PLANT EDWIN I. HATCH UNITS 1 AND 2
THERMAL PLUME MODEL VERI. ICATION

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1. During 1980, water temperatures in the mixing zone were within the limits required by the NPDES permit (90 °F maximum or 5 °F rise above ambient river temperatures).

2. Comparison of observed plumes with predictions of the Carter three-dimensional bouyant plume model demonstrates that this model is a reasonable approximation of the Edwin I. Hatch Nuclear Plant thermal plume.

3. The results of this investigation fulfill the requirements set forth in NPDES Permit No. GA-0004120, Part I, B-4.

Introduction

Water temperatures were measured at Plant Hatch on a weekly basis as required by the National Pollution Discharge Elimination System (NPDES) Permit No. GA-0004120. In addition, a study to verify the thermal plume predictive model for two-unit operation was completed.

Plant Hatch, owned jointly by Oglethorpe Power Corporation (30.0%), Municipal Electric Authority of Georgia (17.7%), City of Dalton (2.2%), and Georgia Power Company (50.1%) is located approximately 11 miles north of Baxley in Appling County, Georgia. The site is on the south bank of the Altamaha River, east of U.S. Highway 1. The plant consists of two nuclear units. Unit 1 has a generating capacity of 810 megawatts, while Unit 2 has a generating capacity of 820 megawatts. Unit 1 and 2 went into commercial operation on December 31, 1975, and September 5, 1979, respectively.

A cooling water flow diagram for Plant Hatch Unit 2 is presented in Figure 1. The cooling water system for Unit 1 is identical to the system for Unit 2. The mixing box for the river discharge structure (Figure 2) receives cooling tower blowdown, demineralizer waste, cooling tower overflow, and excess service water from both Unit 1 and Unit 2. From the mixing box, two 42-inch lines run down to the river and extend approximately 120 feet out from shore. The point of discharge is approximately 1,260 feet down river from the intake structure and approximately 4 feet below the surface when the river is at its lowest level.

Materials and Methods

In accordance with the NPDES permit, temperatures were measured on a weekly basis at the intake structure or at a midstream point upstream of the intake, at the mixing chamber, and at the downstream edge of the mixing zone (approximately 500 feet downstream of the discharge point). A complete listing of the temperatures is given in Table 1. The maximum observed difference between intake and mixing zone temperatures was 3.2 °F, which occurred during one sampling period. All temperatures measured are within the limits required by the NPDES permit (90 °F maximum or 5 °F rise above ambient).

The NPDES permit also requires GPC to field verify and/or fine tune the predictive thermal plume model beginning not later than six months after commercial operation of Unit 2. Twelve thermal plume monitoring surveys were conducted during 1980. During each of the twelve surveys, temperature measurements were taken at depths of 1 ft., 3 ft.. and 5 ft. All temperature measurements were made from a boat moving along pre-selected transects in the river (Figure 3) using a temperature probe and continuous recorder. Monitoring equipment was calibrated in the laboratory before each survey and rechecked in the field before and after each survey. Other data collected, in addition to the temperature measurements, are listed in Table 2. No data were collected during inclement weather.

Results

The temperature data collected for five of the twelve surveys are shown on Figures 4 through 8. These figures show the thermal plumes existing on each of the survey dates and the corresponding computer model predictions. The largest rise above ambient river temperatures was 1.5 °F on the 1-foot transects taken on 6-19-80. This plume did not extend more than 250 feet downstream of the discharge. The maximum rise above ambient water temperature on the 1-foot transects for the remaining surveys was 0.5 °F. The maximum increases in water temperature for the 3-feet and 5-feet transects were 0.5 °F or less for all surveys.

In addition to the five surveys shown in Figures 4 through 8, seven plume surveys yielded inconclusive data (Table 2). Three of these surveys were conducted with only one cooling tower discharging heated water (8-8-80, 10-3-80, and 10-31-80). No thermal plumes were detected in the river on three of the seven surveys (6-18-80, 8-6-80, and 8-13-80). Model predictions suggest the possibility of plumes which would not extend downstream enough to be detected at the transects. The data from the remaining survey (8-12-80, 16:15 EDST) shows the effects of solar heating immediately downstream of the barge slip. During this survey, the ambient air temperature was 97 °F. Because of the low water elevation, 64.7 feet, the shallow areas near the sandbar were heated by extreme solar radiation. Solar heating resulted in a secondary thermal plume which was entrained into the downstream portion of the discharge plume. This secondary plume was evident as a localized increase in water temperature to 90.0 °F, approximately 800 feet below the discharge. The ambient water temperature and discharge temperatures were 88.5 °F and 89.1 °F, respectively. This secondary plume biased the data collected, and no comparison with model predictions could be made. The preceding seven surveys are not presented in figures.

Discussion

The results shown in the 1976 annual report demonstrate that a suitable thermal plume model, the Carter three-dimensional thermal plume model, has been field tested and verified for one-unit operation (Carter et al., 1973, Edinger et al., 1974, and Georgia Power Company, 1977). As required by the NPDES permit, this model must also be verified for two-unit operation.

Comparisons of observed and predicted surface plumes for each of the 1980 surveys are presented in Figures 4 through 8. A dimensionless constant has been adjusted in the model in order to obtain the best fit between observed and predicted plume dimensions. The constant used for the 1980 thermal plume surveys ranges from 4 to 40 with an average value of 18.9. This constant adjusts the point where dilution of excess heat begins and is affected by the ΔT and the discharge volume. The largest value of the constant ($C = 40$) occurred with the lowest ΔT and the highest discharge volume (0.9 $^{\circ}F$ and 98.0 cfs, respectively). Lower discharge volumes or higher ΔT values required intermediate values for the constant (ranging from 12 to 20). The lowest value of the constant ($C = 4$) occurred with a low discharge volume and an elevated ΔT (34.5 cfs and 4.5 $^{\circ}F$, respectively). If the survey with the lowest ΔT and the highest discharge volume is excluded, the constants for the remaining surveys range from 4 to 20.

