2/14/83

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL
	)	

AFFIDAVIT OF JOHN BRADLEY

I, John Bradley, being duly sworn, state that I am the author of the "Testimony of John Bradley on Sinclair Contention 14 (Dresden Fogging and Icing Studies)" and that such testimony is true and correct to the best of my knowledge and belief.

John Bradley
John Bradley

SUBSCRIBED AND SWORN before me this 7th day of Feb., 1983.

John R. Murray

2/14/83

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TESTIMONY OF JOHN BRADLEY
ON
SINCLAIR CONTENTION 14
(DRESDEN FOGGING AND ICING STUDIES)

TESTIMONY OUTLINE

1.0 Introduction

2.0 Purpose of Testimony

3.0 The Dresden Studies
3.1 Dresden Site Description
3.2 Observation Program Description
3.3 Results

4.0 Conclusions Applicable to Midland Pond

5.0 General Conclusion

1.0 Introduction

My name is John Bradley. I am employed by Murray and Trettel, Incorporated (M/T). My business address is 414 West Frontage Road, Northfield, Illinois. At Murray and Trettel I am Vice President and Director of Environmental Applications. I hold a Bachelor of Science Degree in Meteorology from St. Louis University which I received in 1960. In 1962 I was awarded a Master of Science Degree in Meteorology from the University of Chicago. I have done graduate work in the following fields: physical, synoptic and radar meteorology; advanced forecasting; probability theory and statistical applications; and physical chemistry. I have held various positions at Murray and Trettel since I became associated with them in 1964. In my capacity as Chief of the Environmental Group in 1973 I was the principal investigator for the Dresden Plant cooling lake study conducted from November 1971 through March 1973. The work reported in the Report on Meteorological Aspects of Operating the Cooling Lake and Sprays at Dresden Nuclear Power Station (Report No. 1001-5, dated 1 August 1973) was, with the exception of Phases 1 and 2, done by me or by others under my direction.

Subsequently, M/T performed a second observation program during the winter season of 1977-78. That study was much narrower in scope being limited to observations along County Line Road. Results from that observation program were summarized in a Report on Steam Fog Impact Engineering at Dresden Nuclear Power Station (Report No. 1183, dated 26 May 1978).

I am the author of numerous papers concerning meteorology and its environmental applications. I am a certified consulting meteorologist and a professional member of the American Meteorological Society.

My resume is appended to this testimony.

2.0 Purpose of Testimony

The purpose of my testimony is to (1) describe the onsite observation programs that we conducted at Commonwealth Edison Company's Dresden cooling lake; and, (2) discuss the significance of our findings as they relate to the statements made in the Final Environmental Statement for the Midland Plant of Consumers Power Company (NUREG-0537).

3.0 The Dresden Studies

The initial Dresden cooling pond study (1971-73) was designed to gather information on fog conditions as they occur naturally in the area, and to assess the meteorological impact of the cooling lake and sprays on the immediate environs.

The scope of the study included (1) a comprehensive scientific and technical literature search; (2) the analysis of existing climatological records; (3) an onsite observation program; and, (4) the development of fog prediction models.

Scientific and Technical Literature Search

The scientific and technical literature search was undertaken to determine what was already known and available in the literature regarding temperate-latitude fog, particularly steam fog. Such information would be helpful in anticipating the impact of the Dresden cooling lake under operating conditions. It would also be helpful in designing the onsite observation program.

Bibliographies consulted included (1) Engineering Index (1945-1971); (2) Meteorological and Geophysical Abstracts (1950 vol. 1 - 1971 vol. 22); (3) Air Pollution Abstracts (1970 vol. 1 - 1971 vol. 2); and, (4) Nuclear Science Abstracts (1948 vol. 2 - 1971 vol. 25). In addition, the following journals were reviewed. (1) Atmospheric Environment (1967-1971); (2) Journal of the Air Pollution Association (1967-1971); (3) Energietechnik (1967-1971); (4) Energie (1967-1971); (5) VDI-Z (Verein Deutscher Ingenieure, Zeitschrift fur die gesamte Technik) (1967-1971); (6) Brenstoff-Warme-Kraft (1967-1971); and, (7) Teploenergetika (1966-1970). The literature search report is found in Appendix C to the Dresden Report 1001-5. Numerous (33) other references of potential impacts were cited in Appendix B to that same report.

Climatological Analysis

The climatological records were analyzed to provide an adequate representation of background or natural fog occurrences. Climatological data including hourly visibility and fog observations were available from a nearby official U. S. weather station. The observation site was at the Joliet Municipal Airport, approximately 12 miles north-northeast of the cooling lake. The period of record spanned nearly 11 years.

Onsite Observation Program

The purpose of the onsite program was to establish what effects the operating lake had on its immediate environs. To this end, unattended visibility measuring devices (transmissometers) were installed to provide continuous visibility records at four critical locations. However, due to the size of the cooling lake together with its immediate surroundings, the instrumentation alone could not yield a comprehensive measure of the impact over the entire area. Therefore, a manned observation program was established to complement the transmissometer network. A trained meteorological observer routinely patrolled the area during daylight hours seven days per week. He logged his observations regularly and compiled a substantial record of actual conditions as they occurred. Nighttime observations were not routinely made because the darkness severely limited the usefulness of such an observation. The onsite manned observation program was carried out through two winter seasons.

Development of Fog Prediction Models

The data collected at the Dresden site, along with the results derived therefrom, were used in the development of preliminary steam fog models. The purpose of the models was to predict, with an acceptable level of confidence, the occurrence of steam fog, its extent, and associated visibility.

3.1 Dresden Site Description

The following site description was taken from the Dresden Final Environmental Statement (November 1973).

