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STATE OF ILLINOIS
POLLUTION CONTROL BOARD

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

ILLINOIS POWER COMPANY (Clinton Power Station), Petitioner, v. ILLINOIS ENVIRONMENTAL PROTECTION AGENCY, Respondent,	)	PCB No. 92-153 (§ 302.211(f) Hearing)

PETITION FOR HEARING ON HEATED EFFLUENT DEMONSTRATION PURSUANT TO 35 ILL. ADM. CODE § 302.211(f)

In accordance with Title VII of the Environmental Protection Act, Ill. Rev. Stat. 1991, ch. 111½, §§ 1026-29; 35 Ill. Adm. Code Part 106, Subpart A; and 35 Ill. Adm. Code § 302.211,[1] Illinois Power Company ("Illinois Power") hereby submits this petition for a hearing to allow Illinois Power to make the heated effluent demonstration required by § 302.211(f) with respect to the recirculated condenser cooling water discharge to Clinton Lake from Illinois Power's Clinton Power Station (the "Station"). After Illinois Power has had an opportunity to make this demonstration in a hearing, Illinois Power asks the Illinois Pollution Control Board ("Board"), in accordance with § 302.211(f), to find that the recirculated condenser cooling water discharge to Clinton Lake from the Station has not caused, and cannot be reasonably expected to cause, significant ecological damage to the receiving waters.

In support of this petition, Illinois Power states:

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[1] Unless otherwise stated, references hereinafter to "§ xxx.xxx" are to the corresponding section of the Board's rules under Title 35 of the Illinois Administrative Code (35 Ill. Adm. Code).

General Plant Description

1. For its General Plant Description required by § 106.102(a), Illinois Power incorporates by reference paragraphs 1 through 7 of its Petition for Hearing to Determine Specific Thermal Standards Pursuant to 35 Ill. Adm. Code § 302.211(j), filed in PCB 92-142 (the "302.211(j) Petition").[2] Illinois Power also incorporates by reference Figure 1 and Tables 1 and 2 from the 302.211(j) Petition.

Description of Method for Heat Dissipation

2. For its Description of Method for Heat Dissipation and summary information on discharge temperatures required by § 106.102(b), Illinois Power incorporates by reference paragraphs 8 through 16 of the 302.211(j) Petition, as well as Figure 2, Table 3 and Exhibit 1 from the 302.211(j) Petition.

Actual Plume Studies

3. Thermal plume data have been collected on the Salt Creek arm of Clinton Lake. Data were collected in order to document the shape and extent of the thermal plume attributable to the recirculated condenser cooling water discharge from the Station to Clinton Lake, as well as to document movement of the plume both upstream and downstream from the mouth of the discharge canal.

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[2] Concurrently with the filing of the present petition, Illinois Power is filing a Motion to Consolidate Proceedings, requesting the Board to consolidate the proceedings on the present petition with the proceedings in PCB 92-142. The Motion to Consolidate Proceedings also asks the Board to waive the requirement of § 101.106 [Incorporation of Prior Proceedings], that Illinois Power file in the present proceeding four copies of all the materials from PCB 92-142 which are incorporated by reference herein. In the event the Board denies either the request to consolidate proceedings or the request to waive certain requirements of § 101.106, Illinois Power will file four copies of those materials from PCB 92-142 which are to be incorporated in this proceeding.

4. Lake temperature data consisted of instantaneous near-surface and depth profile measurements collected at sites near the mouth of the condenser cooling water discharge canal; i.e., the flume discharge. Instantaneous temperatures of the lake surface were monitored along various transects in 1989, 1990, and 1991. (See Figure 4 to the 302.211(j) Petition, hereby incorporated by reference.) In 1989 lake surface temperatures along the transects were measured on six days during June through September. In 1990 surface temperatures were measured along ten transects once during May and then once-monthly along twelve transects during June through September. Temperatures were measured along the same twelve transects once-monthly during April through October in 1991. Each transect was established along a straight line going generally from the north side of the lake to the south side using distinctive shoreline features as markers. Surveys were always run from north to south using the same boat, operating at idle speed. Readings were taken at the surface of the water along each transect at 15 second intervals. Temperatures were recorded in centigrade to the tenth of a degree in a field notebook.

5. Other pertinent information also was recorded at the time of instantaneous surface temperature data collection. This included time, weather conditions, wind speed and direction, approximate lake level, approximate plant load, and air temperature.

6. Depth profiles of lake temperatures were collected once-monthly in 1989-1991 in May through September and during the months of March and November at various lake sites as part of the Operational Environmental Monitoring Program. These sites are identified in Figure 5 to the 302.211(j) Petition, which is hereby incorporated by reference. Additional depth profiles of lake temperatures were collected twice-monthly April through October during 1989-1991 at the sites identified in Figure 6.2 of Exhibit 3 to the 302.211(j) Petition. The once-monthly profile data at site 2 (Figure 5) and the twice-monthly profile data at segment 16 (Exhibit 3, Figure 6.2)

collected during the periods of the transect measurements were used to configure the thickness of the thermal plume.

7. The distribution of temperatures as measured by Illinois Power throughout Clinton Lake during the late spring through early fall periods of 1987 through 1991 is presented and discussed in two reports prepared by Illinois Power pursuant to the requirements of the Station's NPDES permit: (1) The Environmental Monitoring Program Water Quality Report, 1978-1991 (1992), submitted as Exhibit 2 to the 302.211(j) Petition; and (2) the Environmental Monitoring Program Biological Report, Comparison of Preoperational Data (1983-1986) with Operational Data (1987-1991) (1992), submitted as Exhibit 3 to the 302.211(j) Petition. Exhibits 2 and 3 to the 302.211(j) Petition are hereby incorporated by reference. Temperature profile monitoring information is discussed in Section 8.1 of Exhibit 2, and also in Chapter 6 of Exhibit 3.

8. Actual plume studies prepared by J.E. Edinger Associates, Inc. ("Edinger"), are presented in Exhibit HE-1 submitted herewith.[3] The actual plume studies are limited to data developed during field observations of the Station thermal plume in 1989, 1990, and 1991. No observations were made in 1987 or 1988. The observations consist of continuous, near-surface (six-inch deep) temperature traces over the transects described in paragraph 4 above, and the depth profiles described in paragraph 6 above.

9. Based on these actual observations, the near-field component of the thermal plume can be identified, and is defined as that part of the plume that is three-dimensional, with distinct longitudinal, lateral and vertical variations in temperature. The data show that the near-field component is confined to the 1600-meter area between transects 4 and 7. (See Exhibit 1 to Exhibit HE-1.) That is, the near-field component of the plume extends up the lake as far as 600 meters

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[3] Exhibits which are referenced for the first time in this heated effluent petition are designated with the prefix "HE-" (for Heated Effluent), to distinguish them from those Exhibits to the 302.211(j) Petition which are being incorporated by reference in the present petition.

from the flume discharge (near the Rt. 14 bridge) and down the lake as far as 1000 meters from the discharge, and varies in thickness to a depth of 2.5 meters. During 1989-1991, temperatures monitored from April through September throughout the near-field area ranged from approximately 80°F to 104°F. (See Exhibits 6-8 to Exhibit HE-1.) The theoretical behavior of the near-field component of the thermal plume under typical and worst case conditions is addressed in Edinger's theoretical plume studies report, discussed at paragraphs 11-14 below.

10. The plume also extends into the far-field, in which waste heat from the discharge is carried throughout the cooling loop (which extends around the lake from the discharge to the intake) and dissipated to the atmosphere across the water surface. Excess temperatures attributable to the thermal discharge fall off rapidly away from the discharge, with significant excess temperatures found only within the first 3000 meters of the cooling loop. In fact, the excess temperature (i.e., the increase in temperature caused by the thermal discharge) reduces to less than 2°C within 8000 meters down-lake from the discharge. At the dam (approximately half-way around the cooling loop, the excess temperature is only 0.6°C. At the intake structure (i.e., the end of the cooling loop) excess temperatures were determined to be approximately 0.5°C. Such observations are the basis for Edinger's selection of a far-field plume region consisting of the entire cooling loop area of the lake, as well as the near-field region discussed above, for purposes of the theoretical study. As the transect data demonstrates, in the far-field region the distribution of temperature is generally homogeneous across the width of the lake. (See Exhibit HE-1, Appx. A.)

Theoretical Plume Studies

11. The distributions of theoretical temperatures throughout Clinton Lake (a) for all four seasons of the year and (b) for the combination of meteorological and Station operating conditions that would result in typical and worst case lake water temperatures are presented in the theoretical plume studies performed by Edinger, submitted herewith as Exhibit HE-2. Exhibit HE-2 presents

theoretical plume results in two parts, consisting of the far-field plume results as computed from GLVHT and the near-field plume results as computed from GLLVHT.[4] Theoretical lake water temperatures are determined by adding the excess temperatures computed by GLVHT or GLLVHT to the ambient temperatures computed using a response temperature model. Near-field and far-field plume results are presented for both worst case and typical conditions.

12. The worst case conditions are defined as those that would occur, by season, under conditions of maximum ambient temperature (i.e., once-in-thirty-year meteorological conditions), full load and minimum dilution and flushing. For the far-field simulation, these results are shown for the winter, spring, summer and fall cases in Exhibits 6-9 to Exhibit HE-2. These exhibits show the warmest temperatures in the vicinity of the discharge, with rapid fall off in temperature within 5000-10,000 feet, and a more gradual fall off in temperature to the intake. For example at the Rt. 14 bridge, which is approximately 1000 meters from the flume discharge, surface temperatures during the worst-case summer are predicted to be 37.9°C (100.3°F). Midway across the lake offshore from the Mascoutin State Recreational Area (approximately 6000 meters from the flume discharge), surface temperatures are predicted to be approximately 35°C (95°F). At the dam (approximately 12,000 meters from the flume discharge), worst-case summer surface temperatures are predicted to be 33.4°C (92.2°F).

13. The near-field results for the worst-case simulations for each of the four seasons are shown in Exhibits 10-13 to Exhibit HE-2. These exhibits show a slight down-lake movement of the

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[4] The response temperature model and GLVHT (or Generalized Longitudinal Vertical and Hydrodynamics and Transport) model are discussed in the 302.211(j) Petition, beginning at paragraph 21, and in Exhibit 4 to the 302.211(j) Petition. In Exhibit 4, Edinger re-verified the response temperature and GLVHT models as applied to Clinton Lake. Paragraphs 20 through 23 of the 302.211(j) Petition, and Exhibit 4 thereto, are hereby incorporated by reference in the present petition. The GLLVHT (or Generalized Longitudinal Lateral Vertical and Hydrodynamics and Transport) model is constructed similar to the GLVHT model for the region to which it is applied, and adds a third (i.e., lateral) dimension. (Exhibit HE-2, pp. 6-7.)

plume, consistent with the condition of no freshwater inflow but with Station pumping. The isotherms for the near-field model show lake surface temperatures in the immediate vicinity of the flume discharge which are somewhat higher than the corresponding far-field model results, due to the additional detail supplied by the near-field model. (The far-field model predicts average temperatures throughout the entire lake segment.) The diagrams also show stratification to mid-depth of several degrees centigrade, consistent with the far-field model results as well as the observations. Furthermore, stratification is greater adjacent to the discharge; i.e., as much as 4-5°C in the vicinity of the discharge. During the worst-case summer surface temperatures may reach 107.6°F (42°C) as far offshore as 750 feet from the flume discharge, corresponding to 110.7°F (43.7°C) at the discharge.

14. The typical condition far-field plumes are shown in Exhibits 14-17 to Exhibit HE-2. The typical condition ambient temperature in the winter is low enough that the lake can cool to temperatures less than 4°C, which is the temperature at which the density of water is a maximum. As shown in Exhibit 14, the 4°C water begins to sink to lower levels in parts of the lake and results in temperature inversions (i.e., ice covering) up the North Branch arm of the lake toward the Station intake. The near-field predictions are shown in Exhibits 18-21 to Exhibit HE-2. During a typical summer, surface temperatures of approximately 36°C (97°F) would be expected to extend as far as 750 feet offshore from the flume discharge. The shape of the plumes are essentially the same configuration as those found for the worst-case predictions.

Summary of Observed Biological Data

15. For its description of biological studies on the receiving waters of Clinton Lake, as required by § 106.102(d)(1), Illinois Power incorporates by reference paragraphs 24 through 42 and Figures 5 through 14 from the 302.211(j) Petition. The incorporated materials discuss several trophic levels of aquatic biota in Clinton Lake and indicate that impacts were limited to small areas

adjacent to the discharge and for short time periods. These impacts did not have significant negative effects on the aquatic communities of Clinton Lake, and in several communities a net annual increase was noted in abundance and production.

