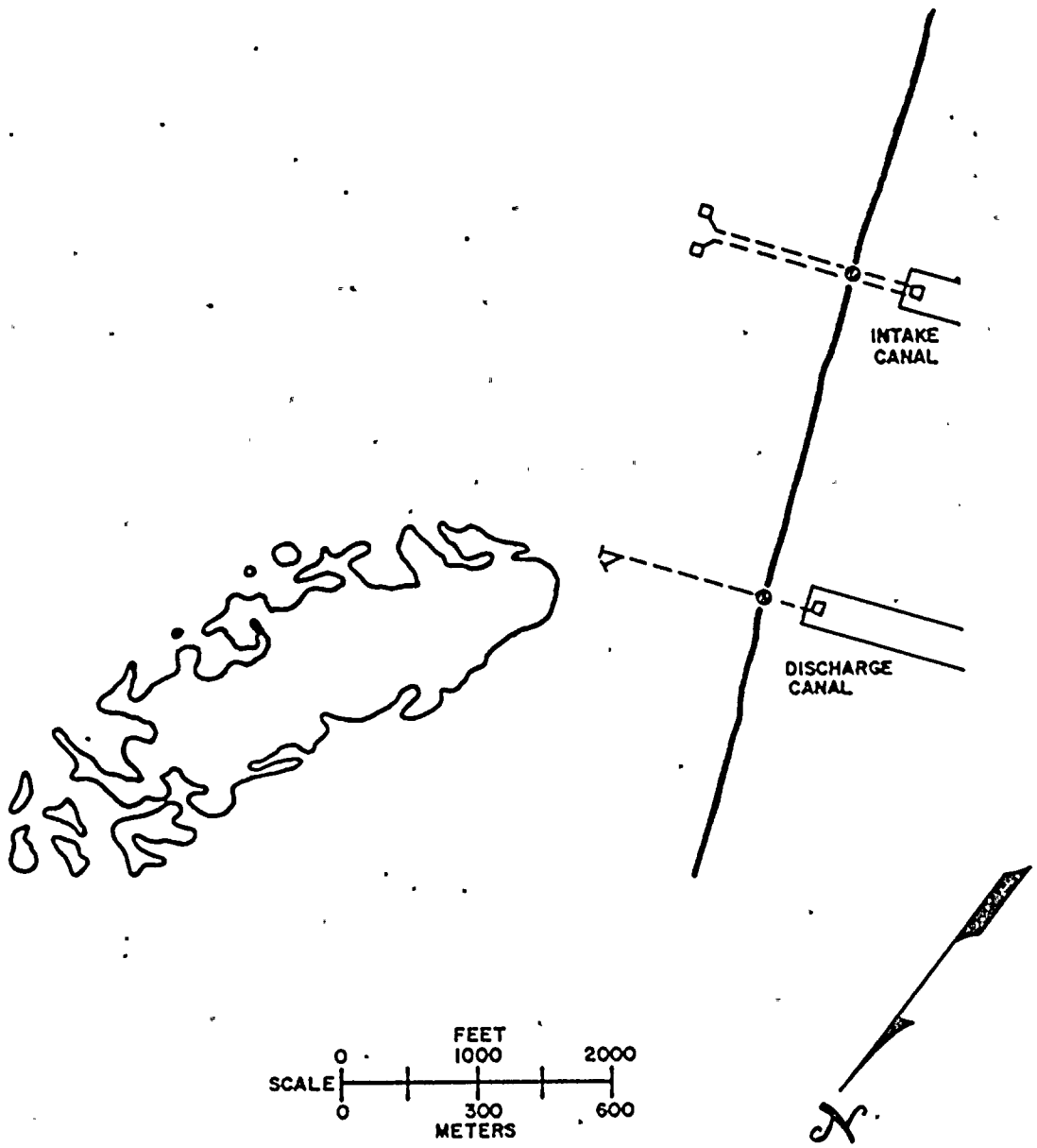


ST. LUCIE PLANT ISOTHERMS PLATE IV-12
FLIGHT PASS 3/11/77, TIME 16:31

A

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME 3°F
AMBIENT OCEAN 70°F
ACRES 84 EST.

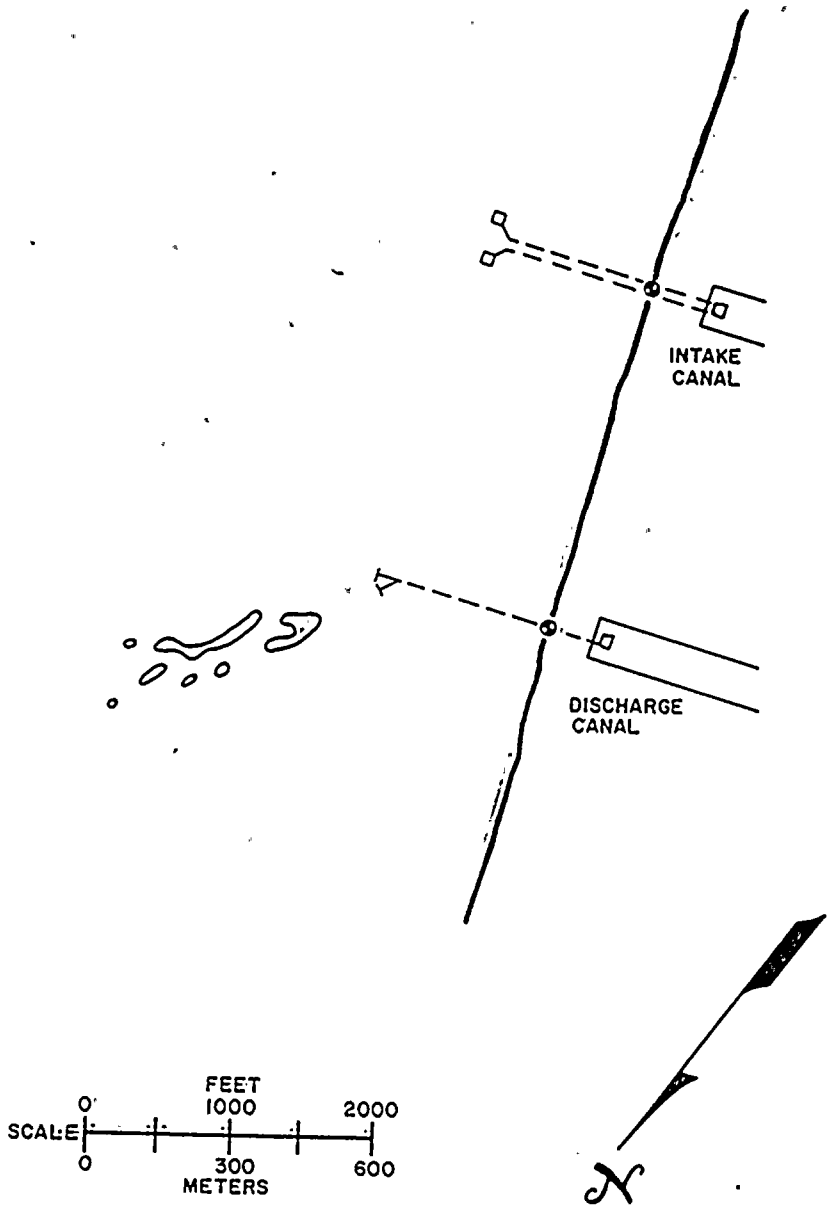
1.5°F



ST. LUCIE PLANT ISOTHERMS PLATE IV-12
FLIGHT PASS 3/11/77, TIME 16:31

C

REACTOR POWER 98.55%
DISCHARGE FLOW 509,000 GPM
WIND S. 8 MPH
INTAKE CANAL 69.41°F
DISCHARGE CANAL 92.93°F
TIDE +0.5 FT.
MAX PLUME 3°F
AMBIENT OCEAN 70°F
ACRES 3.6



SECTION V

DISCUSSION

The imagery taken during March 10-11, 1977 shows the strong effect of the wind direction and wind speed which was previously seen in the January imagery. The hot water appeared to rise to the surface quickly and then diffused along the surface effected by wind, at least as much, as by water currents.

The temperature of the water varied with time and with position along the coast. The flight lines taken on the afternoon of March 11 were longer lines which showed the large mass of warm water separate from the plant plume. The northern and western edges of the warm water mass came within a mile of the plant plume. The southern and eastern edges of the mass were not found, even though the aircraft flew as far south as the St. Lucie Inlet and as far as 8 miles from the coast. The two passes at 16:23 and 16:31 showed the mass with temperatures as high as 3.0°F above the nominal ambient temperature near the plant.

Table V-1 shows the excess temperatures ΔT isotherms with their given areas at high and low tide. Figure V-1 compares flight pass 12:41 and 13:41 at high tide (+2.5). Flight pass 13:41 shows from the bar graph to have lower surface areas. Figure V-2 compares flight passes 07:42, 16:23 and 16:31 at low tide (+0.5), and flight passes 16:23 and 16:31 shows from the bar graph that each ΔT isotherm (except 2.0°F for flight pass 16:31) to have a much lower surface areas as well as lower excess temperatures.

The reason for these lower surface areas and lower excess temperatures could be the warm water intrusion of the Gulf stream.

The mass changed with time. The mass was much farther from shore on 10 March 1977 than on 11 March 1977. On 11 March 1977, the mass appeared

Table V-1

Excess Temperatures ΔT Isotherm

FLIGHT PASS 3/10/77 12:41 REACTOR POWER 98.4% TIDE @13:00 +2.5 ft		FLIGHT PASS 3/11/77 07:42 REACTOR POWER 99.42% TIDE @07:03 +0.3 ft		FLIGHT PASS 3/11/77 13:41 REACTOR POWER 98.41% TIDE @13:00 +2.5 ft		FLIGHT PASS 3/11/77 16:23 REACTOR POWER 98.55% TIDE N/A +0.5 ft		FLIGHT PASS 3/11/77 16:31 REACTOR POWER 98.55% TIDE N/A +0.5 ft	
ΔT ISOTHERMS (°F)	AREA (acres)	ΔT ISOTHERMS (°F)	AREA (acres)	ΔT ISOTHERMS (°F)	AREA (acres)	ΔT ISOTHERMS (°F)	AREA (acres)	ΔT ISOTHERMS (°F)	AREA (acres)
6.0	–	6.0	0.1	6.0	–	6.0	–	6.0	–
5.0	0.2	5.0	0.2	5.0	–	5.0	–	5.0	–
4.0	2.4	4.0	5.4 Est.	4.0	0.1	4.0	–	4.0	–
3.0	9.7	3.0	21.1 Est.	3.0	5.9	3.0	–	3.0	3.6
2.0	159.0	2.0	23.0 Est.	2.0	120.2	2.0	16.5	2.0	27.4
1.5	350-397 Est.	1.5	200.0 Est.	1.5	350.0 Est.	1.5	72.0 Est.	1.5	84.0 Est.

to follow the coast near the St. Lucie Inlet and then turned outward from the coast about two-miles south of the plant. It is possible that the warm water intrusion are offshoots from the Gulf stream which undulates into the shore and back outward on a cyclic principle.

Although the warm water mass described above is separate from the plant's water discharge, it was close enough to the plant's plume that the edges of the 1.5°F isotherm lines of the plume and mass mixed on the 16:23 and 16:31 flight measurements.

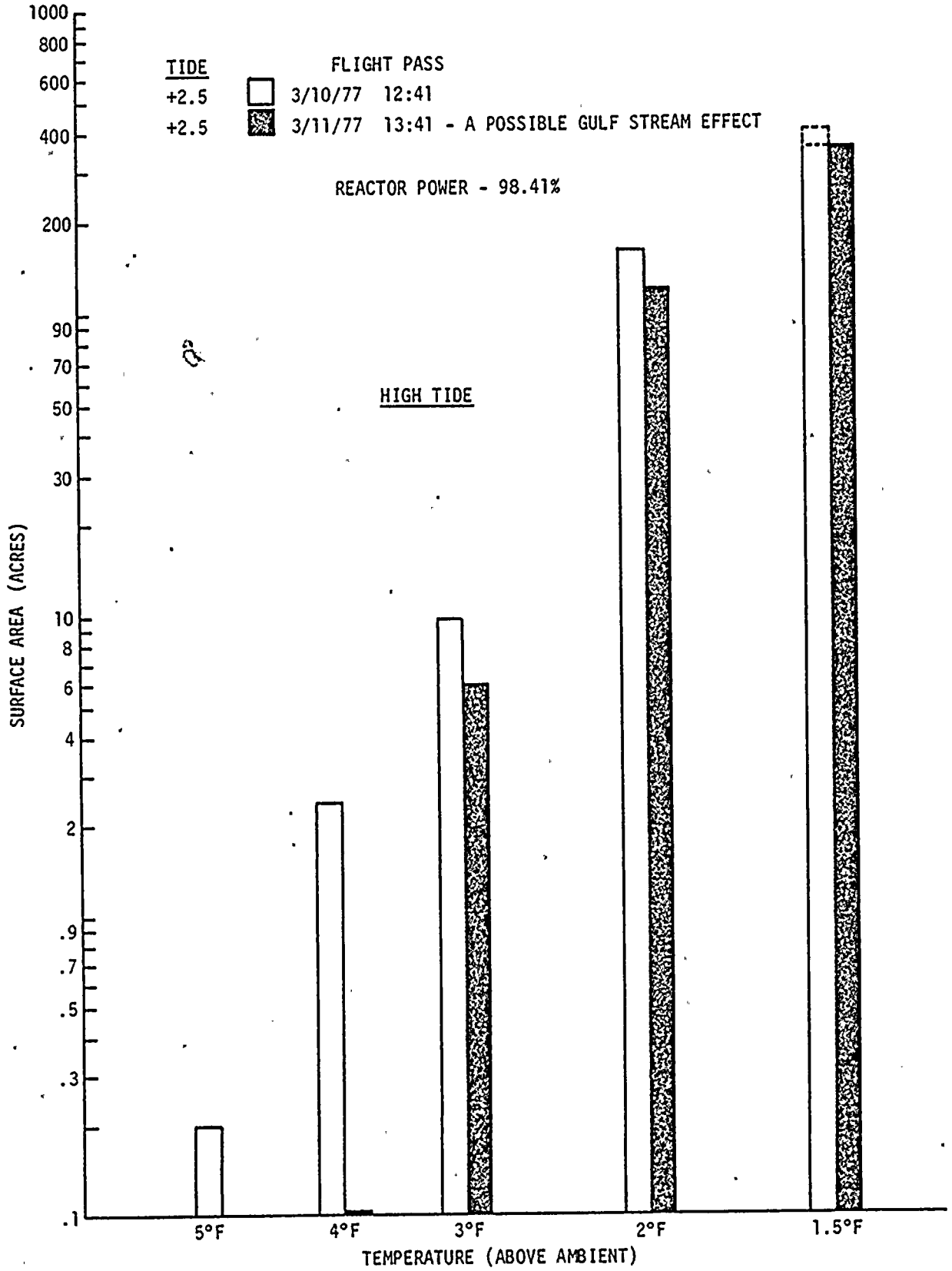


Figure V-1. Flight Pass 12:41 and 13:41 at High Tide (+2.5)

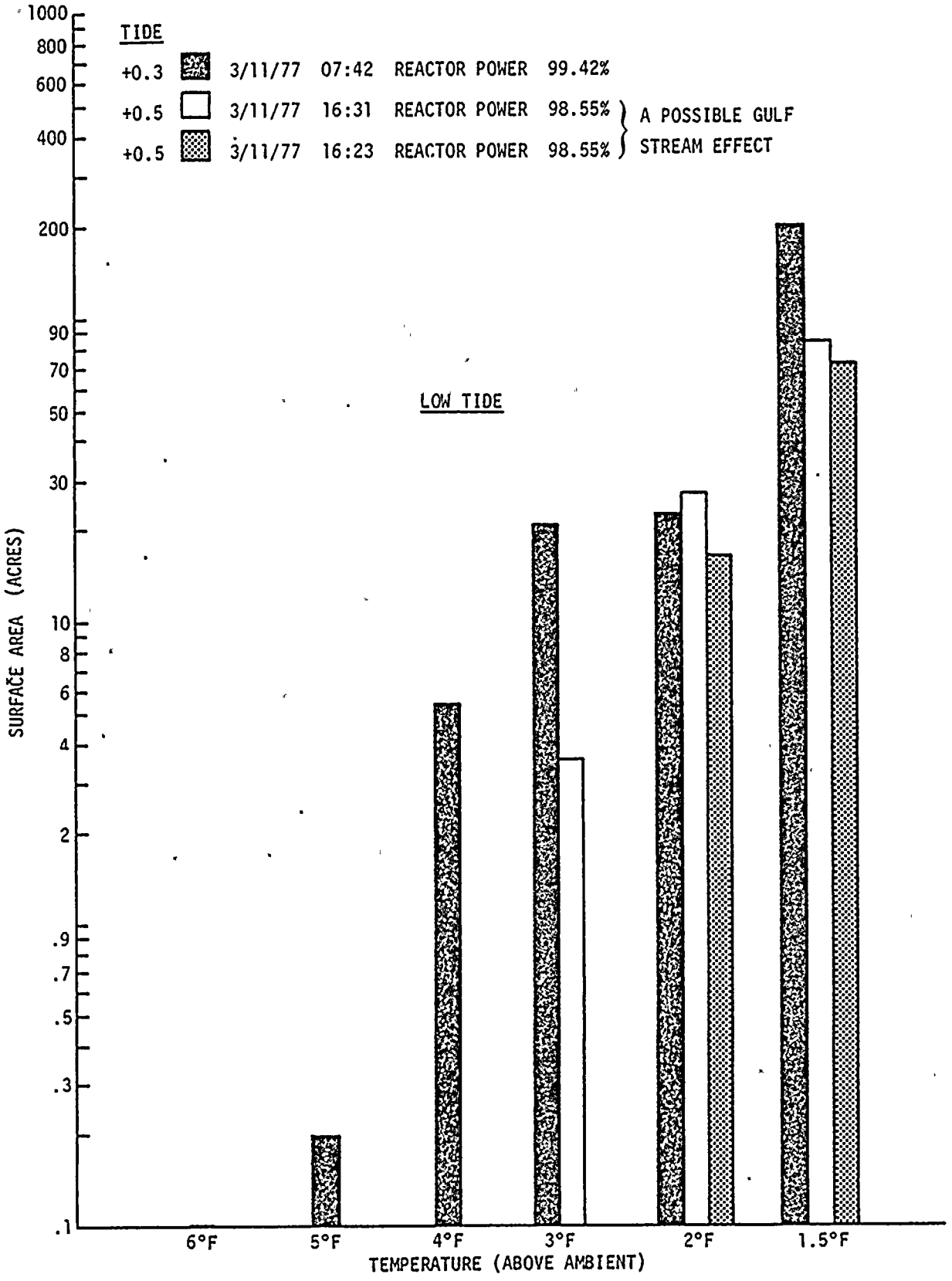


Figure V-2. Flight Pass 07:42, 16:23, and 16:31 at Low Tide (+0.5)

APPENDIX A

FLIGHT LOGS

FLIGHT LOG St. Lucie

DATE 3/10/77 TAKE OFF TIME 11:43 Local time

TAKE OFF WIND 5-15-18 KT TAKE OFF PLACE Stuart Fla

Discharge 90.4 Intake 67.5

RUN #	TIME ON	TIME OFF	TAPE FT ON	TAPE FT OFF	FILM FRAME ON	FILM FRAME OFF	HEADING	ALT	SPEED	
1		12:27	----	----		12:27	E			Tape 1
2		12:33	532	1433		12:33	W			
3		12:41	1439	1900			S			
4		12:48	1900	2569			E			
5		12:52	2569	2961			W			
6		13:10	2961	3459			210°			
7		13:20				13:20	S			

Visual Readings From 500 ft

Cold Cana 0.6CM 67.5°F

Hot Canal 5.6CM 90.4°F

Difference 5.0CM 22.9°F or 4.58°/CM

Hot Spot in Plume 4.58°F

Extremely small Hot Spot in Plume 1 1CM = 5.04°F

Note: Extremely Small Hot Spot in Plume Flashes Through in Much Less Than a Second of Time and Can Not Be Read Accurately. Therefore 1.1CM is an Approximate Estimate of Height of Hot Spot.