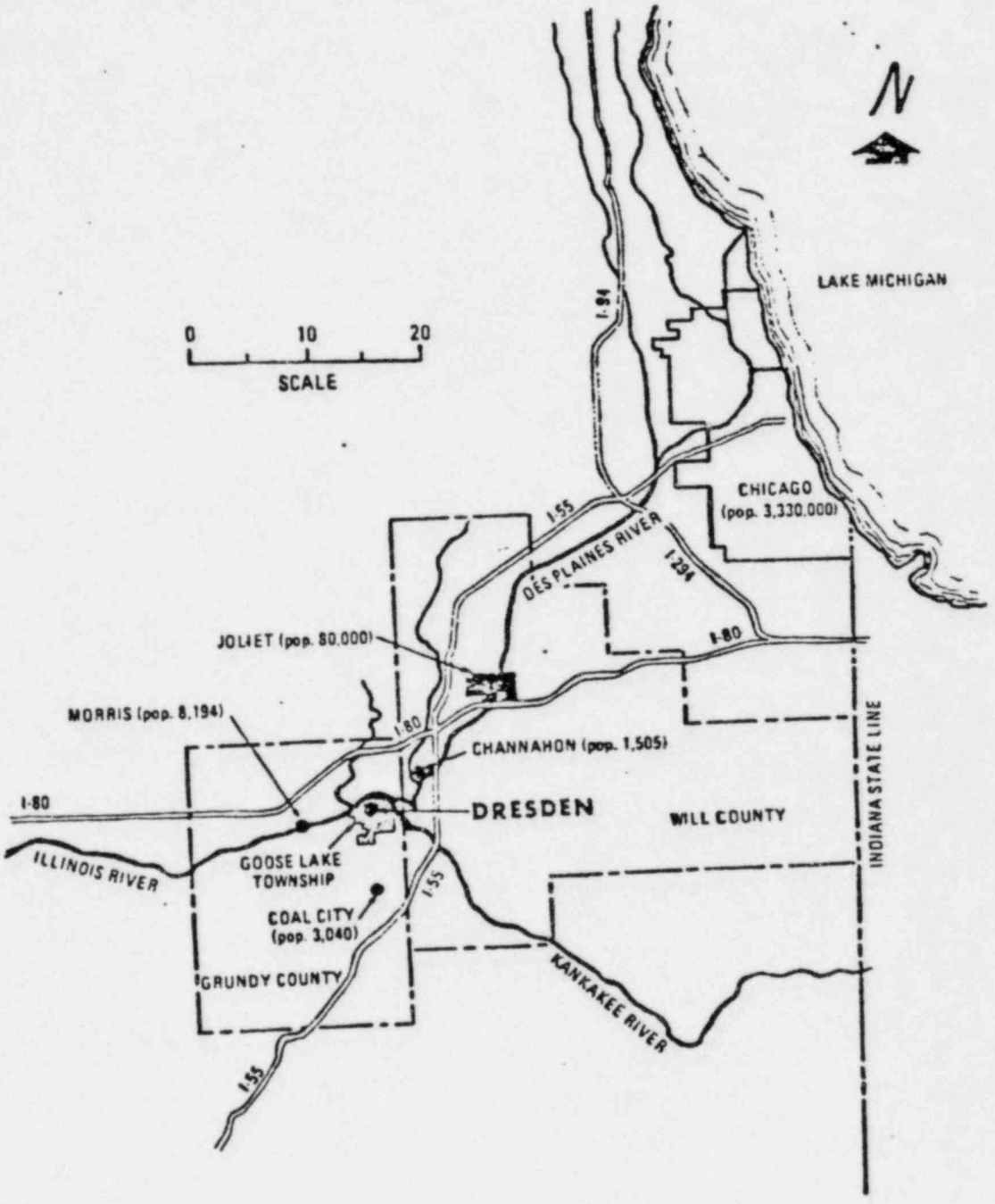


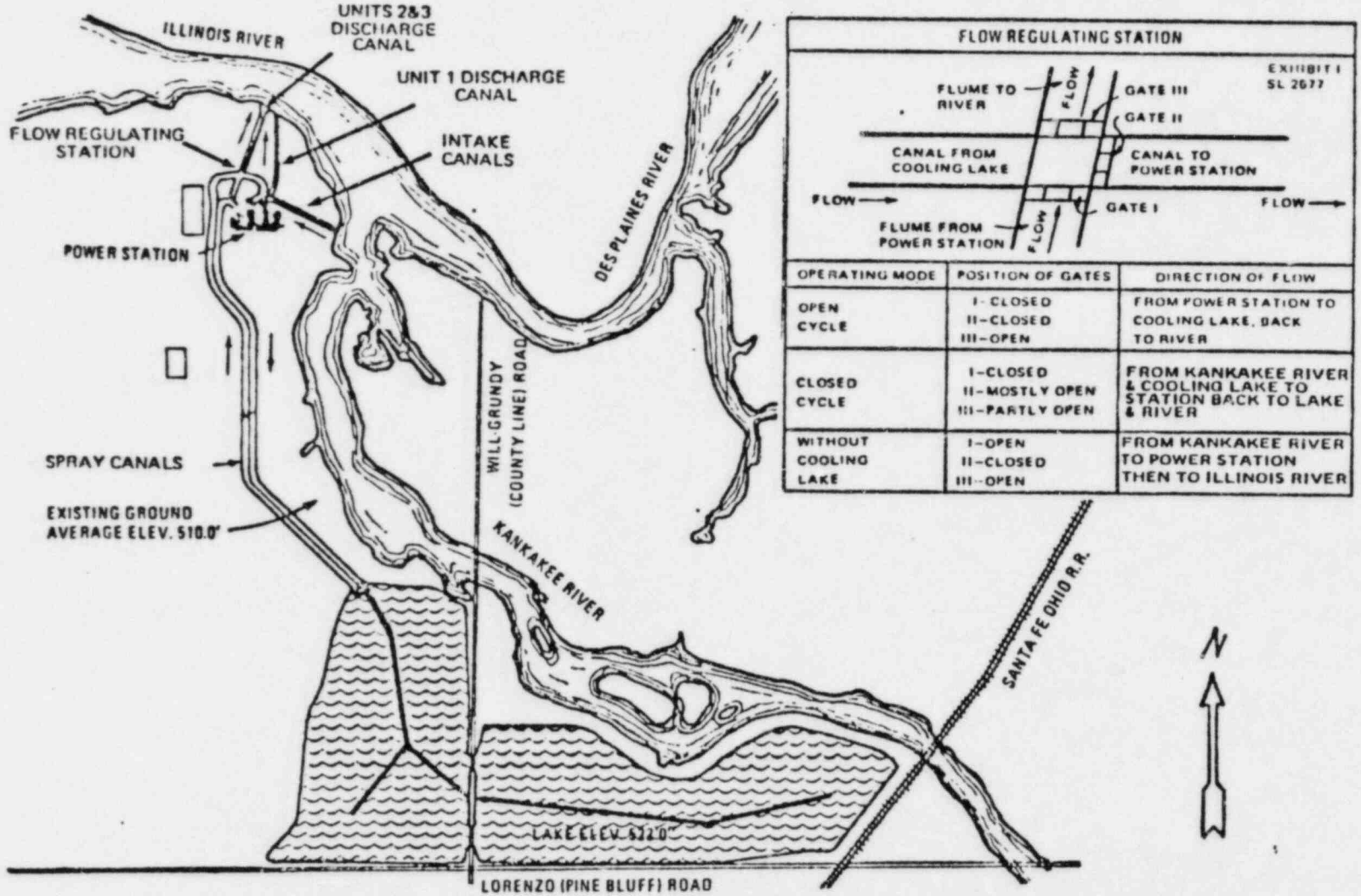
Fig. 1 Dresden Nuclear Power Station Location Map.

