Ecology III, Inc.
Susquehanna SES Environmental Laboratory

804 Salem Boulevard
Berwick, PA 18603

Phone: (570) 542-2191
Fax: (570) 542-1625

17 February 2009

J. S. Fields (GENPL4)
PPL Bell Bend, LLC

SUSQUEHANNA STEAM ELECTRIC STATION
EIPL-1484
THERMAL PLUME SURVEYS – SUMMER 2008 – REV. 2

Attached are the final revised results of "Thermal Plume Surveys in the Susquehanna River at the Susquehanna Steam Electric Station Discharge Diffuser – Summer 2008." Many of the draft comments were incorporated into this final revision.

This report is a supplement to "Thermal Plume Studies in the Susquehanna River at the Discharge Diffuser of the Susquehanna Steam Electric Station, 1986-87".

If you have any questions, please contact me.

Theodore V. Jacobsen,
Project Director

/msh

Attachment

Copy: J. C. Phillips
S. J. Daderko
M. B. Detamore
N. A. Evans
C. H. Saxton
J. J. Kostyal
T. G. Wales
R. R. Sgarro
J. Freels
EIPL
DCC

THERMAL PLUME SURVEYS IN THE SUSQUEHANNA RIVER AT THE SUSQUEHANNA STEAM ELECTRIC STATION DISCHARGE DIFFUSER SUMMER 2008

REVISION 2

Prepared by

Theodore V. Jacobsen
Ecology III, Inc.
804 Salem Blvd.
Berwick, PA 18603

For

PPL Bell Bend, LLC
38 Bomboy Lane, Suite 2
Berwick, PA 18603

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CONTENTS

INTRODUCTION

The Susquehanna Steam Electric Station (Susquehanna SES) is a nuclear power station located along the Susquehanna River in northeastern Pennsylvania. Surveys of the thermal plume from the river water discharge diffuser were conducted in the winter, autumn, and spring, 1986-87 (Ecology III, 1987). All three plumes were very limited and posed no environmental hazards to aquatic life in the river. With this documented, and, due to other time constraints, a summer survey was never done.

In 2008, PPL proposed construction of the Bell Bend Nuclear Power Plant (BBNPP) on a site adjacent to the Susquehanna SES. This power plant would construct its own intake 300 feet downriver from the Susquehanna SES intake (315 feet upriver from the SSES diffuser) and its own river discharge diffuser 380 feet downriver from the SSES diffuser (Fig. 1). With the close proximity of these proposed structures to the existing Susquehanna SES diffuser, it was deemed necessary to conduct a summer thermal plume survey(s) at the Susquehanna SES diffuser to complete baseline studies in all four seasons.

The Susquehanna SES diffuser is a 42-inch diameter, 115-feet long pipe located on the river bottom about 200 feet from the west riverbank. Blowdown water is released into the river through a series of 72, 4-inch diameter ports spaced at 18-inch intervals along the upper edge of the downriver side of the diffuser. The effluent pipe connected to the diffuser is also 42-inches in diameter and approximately ¾-mile long from the diffuser to the cooling tower basins at the power station.

PROCEDURES

Summer thermal plume surveys were conducted at the Susquehanna SES river water diffuser at mid-day on 21 August and 3 September 2008. During each survey both boiling water reactors were at full power (Unit 1 = 94.4% and Unit 2 = 100%), for a total generating capacity of about 2,400 megawatts. At this power level, the river water withdrawal at the intake on both days was approximately 39,000 gallons per minute (gpm) with a mean temperature of 74.4°F, and the blowdown, as it exited the cooling tower basins on site, was 12,000 gpm at an average of 82.7°F (Table 1).

During both surveys, river water temperatures were measured with a YSI 650 MDS Sonde that was calibrated prior to use. A vertical series of temperatures were determined to the nearest 0.1°F from the surface to the river bottom at one-foot depths at each site downriver from the diffuser. Ambient river temperatures were measured immediately upriver from the diffuser before and after each survey. The surveys were done within 1½ hours to avoid too much of a change in ambient river temperature.

A crew of three in a boat and a surveyor on shore used a plane table mapping technique to locate the diffuser and each site. The boat driver first anchored over either end of the diffuser and then moved to each site within the probable location of the plume and anchored, while two crewmembers measured a vertical temperature series. At each anchorage, the surveyor sighted a stadia rod mounted on the boat with a Watts microptic alidade on top of the plane table set up along the shoreline. These sightings were then transcribed onto a base map at a scale of 1 inch = 50 feet.