The overall dimensions of the observed and predicted plumes are summarized for each survey in Table 3. The observed and predicted lengths are tabulated to the nearest 50 feet, which is the accuracy to which the plumes could be predicted from the data. Table 3 shows a reasonable comparison between the observed and predicted lengths, considering that excess temperature isotherms no greater than 1.5 $^{\circ}F$ could be identified from the field data. Similar results are shown for the plume surface areas. The higher surface areas of the observed plumes are attributed to increased surface spreading caused by the sandbar. These results are within the accuracy to be expected from a simple empirical model for low excess temperature isotherms.

The plume model verification was conducted under conditions comparable to average summer conditions. The estimated fully mixed excess temperature for average summer conditions (average river flow of 3000 cfs and $\Delta T = 4.7$ $^{\circ}F$) is 0.09 $^{\circ}F$ (Georgia Power Company, 1975). During the 1980 thermal plume surveys, the period of lowest river flow and greatest cooling tower heat rejection occurred during the survey on 8-7-80 at 17:30 EDST (Table 2). The river discharge on 8-7-80 was 3220 cfs. The fully mixed excess temperature at 17:30 EDST was 0.05 $^{\circ}F$ with a cooling water discharge of 34 cfs and ΔT of 4.5 $^{\circ}F$. This demonstrates that the cooling towers are operating as predicted.

Summary

Calibration of the Carter model to the 1980 field data for discharge from two units yielded constants ranging from 4 to 20 with an average

value of 13. Model predictions for a ΔT value less than 1 ^{o}F, and cooling tower discharge of 98 cfs required a constant of 40 and is not considered typical of normal conditions. Results reported for Unit 1 operation during 1976 yielded constants ranging from 5 to 16 with an average value of 10 (Georgia Power Company, 1977). These comparisons demonstrate that the Carter model is a reasonable approximation for the Hatch thermal plume. Thus, a suitable thermal plume model has been verified and calibrated with field surveys as required in the NPDES permit.

References

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Edinger, J. E., D. K. Brady and J. C. Geyer. 1974. Heat exchange and transport in the environment. Electric Power Research Institute RE-49 Report No. 14. Palo Alto, Ca.

Georgia Power Company. 1975. Hatch Nuclear Plant Unit No. 2 Environmental Report Operating License Stage, Volume 1, Figure 5.1-2. Georgia Power Company, Atlanta, Ga.

Georgia Power Company. 1977. Edwin I. Hatch Nuclear Plant Annual Environmental Surveillance Report for Calendar Year 1976, Section 1.2. Georgia Power Company, Atlanta, Ga.

TABLE 1. EDWIN I. HATCH NUCLEAR PLANT
NPDES TEMPERATURE MONITORING DURING 1980

Date	Intake Temp. (°F)	Mixing Chamber Unit I Discharge Temp. (°F)	Mixing Chamber Unit II Discharge Temp. (°F)	Mixing Zone Temp. (°F)	ΔT
01/02/80	52.0	52.0	79.0	52.0	0.0
01/10/80	48.0	71.0	75.0	48.0	0.0
01/16/80	51.0	71.0	79.0	51.0	0.0
01/23/80	52.0	71.0	75.0	52.0	0.0
01/30/80	50.0	67.0	52.0	50.0	0.0
02/07/80	44.0	63.5	64.0	44.0	0.0
02/19/80	46.5	68.0	72.0	46.5	0.0
02/20/80	48.0	66.0	58.0	48.0	0.0
02/28/80	51.5	74.0	76.0	51.5	0.0
03/05/80	48.0	76.8	53.4	48.0	0.0
03/12/80	54.0	75.0	58.0	54.0	0.0
03/19/80	55.0	63.0	60.0	55.0	0.0
03/26/80	59.0	69.0	63.0	59.0	0.0
04/02/80	62.0	70.0	65.0	62.0	0.0
04/09/80	62.0	73.0	66.0	62.0	0.0
04/16/80	64.0	67.0	64.0	64.0	0.0
04/25/80	66.0	80.0	70.0	66.0	0.0
04/30/80	67.0	84.0	84.0	67.0	0.0
05/07/80	69.0	88.0	72.0	69.0	0.0
05/14/80	75.0	70.0	78.0	75.0	0.0
05/22/80	77.0	91.0	78.0	77.0	0.0
05/28/80	*	78.0	87.0	*	-
06/05/80	76.0	79.0	78.0	76.0	0.0
06/13/80	79.3	79.0	78.0	79.3	0.0
06/18/80	79.2	74.0	88.0	7[illegible].2	0.0
06/25/80	81.0	90.0	90.0	81.0	0.0
07/02/80	79.0	80.0	*	79.0	0.0
07/09/80	84.0	83.0	89.0	84.0	0.0
07/16/80	86.0	90.0	90.0	88.0	2.0
07/23/80	84.0	79.0	94.0	84.0	0.0
07/31/80	85.0	90.0	*	86.0	1.0
08/06/80	86.0	86.0	82.0	86.0	0.0
08/13/80	85.0	78.0	88.0	85.0	0.0
08/20/80	85.0	95.0	90.0	85.0	0.0
08/28/80	*	90.0	86.0	*	-
09/03/80	84.2	93.2	92.3	84.2	0.0
09/10/80	81.0	89.0	76.0	82.0	1.0
09/17/80	83.0	86.0	85.0	84.0	1.0
09/24/80	82.0	92.0	92.0	83.0	1.0
10/01/80	70.2	82.9	79.5	73.4	3.2
10/08/80	67.8	82.6	74.8	68.4	0.6
10/15/80	66.0	67.0	79.0	66.0	0.0
10/22/80	67.8	82.6	80.2	68.2	0.4

TABLE 1 (Con't.)