The Dresden Station is located in Goose Lake Township, Grundy County, Illinois, approximately 50 miles southwest of downtown Chicago (Fig. 1). It is situated on the parcel of land lying on the south shoreline of the Illinois River and the west shoreline of the Kankakee River at the point where the Kankakee and Des Plaines Rivers join to form the Illinois River. The approximate geographic coordinates are 41°20'N and 88°15'W.

The 1275-acre Dresden cooling lake became operational in October 1971, and is connected to the Station by parallel intake and discharge canals (see Fig. 2).

Dikes constructed within the lake (Fig. 3) divide it into five pools which induce a clockwise flow, maximizing the residence time of the water in the lake. The lake and spray canal systems occupy some 1573 acres of land, with the lake having a surface area of approximately 1275 acres. The average depth of the lake is 10 feet, although there are locations that exceed 20 feet, and it contains approximately four billion gallons of water with a recirculation time of about 2-1/2 days.

The lake is connected to the Unit 2 and 3 condenser discharge flume by a canal which is approximately 8500 feet long and 57 feet wide. A lift station with six 167,000 gpm pumps located between the canal and the lake raises the 976,000 gpm of water approximately 22 feet and discharges it into the lake. The water circulates through the lake in a clockwise direction and returns to the lake discharge adjacent to the lift station where the discharge is controlled by a spillway. The lake discharge



OPERATING MODE	POSITION OF GATES	DIRECTION OF FLOW
OPEN CYCLE	I-CLOSED II-CLOSED III-OPEN	FROM POWER STATION TO COOLING LAKE, BACK TO RIVER
CLOSED CYCLE	I-CLOSED II-MOSTLY OPEN III-PARTLY OPEN	FROM KANKAKEE RIVER & COOLING LAKE TO STATION BACK TO LAKE & RIVER
WITHOUT COOLING LAKE	I-OPEN II-CLOSED III-OPEN	FROM KANKAKEE RIVER TO POWER STATION THEN TO ILLINOIS RIVER

Fig. 2. Dresden Station Showing Cooling Water Intake, Spray Canals, Cooling Lake and Discharge Canal. From Applicant's Environmental Report, Supplement II, Fig. 2.2 (modified by Staff).

water then flows through a second canal which runs parallel to the aforementioned canal and is returned to a point near the Unit 2 and 3 intake. Gate structures in the return canal, intake canal, and river discharge canal are used to regulate the division of flow for recirculation and discharge to the Illinois River.

3.2 Observation Program Description

A meteorological observer was stationed at the Dresden site from 26 November 1971 through 31 March 1973. His schedule of observations began at sunrise and continued into mid-afternoon seven days each week. The schedule was kept flexible enough to assure adequate coverage of unusual meteorological conditions that might occur beyond the regular observation period. Numerous data were logged at seven strategic locations including County Line Road and Lorenzo Road (Fig. 3). In addition to the usual meteorological observations, the log contained information on steam fog plume extent and movement, road conditions and other items of interest.

The manual observations record was supplemented by data from four transmissometers designed to continuously measure visibility near the ground at key locations (Fig. 3).

3.3 Results

Natural Fog Climatology

Meteorological observations at Joliet Municipal Airport representing 99,165 hours (about 11 years) were examined for the occurrence of fog with associated visibilities of 6 miles or less. A total of 12,284 hours