In the laboratory, these data were used to define the edge of the plume at 0.5°F and 1.0°F isotherms above ambient river temperature by interpolating its location

among the vertical series of temperatures at each site. Planar views were then drawn for each survey to show the extent of the thermal plume.

RESULTS

During the first survey on 21 August 2008, the weather was overcast and ambient river temperature did not change throughout the survey. The average river flow on this date was 3,230 cubic feet per second (cfs) at a river level of 487.0 feet above mean sea level (msl) as recorded on the calibrated river level gage at the Susquehanna SES Environmental Laboratory (Water Quality Procedures 2004). The relationship of river level to river flow at the Lab was documented by Soya (1991). The plume was detected within 6 of the 28 sites (Table 2). The vertical temperature measurements show that it did not reach the surface before dissipating. The planar view in Fig. 2 defines the plume at the 0.5°F isotherm. It was less than 40 feet wide at the diffuser and narrowed as it extended 120 feet downriver.

In the second survey on 3 September 2008, bright sunlight warmed the river temperature nearly 1°F during the 1½-hour data collection period at 22 sites (Table 3). This warming necessitated the adjustment of the temperatures recorded midway through the period by subtracting 0.5°F from each temperature. The average river flow on this date was 2,140 cfs at a river level of 486.5 ft above msl. This river flow was one-third less than the flow during the first survey.

A thermal plume at 0.5°F was detected at most sites (Fig. 3); it was about 100 feet wide and extended downriver from the diffuser 300 feet. A smaller 1.0°F isotherm was found immediately downriver from the diffuser. Overall, the plume appeared to

reach the surface of the river throughout the 0.5°F isotherm (Fig. 3), ranging from 0.1°F or less at Sites 12 and14 and to 0.8°F at Sites 21 and 22 (Table 3). However, surface temperatures at Sites 21 and 22 were probably more influenced by solar warming than by a thermal plume from the blowdown discharge. Furthermore, the adjusted 0.8°F temperatures at these two sites is perhaps quite conservative since they were the last to be measured during the survey and were within 0.1°F of the final ambient temperature recorded at 1252 hours (Table 3). They were actually 0.1°F cooler than the final ambient reading indicating that the surface heating at Sites 21 and 22 may possibly have been closer to zero than to 0.8°F. Additionally, subsurface temperatures from 1 to 3 feet at both sites were lower than the surface temperatures, and since any thermal heating reaching the river surface would first have to pass through these levels, the thermal plume may not have even reached the surface of the river at these sites.

Averaging the delta t surface temperatures of the 20 sites within the 0.5°F plume (less Sites 13 and 14) reveals that the surface temperature of the plume may have increased the ambient river temperature by 0.4°F only immediately above the plume, but that some of this increase was also caused by solar radiation despite an attempt to adjust for it.

SUMMARY

The water temperature in the cooling tower basins was a maximum of 7.4°F and 11.7°F above ambient river temperature during the surveys on 21 August and 3 September 2008, respectively (Table 1). With these delta t's, one might have expected a more extensive thermal plume in the river on both survey dates. However,

the blowdown probably cools as it flows through the ¾-mile blowdown effluent pipe and, even more so, when it mixes with the water backed up into the effluent pipe and the diffuser before it exits out of the diffuser ports and into the river.

This cooling effect could be evaluated further with other surveys throughout the blowdown effluent pipe, but the fact remains that the thermal plume from the Susquehanna SES diffuser is very limited even during low river flow conditions. Thermal plumes of this size will pose no thermal environmental hazard to aquatic life in the Susquehanna River.

REFERENCES

Ecology III, Inc. 1987. Thermal plume studies in the Susquehanna River at the discharge diffuser of the Susquehanna Steam Electric Station, 1986-87. Prepared for Pennsylvania Power and Light Company. 8 pp.

Ecology III, Inc. 2004. Water quality procedures, 15 pp. *In* Procedures for Nonradiological Environmental Monitoring Program (Non-Quality) and Safety Programs at the Susquehanna SES Environmental Laboratory. Ecology III, Inc., Berwick, PA.

Soya, W. J. 1991. Depth – level – flow relationship of the Susquehanna River at the Susquehanna SES Environmental Laboratory. Ecology III, Inc., Berwick, PA. 10 pp.