16. For its description of the impact on other animal life (wildfowl, amphibians, etc.) in and around Clinton Lake as a result of the thermal discharge, as required by § 106.102(d)(2), Illinois Power incorporates by reference paragraphs 43 through 46 of the 302.211(j) Petition. The incorporated materials reflect no observations of any negative impacts to such other animal life, and no evidence that such impacts are occurring.

Impacts on Recreation

17. For its description of the possible and known impacts on recreation in and around Clinton Lake as a result of the thermal discharge, as required by § 106.102(d)(3)(A), Illinois Power incorporates by reference paragraphs 47 through 51 and Figure 15 from the 302.211(j) Petition. The incorporated materials reflect no observations of any negative impacts on such recreation, and no evidence that such impacts are occurring.

Management Practices to Limit Thermal Effects

18. For its description of management practices employed or planned in order to limit the environmental effects attributable to the thermal discharge, as required by § 106.102(d)(3)(B), Illinois Power incorporates by reference paragraphs 52 through 55 from the 302.211(j) Petition. The incorporated materials indicate that Illinois Power has policies and procedures in place, and implements appropriate training of its personnel, to assure compliance with the thermal standards and other environmental requirements applicable to the recirculated condenser cooling water discharge from the Station to Clinton Lake.

Demonstration Pursuant to §§ 106.102(d) and 302.211(f)

19. The Board's Water Pollution regulations, at § 302.211(f), require Illinois Power, as the owner or operator of a source of heated effluent which discharges 150 megawatts (0.5 billion BTU/hr) or more (i.e., the Station) to demonstrate in a hearing before the Board, not less than 5 nor more than 6 years after the commencement of operation, that discharges from the Station have not caused and cannot be reasonably expected to cause significant ecological damage to the receiving waters (i.e., Clinton Lake). The applicable procedural regulations, at § 106.102(d)(4), provide that the required showing under § 302.211(f) may take the form, inter alia, of a showing pursuant to § 302.211(j).

20. Illinois Power satisfies the requirements for a showing under § 302.211(j) for the reasons stated in paragraphs 56 through 86 and Exhibits 5 through 9 of the 302.211(j) Petition, all of which are hereby incorporated by reference. Specifically:

a. Illinois Power satisfies the requirements of § 302.211(j)(1), that all discharges from Clinton Lake to other waters of the State comply with the applicable provisions of § 302.211(b)-(e), for the reasons stated in paragraphs 59 through 61 of the 302.211(j) Petition;

b. Illinois Power satisfies the requirements of § 302.211(j)(2), that the heated effluent discharged to Clinton Lake via the discharge flume complies with all other applicable provisions of the Board's rules, for the reasons stated in paragraphs 62 and 63 of the 302.211(j) Petition;

c. Illinois Power satisfies the requirements of § 302.211(j)(3)(A), that Illinois Power's requested thermal standards will continue to allow for provision of conditions at Clinton Lake capable of supporting shellfish, fish and wildlife, and recreational uses consistent with good management practices, for the reasons stated in paragraphs 65 through 80 and Exhibits 5 through 7 of the 302.211(j) Petition; and

d. Illinois Power satisfies the requirements of § 302.211(j)(3)(B), that it provide for control of the thermal component of the effluent from the Station by a technologically feasible and economically reasonable method, for the reasons stated in paragraphs 81 through 86 and Exhibits 8 and 9 of the 302.211(j) Petition.

21. Note that, for the existing thermal standards and for those standards applicable to Clinton Lake during the period of time which is the subject of the § 302.211(f) demonstration,

Illinois Power satisfies the requirements of § 302.211(j)(3)(A), that those thermal standards have allowed for provision of conditions at Clinton Lake capable of supporting shellfish, fish and wildlife, and recreational uses consistent with good management practices, for the reasons stated in paragraphs 24 through 51 and Exhibit 3 of the 302.211(j) Petition. Illinois Power also satisfies the requirements of § 302.211(j)(3)(B), that it has provided for control of the thermal component of the effluent from the Station by a technologically feasible and economically reasonable method, for the reasons stated in paragraphs 52 through 55 and 81 of the 302.211(j) Petition.

22. Because Illinois Power satisfies all of the requirements for a showing pursuant to § 302.211(j), Illinois Power also satisfies the requirements for a demonstration pursuant to §§ 106.102(d) and 302.211(f). Illinois Power therefore is entitled to a determination by the Board, that the recirculated condenser cooling water discharge from the Station has not caused, and cannot be reasonably expected to cause, significant ecological damage to the receiving waters of Clinton Lake.

Consistency with Federal Law

23. The relief requested in the present petition, a determination by the Board that the recirculated condenser cooling water discharge from the Station has not caused, and cannot be reasonably expected to cause, significant ecological damage to the receiving waters of Clinton Lake, has no parallel under federal law. In fact, federal law most likely is not implicated by the present petition, since Illinois Power is merely asking the Board to make a factual determination, and is not requesting the Board to impose any new or different thermal standards or otherwise to regulate or not regulate any discharges to Clinton Lake. The relief requested by Illinois Power thus would appear to be, at a minimum, not inconsistent with federal law.[5]

[5] If the Board determines that Illinois Power has not made the showing under § 302.211(f) to the Board's satisfaction, then the Board has the authority to order that Illinois Power take certain corrective action within a reasonable time as determined by the Board. This petition does not address whether such corrective action would be, or would not be, consistent with federal law.

24. In its 302.211(j) Petition, Illinois Power is requesting the Board for additional relief in the form of specific thermal standards. The Board most likely will be required to consider the potential ecological impacts of the thermal standards requested in the 302.211(j) Petition in order to make the prospective determination required under § 302.211(f), that the recirculated condenser cooling water discharge from the Station "cannot be reasonably expected to cause significant ecological damage" to Clinton Lake. The relief requested in the 302.211(j) Petition is consistent with federal law for the reasons stated therein (and hereby incorporated by reference), at paragraphs 87 and 88.

Request for Hearing; Summary of Evidence

25. The Board's rules governing heated effluent demonstrations, §§ 106.101 et seq. and § 302.211(f), require that such demonstrations be made at an adjudicative hearing before the Board. Illinois Power therefore requests that the Board schedule a hearing on the present petition in accordance with § 106.105.

26. In support of the factual assertions herein, Illinois Power incorporates by reference Figures 1 and 2, Figures 4 through 15 and Tables 1 through 3 to the 302.211(j) Petition, as well as Exhibits 1 through 9 thereto. Illinois Power also incorporates by reference Exhibits 10 through 14 to the 302.211(j) Petition, consisting of, respectively, the affidavits of Thomas L. Davis, John E. Edinger, Ph.D, Gary D. Matthews, James A. Smithson, and Edward F. Stoneburg.

27. Illinois Power also is submitting Exhibits HE-1 and HE-2, which were not referenced in the 302.211(j) Petition. As further support for the factual assertions in these Exhibits, Illinois Power submits the Supplemental Affidavit of James A. Smithson and the Supplemental Affidavit of John E. Edinger, Ph.D., as Exhibits HE-3 and HE-4, respectively. Exhibits HE-1 through HE-4 are being submitted concurrently herewith in a separately-bound volume.

WHEREFORE, Illinois Power respectfully requests the Board to schedule a hearing herein to allow Illinois Power to make the demonstration required by §§ 106.102(d) and 302.211(f), and thereafter to enter an order including a finding that the recirculated condenser cooling water discharge to Clinton Lake from the Station has not caused, and cannot be reasonably expected to cause, significant ecological damage to the receiving waters.

Respectfully submitted,

ILLINOIS POWER COMPANY

By: Eric L. Lohrenz
One of its Attorneys

Sheldon A. Zabel
Eric L. Lohrenz

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CERTIFICATE OF SERVICE

I, Eric L. Lohrenz, hereby certify that on October 14, 1992, I served the foregoing Notice of Filing and documents referenced therein, by causing the requisite number of copies to be hand-delivered to:

Dorothy M. Gunn, Clerk
Illinois Pollution Control Board
100 W. Randolph St., Suite 11-500
Chicago, Illinois 60601

and by causing a copy to by sent by the United States mail, properly addressed, first-class postage prepaid, to:

Illinois Environmental Protection Agency
Enforcement Programs
2200 Churchill Road
Springfield, Illinois 62706

Eric L. Lohrenz

One of the Attorneys for Petitioner
Illinois Power Company

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ILLINOIS POWER COMPANY'S
ADDITIONAL EXHIBITS IN SUPPORT OF
PETITION FOR HEARING ON
HEATED EFFLUENT DEMONSTRATION
PURSUANT TO 35 ILL. ADM. CODE
§ 302.211(f)

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ILLINOIS POWER COMPANY'S ADDITIONAL EXHIBITS IN SUPPORT OF PETITION FOR HEARING ON HEATED EFFLUENT DEMONSTRATION PURSUANT TO 35 ILL. ADM. CODE § 302.211(f)*

Tab No.	Description
1	**Exhibit HE-1.** Actual Plume Studies for Heated Effluent Demonstration, Section 106.102(c)(1), prepared by J.E. Edinger Associates, Inc.
2	**Exhibit HE-2.** Theoretical Plume Studies for Heated Effluent Demonstration, Section 106.102(c)(2) and (3), prepared by J.E. Edinger Associates, Inc.
3	**Exhibit HE-3.** Supplemental Affidavit of James A. Smithson.
4	**Exhibit HE-4.** Supplemental Affidavit of John E. Edinger, Ph.D.

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* Illinois Power Company also is incorporating by reference Exhibits 1 through 14 to its Petition for Hearing to Determine Specific Thermal Standards Pursuant to 35 Ill. Adm. Code § 302.211(j), pending before the Illinois Pollution Control Board in PCB 92-142, as exhibits in support of the present petition.

Exhibit HE-1

Clinton Power Station

Actual Plume Studies for Heated Effluent Demonstration Section 106.102(c)(1)

Prepared for

Environmental Affairs Department
Illinois Power Company
500 South 27th Street
Decatur, IL 62525

Prepared by

J. E. Edinger Associates, Inc.
37 West Avenue
Wayne, Pennsylvania 19087-3226

October 6, 1992

Document No. 92-122-R

Introduction

The Illinois Pollution Control Board Heated Effluent Demonstration regulation (Title 35, Subpart A, Section 106.102(c)(1)) requires that actual plume studies be conducted for a heated effluent during the first five years of discharge correlated to station operation and meteorological conditions. Clinton Lake near-surface temperatures were measured once a month, generally May through September, 1989 through 1991, along several transects near the flume discharge. These temperature data were studied by J. E. Edinger Associates, Inc. in order to identify the extent of the thermal plume in the lake during those periods.

Field Observations

Field observations of the CPS thermal plume were made in 1989, 1990 and 1991. No observations were made in 1987 or 1988. The observations consist of continuous, near-surface (six-inch depth) temperature traces over the 12 transects shown in Exhibit 1. This set of observations will be referred to as the transect data. In 1990 and 1991, observations were made at 12 transects; in 1989 observations were made at transects 1 through 10. The dates of the transect surveys are shown in Exhibit 2, which also shows CPS load for the survey dates.

Exhibit 2 also shows dates for supporting vertical temperature profile data from monthly observations collected for water quality purposes and bimonthly observations collected for biological assessment purposes. The bimonthly observations were collected near the center of the longitudinal-vertical model segments. Sites for these two data sets are shown on Exhibits 3 and 4. Each of these data sets includes a site in the immediate vicinity of the discharge that provides vertical temperature detail for the thermal plume. The Site 2 (Exhibit 3) monthly observations were collected immediately adjacent to the discharge. The Site 16 (Exhibit 4) bimonthly observations were collected closest to the discharge. The remaining sites from both data sets provide longitudinal-vertical temperatures throughout the lake.

Near-field Plume

Exhibit 5 shows the transect data for July 11, 1989, a day on which the CPS operated at full load. Significant temperature variations along the transects in the lateral direction attributable to the discharge are found only between transects 4 and 7. Similar data for all of the surveys conducted when the CPS load exceeds 90% of capacity are presented in Appendix A for 1989, 1990 and 1991, along with ambient environmental conditions for the dates of the transect surveys. An examination of these surveys also shows that significant temperature variations along the transects are found only between transects 4 and 7. Transect 4 is approximately 600 m above the discharge and transect 7 is approximately 1000 m below the discharge (Exhibit 1).

Exhibits 6, 7 and 8 show surface details of the thermal plume between transects 4 and 7 for a date selected from each year when the CPS load was at or near 100%. These dates also represent late-May, mid-July and late-August periods and so cover much of the summer. The exhibits show temperature contours that radiate from the discharge structure; this behavior is characteristic of discharges dominated by buoyancy.