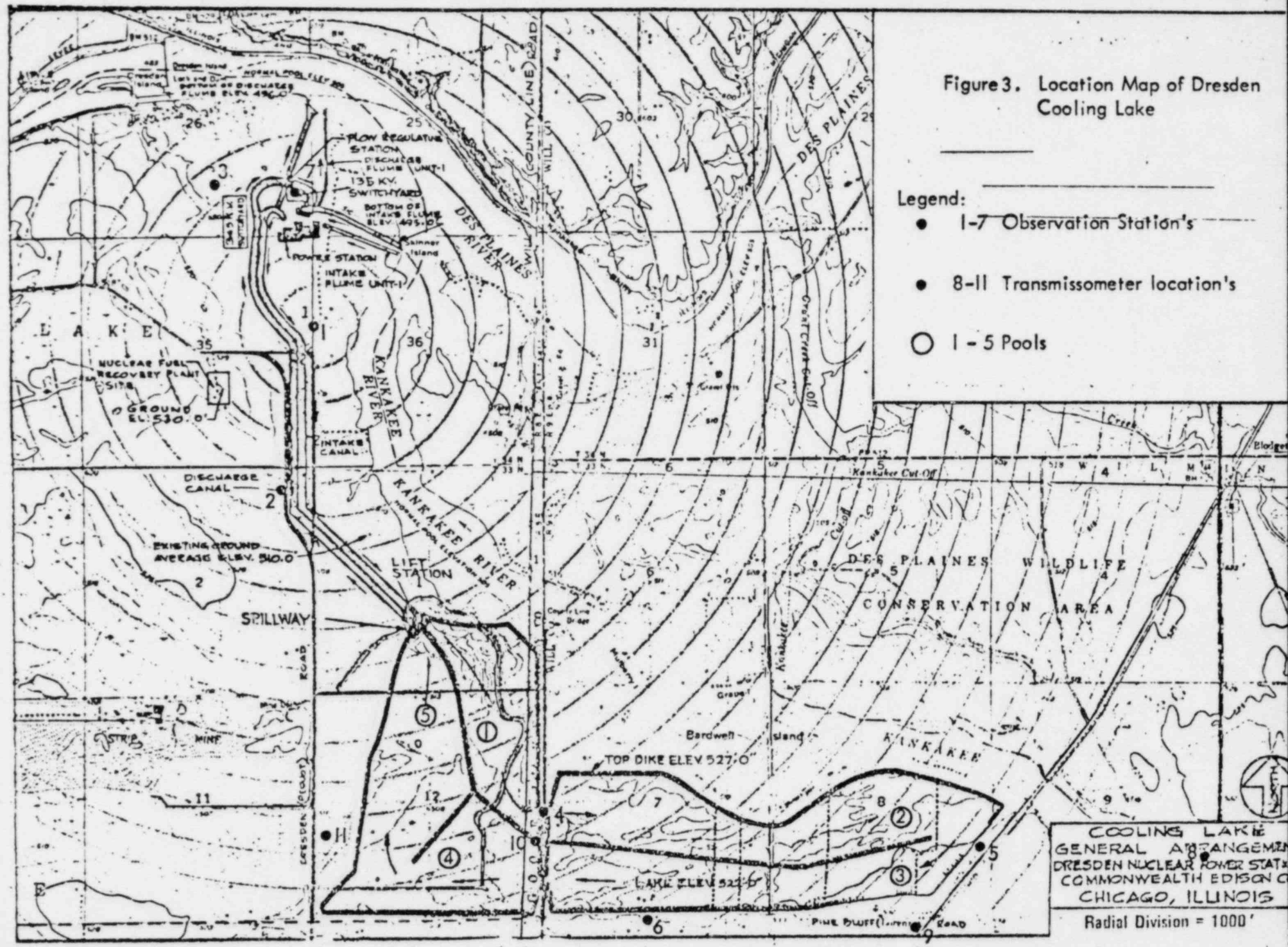


Figure 3. Location Map of Dresden Cooling Lake
Legend:
1-7 Observation Station's
8-11 Transmissometer location's
1 - 5 Pools
L A K E
NUCLEAR FUEL RECOVERY PLANT SITE
GROUND EL 530.0'
DISCHARGE CANAL
EXISTING GROUND AVERAGE ELEV. 510.0
SPILLWAY
FLOW REGULATOR STATION
DISCHARGE FLUME UNIT-1
135 KV. SWITCHYARD
BOTTOM OF INTAKE FLUME ELEV. 495.0'
POWER STATION
INTAKE FLUME UNIT-1
INTAKE CANAL
KANKAKEE RIVER
DES PLAINES RIVER
LIFT STATION
TOP DIKE ELEV 527.0'
LAKE ELEV 522.0'
DES PLAINES WILDLIFE CONSERVATION AREA
Kankakee Cut-Off
Bardwell Island
KANKAKEE
COOLING LAKE
GENERAL ARRANGEMENT
DRESDEN NUCLEAR POWER STATION
COMMONWEALTH EDISON CO.
CHICAGO, ILLINOIS
Radial Division = 1000'

(12.4%) satisfied the criteria. The fog-reduced visibilities occurred with varying frequencies depending on the season, month, and the time of day. Fog occurred most frequently in the winter and least in the summer. On a monthly basis, fog was observed most frequently in March and least in June. Diurnally, it was most frequently observed during the early morning hours and least frequently during the late afternoon. The diurnal patterns of occurrences were strongly dependent on the month and season. Diurnally over the period of record, fog occurred most often around 0600 CST in August and least often around 1700-1800 CST, also in August. The time of the diurnal frequency maxima was strongly dependent upon the season, occurring at 0500 CST during the summer and at 0800 CST during the winter. In other words, the most likely time for fog was about 1 hour after sunrise.

Dense fog having 0 miles visibility (up to 330 ft.) occurred about 23 hours per year (0.26%). Fog with visibilities up to 1/4 mile occurred 99 hours per year (1.13%). These critical cases occurred most often in winter, least in summer, most often in January, and least in June, and most often in the early morning hours (0500-0900 CST).

The 0 mile fogs had a median persistence of up to 3 consecutive hours. However, they occurred once for 12 consecutive hours with a return period of 10-20 years.

Transmissometer Data

Actual visibility was continuously measured at several sites. Visibility is defined as the greatest distance at which a sufficiently large black object can be seen against the daytime horizon sky. A Skopograph, a

transmissometer manufactured by FF Impulsphysiks, is located approximately 625 feet south of the southeast corner of the Dresden Cooling Lake (location No. 9, Fig. 3). The particular location was chosen because it is downwind of the lake's major axis, affording a maximum fetch during anticipated steam fog meteorological conditions. (Subsequent onsite observations confirmed that steam fog was most often accompanied by a northwest wind.) The site was important also because of the intersection of the railroad tracks and Lorenzo Road.

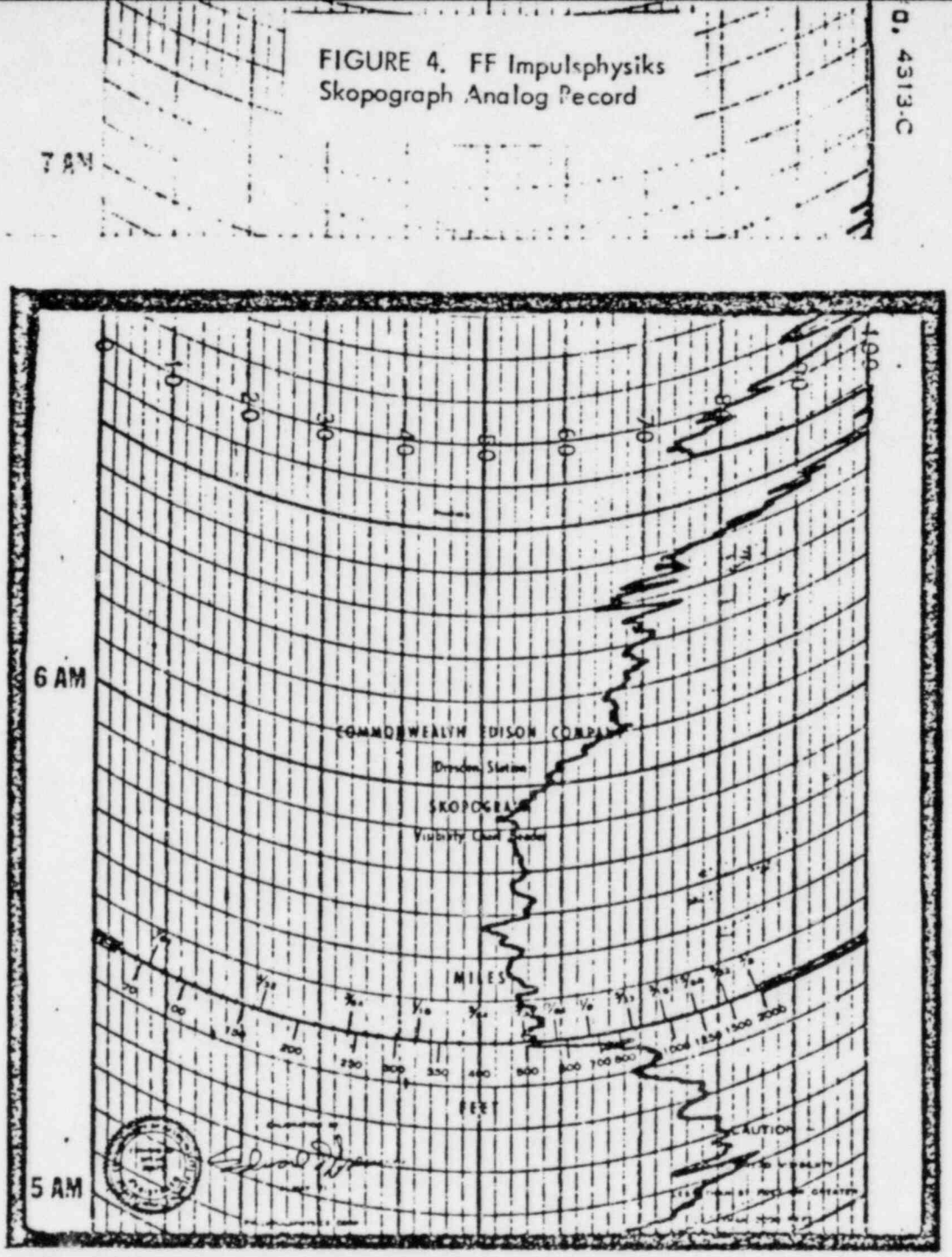
The period of record processed extended from 1 June 1971 through 31 May 1973. The data recovery for the period was in excess of 98 percent (17,298 out of a possible 17,544 hours).