Table 1
River water intake temperature and blowdown discharge temperature (as calculated from monitoring points in the cooling tower basins) at the Susquehanna Steam Electric Station during times of thermal plume surveys, 21 August and 3 September 2008. (Data provided by J. J. Kostyal, PPL Susquehanna)

Archived SSES Data (PI System)
Start: 8/21/2008 11:00
End 8/21/2008 13:00

	River Water Intake Temp (°F)	Unit 1 Blowdown* Temp (° F)	Delta t (° F)	Unit 2 Blowdown* Temp (° F)	Delta t (° F)
Min	74.5	79.6	5.1	81.0	6.5
Avg	74.5	80.6	6.1	81.6	7.0
Max	74.6	81.2	6.6	82.0	7.4

Archived SSES Data (PI System)
Start: 9/3/2008 11:00
End: 9/3/2008 13:00

	River Water Intake Temp (°F)	Unit 1 Blowdown* Temp (° F)	Delta t (° F)	Unit 2 Blowdown* Temp (° F)	Delta t (° F)
Min	74.2	82.1	7.9	83.6	9.4
Avg	74.3	83.7	9.4	84.8	10.6
Max	74.3	85.3	11.0	85.9	11.7

*Average CW/LP Inlet (Basin temperature, °F)

Table 2

Temperatures (°F) recorded at 1-foot intervals from surface to bottom at 28 sites on the Susquehanna River downriver from the Susquehanna Steam Electric Station discharge diffuser, 21 August 2008.

Site No.	Time	Temperature (F)		Depth in Feet																Bottom	
		Air	Surface	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Depth	Temp
Ambient	1038	77.0	74.0	74.0	74.0	74.0	74.0	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9						12	73.9
1	1045		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.1					13	74.1
2	1049		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.1					13	74.1
3	1050		74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0		16	74.0
4	1054		74.0	74.0	74.0	74.0	74.0	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0			15	74.0
5	1055		74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0				14	74.0
6	1056		74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0				14	74.0
7	1058		74.0	74.0	74.0	74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0				14	74.0
8	1100		73.9	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0				14	74.0
9	1102		74.0	74.0	74.0	74.1	74.1	74.1	74.5	74.5	74.5	74.5	74.6	74.4	74.4	74.4	74.3	74.2	74.2		16	74.2
10	1104		74.0	74.1	74.1	74.1	74.1	74.3	74.2	74.1	74.1	74.1	74.2	74.1	74.1						12	74.1
11	1106		74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1					13	74.1
12	1108		74.0	74.0	74.0	74.0	74.1	74.1	74.2	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1				14	74.1
13	1111		74.0	74.0	74.1	74.1	74.1	74.1	74.2	74.2	74.4	74.3	74.4	74.6	74.6	74.7	74.5	74.5	74.5		16	74.5
14	1114		74.0	74.0	74.0	74.1	74.1	74.1	74.1	74.1	74.2	74.2	74.1	74.1	74.0	74.1	74.1	74.2	74.2		16	74.2
15	1116		74.0	74.0	74.0	74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0		16	74.0
16	1118		74.0	74.0	74.0	74.0	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0						12	74.0
17	1119		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0			15	74.0
18	1123		74.0	74.0	74.0	74.1	74.1	74.1	74.1	74.0	74.0	74.0	74.0	74.0	74.0	74.1	74.1	74.1	74.1		16	74.1
19	1126		74.0	74.0	74.1	74.0	74.1	74.0	74.0	74.0	74.0	74.0	74.1	74.0	74.0	74.0	74.0	74.0			15	74.0
20	1128		73.9	74.0	74.0	74.0	74.0	74.1	74.0	74.0	74.0	74.0	74.1	74.0	74.0	74.1					13	74.1
21	1138		74.0	74.0	74.0	74.0	74.0	74.5	74.5	74.5	75.0	75.0	75.0	74.5	74.5	74.5	74.5	75.0	75.0	75.0	17	75.0
22	1141		74.0	74.0	74.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	75.0	74.5	74.5	74.5	74.5				14	74.5
23	1145		74.0	74.0	74.0	74.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5							11	74.5
24	1147		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0			15	74.0
25	1150		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0		16	74.0
26	1152		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0								10	74.0
27	1155		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0											7	74.0
28	1156		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0						12	74.0
Ambient*	1200	78.0	74.0																			

*Only surface temperature recorded. Constant surface to bottom temperatures at sites 26-28 indicate that ambient temperature remained at 74°F throughout the survey.