Date	Intake Temp. (°F)	Mixing Chamber Unit I Discharge Temp. (°F)	Unit II Discharge Temp. (°F)	Mixing Zone Temp. (°F)	ΔT
10/29/80	62.8	82.6	84.4	64.9	2.1
11/05/80	62.4	73.8	67.1	63.5	1.1
11/12/80	58.5	73.0	63.3	59.7	1.2
11/19/80	57.0	71.1	59.5	57.0	0.0
11/26/80	54.5	70.0	58.5	56.8	2.3
12/03/80	53.6	58.6	56.3	53.6	0.0
12/10/80	55.4	76.8	59.9	55.6	0.2
12/17/80	51.3	69.4	54.1	50.5	-0.8
12/23/80	48.4	68.0	52.0	47.1	-1.3

*Monitor out of service for repairs.

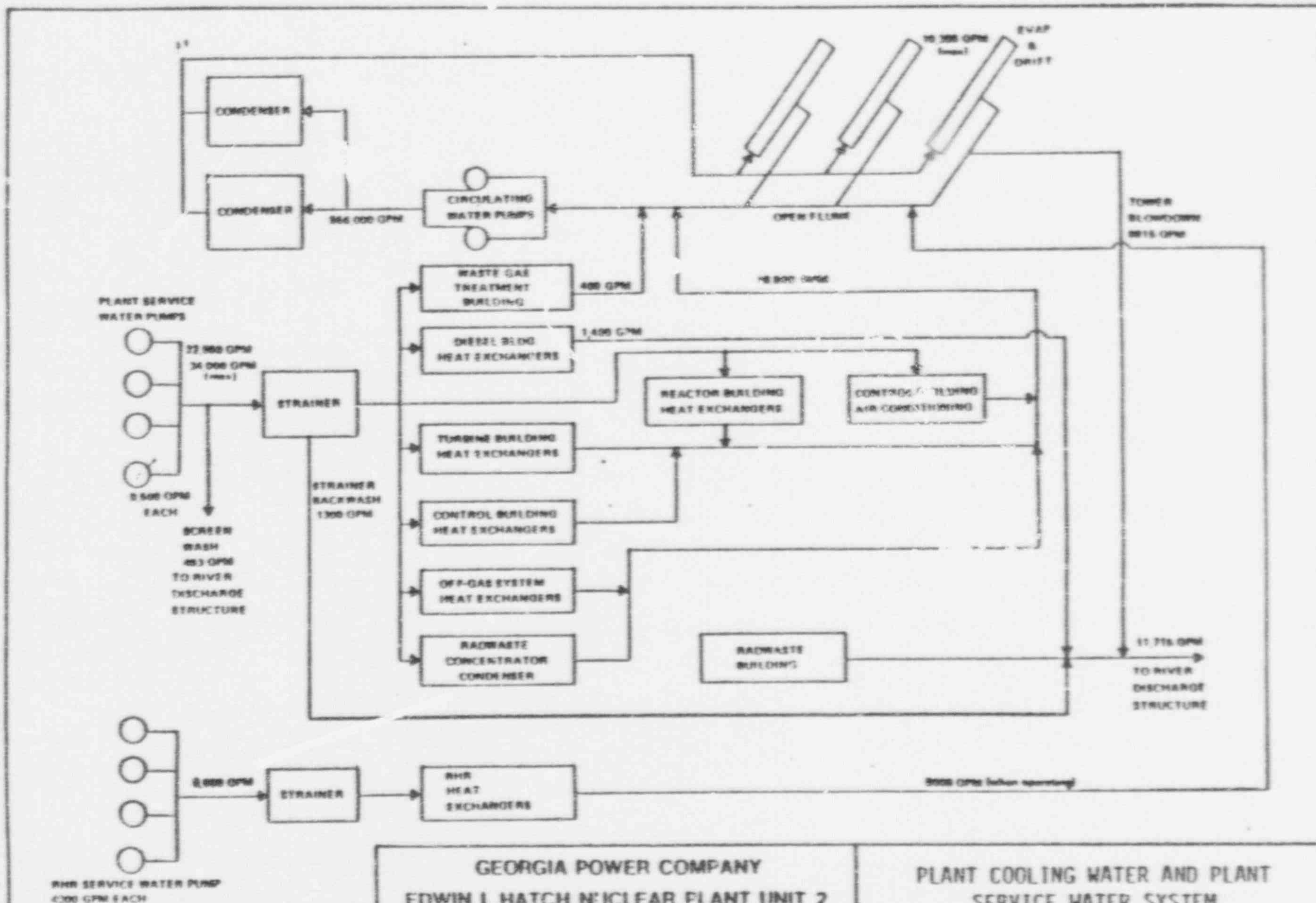
TABLE 2. EDWIN I. HATCH NUCLEAR PLANT THERMAL PLUME SURVEYS

Date	Megawatts Thermal Unit 1	Megawatts Thermal Unit 2	River Elevation (ft)	River Discharge (cfs)	River Velocity (ft/s)	Discharge Volume (cfs)	Discharge Velocity (ft/s)	Discharge Temperature (°F)	River Temperature (°F)
06-18-80[1] (14:30)	70	2421	66.2	4970	1.40	71.3	3.71	87.1	83.0
06-19-80 (9:25)	2010	2399	66.0	4720	1.25	75.7	3.98	88.3	81.3
08-06-80[2] (15:10)	1731	2397	65.0	3220	1.64	64.6	3.36	86.0	89.2
08-07-80 (9:30)	2061	2389	65.0	3220	1.31	98.0	5.09	88.0	87.1
08-07-80 (17:30)	2247	2383	65.0	3220	1.64	34.5	1.79	93.9	89.4
08-08-80[3] (10:15)	2348	2320	65.0	3220	1.64	35.6	3.71	93.9	86.9
08-11-80 (16:10)	2403	2400	64.7	2890	1.31	33.4	1.74	88.0	86.4
08-12-80 (12:02)	2415	2419	64.7	2890	1.48	32.3	1.68	89.1	87.4
08-12-80[4] (16:15)	2405	2392	64.7	2890	1.31	36.8	1.91	89.1	88.5
08-13-80[1] (10:45)	150	2409	64.7	2890	1.31	70.8	3.68	88.0	87.1
10-30-80[3] (14:00)	1951	2380	64.6	2840	0.98	40.1	2.08	81.0	65.5
10-31-80[3] (10:10)	1903	2400	64.6	2840	0.98	39.0	2.03	74.5	63.5

[1] No plume detected.
[2] Discharge temperature less than river temperature.
[3] Discharge from Unit 1 cooling towers only.
[4] Thermal plume affected by solar heating.