The lowest recorded visibility was logged instead of the average visibility during the hour. Usually the lowest value lasted only a small fraction of the 60-minute period. (cf. Fig. 4)

The visibility readings at the Skopograph site ranged from approximately 200 feet to greater than 2,000 feet. Visibility up to 300 feet occurred 0.13 percent of the hours; visibility up to 400 feet occurred 0.36 percent; and, visibility up to 1,300 feet occurred 1.10 percent of the hours. (cf. Table 1)

These frequencies agree with natural fog climatological expectations for that area at 0.26 percent hours per year for visibility up to 330 feet and 1.13 percent for visibility up to 1,320 feet (1/4 mile).

FIGURE 4. FF Impulsphysiks Skopograph Analog Record



This portion of the chart is for April 17, 1972. Visibility increases to the right.

TABLE 1

Visibility Summary at Station 9

June 1, 1971 - May 31, 1973

FF Impulsphysiks Skopograph

Range (Feet)	Hours			
	Absolute	%	Cumulative	%
1 - 100	0	0.000	0	0.000
101 - 200	1	0.006	1	0.006
201 - 300	22	0.125	23	0.131
301 - 400	41	0.234	64	0.365
401 - 500	21	0.120	85	0.484
501 - 600	20	0.114	105	0.598
601 - 700	19	0.108	124	0.707
701 - 800	16	0.091	140	0.798
801 - 900	18	0.102	158	0.900
901 - 1000	13	0.074	171	0.975
1001 - 1100	3	0.017	174	0.992
1101 - 1200	7	0.040	181	1.032
1201 - 1300	12	0.068	193	1.100
1301 - 1400	3	0.017	196	1.117
1401 - 1500	16	0.091	212	1.208
1501 - 1600	6	0.034	218	1.242
1601 - 1700	8	0.046	226	1.288
1701 - 1800	15	0.085	241	1.374
1801 - 1900	2	0.011	243	1.385
1901 - 2000	10	0.057	253	1.442
greater than 2000	17,045	97.156	17,298	98.598
Missing	246	1.402	17,544	100.000

TABLE 2

Lowest Visibility (Less than 301 feet) Recorded by Skopograph

	Date		Local Time	Visibility (Feet)	Nearby Wind and Fog Observations	
					Midway Airport	DNPS Observer
1.	24 June	1971	0400	215		
2.	24 June	1971	0600	225		
3.	24 June	1971	0700	240		
4.	7 July	1971	0500	275		
5.	17 August	1971	0400	210		
6.	17 August	1971	0600	270		
7.	17 August	1971	0700	230		
8.	29 August	1971	0600	300		
9.	31 August	1971	0600	230		
10.	31 August	1971	0700	270		
11.	11 December	1971	1600	235	SSW 12 mph	N/A
12.	16 December	1971	2000	275	SSW 9 mph	N/A
13.	1 January	1972	1300	300	SSW 13 mph	SW 7 mph
14.	17 April	1972	0500	300	Calm (gf)	N/A
15.	17 May	1972	0500	275	Calm (gf)	N/A
16.	17 May	1972	0600	190	Calm (gf)	Calm (f)
17.	17 May	1972	0700	285	Calm (gf)	N/A
18.	10 July	1972	0400	290	SW 3 mph	N/A
19.	10 July	1972	0600	210	S 3 mph	ESE 2 mph (gf)
20.	10 July	1972	0700	300	S 3 mph	ESE 4 mph (gf)
21.	8 September	1972	0200	240	NNE 7 mph (f)	N/A
22.	5 March	1973	2300	295	SSW 6 mph (f)	N/A
23.	8 May	1973	2400	220	SW 6 mph (gf)	N/A

1. thru 10. are prior to lake operation.

	Mean	s.d.
Prior to Lake Operation	246.5	30
Lake Operational	262.6	39

N/A = Not Available (gf) = ground fog (f) = fog

The 23 hours of lowest recorded visibility taken from the Skopograph records are summarized in Table 2. Ten of the hours were recorded prior to the cooling lake becoming operational in October 1971. Those hours could only, therefore, represent fog occurring from natural processes. The remaining 13 hours were examined in detail with respect to wind direction and natural fog conditions in the area: there is no evidence to show that the cooling lake was involved in any of these 13 hours of low visibility. The mean visibility associated with the first group before the cooling lake was operational was lower than that of the second group (after the cooling lake was operational).

One may conclude from this that if, indeed, a fog, caused by the lake, reached the Skopograph, then the visibility associated with it was no lower than that occurring at that location with natural fog.

A second transmissometer was located along and just west of County Line Road between pools 1 and 4 (location No. 10, Fig. 3). This pool side location was chosen because of its proximity to the road and because maximum steam fog effects were anticipated there. Numerous engineering design modifications were required to improve the effectiveness of the instrument at this site. For example, measures were required to prevent rime ice from accumulating on the instruments and blocking the optical path. During the period 1 September 1972 through 31 May 1973, nearly 26 percent of the data were lost from this and other mechanical problems. The results for this period are summarized in Table 3.