FLIGHT LOG St. Lucie

DATE 3/11/77 TAKE OFF TIME 06:38

TAKE OFF WIND _____ TAKE OFF PLACE Stuart

Low High EBB Low
6:57 13:21 16:33 19:45

Discharge 91.9°F Intake 68.8°F

RUN #	TIME ON	TIME OFF		TAPE FT ON	TAPE FT OFF	FILM FRAME ON	FILM FRAME OFF	HEADING	ALT	SPEED	
1		7:01		3459	3539			210°			Tape 1
2		7:07		----	----						
3		7:14		----	----						
4		7:31		0005	0428						Tape 1 continued
5		7:42		0428	0882						#system restarte
6		7:51		0882	1248						
7		7:55		1248	1595						
8		7:59		1595	1855						
---				1953	1953	End of flight announcement on Tape					

FLIGHT LOG St. Lucie

DATE 3/11/77 TAKE OFF TIME 12:40

TAKE OFF WIND 120° 15 KT TAKE OFF PLACE Stuart

Discharge 92.1°F Intake 68.97 Cal 20/35

RUN #	TIME ON	TIME OFF	TAPE FT ON	TAPE FT OFF	FILM FRAME ON	FILM FRAME OFF	HEADING	ALT	SPEED	
1		13:10	1953	5100				4000		End of Tape 1
2		13:20	----	----				"		
3		13:31	0	425			S	"		Start of Tape 2
4		13:39	425	966			E	"		
5		13:41	966	1342			W	"		
6		13:47	1342	1950			E	"		
7		13:51	1950	2350			SW	"		

FLIGHT LOG St. Lucie

DATE 3/11/77 TAKE OFF TIME 15:40

TAKE OFF WIND _____ TAKE OFF PLACE Stuart

Discharge 92.93 Inlet 69.41

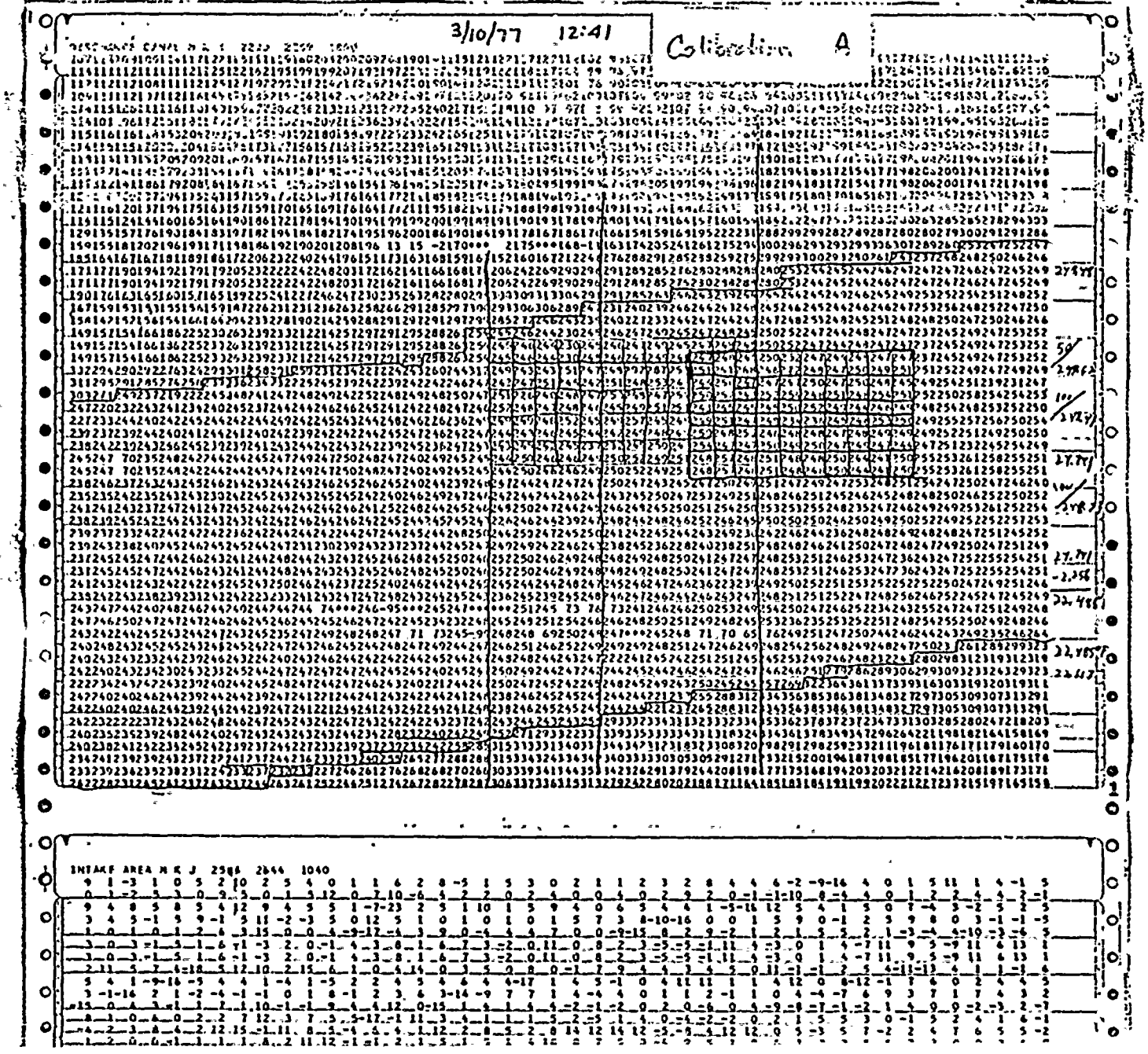
RUN #	TIME			TAPE FT		FILM FRAME		HEADING		ALT	SPEED	
	ON	OFF		ON	OFF	ON	OFF					
1		15:58		2350	4400			4000 S			150 KT	Tape 2
2		16:05		4400	5103			4000 SW			"	
3		16:09		5103	5850			4000 E			"	
4		16:23		5850	7534			8000 S			"	
5		16:41		7534	8825			6000 NW			"	