Vertical profile data at Sites 2 and 16 for the dates corresponding to Exhibits 6, 7 and 8 are shown in Exhibit 9. These data come either from the monthly or the bi-monthly data sets and, together with the transect data, furnish a three-dimensional view of the thermal plume.

The near-field plume is a relatively confined, buoyant and stratified plume that is well mixed laterally a short distance from the discharge structure. The plume is also well mixed to half the depth of water and lies on top of cooler bottom water. This behavior is consistent with a low momentum, buoyant discharge in an ambient flow field induced primarily by plant pumping and density effects. The size of the near-field plume is determined primarily by the Station heat rejection rate and secondarily by the Station pumping rate. The location of the upstream convergence of isotherms shown in Exhibits 6, 7 and 8 is determined by freshwater inflow from Salt Creek. Since the transect data show that there are only small variations in the lateral between transects 4 and 7, the near-field plume is not distinguishable downstream of the Route 14 bridge nor upstream of the Route 48 bridge (Exhibit 1).

Far-field Plume

The plume extends into the far-field, in which waste heat from the discharge is carried throughout the lake and dissipated to the atmosphere across the water surface. This far-field behavior can be demonstrated by examining the lake-wide data. Exhibit 10 shows the longitudinal-vertical temperatures from the bi-monthly survey for August 22, 1989. This date represents another occasion with CPS load near 100% and is simultaneous with transect data, shown in Appendix A. The extent of the lake affected by CPS waste heat can be approximated first by defining an ambient temperature, and then computing rises above that ambient. In this case ambient can be estimated by using the lowest observed temperature, 25.1 C. This temperature can be found at Segment 3 (Exhibit 4) at 2.5 m depth and again at Segment 5 at 6.5 m depth, both near the CPS intake. Since the observed data set does not cover the entire lake and since Segment 5 may be affected by waste heat, this estimated ambient may be slightly high. The longitudinal distribution of excess temperature, computed as the difference between observed temperatures and the estimated ambient temperature for August 22, 1989, is as follows:

segment	3	5	8	10	12	14	16	18
temp., C	25.3	25.6	25.7	26.0	27.4	30.5	34.7	27.8
excess temp. °C	0.2	0.5	0.6	0.9	2.3	5.4	9.6	2.7

The excess temperatures fall off rapidly away from the discharge. Excess temperatures reduce to less than 2°C 8000 m from the discharge in the direction of the intake and are barely detectable near the intake (Segment 3 and 5).

Summary

Examination of the Clinton Lake data shows that it is important to distinguish between the far-field and near-field thermal plumes. Because of the recirculating nature of the CPS cooling water system, much of Clinton Lake is subject to a rise in temperature over what might have occurred naturally. The field data from these near field and far field regions show that the cooling loop area of the lake extends from Segment 16 through to Segment 4 as shown in Exhibit 4. The excess temperatures shown above, as well as the results of the analyses in Edinger Associates (1992), indicate that only the cooling loop area of the lake is more than marginally affected by waste heat from the CPS.

Reference

Edinger Associates. 1992. Clinton Lake Hydrothermal Modeling Verification for 1989, 1990, 1991 and Determination of Adequacy of Variance Limits for Clinton Station. Exhibit X of Clinton Station Condenser Cooling Water and Cooling Lake Discharge Temperature Evaluations. Document 92-121. September 22.

Exhibit 1. Thermal plume transect locations, Clinton Lake, Clinton, Illinois.

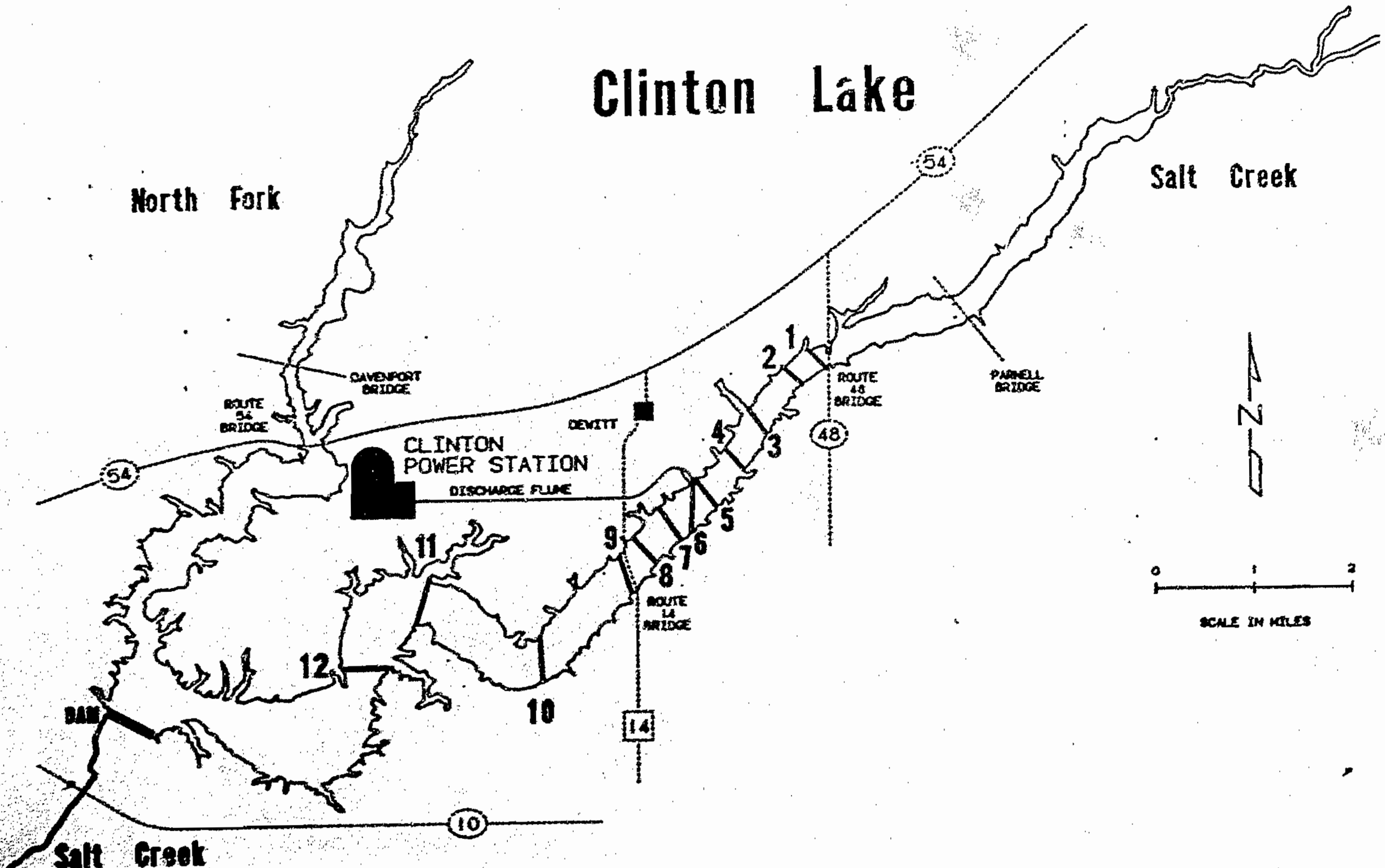

Exhibit 2. **Thermal plume survey dates.** The survey types include the surface plume measurements in the vicinity of the discharge (transect), the monthly vertical profile observations made for the Environmental Monitoring Program (monthly), and the bimonthly vertical profile observations that coincide with the longitudinal-vertical model segments (bi-monthly). The latter two types of observations were made throughout Clinton Lake. **Highlighted** entries indicate data discussed in this section.

date	survey type	CPS load, %
4/11/89	monthly	0
5/9/89	monthly	0
6/5/89	monthly	0
6/6/89	bi-monthly	0
6/27/89	transect	83
6/27/89	bi-monthly	83
7/11/89	**transect**	**99**
7/11/89	**bi-monthly**	**99**
7/24/89	bi-monthly	0
7/25/89	monthly	1
7/28/89	transect	58
8/7/89	bi-monthly	6
8/11/89	transect	62
8/22/89	**bi-monthly**	**100**
8/22/89	**transect**	**100**
8/29/89	monthly	99
9/12/89	monthly	99
9/25/89	transect	68
10/12/89	monthly	85
11/7/89	monthly	85
4/24/90	monthly	10
5/24/90	bi-monthly	99

date	survey type	CPS load, %
5/29/90	**transect**	**99**
5/29/90	**monthly**	**99**
6/15/90	bi-monthly	98
6/27/90	monthly	94
6/28/90	bi-monthly	94
6/30/90	transect	93
7/18/90	bi-monthly	0
7/25/90	monthly	0
7/26/90	bi-monthly	0
7/30/90	transect	91
8/10/90	transect	90
8/13/90	bi-monthly	89
8/28/90	monthly	83
8/29/90	bi-monthly	82
8/29/90	transect	82
9/11/90	bi-monthly	79
9/17/90	transect	77
9/19/90	monthly	76
9/28/90	bi-monthly	74
10/11/90	monthly	70
11/2/90	monthly	0
11/13/90	monthly	0
4/5/91	bi-monthly	99
4/24/91	**transect**	**99**
4/24/91	**bi-monthly**	**99**
5/7/91	bi-monthly	97
5/30/91	transect	100
5/31/91	bi-monthly	100

date	survey type	CPS load, %
6/10/91	bi-monthly	100
6/26/91	transect	98
7/8/91	bi-monthly	99
7/24/91	bi-monthly	98
7/25/91	transect	99
8/9/91	bi-monthly	100
8/22/91	**bi-monthly**	**99**
8/22/91	**transect**	**99**
9/9/91	bi-monthly	100
9/23/91	transect	99
10/9/91	bi-monthly	na
10/31/91	bi-monthly	na
10/31/91	transect	99

Exhibit 3. Environmental monitoring program sampling sites, Clinton Lake, Clinton, Illinois.

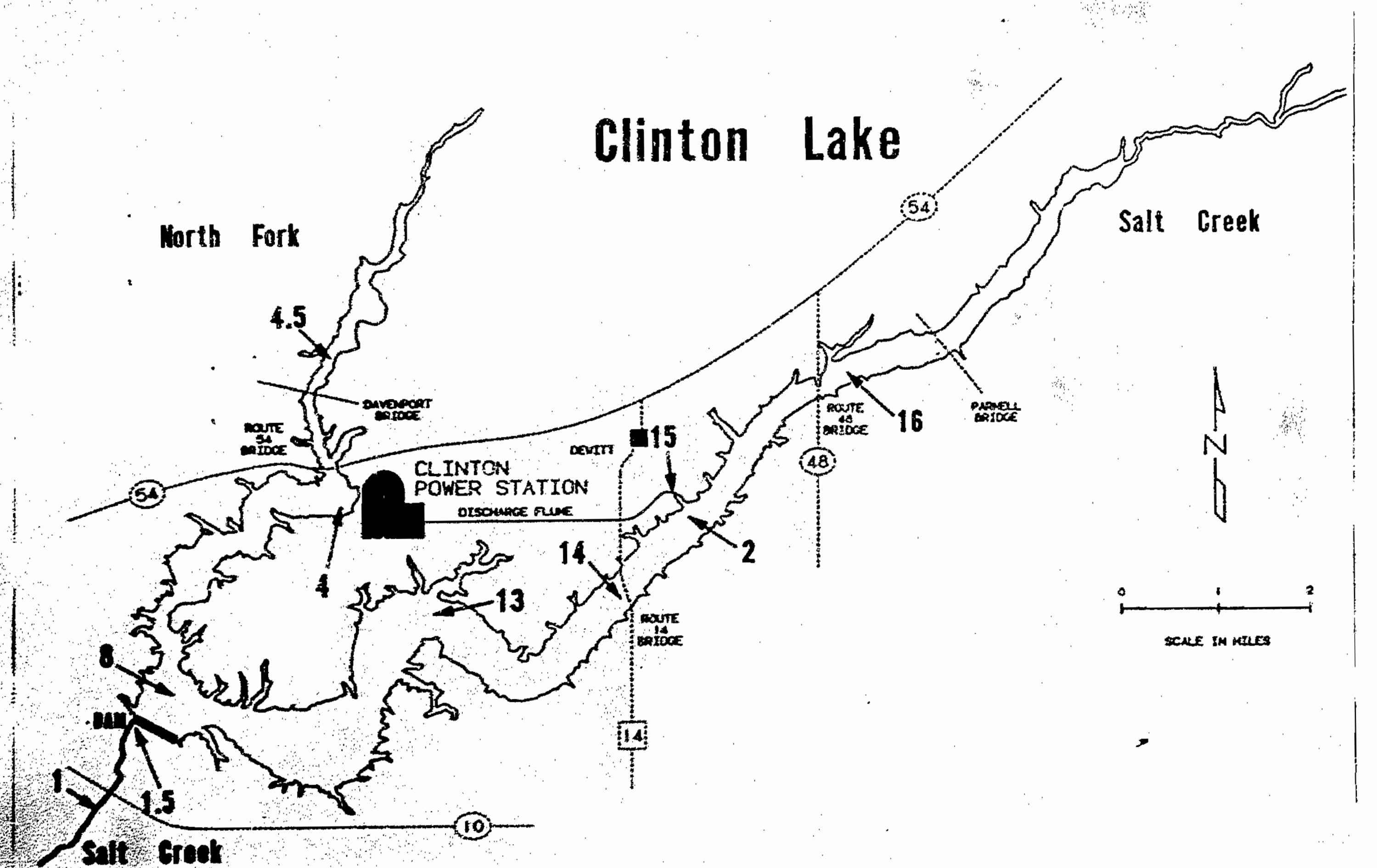

Exhibit 4. GLVHT model segments and bi-monthly sampling sites, Clinton Lake, Clinton, Illinois.