The lowest visibility recorded during an hour was recorded rather than an average value. The values ranged from approximately 100 feet to greater

TABLE 3

Visibility Summary at Station 10

1 September 1972 - 31 May 1973

MRI Fog Visiometer

Range (Feet)	Hours			
	Absolute	%	Cumulative	%
1 - 100	18	0.371	18	0.371
101 - 200	15	0.309	33	0.680
201 - 300	23	0.474	56	1.155
301 - 400	37	0.763	93	1.918
401 - 500	43	0.887	136	2.804
501 - 600	40	0.825	176	3.629
601 - 700	36	0.742	212	4.371
701 - 800	36	0.742	248	5.113
801 - 900	28	0.577	276	5.691
901 - 1000	33	0.680	309	6.371
1001 - 1100	28	0.577	337	6.948
1101 - 1200	20	0.412	357	7.361
1201 - 1300	21	0.433	378	7.794
1301 - 1400	9	0.186	387	7.979
1401 - 1500	20	0.412	407	8.392
1501 - 1600	14	0.289	421	8.680
1601 - 1700	6	0.124	427	8.804
1701 - 1800	15	0.309	442	9.113
1801 - 1900	23	0.474	465	9.588
1901 - 2000	36	0.742	501	10.330
greater than 2000	4,349	89.670	4,850	100.000
Missing	1,702	(25.977% in period of 6,552 hours)		

than 2,000 feet. Visibility up to 300 feet occurred 1.16 percent of the hours; to 400 feet occurred 1.92 percent and up to 1,300 feet occurred 7.79 percent.

These frequencies are four to seven times more than (1) climatological expectation for the area, and (2) actual measurements nearby at the Skopograph site. The higher frequencies were not unexpected, however, since the measurements were taken at the water's edge by the warmest pool.

An effort was made to establish the frequency and intensity of all steam fog occurrences at the Dresden Cooling Lake during the period 1 January 1972 through 31 December 1972. Only instances in which the lake was operating were considered. It should be noted that after 26 November 1972, the lake was only partially operative.

A total of 1,092 hourly observations was used to compile Table 4. The varying schedule of observations together with the shut-down of the lake (13 October to 26 November) account for the lack of data at some hours. Only the most intense steam fog was logged for each observation (cf. sites 4-6, Fig. 3). Note fog may or may not have occurred at the time of the observation.

The highest hourly frequency (88.0%) occurred at 0700 in December. In other words, fog was observed at 0700 on 27 out of 31 days in the month. The lowest hourly frequency (3.2%) happened during the month of July at 1200.

Monthly frequencies of intensities for 1972 appear in Table 5. Again, some data are missing due to the lake being inoperative.

TABLE 4

Frequency (percent) of All Steam Fog Occurrences at Cooling Lake During 1972

Month	0600	0700	0800	1000	1200	1400	1600
January	N/A	N/A	80.0%	69.0%	N/A	68.0%	53.6%
February	N/A	N/A	65.3%	57.7%	N/A	46.2%	48.1%
March	N/A	N/A	58.3%	37.0%	N/A	13.3%	26.1%
April	N/A	N/A	N/A	37.5%	N/A	8.3%	N/A
May	41.9%	N/A	19.4%	N/A	6.7%	N/A	N/A
June	58.6%	N/A	26.7%	N/A	10.3%	N/A	N/A
July	63.3%	N/A	32.3%	N/A	3.2%	N/A	N/A
August	74.2%	N/A	51.6%	N/A	16.1%	N/A	N/A
September	45.8%	N/A	35.7%	N/A	13.3%	N/A	N/A
October	Lake Inoperative						
November	Lake Inoperative						
December	N/A	88.0%	80.0%	N/A	60.0%	N/A	N/A
Average				50.2%			

N/A = Not Available

TABLE 5

Frequency (percent) of Intensities of Steam Fog at Dresden Cooling Lake in 1972

Month	Wisps	Light	Moderate	Heavy
January	20.6%	23.5%	13.2%	42.6%
February	26.0%	24.0%	18.0%	32.0%
March	51.5%	27.3%	6.1%	15.1%
April	50.0%	30.0%	5.0%	15.0%
May	22.7%	40.9%	27.3%	9.1%
June	46.7%	33.3%	13.3%	6.7%
July	35.5%	51.6%	3.2%	9.7%
August	31.3%	52.1%	4.2%	12.5%
September	51.7%	20.7%	13.8%	13.8%
October		Lake Inoperative		
November		Lake Inoperative		
December	18.8%	21.2%	12.9%	47.1%
Average	31.2%	30.7%	12.3%	25.8%

Lake steam fog intensities are defined in the attached appendix. Of significance was the observation that "wisps" were never observed to cause visibility reductions along County Line Road and "light" fog only rarely restricted visibility on this road. The most serious visibility reductions were the result of "moderate" and "heavy" steam fog intensities. The median height to which the lake steam fog rose was 25 feet; on five percent of the observations the fog reached 200 feet and "heavy" steam fog was occasionally observed to rise above 700 feet.

A total of 446 hourly steam fog observations was used. Several categories were combined; "wisps to light" into light, "light to moderate" into moderate, and "moderate to heavy" into heavy.

Steam fog was most often wispy or light (87.1%) in July. It was most often moderate or heavy (60.0%) in December. Over the entire year, steam fog was wispy or light 61.9 percent of the hours during which it was observed, and moderate or heavy 38.1 percent of the observed hours.

Steam fog was observed to have remained at or near the ground and to travel beyond the lake boundary for short periods of time:

> on 22 days out of the 456 from January 1972 through March 1973, or 4.82 percent of the days. This is equivalent to an average of 17.6 days per year. On the remaining 432 days, fog may have (1) not occurred or (2) remained within the lake boundary or (3) travelled aloft beyond the lake boundary.

The actual number in 1972 was 13 days. The inland travel distance ranged from approximately 100 feet to approximately 1.5 miles.

The cases are summarized in Table 6.

The County Line Road traverses north-to-south across the Dresden Cooling Lake. Because of its location, this road is more susceptible to steam fog visibility reductions than any other road near the lake.

Analysis of the observation logs for the period 1 January 1972 through 31 March 1973 showed that visibility along County Line Road (site No. 4) was reduced to 100 feet or lower on twenty-two (22) out of 456 days (cf. Table 7).

The frequency of occurrence of the poor visibilities along County Line Road was attained by logging the lowest observed visibility for each day of the period. Results (Table 8) showed that the twenty-two (22) days represented 4.83 percent of the period. Visibilities up to 25 feet were observed 2.41 percent of the time, visibilities up to 50 feet, 3.73 percent; and, visibilities up to 75 feet, 3.95 percent of the period.

Rime, a milky granular deposit of ice having a density of 0.2 to 0.3 gm/cm^3, was observed on 11 days on vegetation along East Lake (Cottage) Road, approximately 125 feet east of the lake. The accumulations measured are listed in Table 9.