TABLE 3. COMPARISON OF OBSERVED PLUME LENGTHS AND SURFACE AREAS WITH THOSE PREDICTED BY THE CARTER THREE-DIMENSIONAL BOUYANT PLUME MODEL

Survey Date	Constant	Contour (°F)	Length (ft) Observed	Length (ft) Predicted	Surface Area (ft^2) Observed	Surface Area (ft^2) Predicted
06-19-80 (9:25)	17	1.0	400	400	6.7×10^4	1.0×10^4
		0.5	1000+	1250	14.8×10^4	7.4×10^4
08-07-80 (9:30)	40	0.5	300	300	2.4×10^4	0.5×10^4
08-07-80 (17:30)	4	0.5	250	250	0.7×10^4	0.4×10^4
08-11-80 (16:10)	20	0.5	200	200	0.6×10^4	0.4×10^4
08-12-80 (12:02)	12	0.3	250	250	1.0×10^4	0.2×10^4



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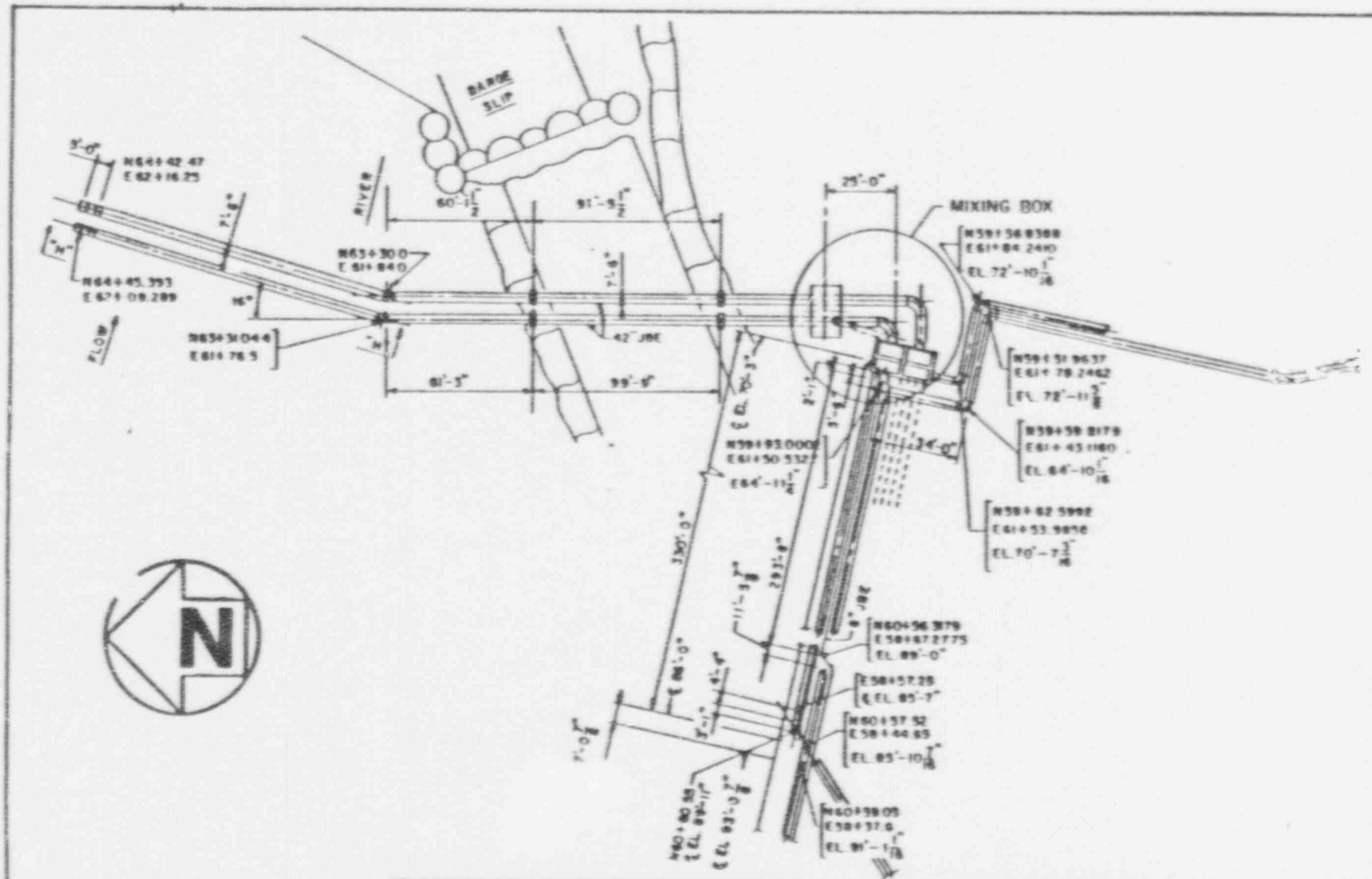
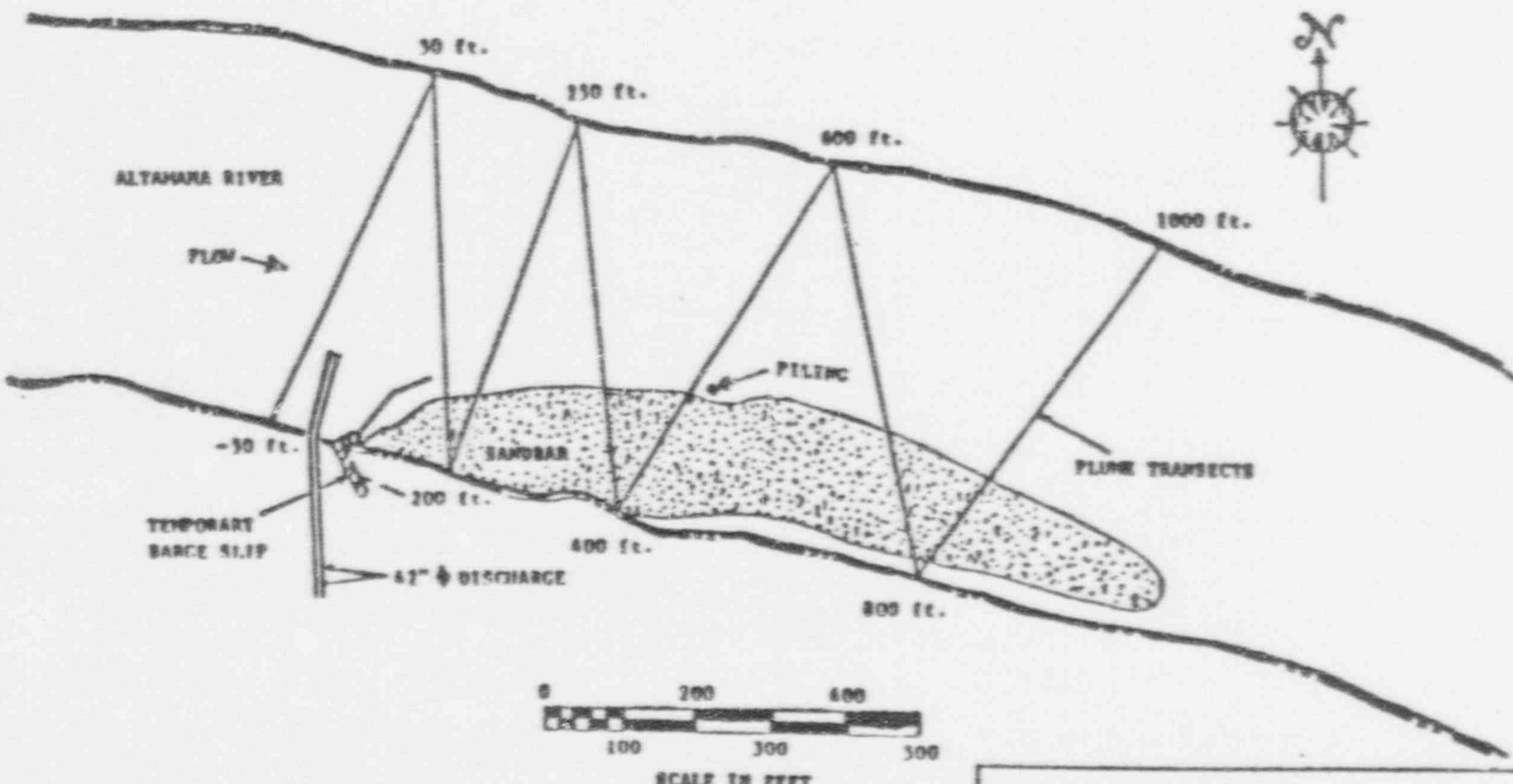
EDWIN I. HATCH NUCLEAR PLANT UNIT 2