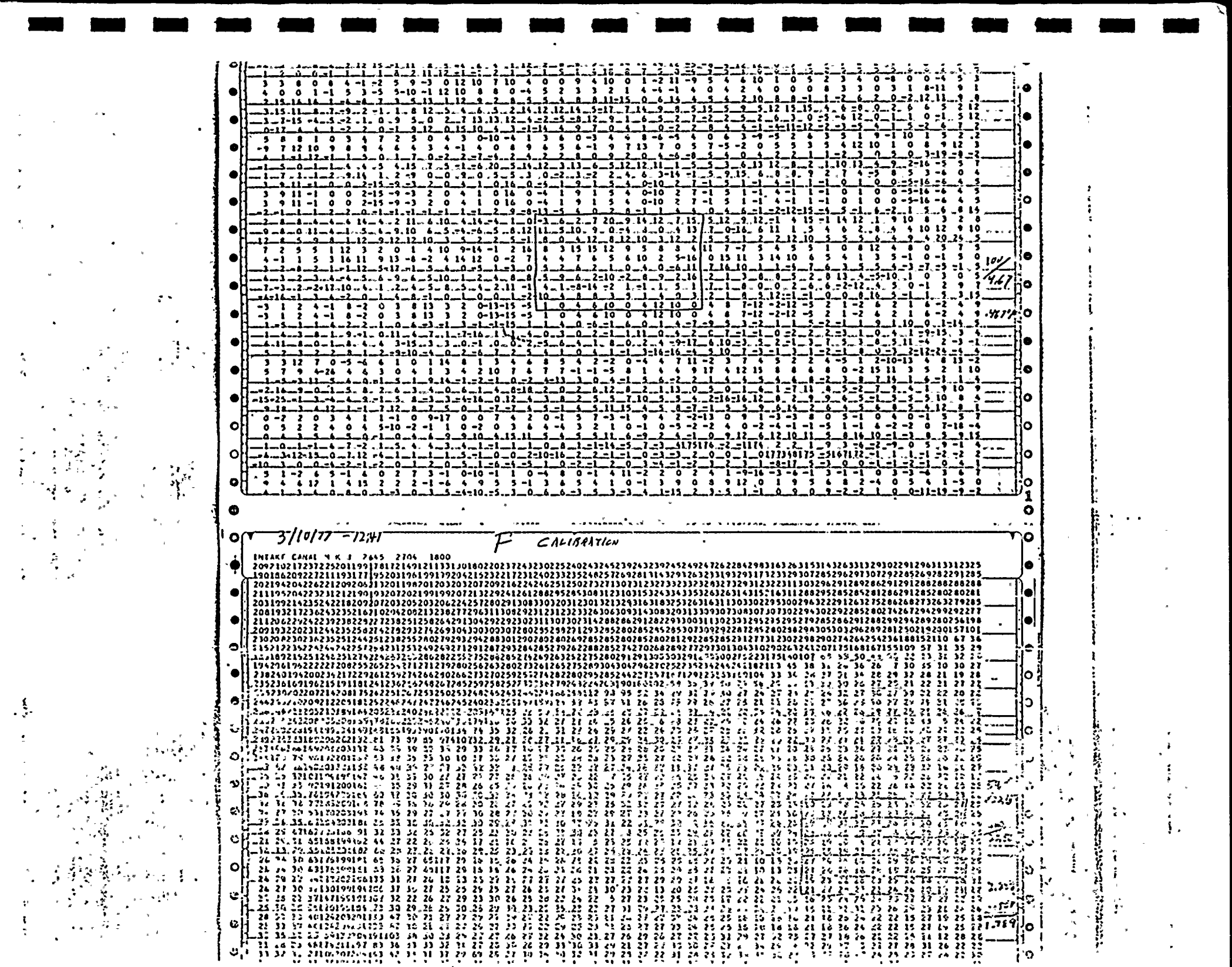
APPENDIX B

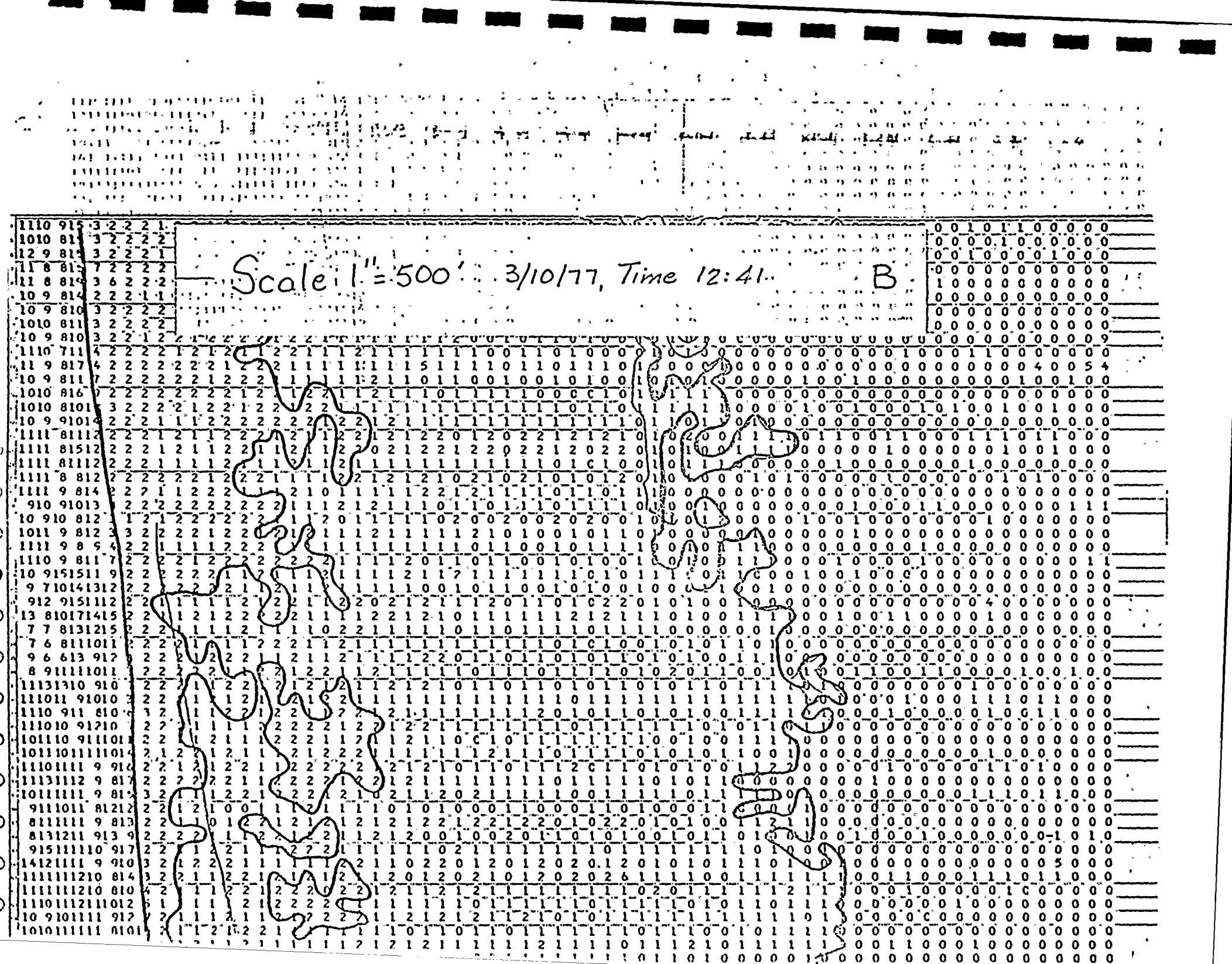
DATA PRINTOUTS

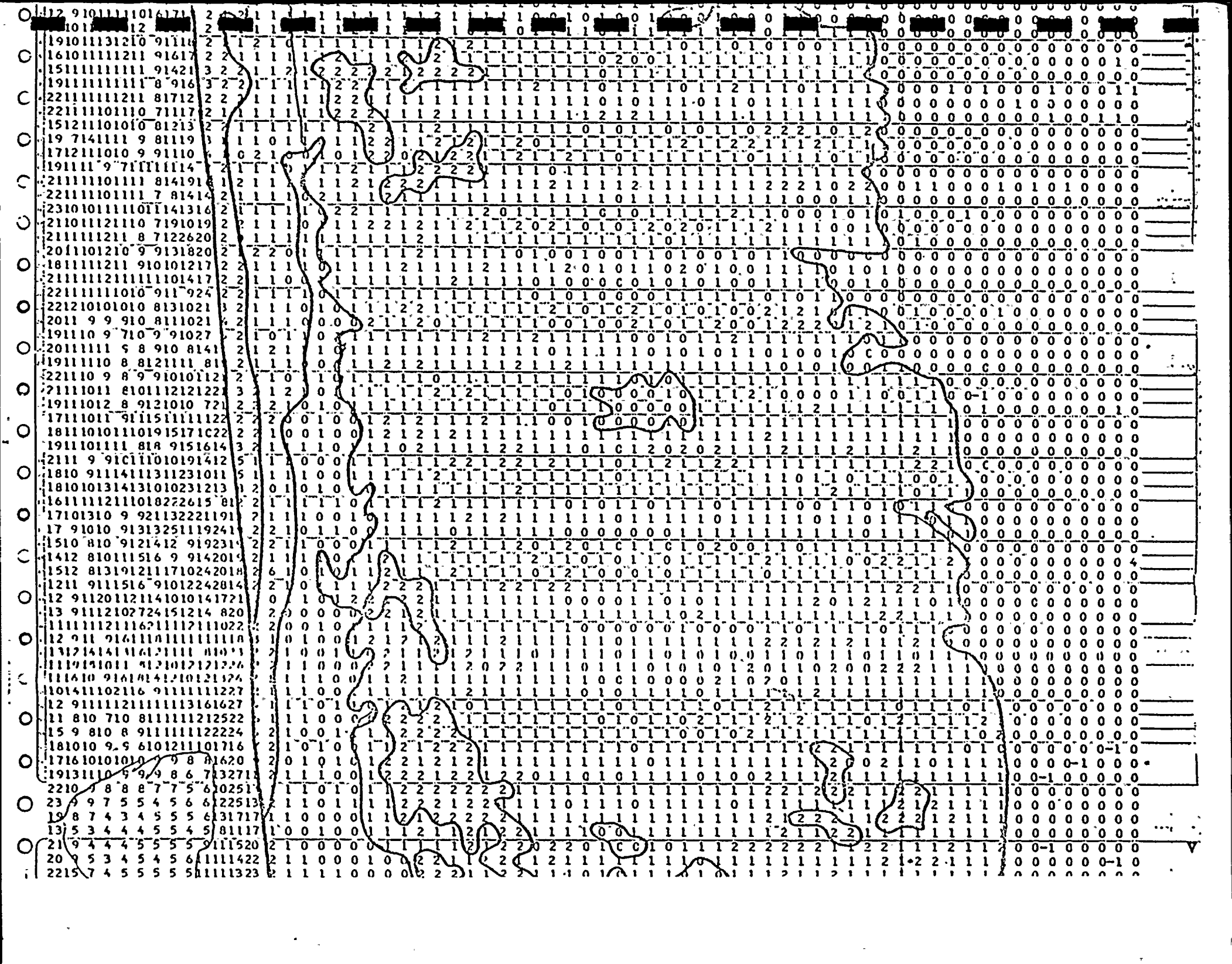
ATTACHMENTS

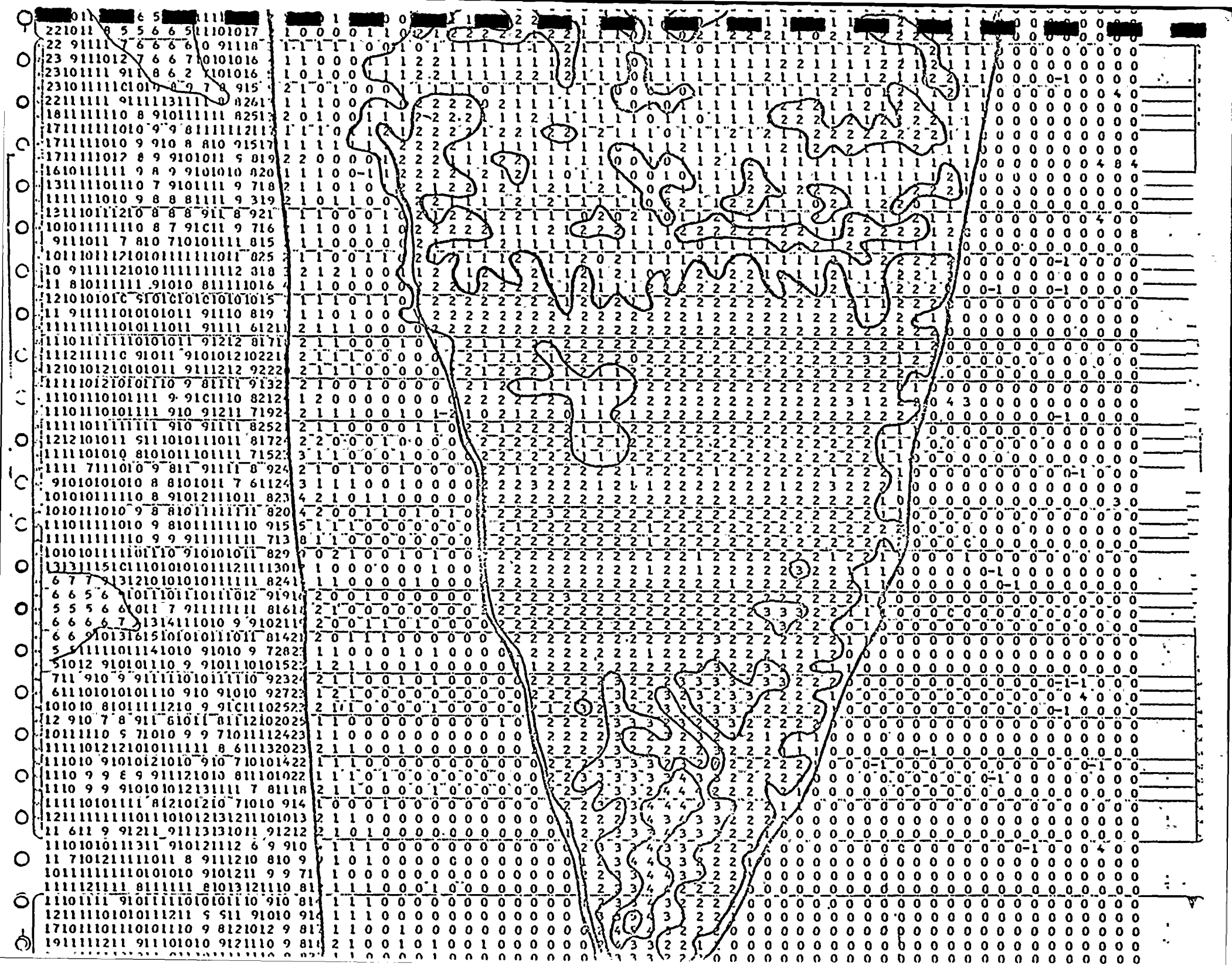
A - K

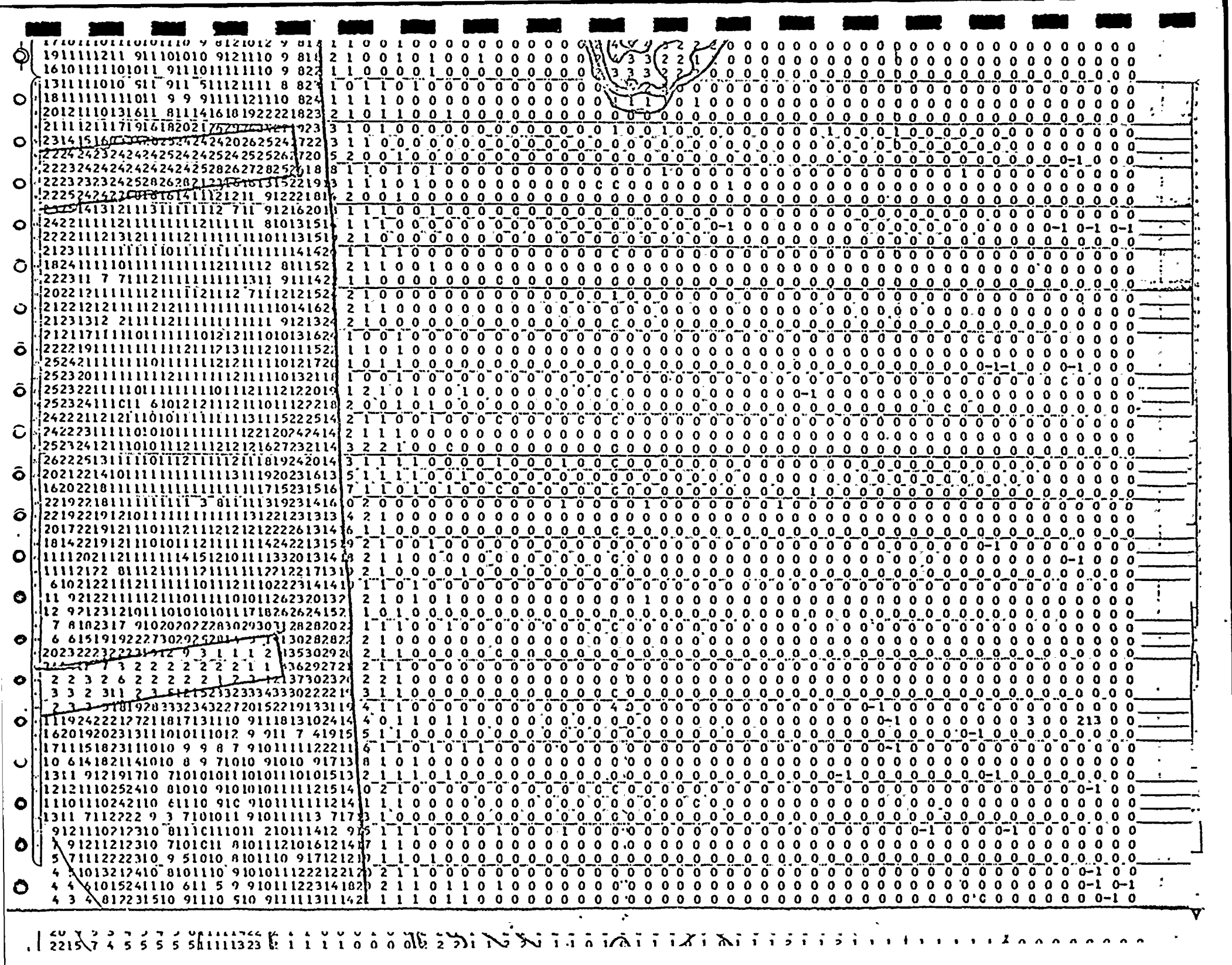

3/10/77 12:41
Calibration A
INTAKE AREA

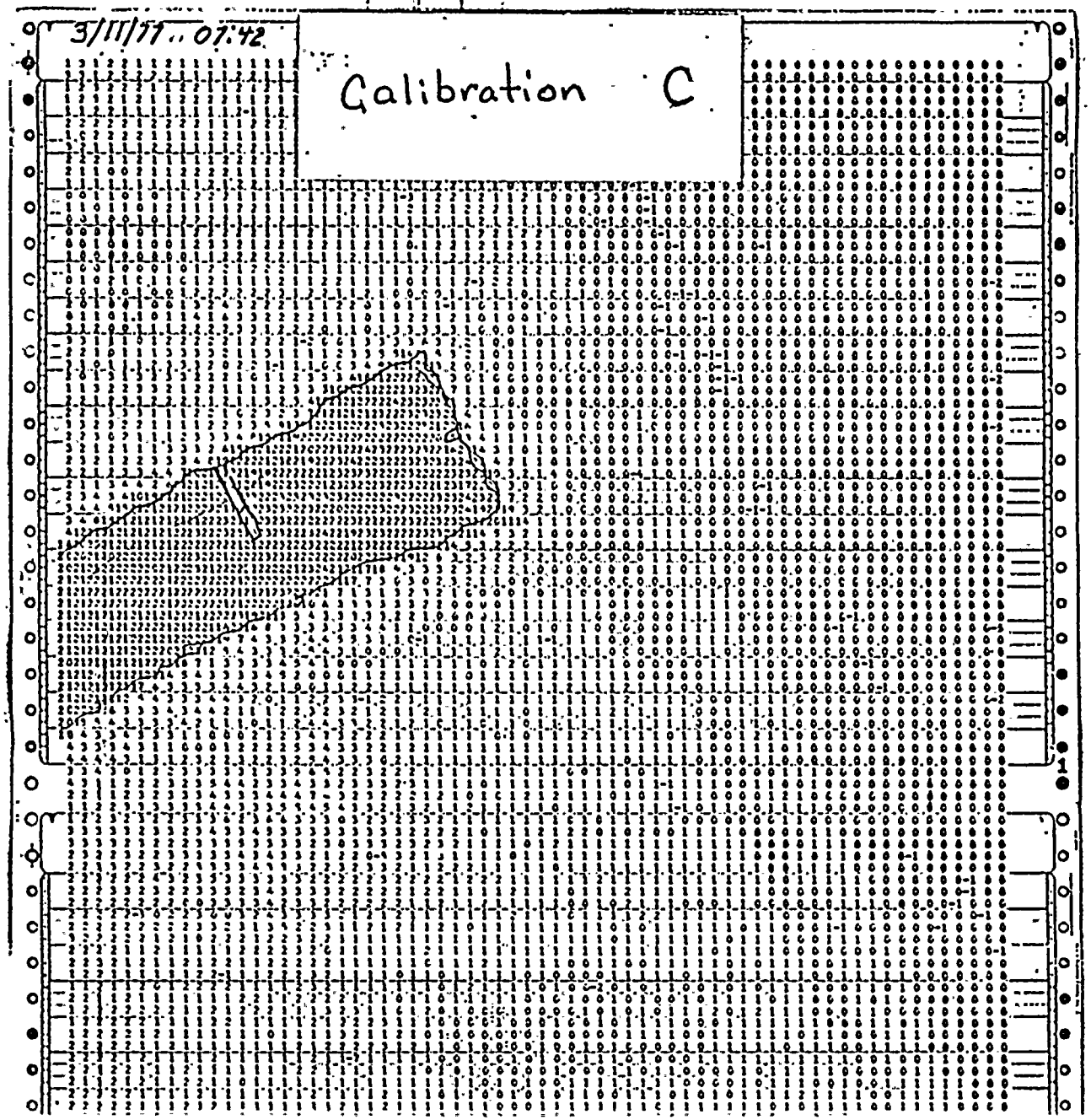

3/10/77 -12:41
F CALIBRATION
INTAKE CANAL N K J 2645 2706 1800

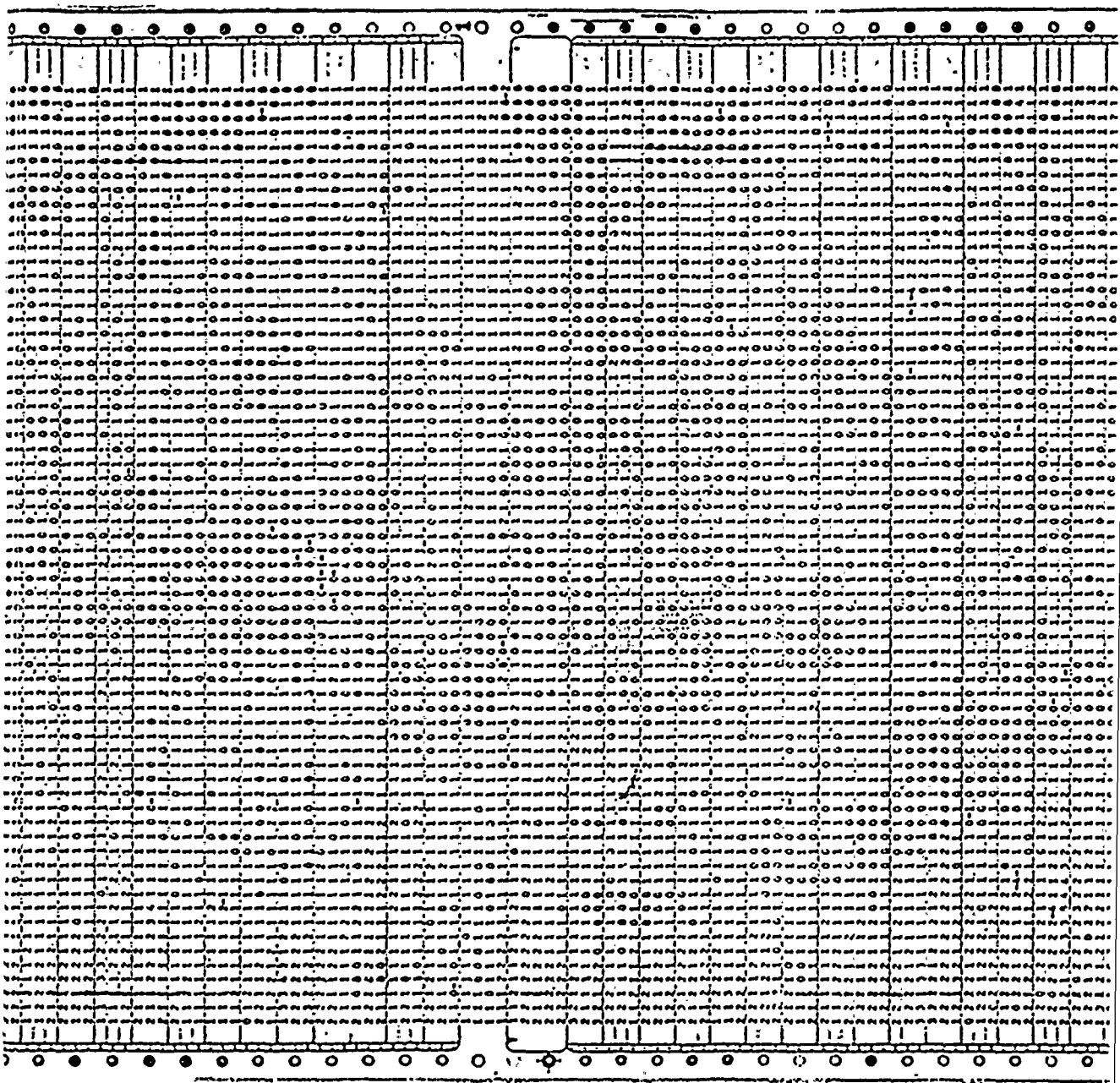

Scale 1" = 500'
3/10/77, Time 12:41