TABLE 6

Cases of Reduced Ground-Level Visibility

Beyond the Dresden Cooling Lake Boundary Due to Steam Fog

Date	Approximate Inland Distance	Lowest Visibility
January 5, 1972	N/A	N/A
January 14, 1972	0.1 to 0.2 mile (mostly above ground)	N/A
January 15, 1972	N/A	250 feet
January 28, 1972	N/A	25-50 feet
January 30, 1972	N/A	Occasional Reduction
February 3, 1972	at least 250 feet	less than 50 feet
February 4, 1972	N/A	less than 50 feet
February 7, 1972	N/A	200 feet
February 9, 1972	N/A	N/A
November 27, 1972	350 feet	100 feet
December 7, 1972	at least 0.7 mile	1000 feet
December 14, 1972	N/A	1/2 mile
December 16, 1972	N/A	No Visibility Reduction
January 9, 1973	N/A	No Visibility Reduction
January 10, 1973	750 feet	100-150 feet
January 26, 1973	1.5 miles	more than 100 feet
February 3, 1973	200 feet	more than 100 feet
February 7, 1973	N/A	No Visibility Reduction
February 8, 1973	N/A	No Visibility Reduction
February 9, 1973	1.5 miles	more than 100 feet
February 11, 1973	250 feet	more than 100 feet
February 16, 1973	N/A	No Visibility Reduction

N/A = Not Available

TABLE 7

Occurrence of Steam Fog Limiting Visibility

To 100 Feet or Less on County Line Road

Date	Time	Lowest Visibility (feet)
4 January 1972	1415, 1615	75
5 January 1972	0820	100
14 January 1972	0815	10
15 January 1972	0840	10
25 January 1972	0820	100
28 January 1972	0820	10
30 January 1972	1015, 1225	50
1 February 1972	0820	25
3 February 1972	1440	30
4 February 1972	0820, 1040, 1435	20
7 February 1972	0800	50
10 February 1972	0815, 1015	25
29 March 1972	1615	25
17 May 1972	0600	50
30 May 1972	0815	20
30 September 1972	0715	30
6 December 1972	0700	20
10 January 1973	0700, 0825, 1015	100
8 February 1973	0700	25
11 February 1973	0655	100
15 February 1973	1215	25
16 February 1973	0615, 0720	40

TABLE 8

Frequency of Occurrence of Days with Visibility

100 Feet or Lower at County Line Road

1 January 1972 - 31 March 1973

Visibility (feet)	Number of Occurrences	%	Cumulative	%
0	0	0.000	0	0.000
5	0	0.000	0	0.000
10	3	0.658	3	0.658
15	0	0.000	3	0.658
20	3	0.658	6	1.316
25	5	1.096	11	2.412
30	2	0.439	13	2.851
35	0	0.000	13	2.851
40	1	0.219	14	3.070
45	0	0.000	14	3.070
50	3	0.658	17	3.728
55	0	0.000	17	3.728
60	0	0.000	17	3.728
65	0	0.000	17	3.728
70	0	0.000	17	3.728
75	1	0.219	18	3.947
80	0	0.000	18	3.947
85	0	0.000	18	3.947
90	0	0.000	18	3.947
95	0	0.000	18	3.947
100	4	0.877	22	4.825
greater than 100	434	95.175	456	100.000

TABLE 9

Frequency of Rime Ice Along Cottage Road

Amount	Trace	1/8"	3/16"	5/16"	3/8"	3/4"	3"	3 1/2"
No. of Occurrences:	1	2	2	2	1	1	1	1

On two of the days indicated above rime ice was also noted on trees along Lorenzo Road, within approximately 300 feet of the lake.

A deposition of rime 200 feet east of pool 1 occurred once when nothing similar was observed elsewhere around the lake. Exact measurements from the above three (3) occurrences were not available, but each is believed to have been less than 1/2 to 3/4 inches.

Considering that the two instances of rime deposition at Lorenzo Road occurred coincidentally with rime deposition at Cottage Road and that rime was only observed during the winter months of December, January and February, the overall frequency of downwind rime icing at distances of 100 feet or greater was found to be 6.6 percent (12 days out of 181). Based on this frequency, one may expect to observe rime deposition beyond 100 feet downwind on 6 days per year.

From time to time during the winter months snow was observed to fall out of the steam fog plume. It occurred typically during the mid-morning hours after sunrise and lasted a short time. When visibility was affected it was usually due to a combination of snow and fog. The character of the snow was light snow, snow showers or flurries. Accumulation on the ground in most cases ranged from a trace to less than 0.25 inches. In all cases

the snow was extremely light and fluffy and would blow off the ground surface with a slight wind. Once 1.75 inches was measured. The inland distance to which deposition was observed ranged up to approximately 1.5 miles. The data for the five days snow was observed are summarized in Table 10.

In summary, the Dresden Nuclear Power Station cooling lake operation affected the immediate environs to varying degrees and in different ways. By far the most frequently observed and, consequently, most significnat aspect of the operation was the production of steam fog. Other related aspects were that under certain meteorological conditions the steam fog deposited a measurable amount of rime ice on trees and other objects over a large area. Snow flakes were also observed to fall out of the steam fog plume. These latter aspects are considered to be of secondary significance in the sense that they occurred infrequently.

Except under rare circumstances, the steam fog effects were localized and primarily confined to the lake itself, including County Line Road where it bisects the lake in a north-south orientation. The primary significant effect of the steam fog was the restriction it placed on local visibility near the ground. Along County Line Road fog-restricted visibility of less than 300 feet occurred nearly three times more often than climatological expectation (75 hours/year as opposed to 23 hours/year). In contrast, no increase over climatological expectation in fog-restricted visibility of less than 500 feet was detected at a continuous recording station located 625 feet southeast of the lake.

TABLE 10

Snowfall From Steam Fog Plumes Off Lake

Date	Observation Point	Time (CST)	Visibility	Amount	Character	Extent
5 January 1972	Cottage Road	0745	N/A	Trace	Very fine snow and sleet	125'
7 December 1972	Lorenzo & Dresden Roads	0700 0830	0.5 - 1 mile	0.25"	Light snow showers	3,000'
14 December 1972	Lorenzo & Dresden Roads	1020	0.5 - 1 mile	0.25"	Light snow showers	3,000'
28 December 1972	Lorenzo Road	0850	N/A	Trace	Flurries	300'
9 February 1973	Interstate 55	0650	1 mile	Trace	Very light snow	1.5 miles
9 February 1973	Cottage Road	0655	1 mile	Trace	Very light snow	125'
9 February 1973	Cottage Road	0835	0.2 mile	0.25"	Large flakes	400'
		0850		1.75"		

On rare occasions meteorological conditions were such that large amounts of steam fog were generated, while light winds and a strong inversion contributed to an unusually persistent fog plume. Instead of the usually rapid mixing with drier air and resultant evaporation, the fog will persist and travel great distances (in excess of one mile) downwind of the lake.