PLANT COOLING WATER AND PLANT SERVICE WATER SYSTEM

FIGURE 1

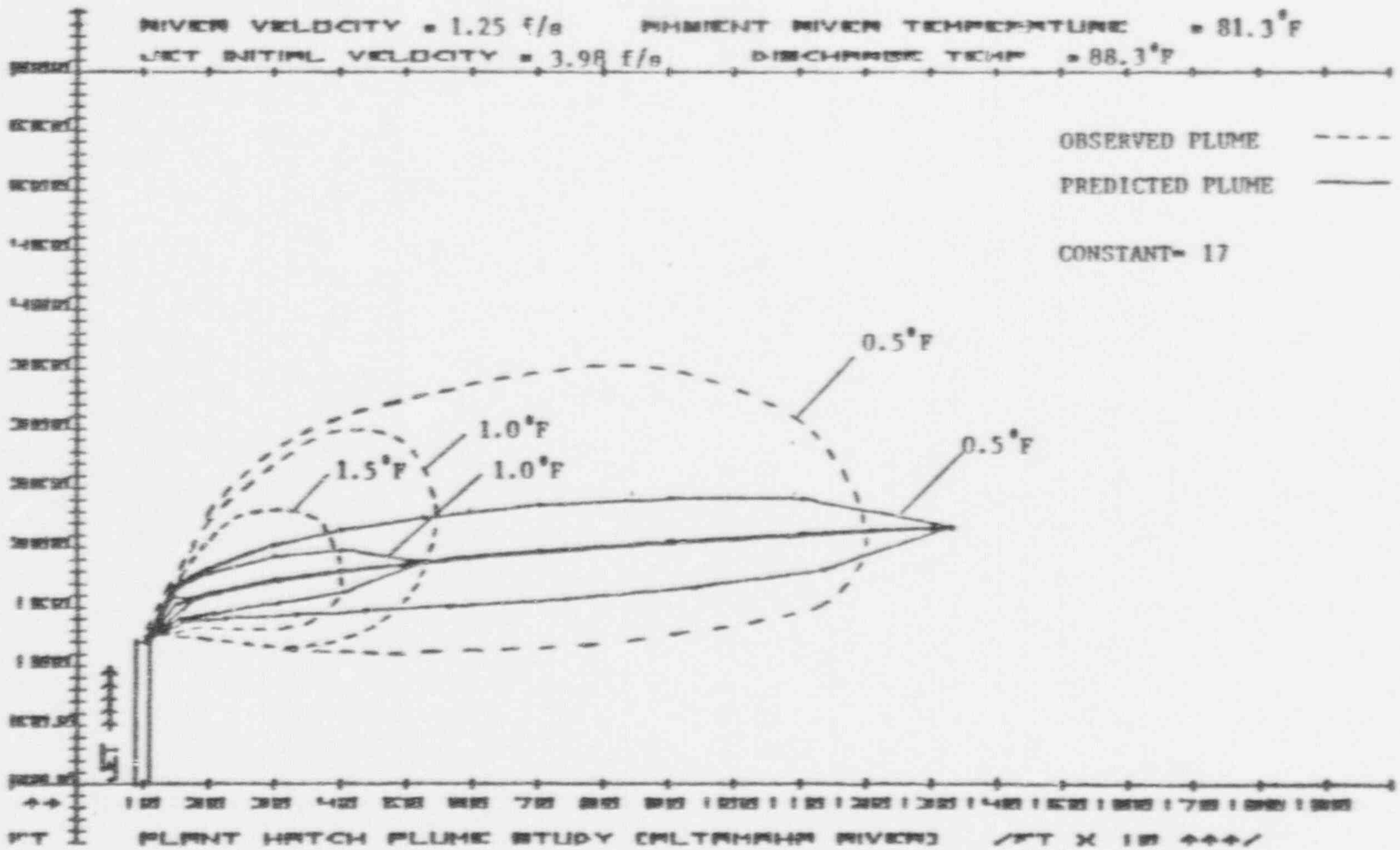


GEORGIA POWER COMPANY EDWIN I. HATCH NUCLEAR PLANT UNIT 2	RIVER DISCHARGE STRUCTURE AND MIXING BOX FIGURE 2



GEORGIA POWER COMPANY
EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER
THERMAL PLUME TRANSECTS



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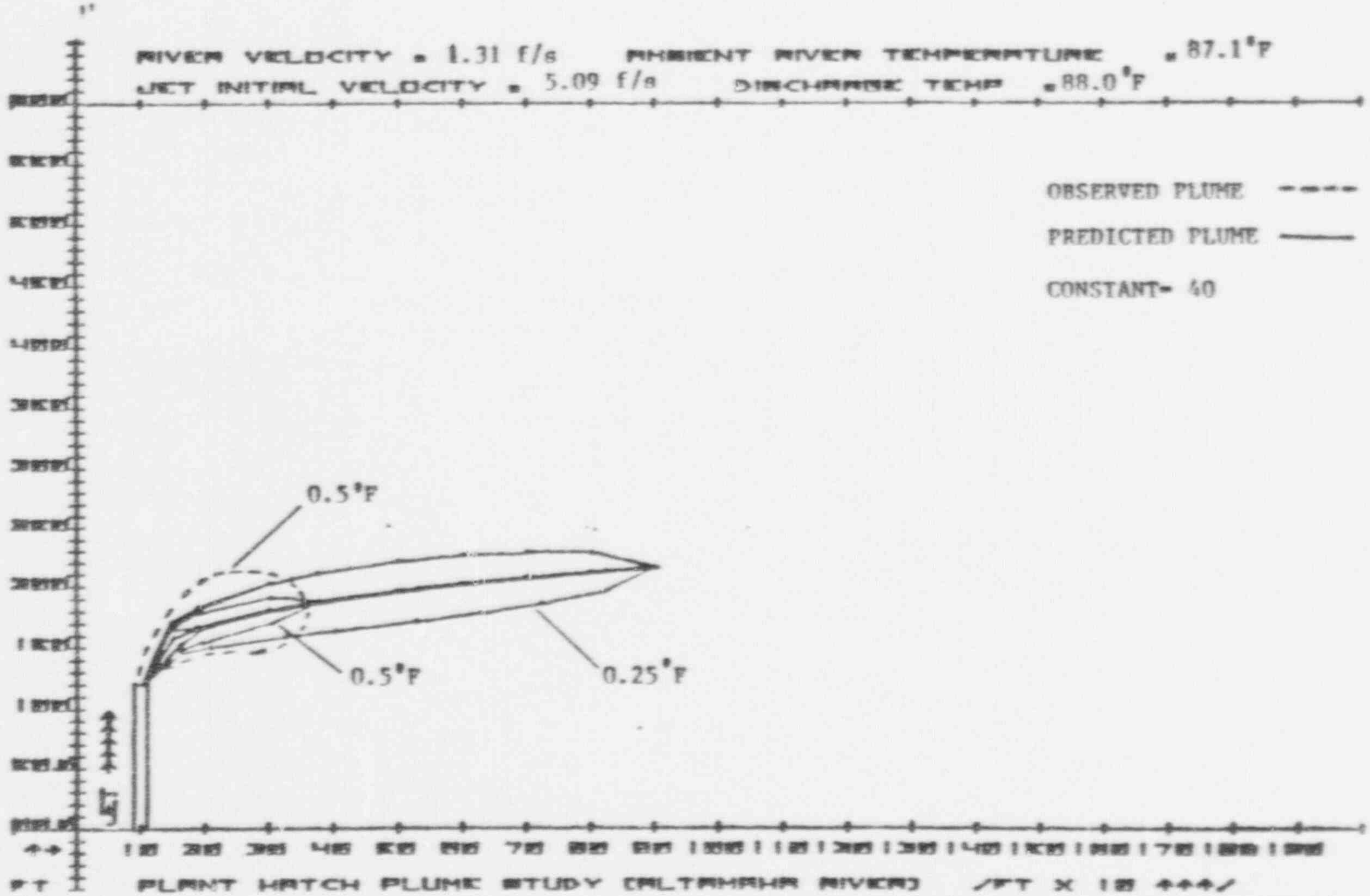
EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER THERMAL PLUME SURVEY FOR
JUNE 19, 1980 (9:25)