B

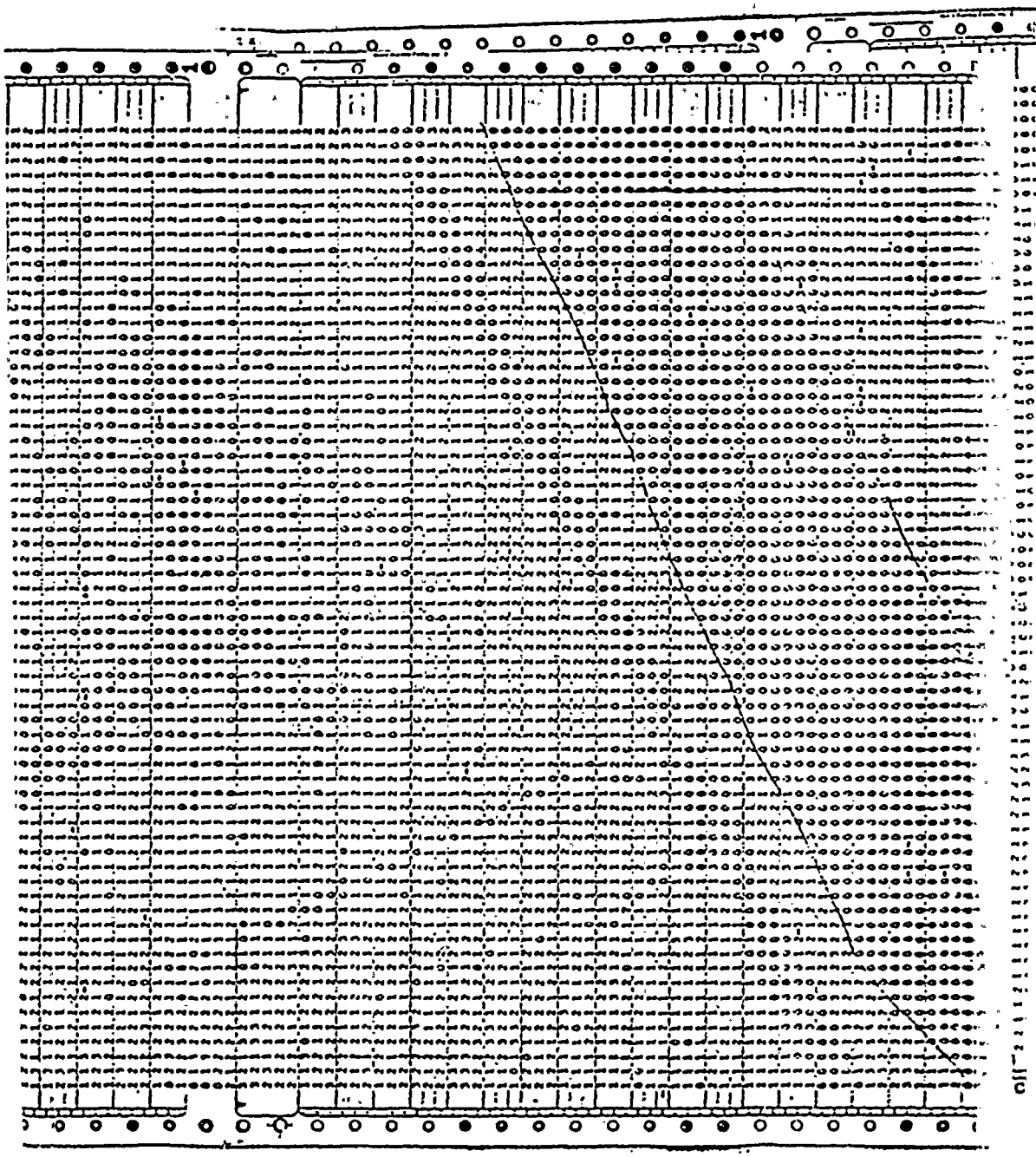


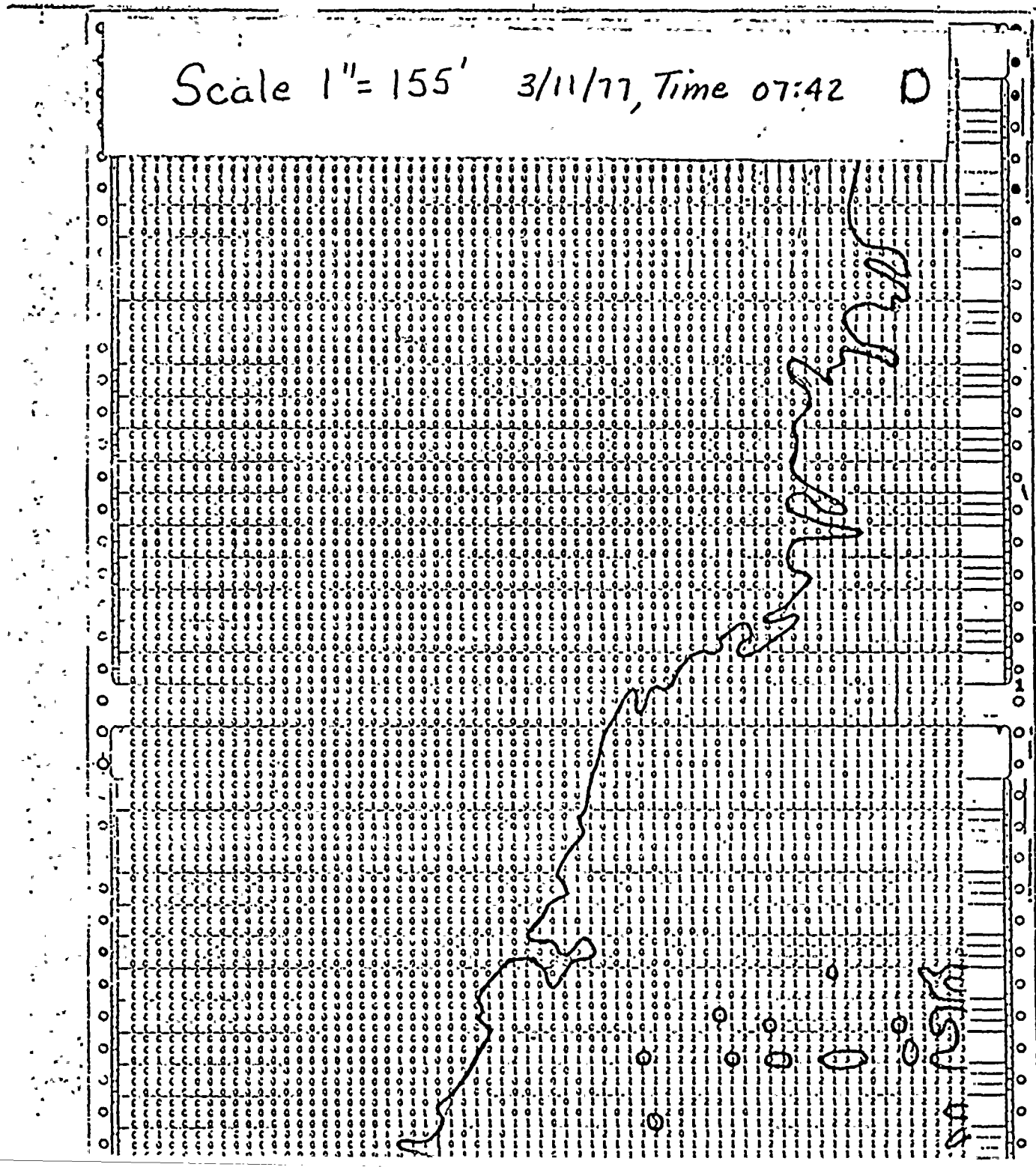





3/11/77 .. 07:42
Calibration C



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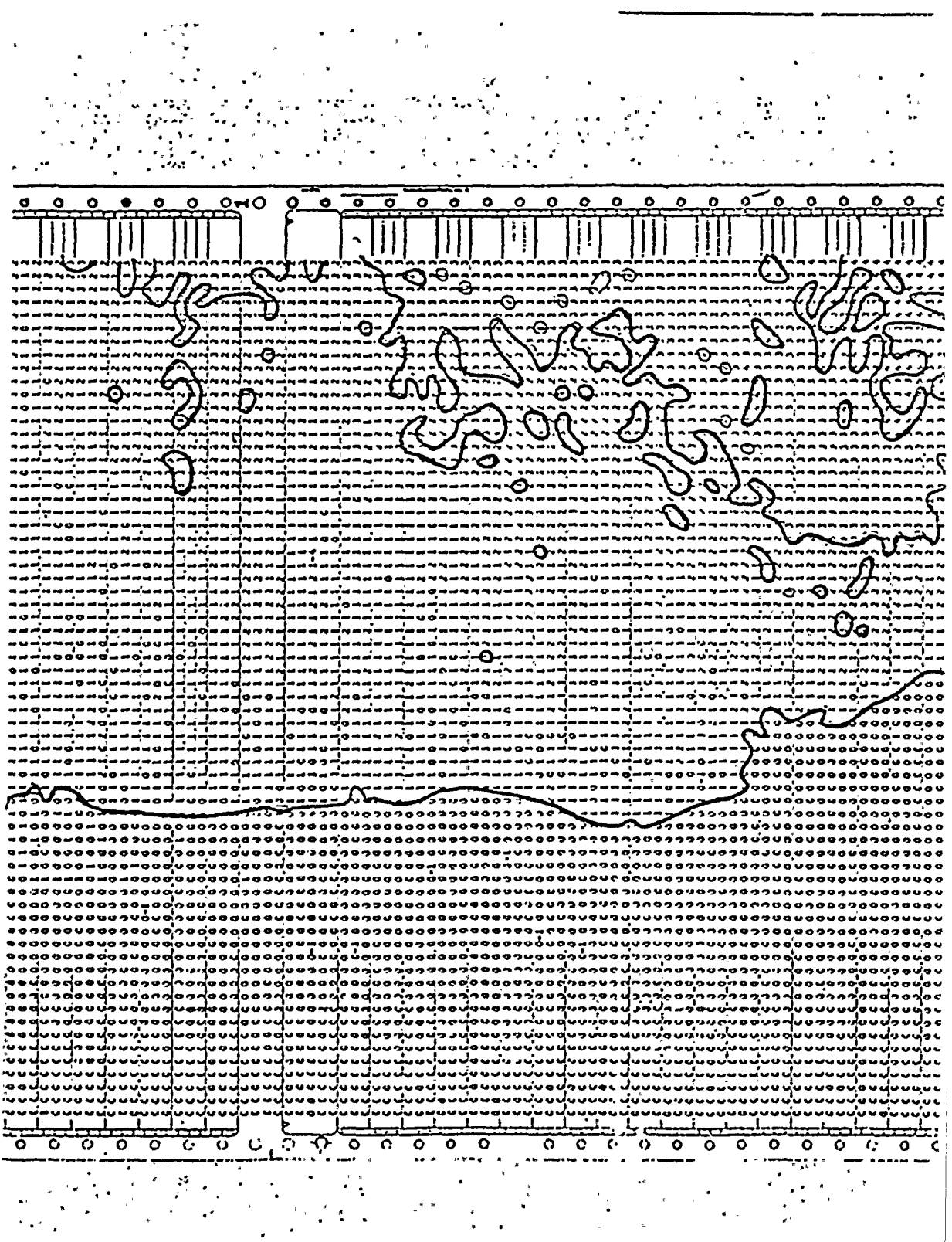

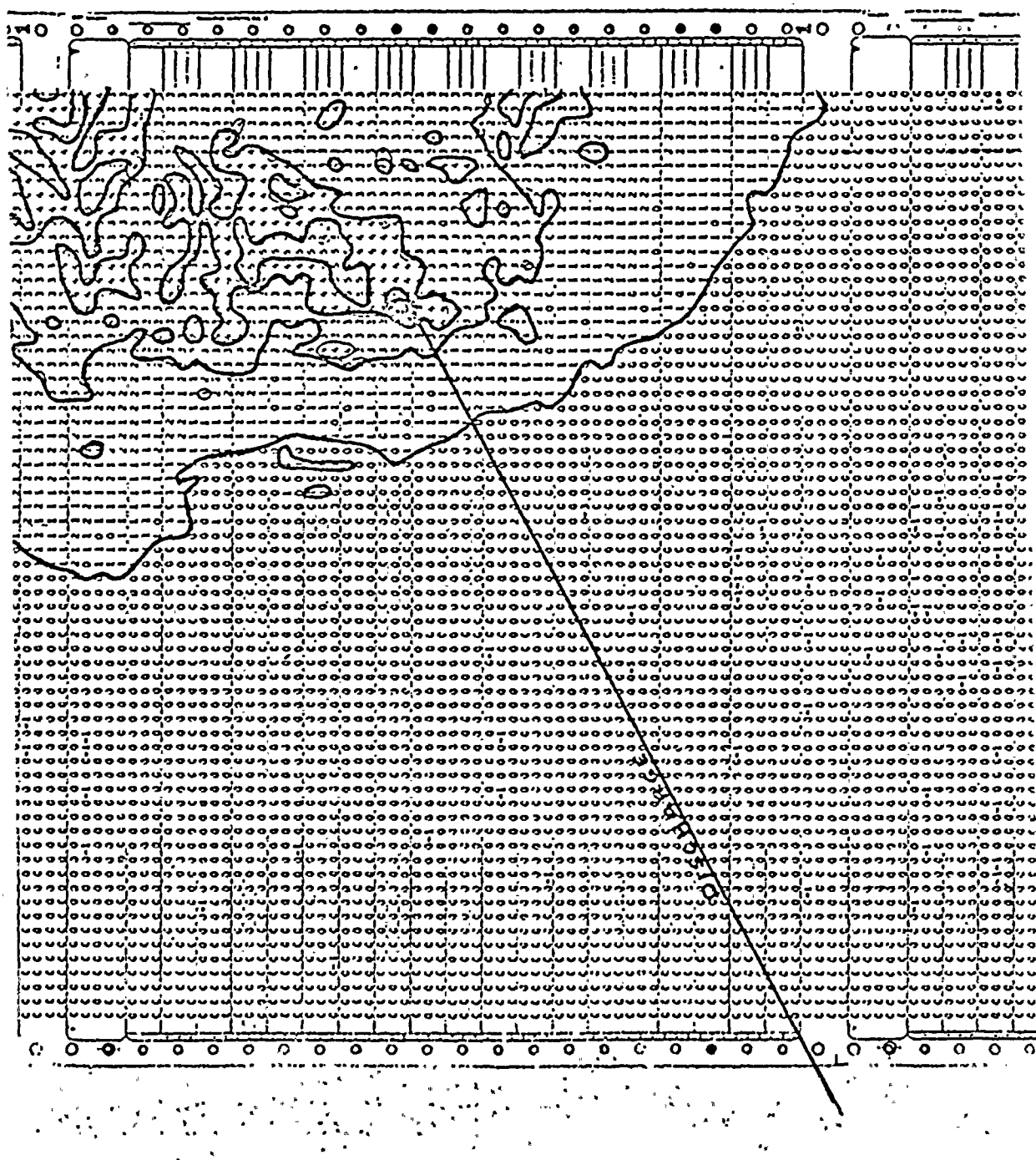

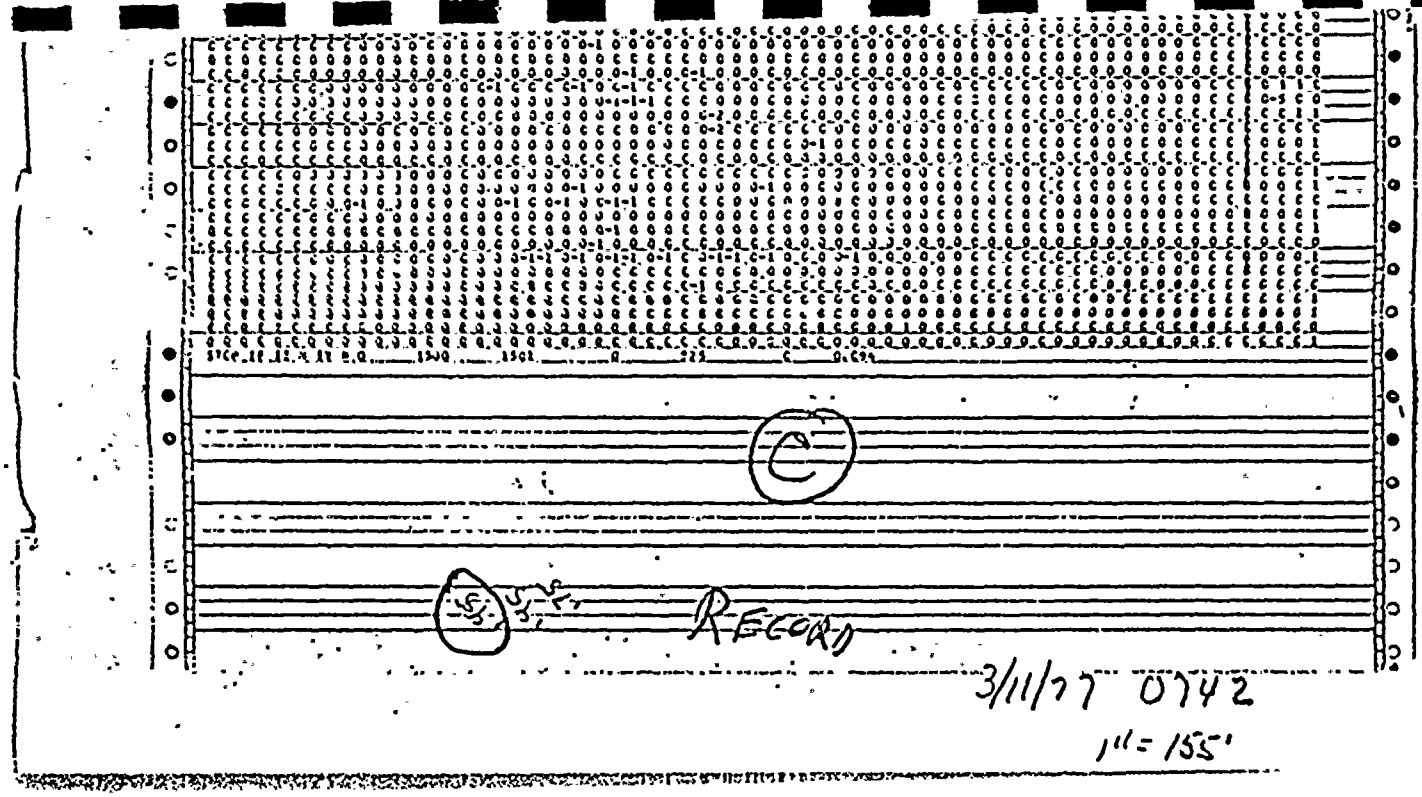
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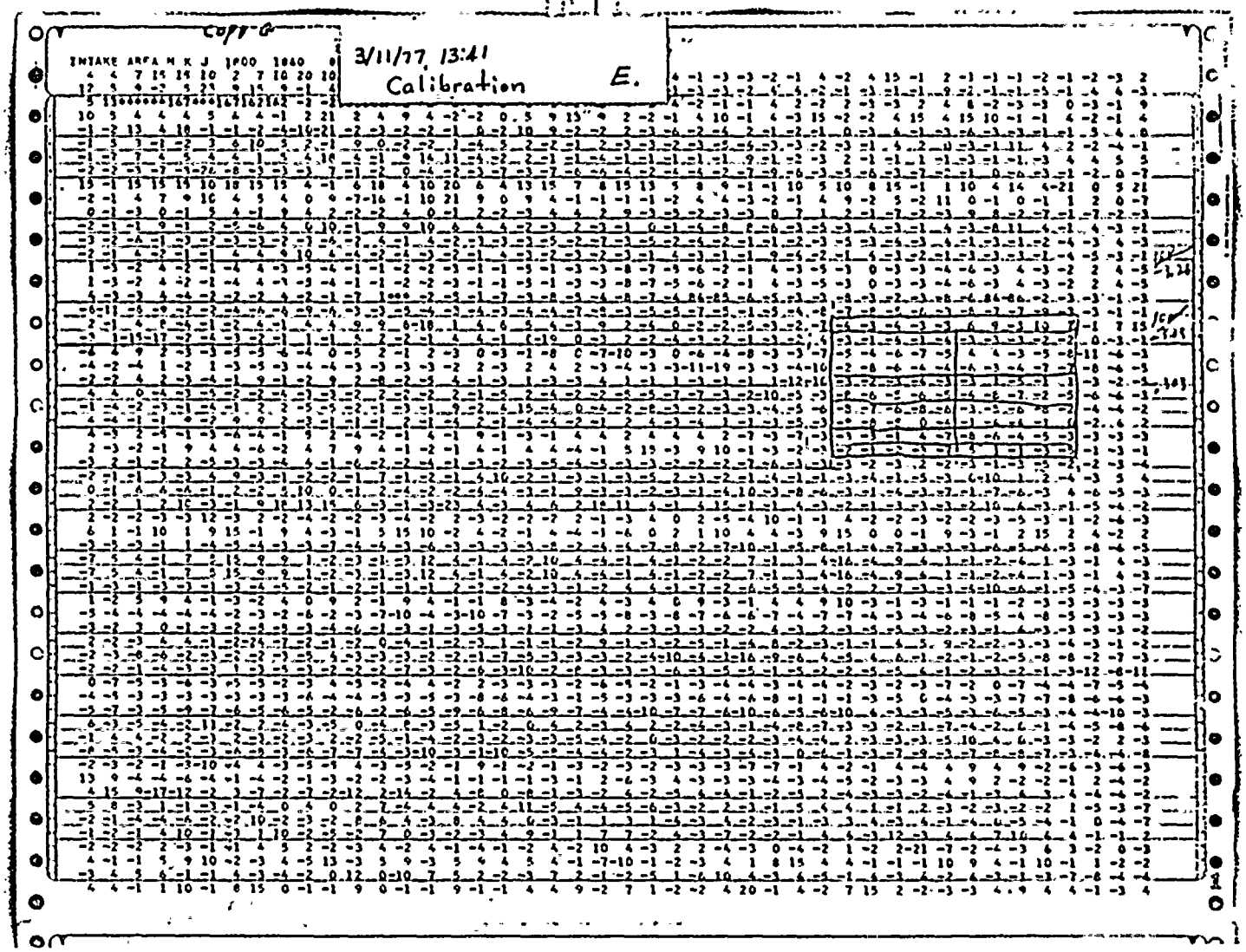
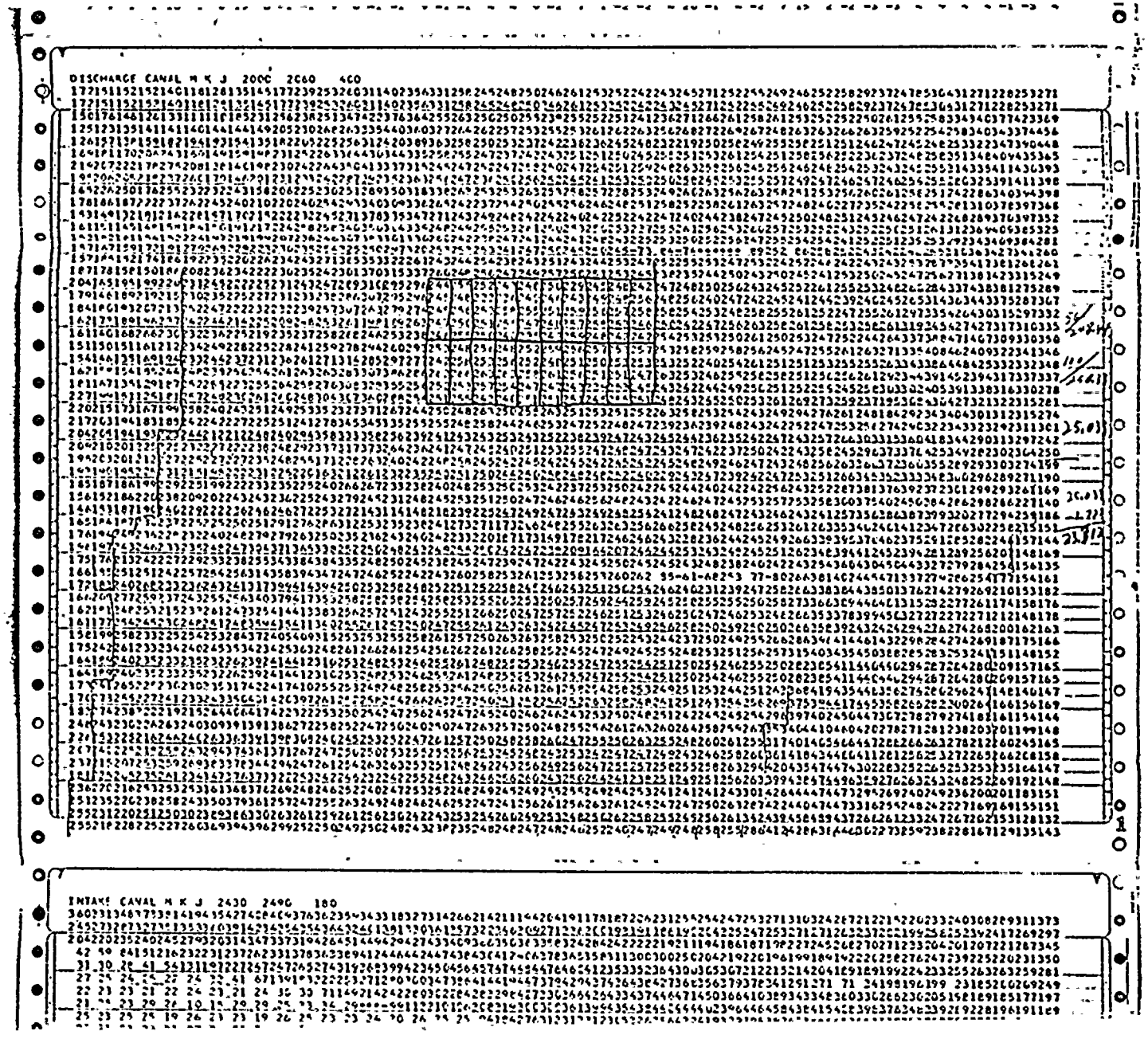
3/11/77 0742
1" = 155'
100%