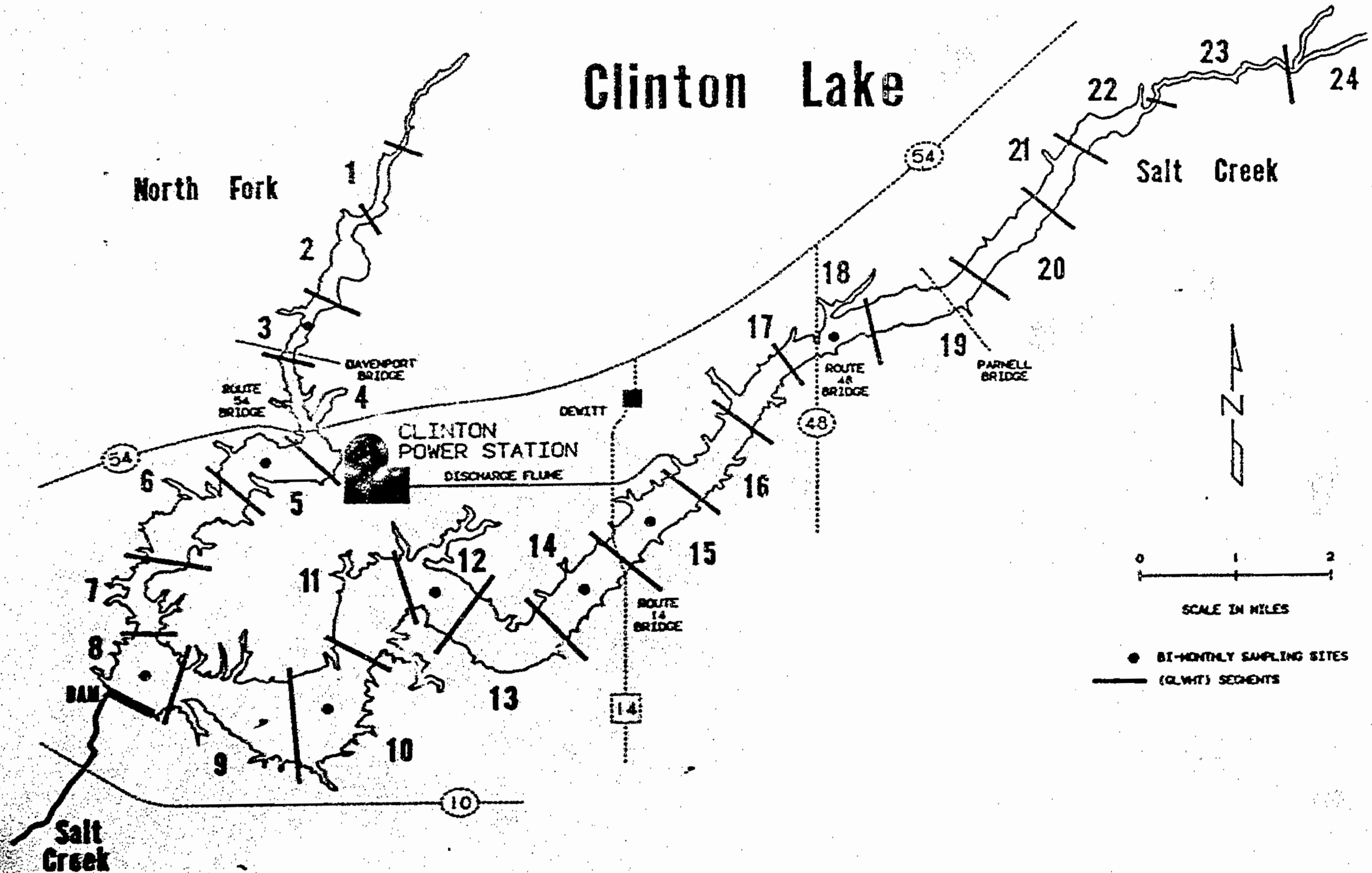

Exhibit 5. Transect temperature data (C) for July 11, 1989. The transect locations are identified in Exhibit 1. Temperatures begin at the top of the column with north shore values and proceed to the south shore. The CPS discharge is located at the north shore of transect 5. Note that transect 6 also begins near the CPS discharge but is directed both across and down Clinton Lake.

transect									
10	9	8	7	6	5	4	3	2	1
33.0	35.5	35.9	36.7	39.7	39.6	37.0	35.8	35.8	34.7
33.0	35.5	35.8	36.8	39.7	39.6	37.0	36.5	35.7	34.9
33.0	35.1	35.8	37.1	39.6	39.6	37.0	36.0	35.2	34.9
33.1	35.3	35.8	37.1	39.3	39.1	37.2	36.1	35.1	34.8
33.1	35.1	35.9	37.2	39.4	38.4	37.4	36.2	35.1	34.8
33.3	35.3	36.0	37.3	38.8	38.8	37.2	36.3	35.1	34.9
33.3	35.6	36.0	37.3	38.8	38.8	37.3	36.6	35.3	34.9
33.3	35.6	36.0	37.3	38.5	38.8	37.4	36.7	35.3	34.9
33.2	35.1	36.1	37.3	38.7	38.8	37.4	36.6	35.5	34.8
33.2	35.0	36.1	37.4	38.4	38.7	37.4	36.7	35.7	35.4
33.1	34.8	36.2	37.5	38.5	38.0	37.4	36.8	35.6	35.1
33.0	34.8	36.2	37.5	38.3	38.0	37.4	36.8	35.8	35.3
32.9	34.8	36.2	37.5	38.1	38.1	37.4	36.8	35.9	35.4
33.0	34.9	36.3	37.5	38.0	37.9	37.4	36.9	36.0	35.5
33.0	34.8	36.5	37.5	38.0	37.8	37.3	36.9	36.0	35.5
33.0	34.8	36.4	37.5	38.0	37.8	37.4	36.9	36.1	35.5
33.0	35.3	36.5	37.5	37.8	37.8	37.4	36.9	36.1	
32.9	34.9	36.5	37.5	38.0	37.7	37.4	37.0	36.0	
32.8	34.9	36.5	37.5	38.0	37.7	37.4	37.0		
32.9	34.4	36.6	37.6	37.9	37.7	37.4	37.0		
32.9	34.4	36.5	37.6	37.8	37.8	37.4	37.0		
33.0	34.3	36.5	37.6	37.8		37.4			
33.1	34.4	36.5	37.6	37.7					
33.1	34.4		37.6	37.6					
33.1	34.4		37.6	37.6					
33.1	34.4		37.6	37.6					
33.2	34.2		37.6	37.7					
33.2	34.2			37.7					
33.3	34.3			37.7					
33.4	34.4			37.7					
34.0	34.4			37.7					
	34.4			37.7					
	34.4			37.6					
	34.7			37.6					
	35.0								

Exhibit 6. Contoured, near-field transect data for July 11, 1989. The mouth of the flume discharge canal on Clinton Lake is at coordinate points 0,0.

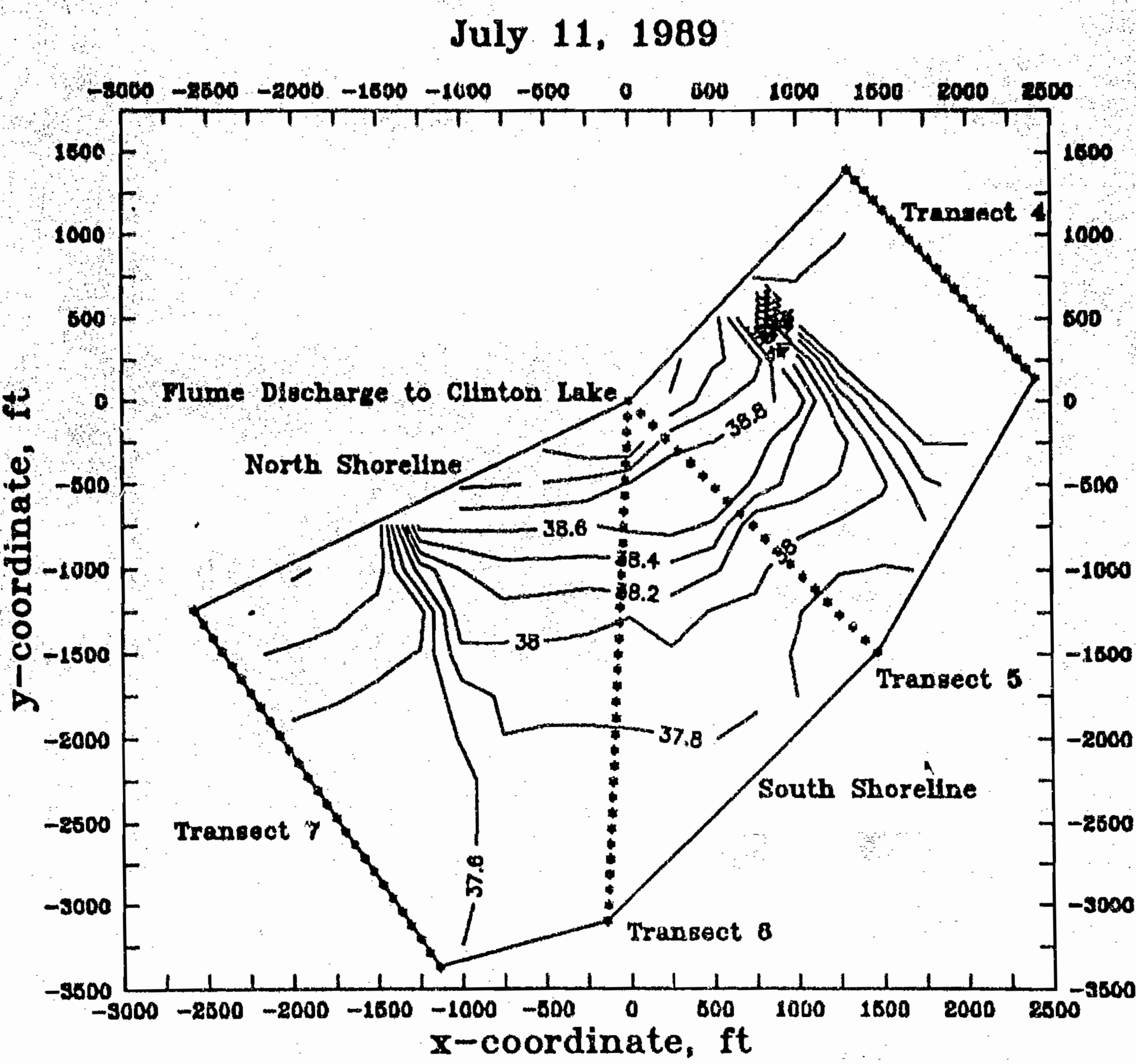

Exhibit 7. Contoured near-field transect data for May 29, 1990. The mouth of the flume discharge canal on Clinton Lake is at coordinate points 0,0.