FIGURE 4



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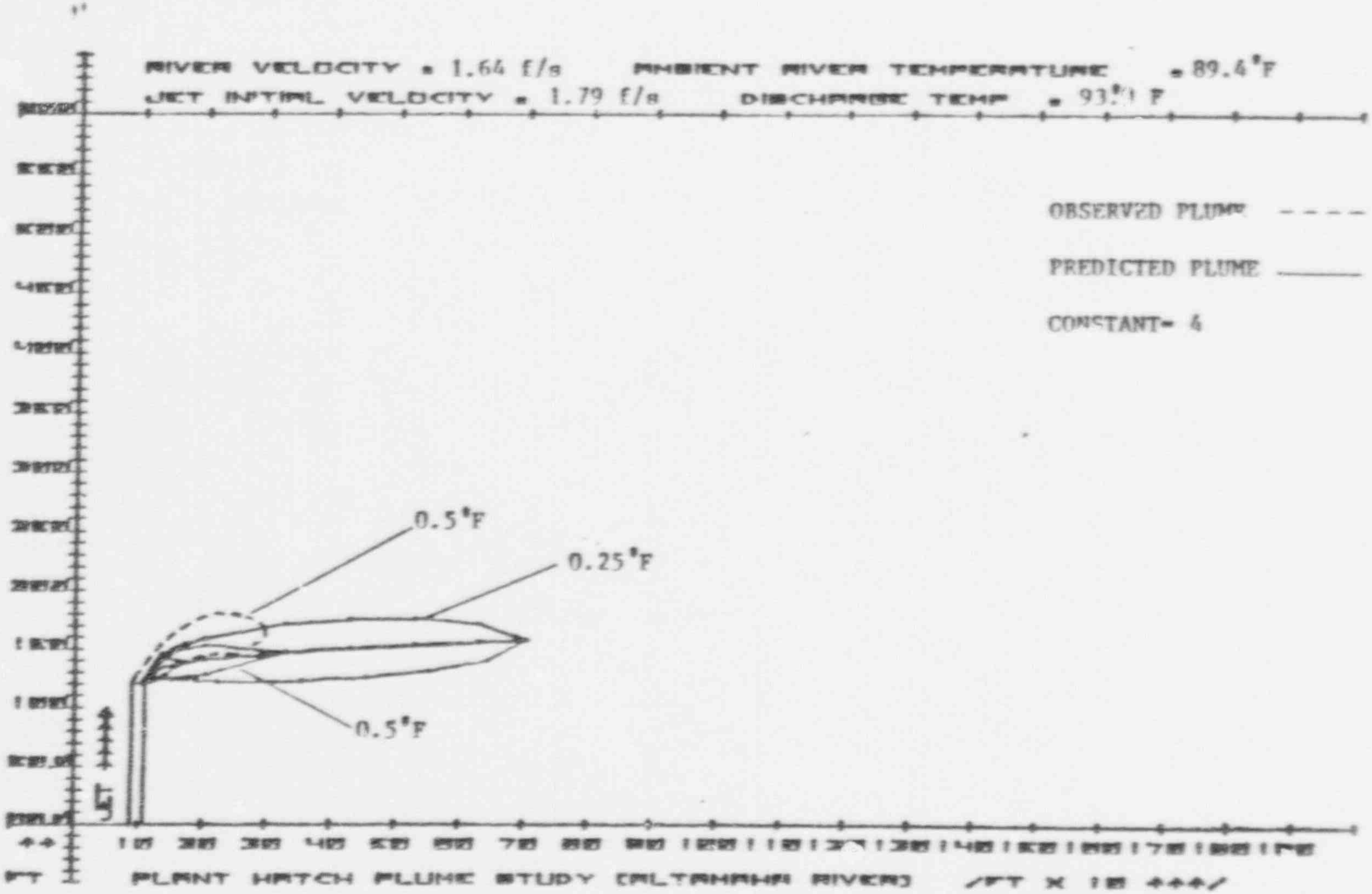
EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER THERMAL PLUME SURVEY FOR
AUGUST 7, 1980 (9:30)

FIGURE 5



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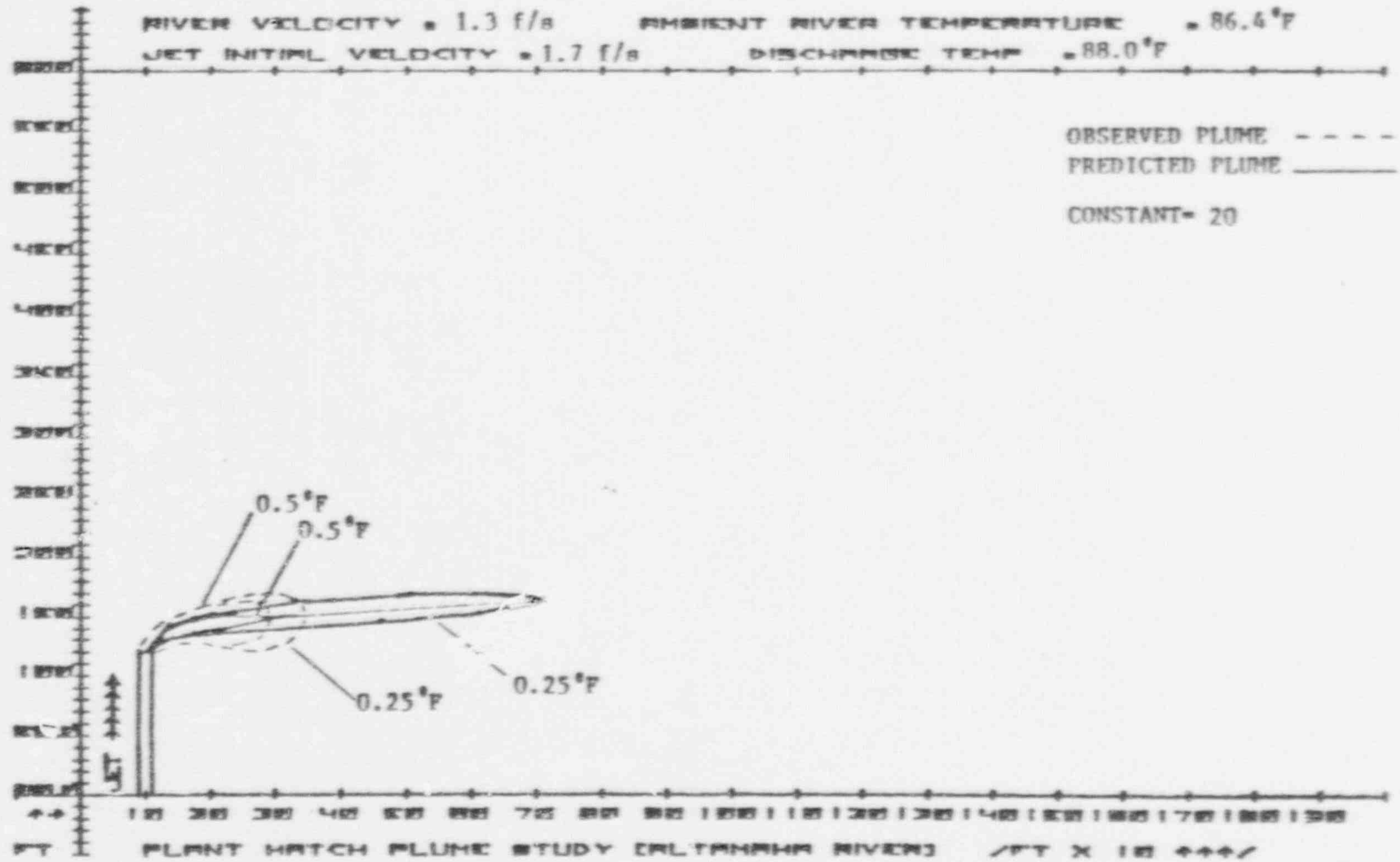
EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER THERMAL PLUME SURVEY FOR AUGUST 7, 1980 (17:30)