Copy-C
3/11/77 13:41
Calibration
E.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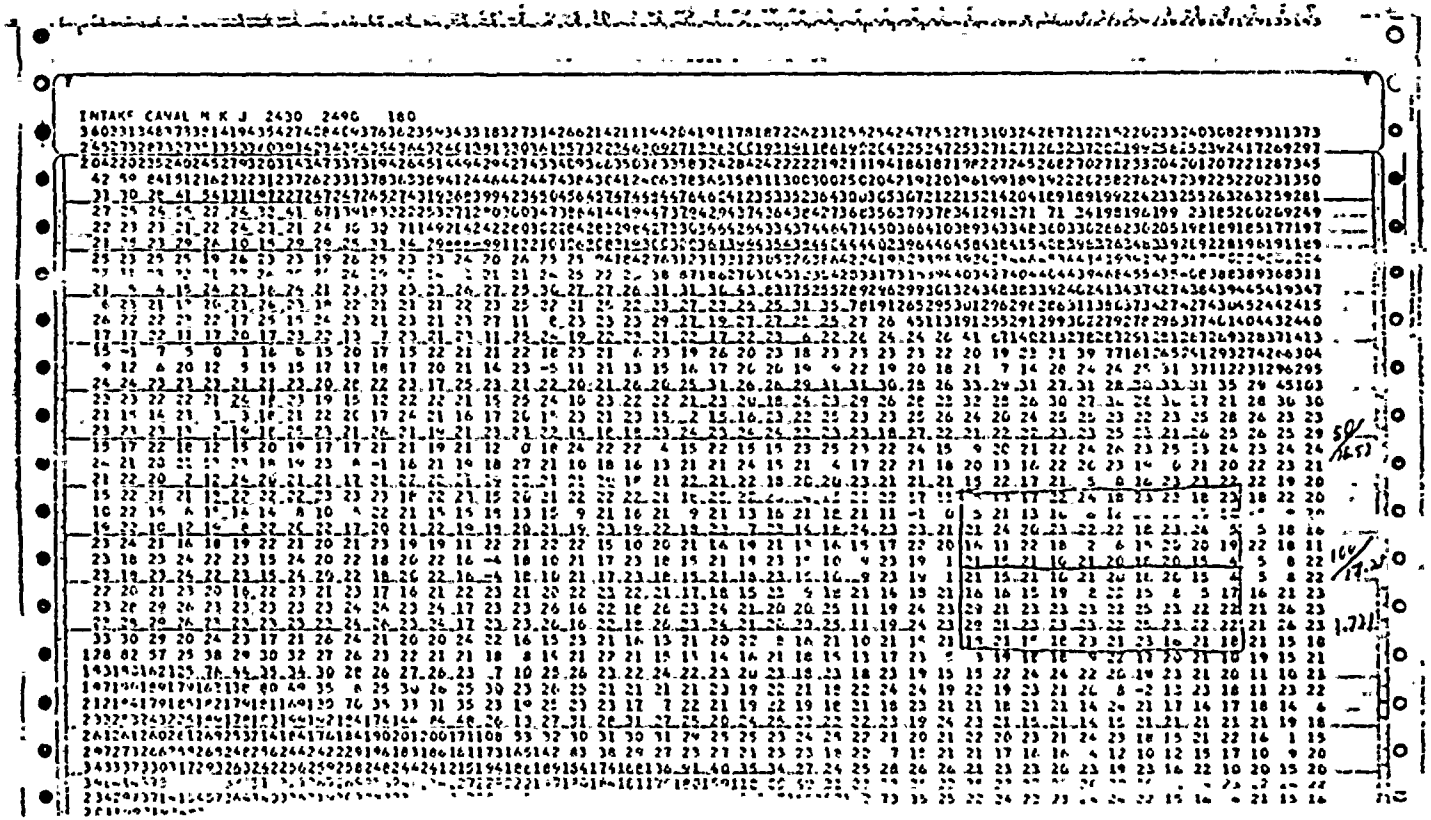
INTAKE CANAL M K J 2430 2490 180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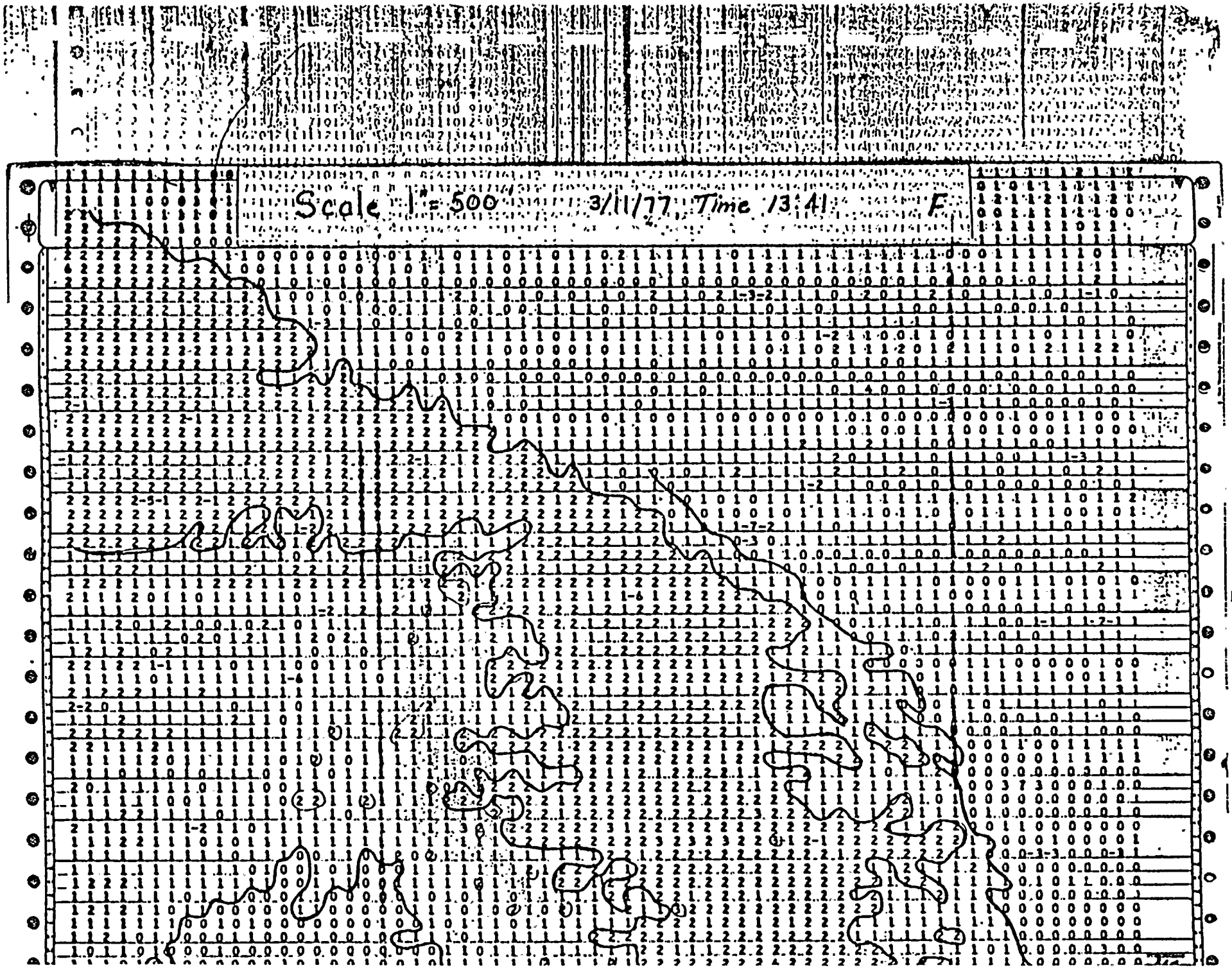
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3/11/77
Time 13:41
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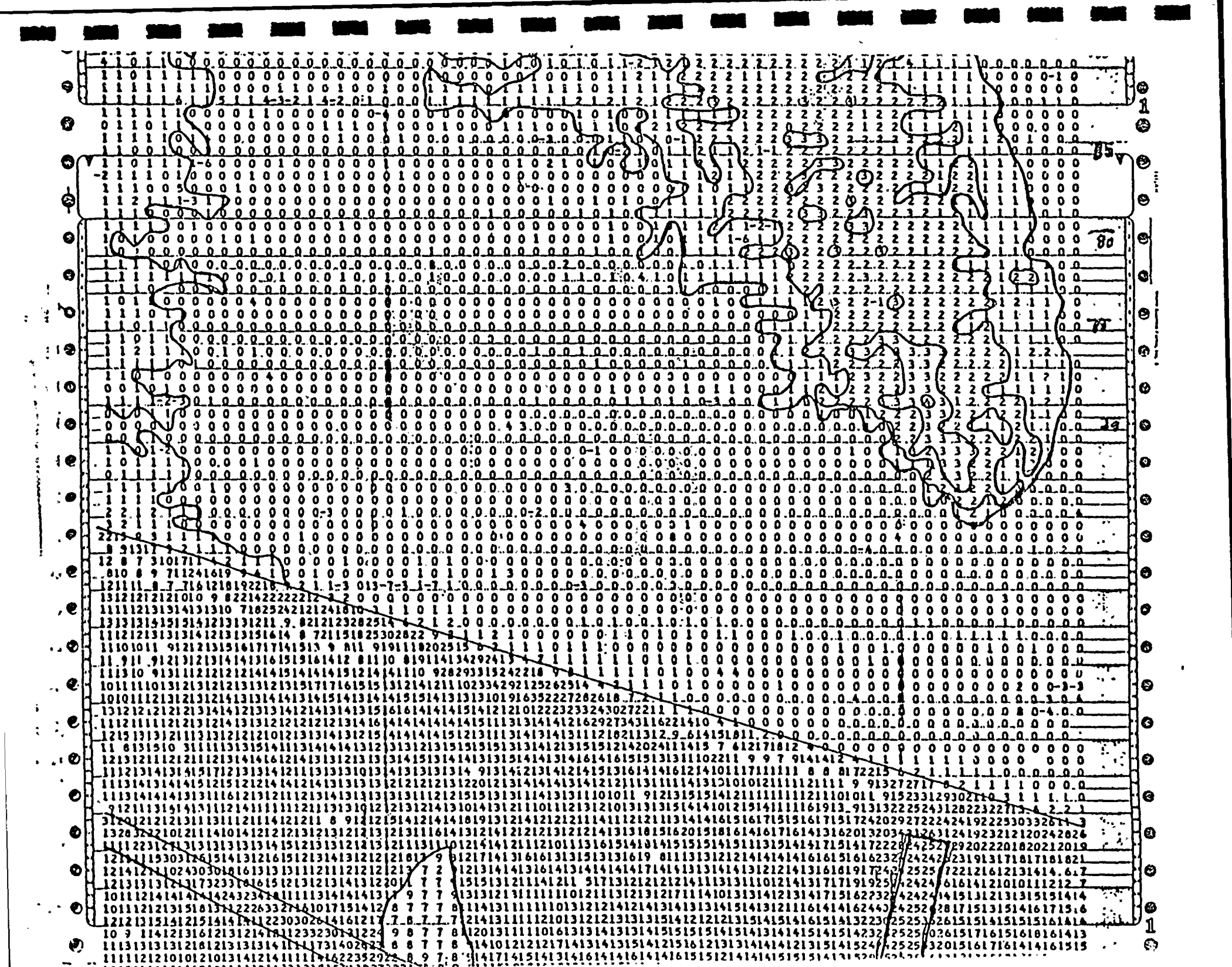
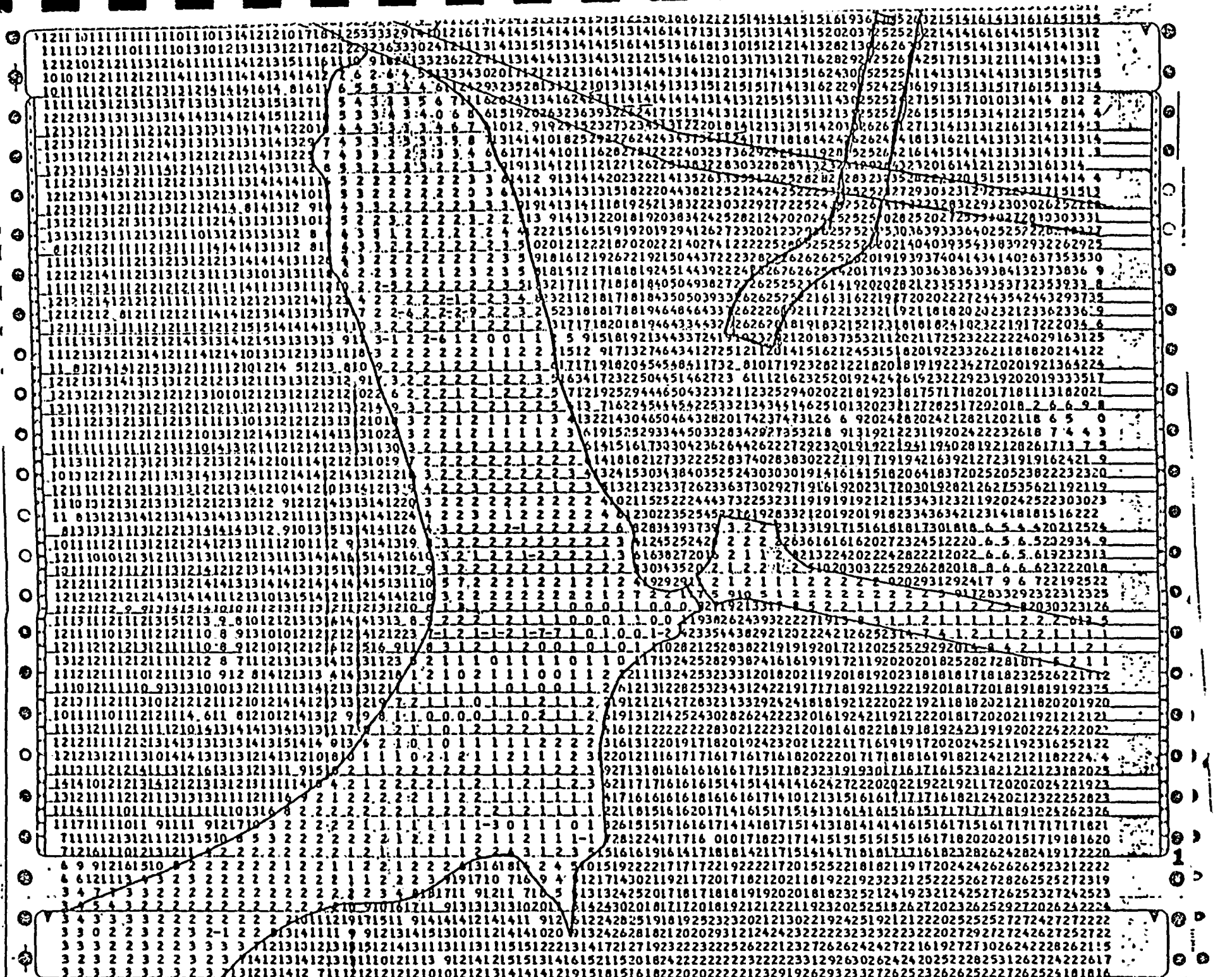
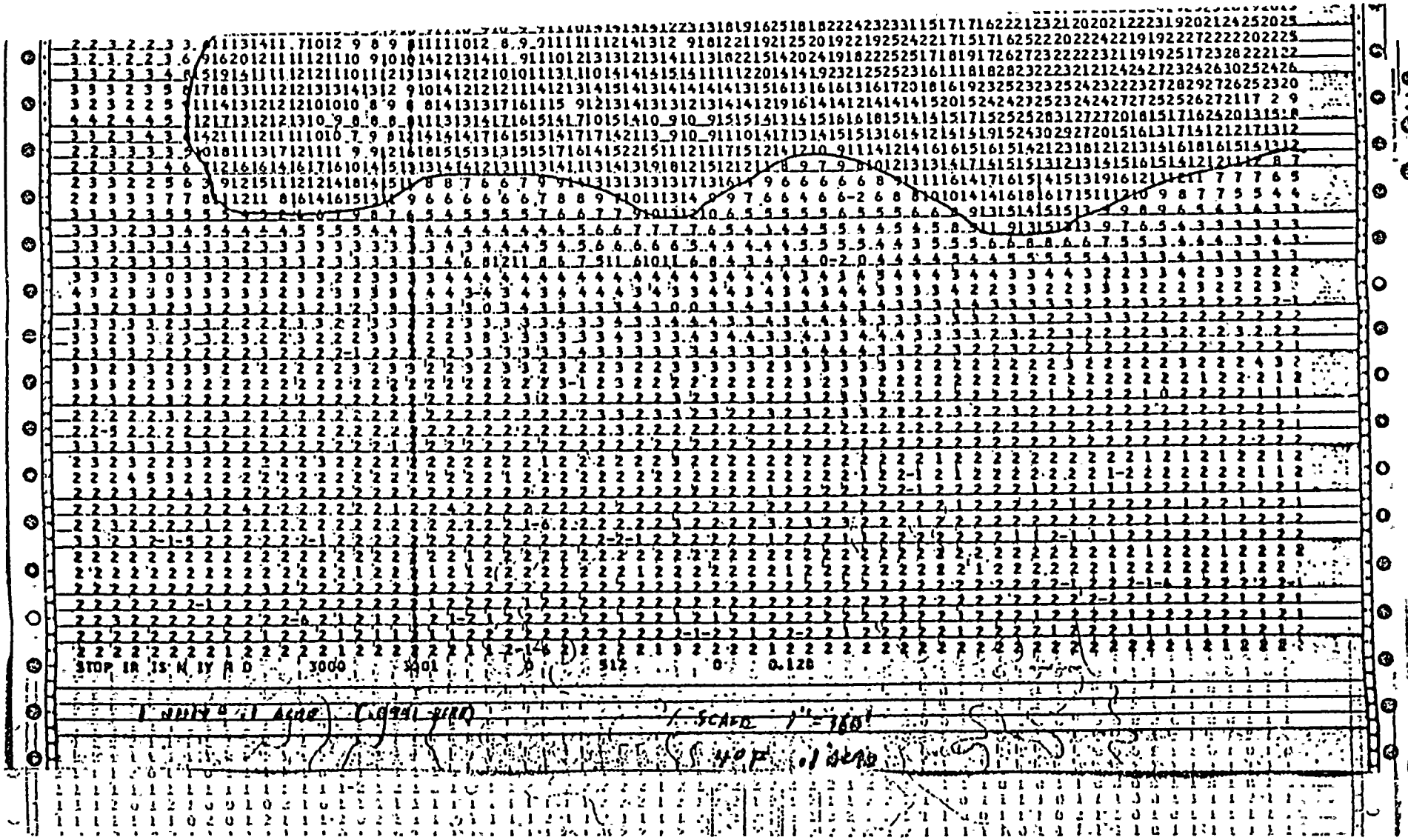
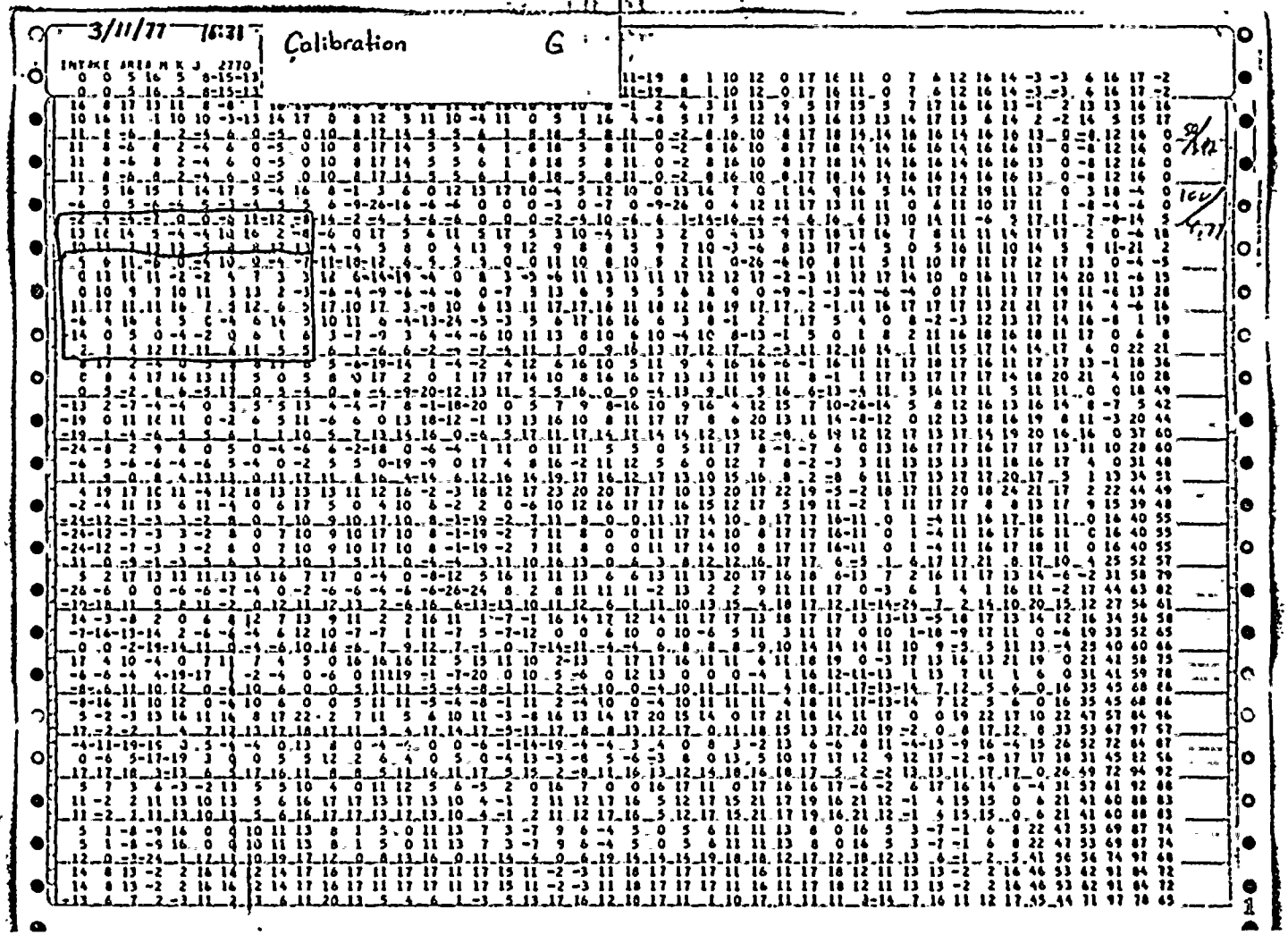
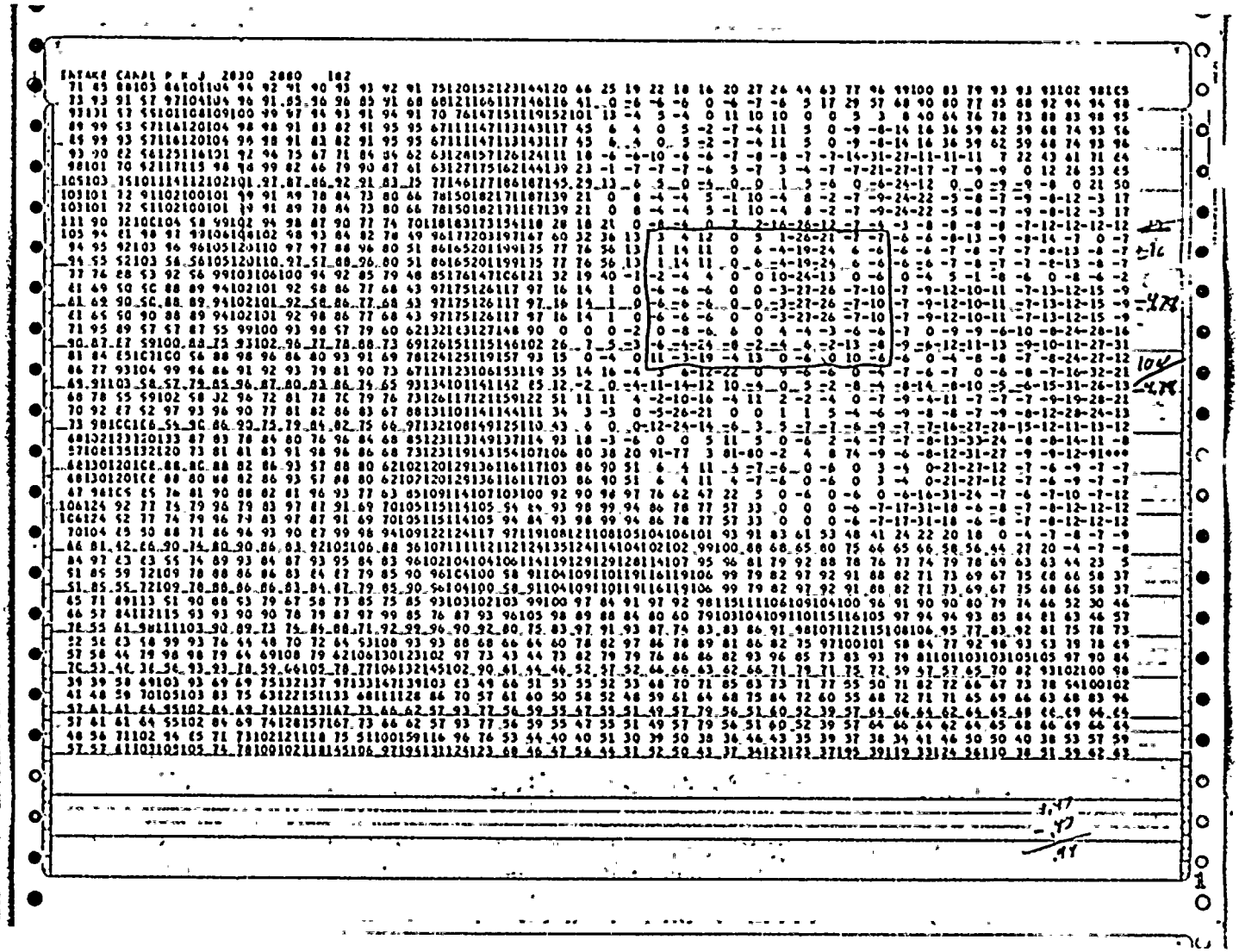
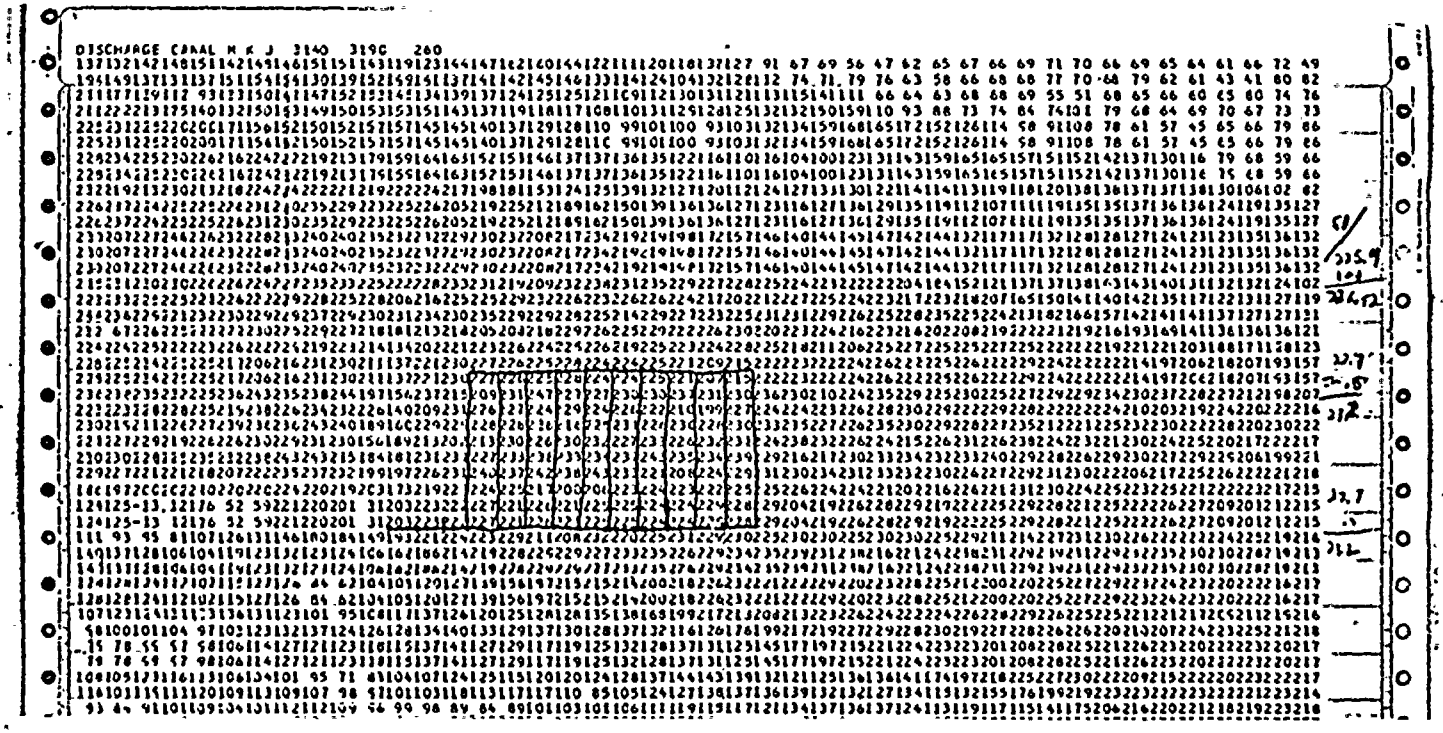