Table 3

Temperatures (°F) recorded at 1-foot intervals from surface to bottom at 22 sites on the Susquehanna River downriver from the Susquehanna Steam Electric Station discharge diffuser, 3 September 2008.

Site No.	Time	Temperature (F)		Depth in Feet															Bottom	
		Air	Surface	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Depth	Temp
Ambient	1126	77.6	74.6	74.5	74.5	74.5	74.4	74.4	74.3	74.3	74.3	74.3	74.3	74.3					11	74.3
1	1129		74.9	74.8	74.9	74.9	74.9	74.9	74.9	74.9	75.0	75.0	75.0	75.0	74.9	74.9	74.9		14	74.9
2	1134		75.0	75.1	75.0	75.1	75.0	75.0	75.0	75.0	75.0	75.1	75.0	75.0	75.0	75.0	75.0		14	75.0
3	1138		74.9	75.0	75.0	75.0	75.0	75.0	74.9	74.9	75.0	75.0	74.9	74.9	74.9	74.9			13	74.9
4	1141		75.1	75.0	75.0	74.9	74.9	74.9	75.0	75.0	74.9	74.9	74.9	74.8	74.8				12	74.8
5	1144		75.0	75.0	75.0	74.9	75.0	74.8	74.8	74.8	74.8	74.8	74.8	74.7	74.7				12	74.7
6	1147		74.9	75.0	75.1	74.8	74.8	74.9	74.7	74.8	74.9	74.7	74.9	74.9	74.9	75.0	74.9	74.9	15	74.9
7	1151		75.0	75.0	74.9	74.9	74.8	74.7	74.7	74.7	74.8	74.8	74.7	74.7	74.7	74.8	74.8	74.8	15	74.8
8	1154		75.1	75.1	74.8	74.7	75.1	74.9	74.8	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7		14	74.7
9	1201		74.8	74.8	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.8	74.8	74.7	74.6	74.6	74.6		14	74.6
10	1204		74.9	74.8	74.8	74.8	74.8	74.8	74.9	75.0	74.9	74.8	74.8	74.8	74.7	74.7	74.7		14	74.7
11	1207		75.2	75.1	75.0	74.8	74.9	74.8	74.8	74.8	74.8	74.8	74.8	74.8	74.8				12	74.8
12*	1210		74.5	74.5	74.5	74.5	74.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4					11	74.4
13	1213		74.8	74.7	74.6	74.4	74.3	74.3	74.4	74.3	74.3	74.4	74.4	74.3	74.3	74.3			13	74.3
14	1216		74.7	74.7	74.6	74.5	74.5	74.4	74.4	74.4	74.4	74.3	74.3	74.3					11	74.3
15	1229		75.1	75.1	75.0	75.1	75.0	75.1	75.0	74.8	75.1	75.2	75.0	74.9	74.8	74.7	74.7	74.7	15	74.7
16	1228		75.0	74.9	74.8	74.8	74.7	74.8	74.8	74.8	74.7	74.7	74.7	74.7	74.7	74.6			13	74.6
17	1230		75.1	75.0	75.0	75.0	74.9	74.9	74.9	74.8	74.8	74.8	74.9	74.9	74.9	74.9	74.7		14	74.7
18	1232		75.0	75.0	75.0	75.0	75.0	75.0	74.9	74.9	74.9	74.9	74.8	74.8	74.7	74.6			13	74.6
19	1234		75.0	75.0	75.0	74.9	74.9	74.8	74.9	74.8	74.8	74.8	74.8	74.8	74.8				12	74.8
20	1239		74.8	75.1	75.1	75.2	75.1	75.0	75.0	75.2	75.1	75.0	74.9	75.0	74.9	74.9	74.8		14	74.8
21	1244		75.4	75.0	74.8	74.7	74.5	74.5	74.5	74.4	74.5	74.4	74.5	74.5					11	74.5
22	1249		75.4	74.9	75.2	75.1	75.5	75.5	75.4	75.6	75.5	75.4	75.3	75.3	75.3	75.2	75.2		14	75.2
Ambient	1252	79.5	75.5	75.3	75.3	75.2	75.1	75.1	75.1	75.1	75.0	75.0	75.0	75.0	75.0				12	75.0

*All temperatures (except ambient) measured after 1210 hours were adjusted for an increase in ambient temperature by subtracting 0.5°F.