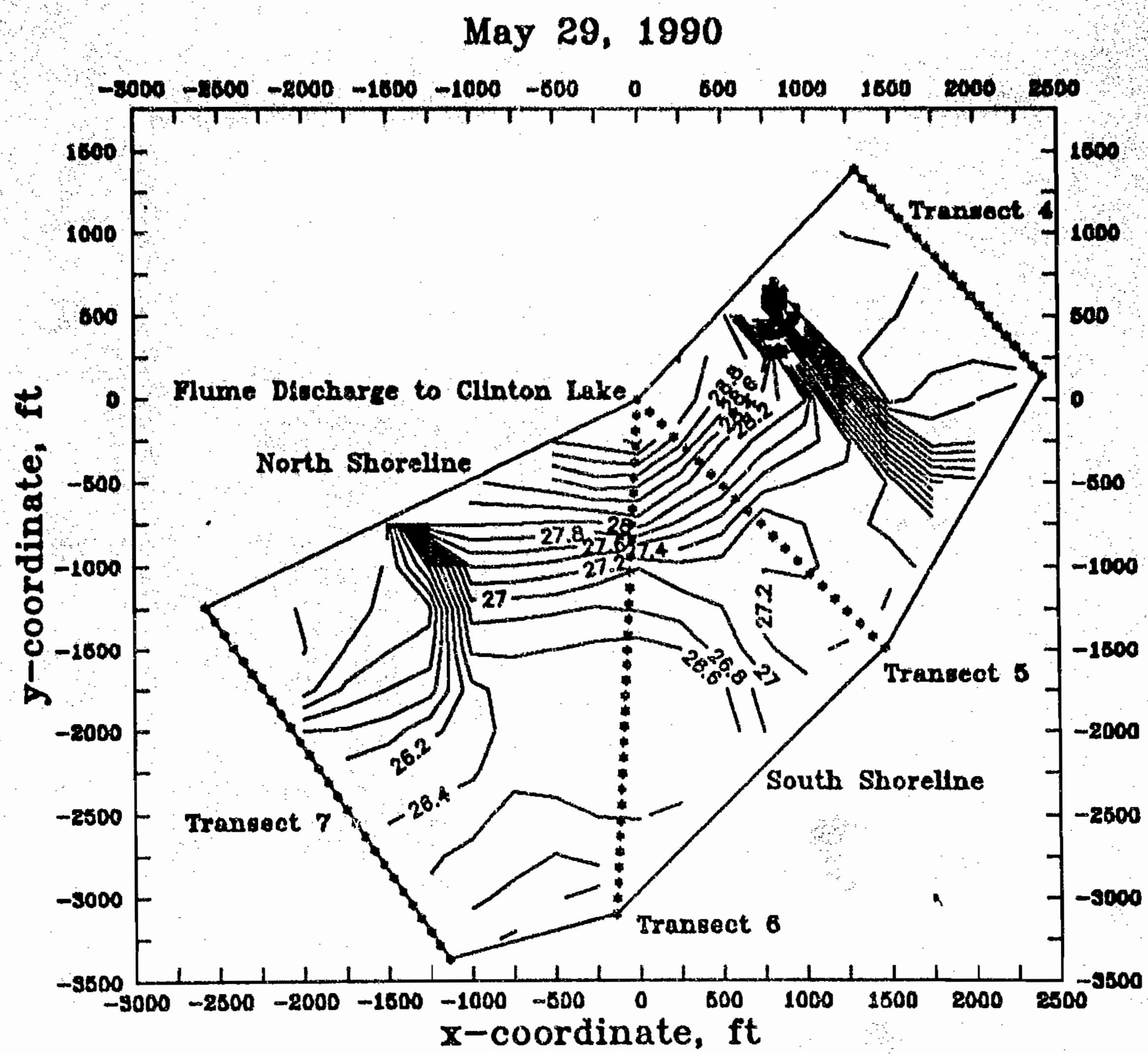

Exhibit 8. Contoured near-field transect data for August 22, 1991. The mouth of the flume discharge canal on Clinton Lake is at coordinate points 0,0.

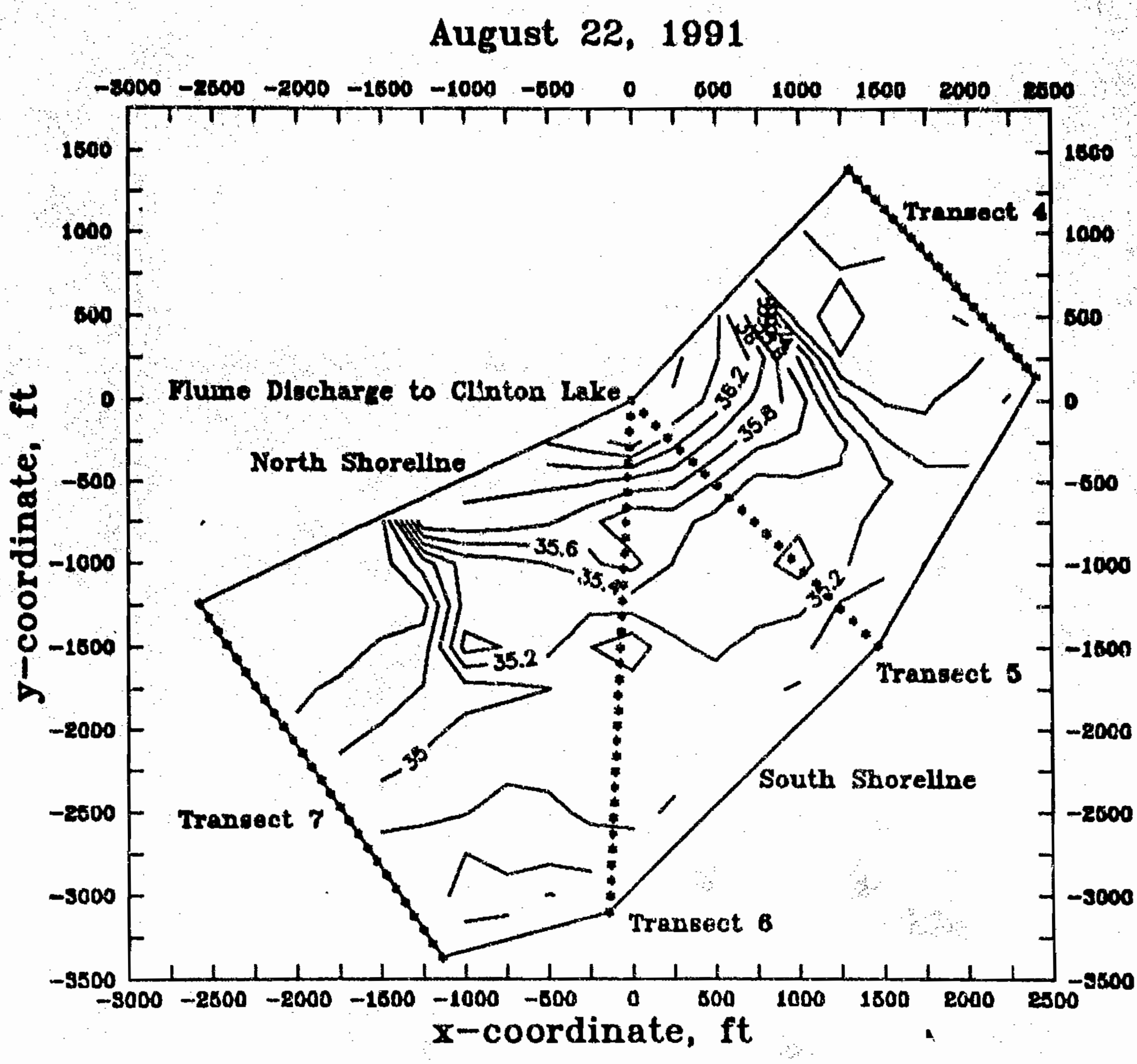

Exhibit 9. Vertical profile data at Sites 2 and 16 (Exhibit 3) for the dates corresponding to Exhibits 5, 6 and 7.

7/11/89	
depth, m	bi-monthly, Site 16
(surface)	37.3
0.5	37.3
1.5	37.0
2.5	36.0
3.5	33.4
4.5	32.4

5/29/90	
depth, m	monthly, Site 2
0.5	26.0
1.0	26.2
1.5	26.1
2.0	26.0
2.5	24.6
3.0	22.0
3.5	21.2

8/22/91	
depth, m	bi-monthly, Site 16
(surface)	35.1
0.5	34.2
1.5	33.5
2.5	31.7
3.5	29.7

Exhibit 10. Bi-monthly temperature observations for August 22, 1989.

depth, m	site number							
	3	5 (intake)	8	10	12	14	16 (discharge)	18
(surface)	25.3	25.6	25.7	26.0	27.4	30.5	34.7	27.8
0.5	25.3	25.6	25.7	26.0	27.5	30.5	34.7	27.8
1.5	25.2	25.6	25.6	25.9	27.4	29.8	34.2	27.8
2.5	25.1	25.6	25.6	25.9	27.2	28.6	33.0	26.7
3.5		25.5	25.5	25.9	27.1	28.0	29.7	
4.5		25.4	25.4	25.9	26.4	27.6	29.0	
5.5		25.4	25.4	25.9	26.1	26.3		
6.5		25.1	25.4		25.7			
7.5			25.3					
8.5			25.3					
9.5			25.2					

Appendix A. Transect Data (C) for Full or Near-full Load Conditions, 1989, 1990 and 1991. The transect locations are identified in Exhibit 1. Temperatures begin at the top of the column with north shore values and proceed to the south shore. The CPS discharge is located at the north shore of transect 5. Note that transect 6 also begins at the CPS discharge but is directed both across and down Clinton Lake.

7/11/89

transect

Wind:	10	9	8	7	6	5	4	3	2	1
W	33.0	35.5	35.9	36.7	39.7	39.6	37.0	35.8	35.8	34.7
10 mph	33.0	35.5	35.8	36.8	39.7	39.6	37.0	36.5	35.7	34.9
Air temp, C:	33.0	35.1	35.8	37.1	39.6	39.6	37.0	36.0	35.2	34.9
30.5	33.1	35.3	35.8	37.1	39.3	39.1	37.2	36.1	35.1	34.8
CPS load:	33.1	35.1	35.9	37.2	39.4	38.4	37.4	36.2	35.1	34.8
99%	33.3	35.3	36.0	37.3	38.8	38.8	37.2	36.3	35.1	34.9
discharge	33.3	35.6	36.0	37.3	38.8	38.8	37.3	36.6	35.3	34.9
temp, C:	33.3	35.6	36.0	37.3	38.5	38.8	37.4	36.7	35.3	34.9
40.0	33.2	35.1	36.1	37.3	38.7	38.8	37.4	36.6	35.5	34.8
	33.2	35.0	36.1	37.4	38.4	38.7	37.4	36.7	35.7	35.4
	33.1	34.8	36.2	37.5	38.5	38.0	37.4	36.8	35.6	35.1
	33.0	34.8	36.2	37.5	38.3	38.0	37.4	36.8	35.8	35.3
	32.9	34.8	36.2	37.5	38.1	38.1	37.4	36.8	35.9	35.4
	33.0	34.9	36.3	37.5	38.0	37.9	37.4	36.9	36.0	35.5
	33.0	34.8	36.5	37.5	38.0	37.8	37.3	36.9	36.0	35.5
	33.0	34.8	36.4	37.5	38.0	37.8	37.4	36.9	36.1	35.5
	33.0	35.3	36.5	37.5	37.8	37.8	37.4	36.9	36.1	
	32.9	34.9	36.5	37.5	38.0	37.7	37.4	37.0	36.0	
	32.8	34.9	36.5	37.5	38.0	37.7	37.4	37.0		
	32.9	34.4	36.6	37.6	37.9	37.7	37.4	37.0		
	32.9	34.4	36.5	37.6	37.8	37.8	37.4	37.0		
	33.0	34.3	36.5	37.6	37.8		37.4			
	33.1	34.4	36.5	37.6	37.7					
	33.1	34.4		37.6	37.6					
	33.1	34.4		37.6	37.6					
	33.1	34.4		37.6	37.6					
	33.2	34.2		37.6	37.7					
	33.2	34.2			37.7					
	33.3	34.3			37.7					
	33.4	34.4			37.7					
	34.0	34.4			37.7					
		34.4			37.7					
		34.4			37.6					
		34.7			37.6					
		35.0								