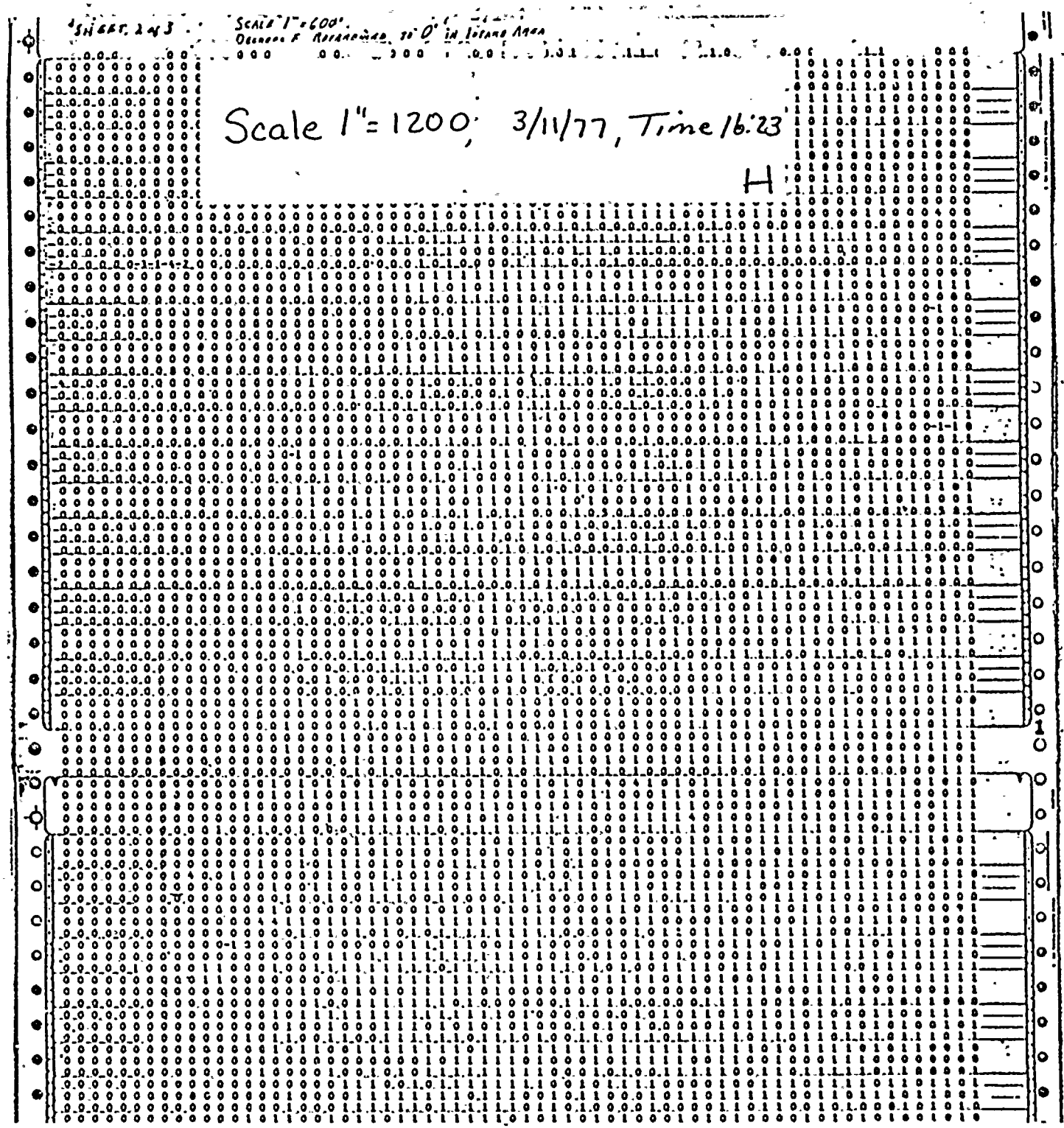


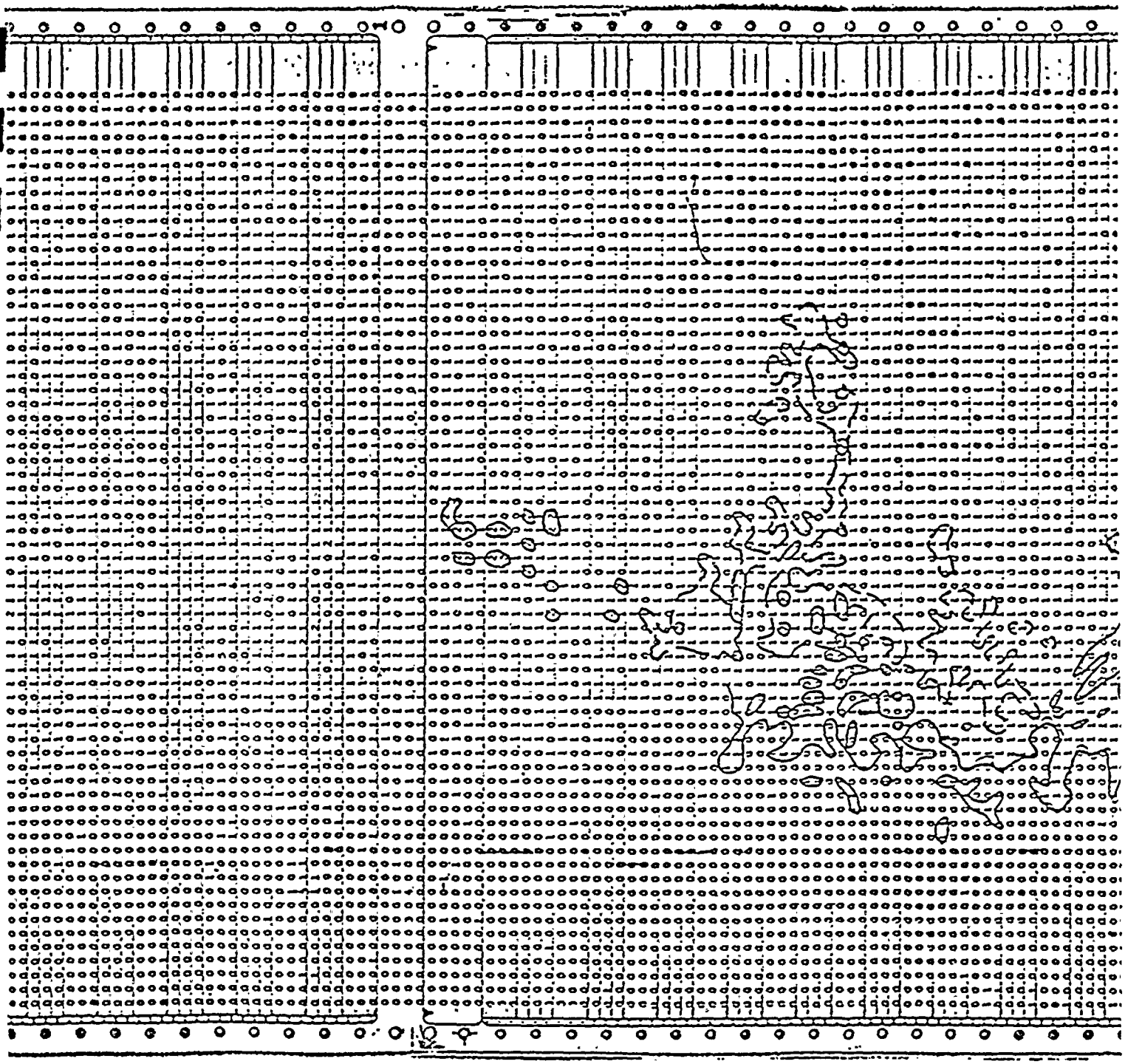

STOP IR IS M IY A D
3000
3001
0
512
0
0.128
SCALE 1"=760'