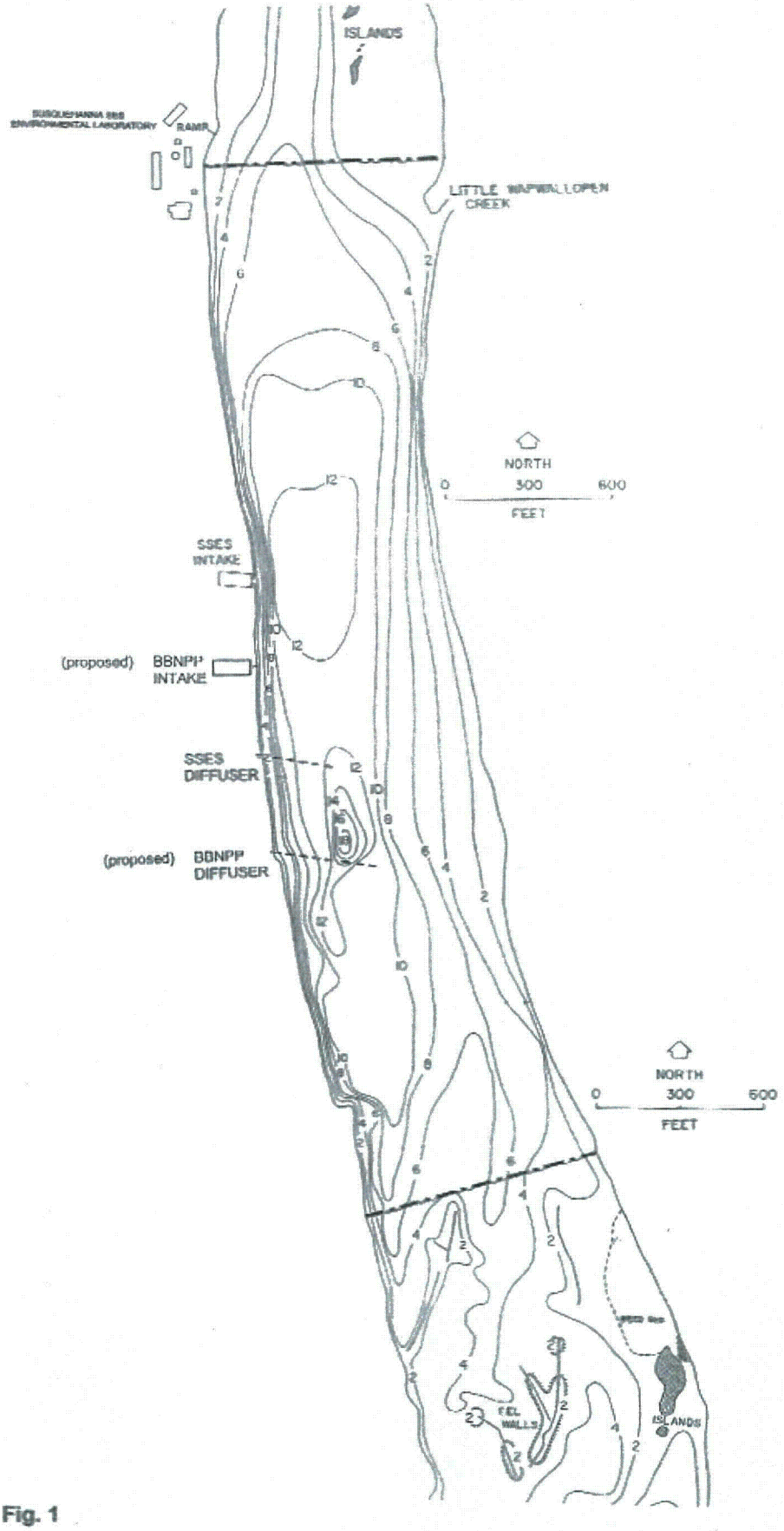

Fig. 1

Location of the Susquehanna Steam Electric Station (SSES) and the proposed Bell Bend Nuclear Power Plant (BBNPP) river water intakes and discharge diffusers along the west bank of a pool in the Susquehanna River, six miles upriver from Berwick, PA, 2008. Depth contours at 2-foot intervals based on a river level at 486.2 feet above mean sea level surveyed in 1983.