FIGURE 6



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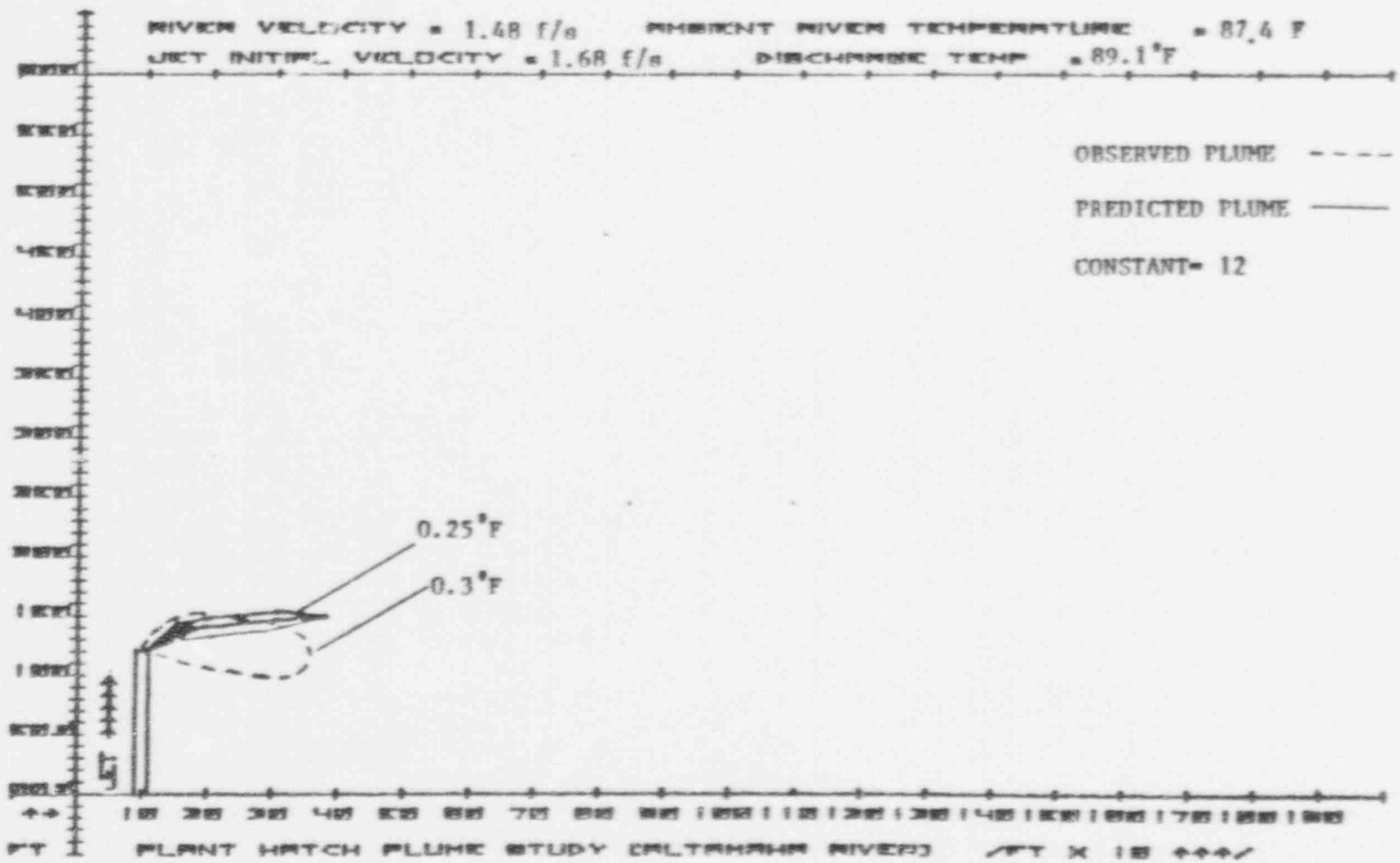
EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER THERMAL PLUME SURVEY FOR AUGUST 11,1980 (16:10)

FIGURE 7



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EDWIN I. HATCH NUCLEAR PLANT

ALTAMAHA RIVER THERMAL PLUME SURVEY FOR AUGUST 12, 1980 (12:02)

FIGURE 8