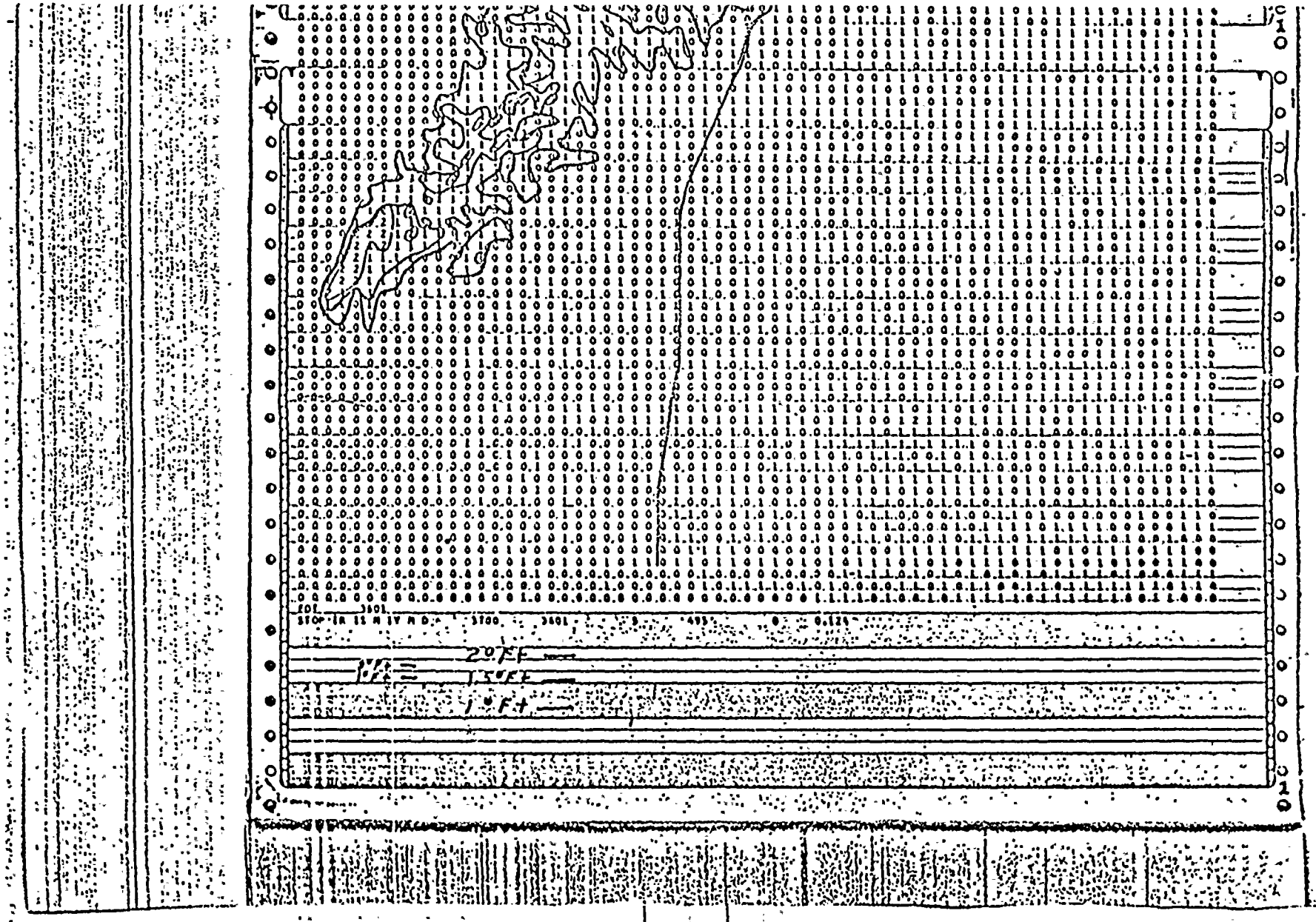

3/11/77 16:31
Calibration
G



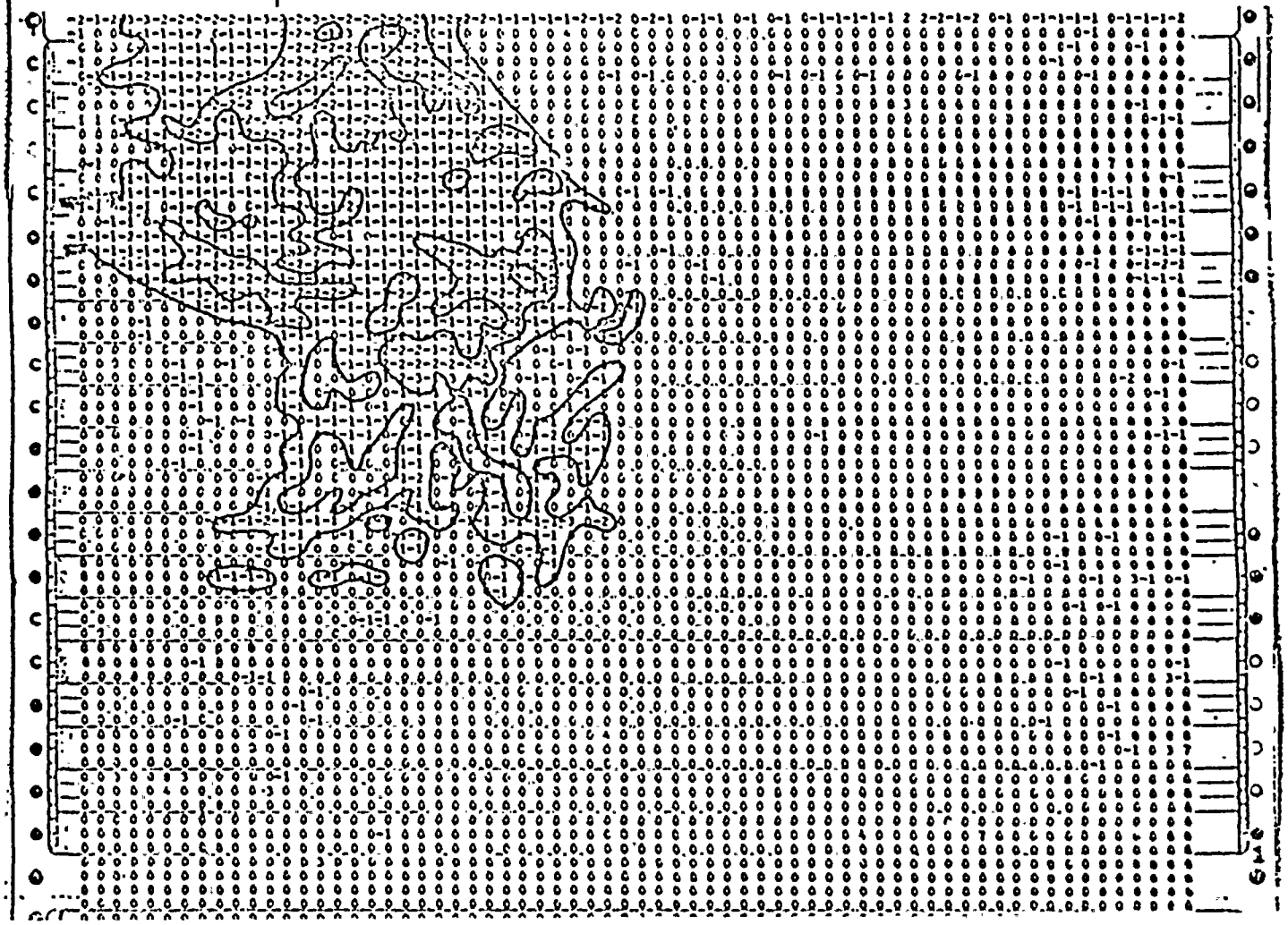

DISCHARGE CANAL M K J 3140 3190 260

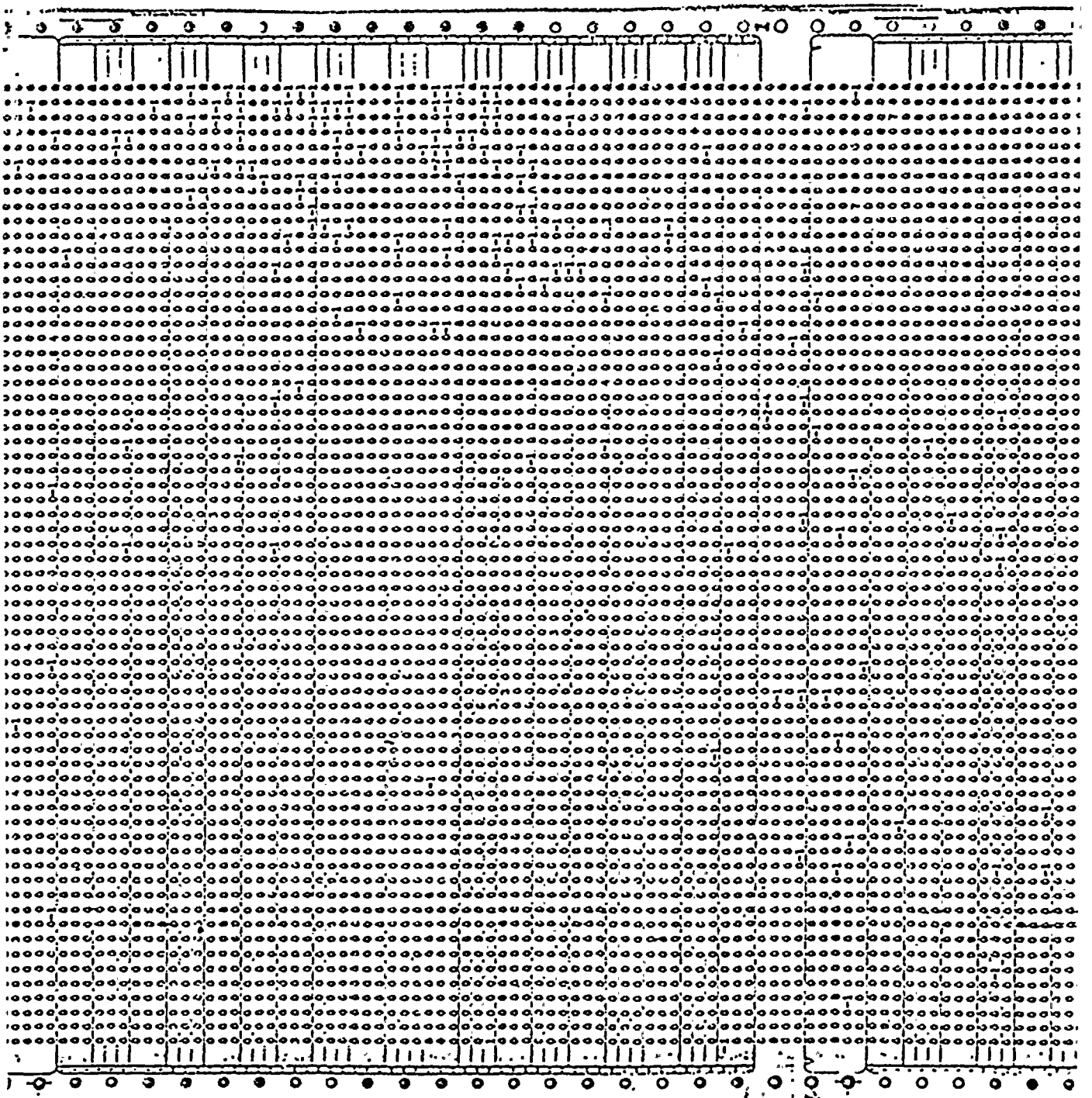

SHEET 2 of 3
SCALE 1"=600'
Scale 1"=1200' 3/11/77, Time 16:23
H

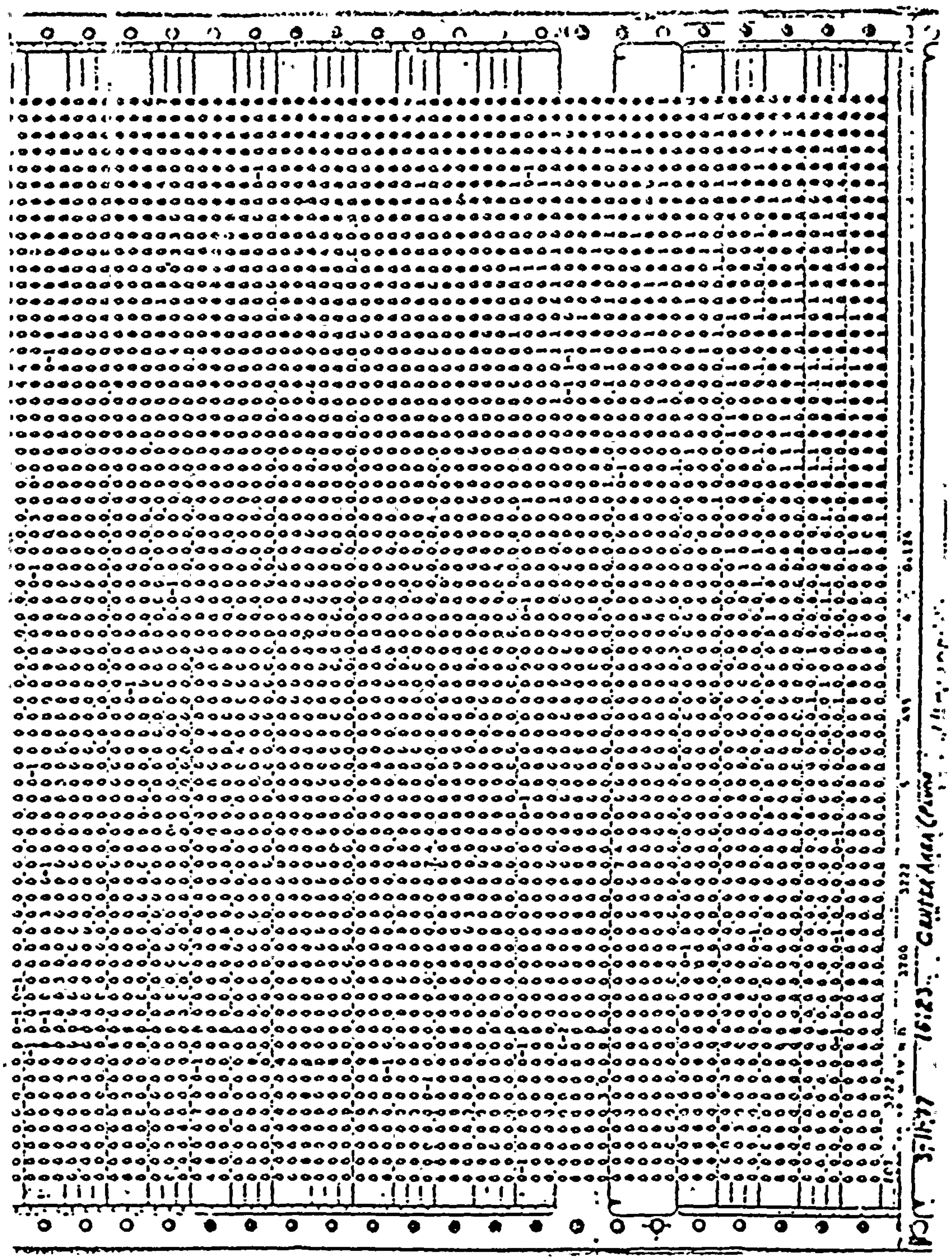



20FF
1.5FF
1 FF

Scale 1" = 1200' 3/11/77, Time 16:23

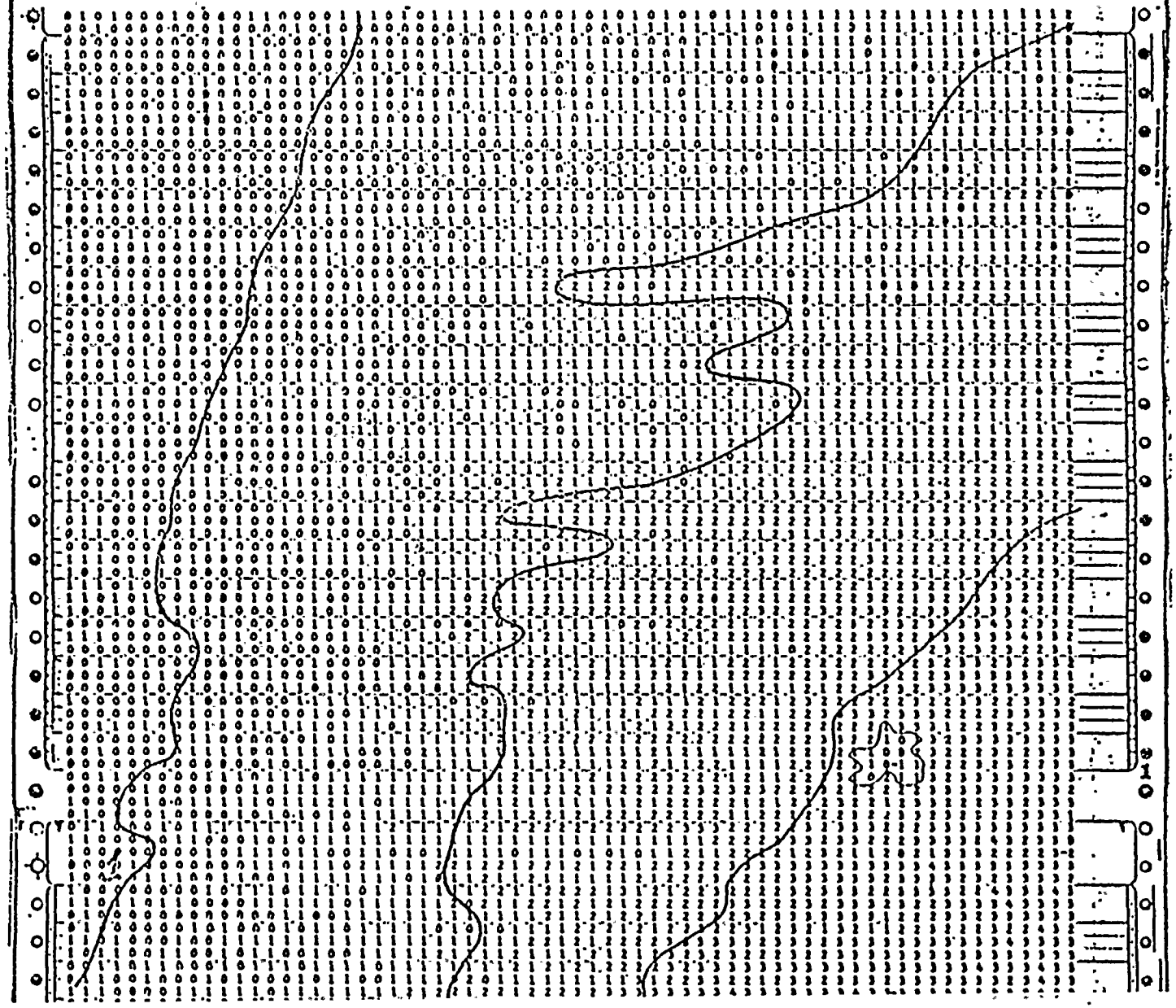