8/22/89
Wind:
SW
10 mph
Air temp, C:
26.8
CPS load:
100%
discharge
temp, C:
36.7

transect

10	9	8	7	6	5	4	3	2	1
29.2	31.3	32.0	32.4	36.5	36.5	33.3	32.2	31.3	30.7
28.8	31.1	31.8	32.3	36.3	36.4	33.2	32.1	31.1	30.3
28.7	31.1	31.9	32.5	36.3	36.3	33.1	31.8	31.0	30.3
28.6	31.1	31.9	32.6	36.2	36.3	33.0	31.8	30.9	30.3
28.3	31.1	31.8	32.6	35.8	36.2	32.9	31.8	30.8	30.3
28.3	31.2	31.9	32.6	35.8	35.6	33.0	32.2	30.8	30.2
28.5	31.5	31.8	32.6	35.5	35.8	33.0	32.3	30.9	30.0
28.4	31.3	31.8	32.6	34.9	35.6	33.1	32.4	31.0	30.1
28.3	31.1	31.8	32.6	33.2	35.3	33.1	32.4	31.1	30.3
28.5	30.9	31.8	32.6	33.2	35.3	33.2	32.4	31.2	30.3
28.5	30.8	31.8	32.6	33.3	35.4	33.2	32.5	31.1	30.6
28.3	30.8	31.8	32.6	33.5	35.0	33.3	32.6	31.3	30.7
28.3	30.8	31.8	32.6	33.6	35.0	33.3	32.6	31.2	30.8
28.4	30.7	31.7	32.6	33.6	35.0	33.5	32.7	31.3	31.0
28.4	30.7	31.7	32.6	33.7	34.8	33.7	33.0	31.5	30.9
28.3	30.8	31.6	32.6	33.7	34.8	33.8	33.0	31.5	30.5
28.3	31.0	31.6	32.5	33.8	34.8	34.0	33.1	31.7	30.6
28.4	31.0	31.6	32.4	33.7	34.8	34.0	33.2		
28.5	30.8	31.5	32.3	33.6	34.7	34.1	33.3		
28.7	30.1	31.5	32.8	33.6	34.6	34.1	33.3		
28.6	30.1	31.3	33.1	34.1	34.6	34.1	33.0		
28.6	30.0	31.3	33.0	34.1	34.6	33.8			
28.6	30.0	31.1	33.1	34.1		33.8			
28.5	29.8		33.1	34.2					
28.3	29.9		33.1	34.2					
27.7	30.0		33.1	34.2					
27.8	30.0		33.0	34.2					
28.0	30.0		32.3	34.2					
28.3	30.0			34.3					
	29.8			34.2					
	29.8			34.2					
	29.8			34.2					
	29.8			34.2					
	29.8			34.1					
				34.1					

5/29/90						transect				
Wind:	10	9	8	7	6	5	4	3	2	1
NE	22.9	25.2	26.0	25.1	29.5	29.5	24.9	24.0	23.6	20.2
10 mph	22.9	25.6	26.0	24.9	29.5	29.5	24.9	23.7	22.7	19.3
Air temp, C:	23.1	25.8	25.8	24.8	29.5	29.3	25.0	23.6	22.1	19.9
18.6	23.2	25.7	25.8	24.8	29.4	29.2	25.3	23.3	22.0	20.1
CPS load:	24.2	25.2	26.0	24.8	29.0	28.6	25.2	23.4	21.9	20.0
99%	23.5	25.7	25.9	24.8	28.6	28.1	25.1	23.4	21.9	20.0
discharge	23.6	25.8	25.8	24.8	28.7	27.9	25.0	23.2	21.8	20.0
temp, C:	23.8	25.7	25.8	24.8	28.3	28.0	24.9	23.3	21.7	20.0
29.17	23.6	24.9	25.9	24.8	27.5	27.6	24.8	23.3	21.2	20.1
	23.6	23.6	25.9	25.8	27.0	27.5	24.7	23.4	21.3	20.1
	23.5	23.6	25.8	25.9	27.0	27.1	24.7	23.3	21.1	20.1
	23.4	23.3	25.8	26.0	26.8	27.0	24.8	23.4	21.0	20.1
	23.4	23.3	25.8	26.0	26.9	27.2	24.8	23.3	20.8	20.2
	23.4	23.3	25.8	26.1	26.6	27.2	24.8	23.2	20.6	20.2
	23.3	25.2	25.8	26.1	26.6	27.1	24.7	23.2	20.6	20.2
	23.3	25.1	25.8	26.2	26.4	27.4	24.7	23.3	20.6	20.5
	23.3	24.6	25.7	26.3	26.5	27.4	24.7	23.3	20.9	20.9
	23.2	23.8	25.7	26.5	26.5	27.3	24.7	23.3	21.1	
	23.2	23.2	25.7	26.5	26.3	27.3	24.7	23.1		
	23.2	22.9	25.7	26.5	26.4	27.2	24.6	23.2		
	23.2	22.5	25.9	26.6	26.5	27.1	24.7	23.4		
	23.2	22.0	25.8	26.6	26.5	27.1	25.5	23.8		
	23.2	21.8	25.9	26.6	26.5					
	23.1	21.7	26.1	26.7	26.5					
	23.1	21.7	26.5	26.7	26.6					
	23.1	21.8	26.9	26.8	26.6					
	23.1	22.0		27.0	26.6					
	23.0	22.3			26.7					
	23.1	22.3			26.8					
	23.6	22.3			27.2					
		22.5			27.3					
		23.2								

6/30/90
Wind:
SW
5 mph
Air temp, C:
25.1
CPS load:
93%
discharge
temp, C:
35.56

transect

12	11	10	9	8	7	6	5	4	3	2	1
26.5	27.6	28.1	29.5	30.8	30.8	35.3	35.2	31.0	30.4	30.0	29.2
26.6	27.6	28.1	29.5	30.7	30.8	35.1	35.3	31.1	30.6	30.0	29.4
26.4	27.6	28.1	29.4	30.7	30.8	35.2	35.1	31.0	30.5	30.0	29.6
26.2	27.6	28.2	29.5	30.7	30.8	35.0	34.2	31.0	30.6	30.0	29.6
26.4	27.6	28.2	29.5	30.7	30.9	34.8	33.8	31.1	30.6	30.0	29.6
26.3	27.6	28.6	29.8	30.7	31.0	33.8	33.8	31.0	30.6	30.1	29.6
26.2	27.6	28.6	29.9	30.6	31.0	33.6	33.6	31.1	30.6	30.1	29.6
26.2	27.5	28.6	30.1	30.5	31.0	33.2	33.7	31.2	30.7	30.1	29.6
26.2	27.5	28.5	30.0	30.5	31.0	33.0	34.0	31.2	30.7	30.1	29.6
26.3	27.5	28.5	29.0	30.5	31.1	32.7	33.5	31.3	30.7	30.1	29.6
26.3	27.5	28.5	29.0	30.5	31.1	32.6	33.3	31.4	30.7	30.1	29.6
26.3	27.5	28.5	28.9	30.4	31.0	32.5	33.5	31.4	30.8	30.1	29.6
26.2	27.5	28.6	29.0	30.4	31.1	31.1	33.1	31.5	30.8	30.1	29.6
26.2	27.5	28.5	29.1	30.3	31.1	31.2	33.2	31.5	30.8	30.1	29.6
26.2	27.4	28.6	29.1	30.3	31.1	31.3	33.1	31.6	30.9	30.1	29.6
26.1	27.3	28.6	29.3	30.3	31.2	31.5	33.0	31.7	31.0	30.1	29.6
26.1	27.3	28.6	29.7	30.2	31.5	31.5	32.7	31.8	31.0	30.0	29.5
26.1	27.3	28.6	29.3	30.3	31.6	31.8	32.6	31.8	31.0		29.5
26.1	27.3	28.5	29.1	30.3	31.8	31.8	32.6	31.9	31.1		
26.2	27.3	28.5	28.6	30.3	31.8	32.0	32.7	32.0	31.1		
26.1	27.3	28.6	28.6	30.3	31.8	32.0	32.5	32.0	31.1		
26.1	27.3	28.6	28.6	30.3	31.9	32.0	32.4	32.0	30.5		
26.1	27.3	28.6	28.5	30.3	31.9	32.0		31.7			
26.0	27.2	28.5	28.6	30.2	32.0	32.1		31.6			
26.0	27.1	28.5	28.0		32.0	32.1					
26.0	27.1	28.6	27.9		31.8	32.2					
		28.6	27.8		31.8	32.1					
		28.5	27.8		31.8	32.2					
		28.6	27.7			32.1					
		28.4	27.7			32.1					
		27.8	27.7			32.1					
			27.7			32.1					
			27.7			32.0					
			27.7			31.8					
						31.6					

7/30/90						transect						
Wind:	12	11	10	9	8	7	6	5	4	3	2	1
NE	27.8	27.2	28.5	31.2	31.4	30.6	36.1	36.1	31.1	31.1	30.9	30.6
5 mph	27.8	27.1	28.5	31.2	31.3	30.6	36.1	36.1	31.1	31.1	31.0	30.6
Air temp, C:	27.5	27.1	28.6	31.1	31.3	30.6	36.0	36.1	31.1	31.0	31.0	30.6
26.3	27.1	26.9	28.6	31.1	31.2	30.7	35.9	35.1	31.2	31.0	21.0	30.6
CPS load:	26.8	26.8	28.6	31.9	31.2	30.6	35.2	34.7	31.3	31.0	31.0	30.6
91%	26.8	26.0	28.7	32.0	31.2	30.6	34.5	34.4	31.5	31.1	31.0	30.5
discharge	26.7	26.0	28.8	32.0	31.2	30.7	34.2	34.4	31.6	31.1	31.0	30.5
temp, C:	26.7	26.0	28.8	32.0	31.3	30.8	33.3	34.4	31.9	31.3	31.0	30.5
35.56	26.7	26.7	29.0	29.8	31.3	31.2	33.0	33.8	32.0	31.5	31.0	30.5
	26.7	26.7	29.0	29.5	31.3	31.3	32.9	33.7	32.2	31.6	31.0	30.5
	26.7	26.7	29.1	29.3	31.2	31.3	32.6	33.6	32.3	31.6	31.0	30.5
	26.7	26.7	29.2	29.2	31.6	31.5	32.5	33.3	32.5	31.7	30.9	30.5
	26.7	26.7	29.2	29.2	31.6	31.6	32.3	33.2	32.5	31.8	30.9	30.5
	26.6	26.7	29.3	29.4	31.7	31.8	32.2	33.2	32.5	31.8	30.8	30.5
	26.7	26.7	29.4	31.5	31.8	31.8	32.2	33.1	32.5	31.8	30.8	30.5
	26.7	26.7	29.5	32.2	31.9	32.0	32.3	33.1	32.5	31.8	30.8	30.5
	26.7	26.7	29.5	30.3	31.9	32.1	32.3	33.0	32.5	31.8	30.8	30.5
	26.7	26.7	29.5	29.8	32.0	32.2	32.3	33.0	32.5	31.7	30.8	30.5
	26.7	26.7	29.3	29.0	32.0	32.5	32.3	33.0	32.4	31.7		30.6
	26.7	26.7	29.1	28.5	32.1	32.7	32.4	33.0	32.3	31.7		30.5
	26.7	26.7	29.1	28.2	32.1	32.8	32.5		32.2	31.5		
	26.7		29.0	28.0	32.0	32.9	32.6		32.0			
	26.8		29.0	28.0	32.0	32.9	32.8					
	26.8		28.9	28.0	31.8	32.8	32.8					
	27.1		29.0	28.2	31.7	32.8	32.9					
			29.2	28.4		32.7	33.0					
			29.3	28.3			33.0					
				28.4			32.8					
				28.4			32.4					
				28.5			32.5					
				28.7								

8/10/90
Wind:
SW
5 mph
Air temp, C:

CPS load:
90%
discharge
temp, C:
36.33

transect

12	11	10	9	8	7	6	5	4	3	2	1
27.0	27.3	27.0	29.7	30.7	30.5	35.2	35.3	30.8	30.6	30.2	30.1
26.7	27.2	27.1	29.6	30.6	30.6	35.1	35.2	30.1	30.6	30.2	30.0
26.8	27.2	27.1	30.0	30.7	30.6	35.1	34.8	31.2	30.5	30.2	30.0
26.9	27.2	27.1	30.5	30.7	30.7	35.1	34.5	31.3	30.6	30.2	30.0
26.8	27.2	27.2	30.7	30.7	30.7	35.1	34.4	31.3	30.6	30.2	30.0
26.8	27.2	27.2	30.7	30.7	30.8	35.0	34.1	31.3	30.6	30.2	30.0
26.9	27.2	27.3	30.7	30.7	31.0	34.4	33.7	31.4	30.6	30.2	30.0
26.9	27.2	27.3	29.8	30.7	31.1	34.4	33.3	31.4	30.6	30.2	30.0
26.8	27.1	27.3	29.2	30.8	31.2	33.6	33.3	31.5	30.7	30.3	30.0
26.8	27.1	27.3	28.7	30.8	31.3	33.2	33.0	31.6	30.7	30.3	30.0
26.8	27.1	27.3	28.7	30.9	31.5	33.1	33.0	31.7	30.7	30.3	30.0
26.8	27.1	27.3	29.1	31.0	31.6	32.8	32.8	31.7	30.7	30.3	30.1
26.8	27.0	27.3	29.1	31.1	31.6	32.8	32.7	31.8	30.7	30.3	30.1
26.8	27.0	27.2	29.4	31.1	31.7	32.7	32.8	31.8	30.8	30.3	30.1
26.8	27.0	27.2	29.6	31.1	31.8	32.2	32.6	31.9	30.8	30.2	30.1
26.7	26.9	27.2	30.6	31.1	31.7	31.7	32.6	32.0	30.8	30.2	30.2
26.7	26.8	27.2	30.6	31.2	31.9	31.7	32.7	32.1	30.9	30.1	30.2
26.7	26.8	27.2	30.4	32.2	32.0	31.8	32.6	32.2	30.9		
26.7	26.7	27.6	29.6	32.2	32.1	31.8	32.6	32.1	30.9		
26.7	26.7	27.7	29.0	32.2	32.1	31.9	32.5	32.1	31.0		
26.7	26.7	27.8	28.3	32.2	32.1	32.1	32.5	31.7	30.9		
26.7	26.6	27.8	28.5	31.1	32.1	32.1		31.5			
26.7	26.6	27.9	28.3	31.1	32.1	32.2					
26.7	26.2	28.1	28.0	30.8	32.1	32.3					
26.7	26.2	28.1	27.5		32.0	32.3					
26.7		28.1	27.5		32.0	32.3					
		28.0	27.5		31.8	32.5					
		27.9	27.2			32.5					
		27.8	27.1			32.6					
		27.6	26.9			32.6					
		27.2	27.0			32.5					
			27.0			32.5					
			27.1			32.4					
			27.1			32.3					
						32.0					