During some of these cases snow flakes, having low liquid water content, fell from the steam fog plume, covering the ground, and/or rime ice was deposited on trees and other objects. These situations almost always developed when abnormally cold (colder than 10 F) stable air masses passed directly over the area, accompanied by light wind and clear sky during the early morning hours.

Subsequent to the onsite observation program conducted by Murray and Trettel, Incorporated (M/T) at the Dresden Nuclear Power Station during 1971-1973, and described in detail in the M/T "Report on Meteorological Aspects of Operating the Cooling Lake and Sprays at Dresden Nuclear Power Station", Report No. 1001-5, 1 August 1973, M/T was requested by Commonwealth Edison Company to return to the Dresden site in 1977. The purpose of this second visit was limited in scope to the observation of fog and/or other impacts along County Line Road. The observation program was conducted beginning 1 November 1977 and continuing through March 1978.

Although the intended purpose of the onsite observation program was narrowly defined to "establish the frequency of visibility reductions along County Line Road, and to determine the effectiveness of certain fog impact control", the data that were collected and summarized in a second

informal "Report on Steam Fog Impact Engineering at Dresden Nuclear Power Station", Report No. 1183, 26 May 1978, were of value for yet another reason, viz, they represented a period when the Dresden plant was operating both units 2 and 3 in a closed-cycle. The fact that these observations were made during an abnormally cold winter enhanced their value.

Fog height and visibility observations from the two studies were compared in this report.

In the earlier study visibility ranges from 0-50 feet were reported on 17 days during the period January 1972 - March 1973 (cf Table 7). This represents 17/456 days or 3.73 percent. During the second study the figure 2.7 percent was reported for County Line Road. The similarity is somewhat surprising considering the differences in plant operation and weather described earlier.

The fog height classifications provided additional insights. Fog frequencies along County Line Road are given in Table 11.

Table 11. Fog Frequencies Along County Line Road

Fog		Frequencies (Percent)	
Description	Height (Ft)	1972-1973	1977-1978
Wisps	0- 10	-	-
Light	10- 40	15.0	21.0
Moderate	40-100	6.2	13.0
Heavy	100 or more	21.3	10.0

The data show light and moderate fog conditions were more frequent during the latter period, whereas heavy fog conditions were more frequent during the former. This implies that heavy fogs won't necessarily increase in frequency when the plant operates closed cycle in unusually cold weather, although less intense fogs may occur more frequently.

Fog and temperature data are summarized in Table 12 for the winter months. No clear relationship between heavy fog frequencies and air temperature are evident.

Table 12. Air Temperatures and Heavy Fog Frequencies - Dresden Site

	MONTH					
	December		January		February	
	1972-1973	1977-1978	1972-1973	1977-1978	1972-1973	1977-1978
Heavy Fog Freq (%)	23.6	5.2	21.3	21.0	16	23
Avg Tmp (MDW)	25	25	29	16	30	17
Normal	29	28	24	24	27	27
Departure	-4	-3	+5	-8	+3	-10

4.0 Conclusions Applicable to Midland Pond

The most significant impact that can be expected from the operation of the Midland cooling pond is the production of steam fog. Except under rare circumstances the fog can be expected to be localized and confined to the pond area. Reduced visibility along Gordonville Road can be expected to occur occasionally during the winter months. Other lesser impacts that can be expected under certain meteorological conditions are the formation of rime ice on trees, bushes and other objects, particularly at or near

the water; and the formation of stratus nebulomutatus clouds several hundred feet above the lake surface. Snow flakes may fall occasionally from the elevated plume, but accumulations should be insignificant.

5.0 General Conclusion

The conclusions drawn in the Final Environmental Statement (NUREG-0537) for the Midland Plant regarding fog and ice are not inconsistent with the Dresden Pond experience. The staff's expectation of frequent periods of dense fog over and south of Gordonville Road during cool weather may be overstated.

APPENDIX

Definitions

The term "wisps" of steam fog implies a very slight intensity of steam fog which is barely visible to the naked eye. Wisps usually rose to heights of 5 to 15 feet above the sprays.

"Light" steam fog was more opaque than "wisps" and it usually rose 10 to 40 feet. Fog of this intensity would usually have a maximum horizontal (downwind) extent comparable to its vertical rise. Also, visibility was usually only slightly reduced in those portions of the plumes close to the sprays.

"Moderate" intensity steam fog lowered the visibility significantly, but the plume tended to diminish and evaporate more readily than did "heavy" steam fog. Heights of moderate steam fog generally ranged from 40 to 100 feet.

"Heavy" intensity steam fog was very opaque and caused serious visibility reductions along its path. Heights varied greatly, depending on the prevailing conditions, sometimes reaching 700 feet into the air.

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- Murray and Trettel, Inc. Temperature Forecasts - July 30, 1965
- Note on Trajectory of Air Parcels - January 20, 1966
- Temperature Forecasts for Midway Airport - March 1, 1966
- Tornado and Severe Thunderstorm Forecast Technique - April 1, 1966
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- A Simplifying Temperature Computation Equation for Verifying Midway Maximum Temperature Under Lake Breeze Situations - November 1966
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- Preliminary Report to CECO, Radiological Monitoring Program Associated with the Accidental Release of Radioactive Gases at Dresden Nuclear Power Station - August 12, 1971 - L. G. Huebner and J. P. Bradley
- Similarity Study of Meteorological Summaries from Zion, Point Beach and Kewaunee Sites - January 13, 1972
- Summary of the Condition of Meteorological Equipment at Dresden, Quad Cities and Zion Stations at the Time of Initial Site Visits September 24, 1971

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket Nos. 50-329 OM
	)	50-330 OM
CONSUMERS POWER COMPANY	)	Docket Nos. 50-329 OL
(Midland Plant, Units 1 & 2)	)	50-330 OL

CERTIFICATE OF SERVICE

I, Rebecca J. Lauer, one of the attorneys for Consumers Power Company, hereby certify that copies of the following were served upon all persons shown in the attached service list by deposit in the United States mail, first class, this 15th day of February, 1983; except where service was made as otherwise indicated.

1. February 14, 1983 letter from Philip P. Steptoe to the Administrative Judges regarding Applicant's testimony on Sinclair Operating License Contention 14.

2. "Testimony of Donald H. Evans and David A. Sommers on Cooling Pond Performance Studies."

3. "Testimony of John Bradley on Sinclair Contention 14 (Dresden Fogging and Icing Studies)".

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