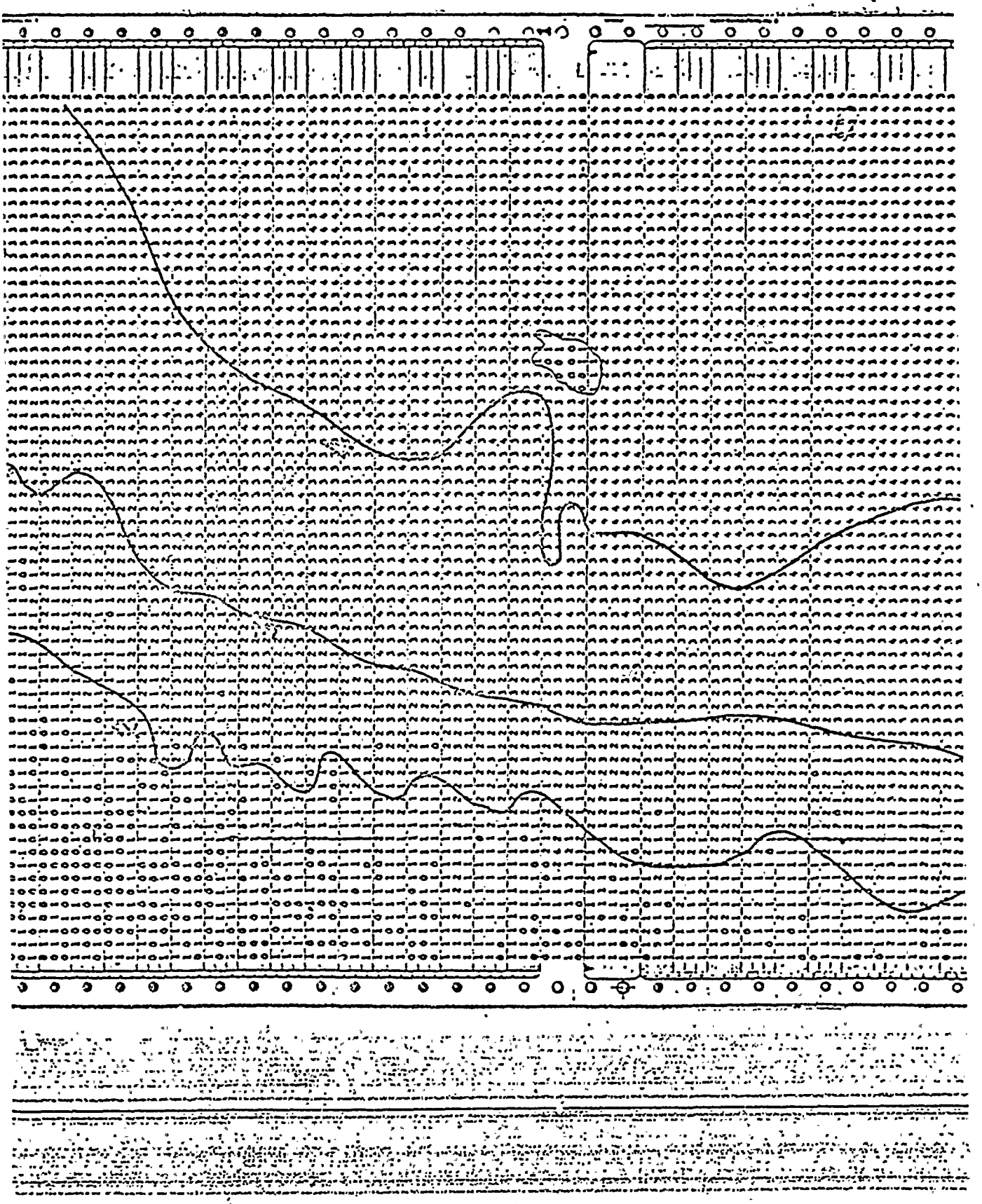


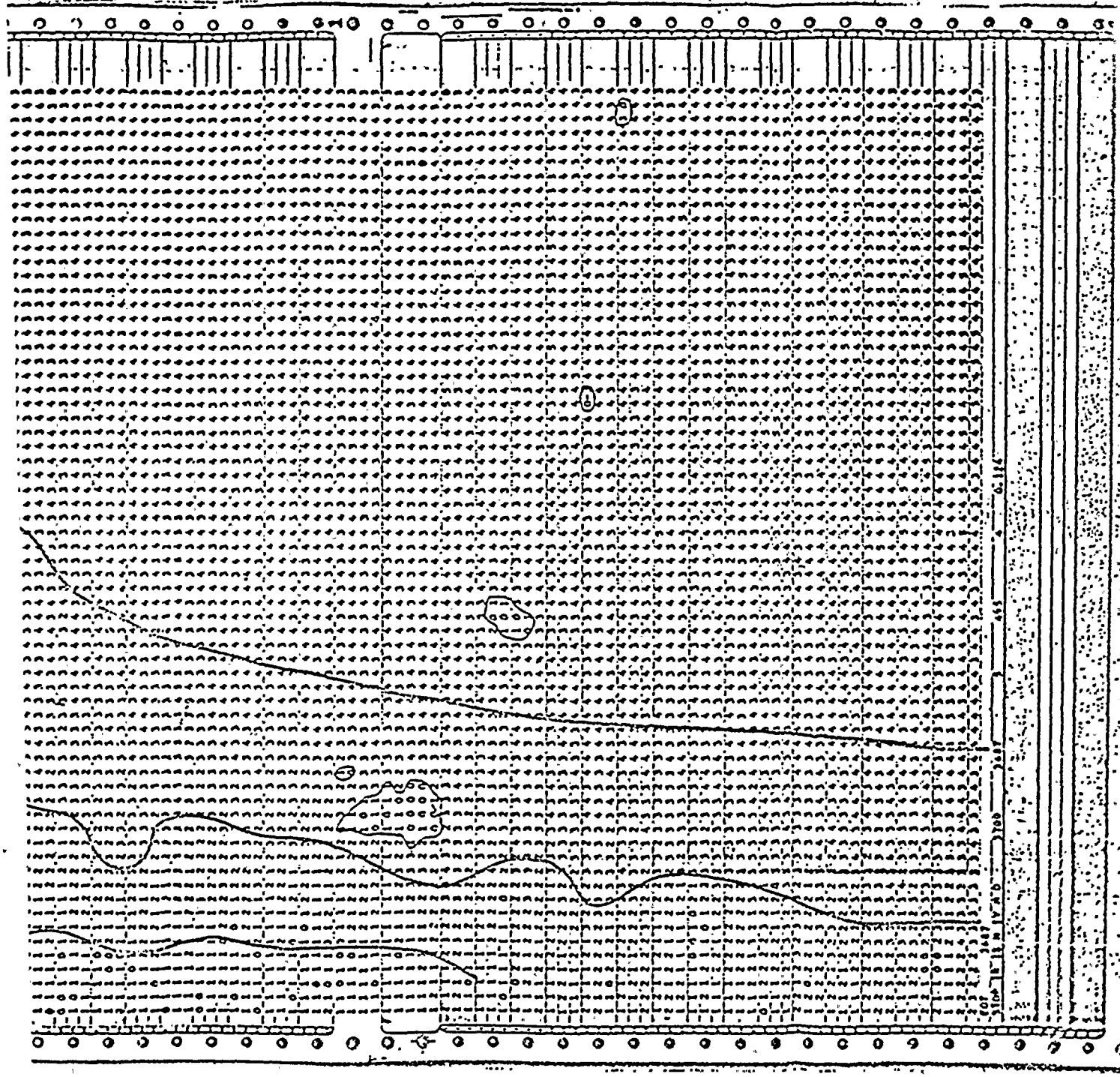

3-11-77
16:23
CENTER AREA

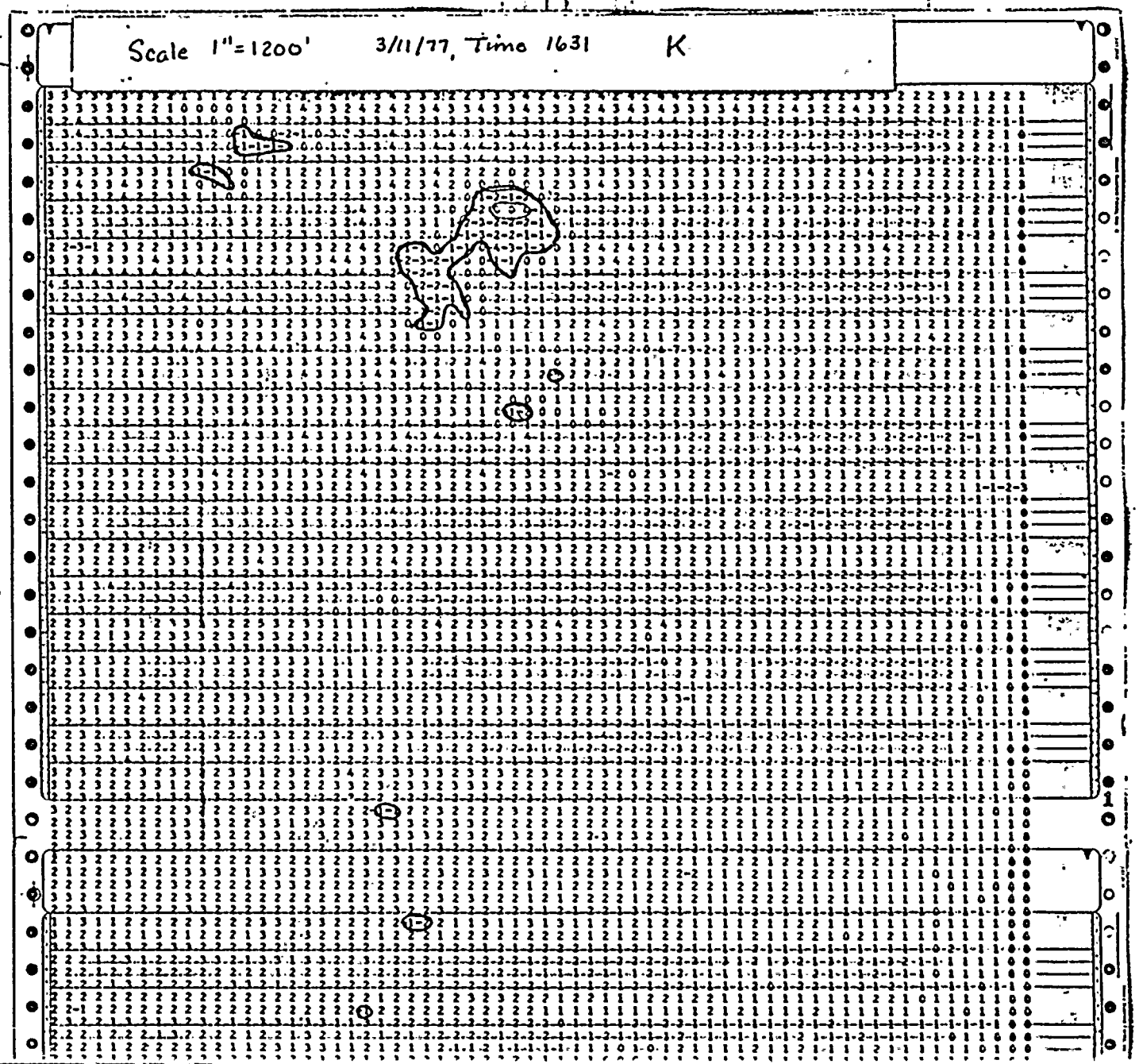
Scale 1" = 1200' 3/11/77, Time 16:23

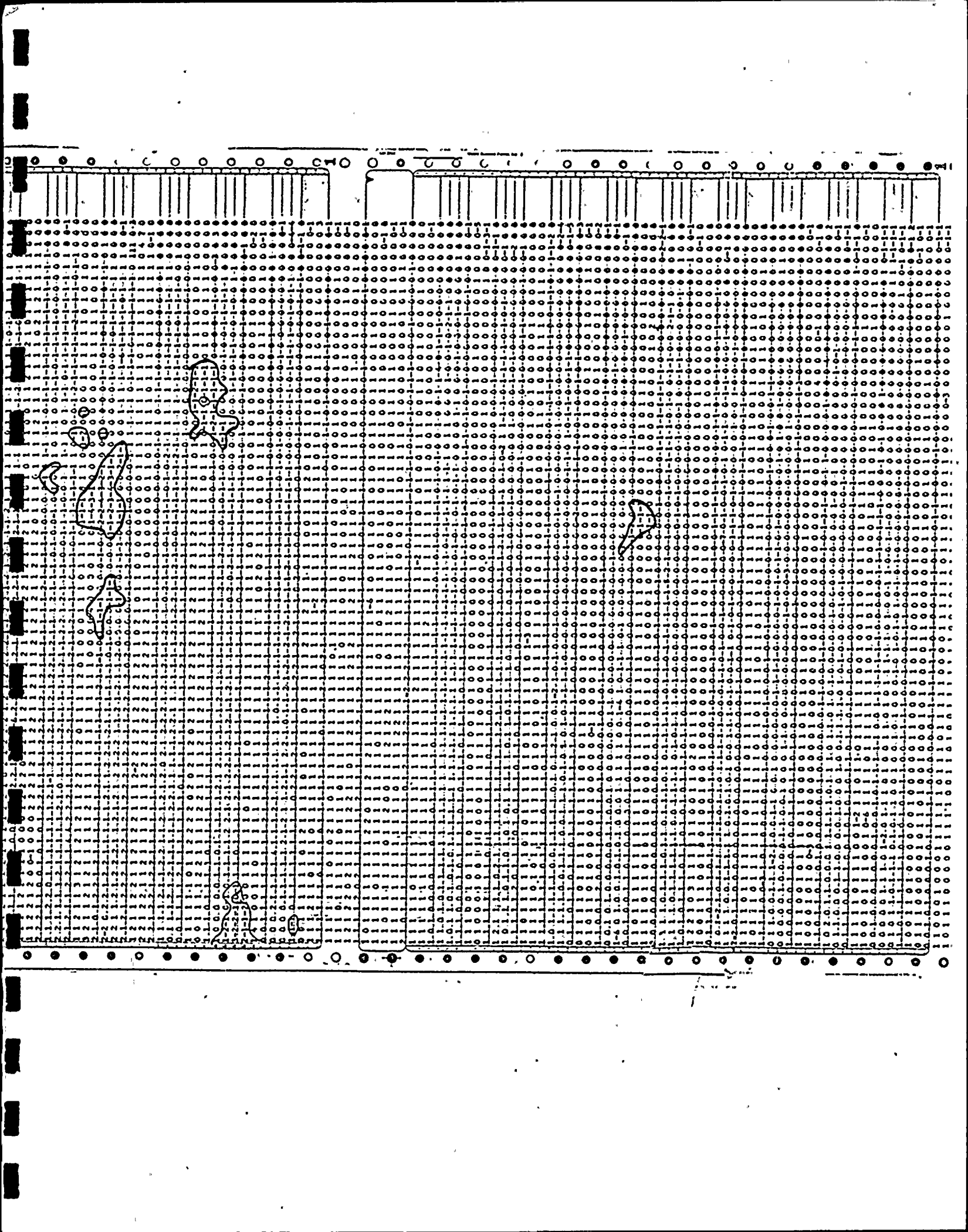
J

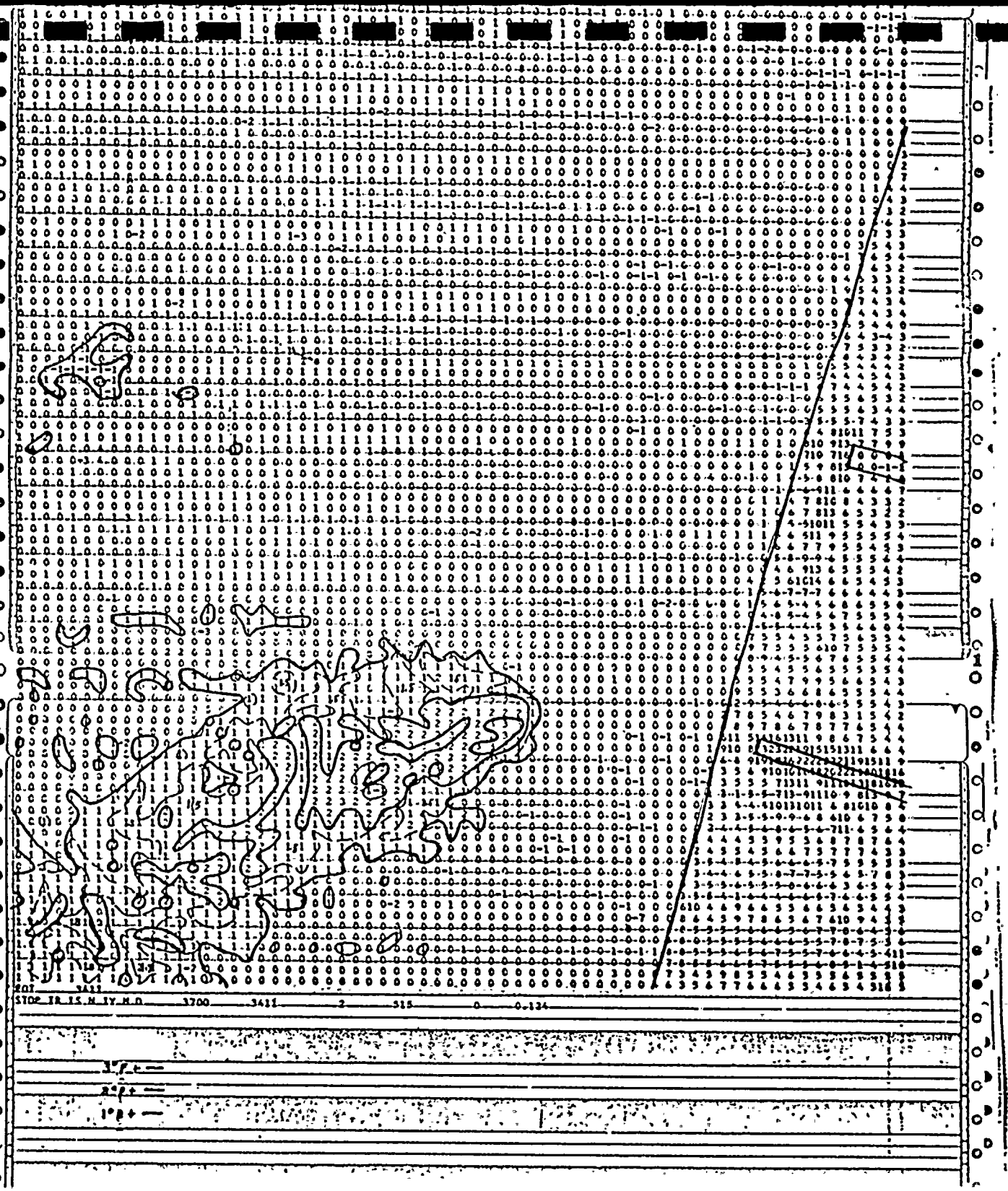







Scale 1"=1200' 3/11/77, Time 1631 K

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