4/24/91

transect

Wind:	12	11	10	9	8	7	6	5	4	3	2	1
NNE	18.7	17.5	18.7	20.7	22.5	21.3	25.5	24.5	21.7	22.6	20.5	19.5
10 mph	18.8	17.4	18.6	20.9	22.5	21.4	25.5	25.1	21.7	22.1	20.1	19.1
Air temp, C:	18.5	17.3	18.2	20.5	22.4	21.2	25.3	24.1	21.7	21.8	19.6	19.9
20.0	18.3	17.2	18.5	20.7	22.3	21.8	25.2	24.3	21.7	21.5	19.7	19.4
CPS load:	18.3	17.1	18.8	21.1	22.3	22.0	24.8	24.1	21.8	21.6	19.8	19.1
99%	18.2	17.1	19.3	21.8	22.2	21.9	24.8	24.3	22.2	21.7	19.7	19.2
discharge	17.9	16.9	19.1	21.9	22.2	22.0	24.6	23.8	22.3	21.7	19.7	19.3
temp, C:	17.1	16.9	19.6	22.0	22.3	22.1	24.3	23.7	22.2	21.7	19.7	19.2
	17.1	16.9	19.6	22.0	22.2	22.2	23.6	23.3	22.2	21.8	19.7	19.0
	17.0	16.8	19.5	20.0	22.3	22.3	23.3	23.6	22.2	21.8	19.7	19.1
	17.0	17.0	19.2	19.6	22.5	22.3	23.1	23.6	22.2	21.8	19.6	19.1
	17.2	16.9	19.3	19.5	22.6	22.4	23.3	23.4	22.3	21.8	19.6	19.1
	17.1	17.0	19.1	19.5	22.7	22.5	23.6	23.1	22.3	21.8	19.7	19.1
	17.0	17.0	19.0	19.5	22.8	22.6	23.3	23.1	22.5	21.8	19.7	19.0
	17.1	17.0	19.0	20.0	22.8	22.7	23.3	23.1	22.5	21.8	19.7	19.1
	17.1	17.1	18.5	22.2	22.8	22.8	23.3	23.1	22.5	21.8	19.7	19.2
	17.0	17.0	18.2	21.5	22.9	22.9	23.2	23.1	22.5	21.8	19.7	19.2
	17.0	17.0	18.3	22.1	22.9	22.9	23.2	23.0	22.6	21.8	19.7	19.4
	17.0	17.1	18.4	20.8	23.0	22.9	23.2	23.0	22.6	21.8		19.7
	17.0	17.0	18.5	19.5	23.0	23.0	23.1	22.9	22.7	21.7		
	16.9	17.1	18.6	18.9	23.0	23.1	23.1	22.9	22.7	21.8		
	16.9	17.1	18.6	18.6	23.0	23.0	23.2	23.0	22.7	21.9		
	17.0	17.2	18.6	19.6	23.0	23.1	23.2	23.1	22.7			
	17.0	17.2	18.6	18.6	23.0	23.1	23.2		22.7			
	17.1	17.3	18.6	18.5	23.2	23.1	23.2		22.8			
	17.3	17.4	18.7	18.5		23.2	23.1					
	18.0		18.7	18.6		23.2	23.1					
			18.7	18.6		23.2	23.0					
			18.7	18.7		23.3	23.1					
			18.8	18.8			23.1					
			18.8	18.8			23.2					
			18.8	18.8			23.5					
			19.5	19.1			23.2					
				19.7								

5/30/91						transect						
Wind:	12	11	10	9	8	7	6	5	4	3	2	1
SW	27.5	28.6	29.1	30.8	31.1	31.8	36.2	36.1	32.8	30.8	30.5	30.3
15 mph	27.7	28.3	29.0	30.8	31.1	31.8	36.0	36.0	32.7	30.7	30.4	30.3
Air temp, C:	27.2	28.1	28.9	30.7	31.1	31.9	36.0	36.0	32.7	30.7	30.3	30.2
27.2	26.7	28.0	29.0	30.8	31.2	31.8	36.0	35.8	32.7	30.6	30.3	30.2
CPS load:	26.8	28.0	28.9	30.8	31.2	31.8	32.2	35.7	32.8	30.8	30.2	30.2
100%	26.7	27.9	28.8	30.9	31.2	32.0	32.3	35.7	33.0	31.0	30.2	30.2
discharge	26.7	27.9	28.8	31.0	31.1	32.1	32.3	35.6	33.1	31.0	30.2	30.2
temp, C:	26.6	27.9	28.7	31.0	31.1	32.0	32.4	35.5	33.2	31.1	30.1	30.2
	26.5	27.8	28.6	30.9	31.1	32.1	32.4	35.3	33.1	31.1	30.1	30.2
	26.5	27.9	28.3	30.8	31.1	32.0	32.4	34.9	33.1	31.1	30.2	30.2
	26.5	28.0	28.3	30.5	31.1	32.0	32.4	35.0	33.0	31.2	30.2	30.1
	26.7	28.0	28.2	30.5	31.1	32.1	32.5	34.9	33.0	31.3	30.2	30.1
	26.7	28.0	28.1	30.2	31.2	32.0	32.6	34.0	33.1	31.3	30.2	30.1
	26.8	28.0	27.9	30.2	31.2	32.0	32.7	33.6	33.0	31.5	30.2	30.1
	26.7	28.0	27.7	30.2	31.1	32.0	32.8	33.8	33.0	31.5	30.1	30.1
	26.7	28.0	27.6	30.2	31.2	32.0	32.8	33.7	33.0	31.6	30.0	30.1
	26.7	28.0	27.7	30.2	31.3	32.1	33.0	33.7	33.0	31.7	30.0	30.1
	27.0	28.0	27.7	30.3	31.3	32.1	33.0	33.7	33.1	31.8	30.2	30.1
	27.0	28.0	27.7	30.5	31.2	32.2	33.1	33.6	33.1	31.9		30.1
	27.1	28.0	27.7	30.5	31.2	32.3	33.1	33.7	33.0	32.0		
	27.1	28.1	27.7	30.2	31.3	32.3	33.0	33.7	33.0	32.2		
	27.3	28.2	27.7	30.0	31.4	32.5	33.1	33.7	33.1			
	27.4	28.2	27.7	29.8	31.5	32.5	33.2		33.1			
	27.5	28.2	27.7	29.6	31.9	32.6	33.2		33.0			
		28.3	27.7	29.6		32.5	33.2		33.1			
		28.3	27.9	29.5		32.4	33.2		33.1			
		28.3	28.0	29.5		32.4	33.2					
		28.4	28.1	29.5		32.4	33.2					
		28.4	28.2	29.5		32.3	33.3					
			28.3	29.5		32.2	33.3					
			28.3	29.6		32.1	33.2					
				29.6			33.2					
				29.6			33.2					
				29.6			32.8					
				29.6			32.5					
				29.6								
				29.7								

6/26/91 transect

Wind:	12	11	10	9	8	7	6	5	4	3	2	1
SW	30.2	31.8	31.4	32.8	32.8	33.1	38.7	38.6	34.7	34.0	32.7	32.8
15 mph	29.6	31.8	31.2	32.8	32.8	33.0	38.7	38.7	34.7	34.0	32.8	32.7
Air temp, C:	29.3	30.9	31.1	32.8	33.0	33.0	38.6	38.7	34.7	34.0	32.9	32.5
32.6	29.2	30.6	30.6	32.7	33.1	33.1	38.5	38.5	34.7	34.0	32.9	32.4
CPS load:	29.1	30.2	29.5	32.7	33.1	33.1	37.6	38.3	35.0	34.0	33.0	32.3
98%	29.0	30.2	29.2	32.7	33.2	34.2	36.1	38.2	35.1	34.0	33.0	32.3
discharge	29.0	30.1	29.1	32.6	33.2	34.1	34.8	37.7	35.3	34.0	33.0	32.4
temp, C:	28.9	30.0	29.2	32.5	33.1	34.3	34.6	38.0	35.1	34.0	32.9	32.4
	28.8	29.8	29.2	32.4	33.1	34.3	34.6	37.8	35.1	34.1	32.7	32.3
	28.8	29.7	29.3	32.5	33.0	34.2	35.0	37.5	35.1	34.1	32.7	32.2
	28.7	29.7	29.2	32.5	33.1	34.2	35.1	37.6	35.0	34.1	32.7	32.2
	28.7	29.8	29.2	32.3	33.2	34.2	35.1	37.2	35.0	34.1	32.7	32.2
	28.7	29.7	29.0	32.1	33.2	34.2	35.3	36.8	35.1	34.0	32.8	32.3
	28.7	29.7	28.6	32.1	33.2	34.2	35.3	36.6	35.2	34.0	32.9	32.3
	28.6	29.5	28.6	32.1	32.9	34.2	35.2	36.9	35.3	34.1	32.9	32.4
	28.6	29.6	28.5	32.1	32.6	34.2	35.1	36.7	35.3	34.0	33.0	32.4
	28.7	29.6	28.6	32.3	32.5	34.2	35.1	36.5	35.3	34.0	33.1	32.5
	28.8	29.6	28.2	32.3	32.5	34.2	35.1	36.4	35.5	34.0	33.2	32.6
	28.8	29.6	28.2	31.6	32.5	34.1	35.2	36.5	35.5	34.1	33.2	32.5
	28.8	29.5	28.2	31.5	32.5	34.2	35.2	36.5	35.5	34.3	33.2	
	28.9	29.5	28.2	31.5	32.5	34.2	35.4	36.5	35.7	34.7		
	28.9	29.5	28.2	31.5	32.6	34.2	35.5		35.7	35.0		
	29.1	29.7	28.4	31.5	32.7	34.1	35.6		35.7			
	29.1	29.8	28.3	31.5	32.7	34.1	35.6		35.7			
	29.0	29.8	28.4	31.4	32.7	34.0	35.6		35.8			
	29.1	30.1	28.3	31.4	32.7	34.8	35.6		35.7			
	29.2	30.3	28.3	31.5	32.9	33.7	35.5		35.8			
	29.2	30.3	28.3	31.4	33.2	33.8	35.4					
			28.5	31.4			35.1					
			28.5	31.3			35.0					
			28.5	31.3			34.9					
			28.6	31.3			34.6					
			28.8	31.3			34.5					
			29.0	31.4			34.5					
			29.1				34.6					
			29.1									
			29.2									