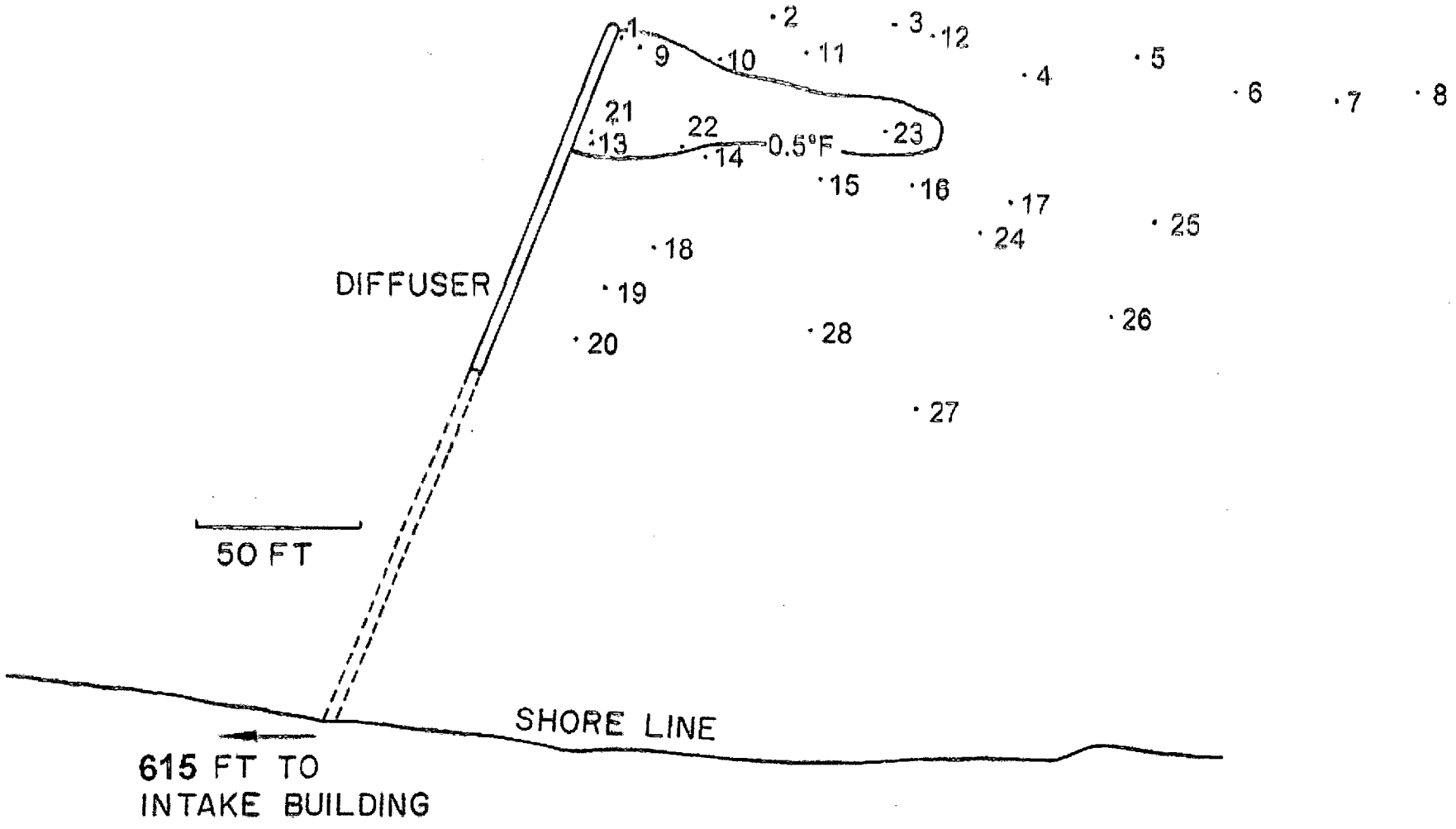

Fig. 2

Limits of a thermal plume (0.5° F above ambient water temperature) in the Susquehanna River caused by the release of cooling tower blowdown (12,000 gpm) from the Susquehanna Steam Electric Station discharge diffuser as measured at 28 sites, 21 August 2008. Average river flow on this date was 3,230 cubic feet/second.

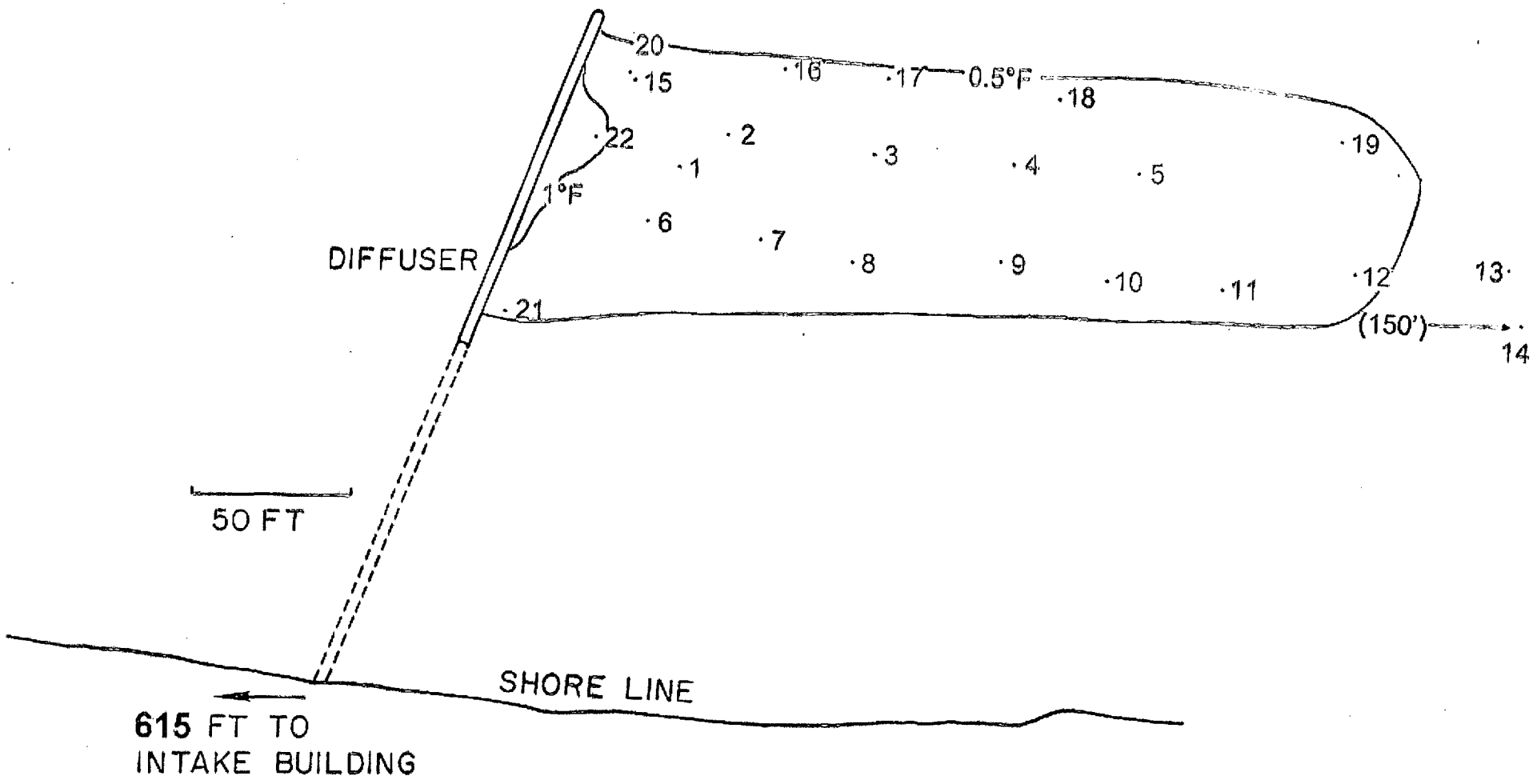

Fig. 3

Limits of a thermal plume (0.5° and 1° F above ambient water temperature) in the Susquehanna River caused by the release of cooling tower blowdown (12,000 gpm) from the Susquehanna Steam Electric Station discharge diffuser as measured at 22 sites, 3 September 2008. Average river flow on this date was 2,140 cubic feet/second.