7/25/91

transect

Wind:	12	11	10	9	8	7	6	5	4	3	2	1
NNE	30.2	30.2	31.7	33.2	34.3	34.4	38.3	38.2	34.3	33.2	32.5	31.6
10 mph	29.9	29.7	31.7	33.0	34.3	34.2	38.1	38.2	34.3	33.0	32.7	31.5
Air temp, C:	29.8	29.6	31.7	32.7	34.3	34.4	38.2	38.0	34.3	33.2	32.4	31.6
26.8	29.8	29.7	31.8	32.8	34.3	34.5	38.0	37.6	34.3	33.3	32.2	31.6
CPS load:	29.6	29.8	32.2	34.0	34.4	34.5	37.9	36.9	34.4	33.4	32.2	31.6
99%	29.6	29.6	32.3	34.1	34.3	34.6	37.8	36.7	34.3	33.5	32.2	31.5
discharge	29.5	29.6	32.2	34.0	34.5	34.6	37.2	36.6	34.3	33.5	32.2	31.5
temp, C:	29.3	29.8	32.0	34.0	34.4	34.5	36.8	36.6	34.3	33.5	32.2	31.3
	29.5	29.7	32.1	34.1	34.4	34.5	36.6	36.7	34.3	33.6	32.1	31.5
	29.3	29.7	32.2	32.6	34.4	34.6	36.5	36.7	34.5	33.6	32.2	31.5
	29.4	29.7	32.1	32.0	34.5	34.7	36.3	36.6	34.6	33.6	32.1	31.5
	29.4	29.8	32.2	31.8	34.5	34.7	36.2	36.6	34.6	33.6	32.1	31.5
	29.5	29.7	32.2	31.8	34.4	34.7	36.0	36.4	34.6	33.6	32.1	31.6
	29.4	29.5	32.2	31.8	34.4	34.7	35.7	36.0	34.7	33.6	32.1	31.6
	29.3	29.5	32.1	32.5	34.3	34.9	35.5	36.0	34.8	33.6	32.1	31.5
	29.4	29.4	32.2	33.0	34.2	34.8	35.5	36.0	34.7	33.6	32.0	31.6
	29.3	29.8	31.8	33.8	34.3	34.8	35.5	36.0	34.7	33.6	32.0	31.6
	29.5	29.8	31.8	33.6	34.1	34.9	35.4	36.1	34.7	33.6	32.3	31.6
	29.5	29.9	31.8	33.1	34.0	35.0	35.4	36.1	34.6	33.5		31.6
	29.5	30.1	31.7	31.8	34.1	34.9	35.5	35.8	34.6	33.5		
	29.3	30.1	31.7	31.3	34.1	34.9	35.5	35.8	34.6	33.5		
	29.3	30.2	31.7	31.3	34.1	35.0	35.4	35.8	34.5	33.4		
	29.3	29.7	31.7	31.2	34.0	35.0	35.4	35.9	34.5	33.5		
	29.3	29.7	31.6	31.0	34.0	35.0	35.5		34.2			
	29.3	30.2	31.5	30.8	34.1	35.0	35.5		34.5			
	29.3	30.0	31.4	30.7		35.0	35.5					
	29.5	29.9	31.3	30.5		35.1	35.6					
	29.5		31.2	30.6		35.1	35.6					
	30.0		31.2	30.7		35.2	35.6					
			31.2	30.7		35.3	35.6					
			31.2	30.8		35.2	35.6					
			31.2	31.0		35.3	35.5					
			31.2	31.1			35.3					
			31.3	31.6			35.2					
			31.7									

8/22/91 transect

Wind:	12	11	10	9	8	7	6	5	4	3	2	1
SSW	30.0	30.1	31.3	33.1	34.0	34.5	36.8	36.8	34.7	33.2	33.3	33.1
10 mph	30.0	30.1	31.2	33.0	34.0	34.3	36.7	36.7	34.6	34.2	33.5	33.2
Air temp, C:	29.8	30.2	31.2	32.8	34.1	34.3	36.7	36.7	34.6	34.2	33.6	33.2
29.7	29.1	30.2	31.2	33.1	34.0	34.3	36.7	36.4	34.3	34.2	33.6	33.2
CFS load:	29.4	30.1	30.8	33.1	34.1	34.5	36.7	36.2	34.4	34.2	33.7	33.1
99%	29.5	30.1	30.8	33.1	34.1	34.4	36.1	36.2	34.3	34.1	33.7	33.1
discharge	29.1	29.9	31.0	33.1	34.1	34.5	35.7	35.7	34.5	34.3	33.7	33.1
temp, C:	29.6	29.9	31.1	33.3	34.0	34.6	35.7	35.9	34.6	34.3	33.6	33.2
	29.5	29.7	31.3	33.5	34.0	34.6	35.4	35.2	34.7	34.3	33.4	33.2
	29.3	29.8	31.5	31.8	34.0	34.6	35.4	35.2	34.7	34.4	33.2	33.2
	29.5	29.8	31.4	32.2	34.0	34.6	35.5	35.2	34.7	34.3	32.8	33.0
	29.7	29.7	31.2	31.7	34.0	34.7	35.6	35.2	34.8	34.4	33.2	33.3
	29.7	29.6	31.5	31.8	34.1	34.7	36.3	35.2	34.9	34.5	33.9	33.4
	29.7	29.7	31.6	31.9	34.1	34.8	35.5	35.5	34.8	34.5	33.8	33.3
	29.3	29.7	31.5	32.1	34.1	34.9	35.2	35.4	34.6	34.5	34.2	33.6
	29.8	29.8	31.6	32.0	34.2	34.9	34.5	35.5	34.5	34.7	34.1	33.7
	29.8	29.7	31.6	32.1	34.2	35.0	34.7	35.3	34.5	34.7	34.3	33.6
	30.0	29.9	31.6	32.5	34.2	35.1	35.0	35.5	34.6	34.7	34.3	33.6
	30.1	29.9	31.8	33.0	34.1	35.2	35.1	34.8	34.7	34.8	34.2	
	30.1	29.8	31.8	32.8	34.1	35.3	35.1	35.1	34.7	34.8		
	30.0	29.8	31.8	32.6	34.1	35.3	35.2	34.8	34.8	34.8		
	30.1	30.3	31.8	32.7	33.9	35.3	35.2	34.7	34.8	35.2		
	30.3	30.5	31.8	32.5	33.9	35.3	35.2	34.8	35.0			
	31.1	30.6	31.7	32.3	33.9	35.3	35.2		35.1			
	31.1	30.4	32.0	32.3	33.7	35.3	35.1		35.1			
		30.4	32.0	32.2	33.7	35.2	35.1					
		30.5	32.0	32.2	34.2	35.3	35.2					
			32.0	32.2		36.0	35.1					
			32.1	32.2			35.1					
			32.1	32.2			35.1					
			32.1	32.2			35.2					
			32.3	32.5			35.5					
			32.6	32.6			35.7					
			32.9	32.5			35.5					
				33.1			35.5					

10/31/91						transect						
Wind:	12	11	10	9	8	7	6	5	4	3	2	1
NNE	15.8	16.1	17.3	20.0	21.8	23.1	29.0	29.0	20.6	18.1	17.4	16.5
10 mph	15.8	16.1	17.4	19.8	21.8	23.1	28.8	29.0	20.5	18.1	17.6	16.5
Air temp, C:	15.8	16.1	17.5	20.6	21.7	23.2	28.7	28.5	20.5	18.2	17.8	16.6
11.2	15.8	16.1	17.7	21.2	21.7	23.2	28.6	27.5	20.2	18.3	17.8	16.6
CPS load:	15.8	16.1	17.7	21.1	21.6	23.2	28.5	27.1	20.6	18.2	17.8	16.7
99%	15.8	16.1	17.8	21.1	21.5	23.2	28.1	27.1	20.7	18.2	17.9	16.8
discharge	15.8	16.0	17.8	20.5	21.4	23.2	27.3	26.5	21.1	18.2	17.8	16.8
temp, C:	15.8	16.0	17.8	19.7	21.4	23.1	26.8	26.5	21.2	18.1	17.9	17.0
	15.8	16.1	17.7	19.5	21.3	23.1	26.0	26.7	21.2	18.0	17.8	17.0
	15.8	16.1	17.7	19.5	21.2	23.3	25.6	27.1	21.5	18.0	17.8	16.8
	15.8	16.1	17.2	19.3	21.1	23.3	26.0	26.7	21.6	18.0	17.8	16.6
	15.8	16.1	17.3	19.5	21.2	23.3	25.6	26.1	21.3	17.9	17.8	16.6
	15.8	16.3	17.2	20.1	21.3	23.3	25.1	25.9	21.3	17.8	17.7	16.5
	15.8	16.4	17.2	20.8	21.3	23.4	24.8	25.9	21.3	17.8	17.8	16.5
	15.8	16.5	17.2	21.0	21.2	23.4	25.1	25.9	21.3	17.7	17.8	16.6
	15.8	16.5	17.2	20.6	21.3	23.6	24.8	25.8	21.3	17.6	17.7	16.8
	15.8	16.4	17.2	19.8	21.3	23.9	25.0	25.7	21.3	17.6	17.6	16.9
	15.8	16.3	17.2	19.4	21.3	24.0	25.1	25.7	21.1	17.6		
	15.8	16.4	17.3	19.4	21.3	24.0	25.0	26.0	21.1	17.5		
	15.7	16.4	17.3	18.3	21.4	24.0	24.9	25.6	21.0	17.5		
	15.7		17.3	18.2	21.5	23.9	24.5	25.8	20.7	17.5		
	15.7		17.4	18.2	21.5	23.8	24.5	25.6	20.7			
	15.7		17.4	18.2	21.5	23.9	24.6	25.0	20.6			
			17.5	18.2	21.6	23.9	24.4	23.7				
			17.6	18.2	21.5	23.8	24.3	23.8				
			17.7	18.2	21.5	23.8	24.3	24.0				
			17.7	18.3		23.7	24.3					
			17.7	18.3		23.7	24.3					
			17.8	18.3		23.6	24.3					
			17.8	18.2			24.2					
				18.2			24.2					
							24.1					
							24.1					

Exhibit HE-2

Clinton Power Station

Theoretical Plume Studies for Heated Effluent Demonstration Section 106.102(c)(2) and (3) -- Predicted Plumes for Typical and Worst Case Conditions

Prepared for

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Introduction

The Illinois Pollution Control Board Heated Effluent Demonstration Regulation (Title 35, Subpart A, Sections 106.102(c)(2) and (3)) require that theoretical plume studies be performed for all four seasons for typical and worst case conditions and that the theoretical plume studies should indicate three-dimensional effects.

As shown in the 106.102(c)(1) Actual Plume Studies (Edinger Associates, 1992b), the Clinton Lake thermal plume has a three-dimensional near-field region in the vicinity of the discharge and a laterally-mixed, longitudinally and vertically distributed, two-dimensional far-field plume region. The theoretical plume studies are designed to encompass both regions. It is necessary to define and evaluate the worst case and typical conditions that should apply to Clinton Station and Lake.

Definition of Worst Case and Typical Conditions

Worst case is assumed to mean thermal plumes of maximum size and temperature. The conditions that contribute to maximum size include (1) Station operations that produce maximum waste heat rates; (2) minimum freshwater inflows to Clinton Lake such that dilution in the lake and discharge through the lake outlet works are minimized; and, (3) meteorological conditions

that result in maximum lake ambient temperatures. The first two conditions produce maximum Station contributions to temperature (excess temperature) and the last condition produces maximum ambient temperature. These three conditions were developed into boundary condition data to be used in the longitudinal-vertical model of Clinton Lake to obtain the far-field thermal plume dimensions, and then in a longitudinal-lateral-vertical model of the discharge region of Clinton Lake to obtain the near-field thermal plume dimensions.

Typical conditions are defined similarly, except that meteorological conditions that result in typical monthly ambient temperatures are adopted. For the purposes of this study, typical conditions thus include maximum waste heat rates, minimum freshwater inflows and typical, mean monthly ambient temperatures.

Ambient temperatures

To identify the maximum and typical ambient temperatures, a long record of meteorological data was examined using a response temperature model. Response temperature is defined as the temperature a completely mixed column of water of specified depth would have if surface heat exchange were the only active heat transfer process. The rate of change of response temperature, T_r, can be written in terms of the net rate of surface heat exchange as

$$\rho c_p D\left(\frac{dT_r}{dt}\right) = H_n \qquad \text{(PP-1)}$$

where

ρ = the density of water, 1000 kg m^{-3}

c_p = the specific heat of water at constant pressure, 4186 J kg^{-1} $°C^{-1}$

D	=	the mean depth of the water column, m
$\frac{dT_r}{dt}$	=	the rate of change of water temperature with time, $^{o}C\ s^{-1}$
H_n	=	the net rate of surface heat exchange as a function of shortwave solar radiation, air temperature, dew point temperature, wind speed and water surface temperature, $W\ m^{-2}$.

The net rate of surface heat exchange is a function of shortwave solar radiation, air temperature, dew point temperature, wind speed and water surface temperature. Since the net rate of surface heat exchange is dependent on the water temperature, the equation must be iterated for temperature as well as integrated over the meteorological record to give time-varying response temperatures. For the Clinton Lake case, hourly (or for some years, three-hourly, depending on availability) meteorological data at Springfield, Illinois for the period 1955 to 1991 were used to compute response temperatures. These temperatures are shown (Edinger Associates, 1992a) to closely represent ambient temperatures in Clinton Lake.

For determining worst case conditions, the response temperature record was organized so that the maximum daily average value that occurred within each month was available for inspection (Exhibit 1). From that table, the highest single value of T_r for each of the four seasons was selected. The results are given in Exhibit 3.

For determining typical conditions, mean monthly values of the response temperature were computed for each month. These are shown in Exhibit 2. The mean seasonal response temperature was computed by taking the average of the three monthly means that represented the season. The results are given in Exhibit 3.

This method of computing the ambient has the advantage of including all the meteorological data important for surface heat exchange in a coincident fashion over a very long record, e.g., naturally occurring high air temperatures with wind speed values that occurred at the same time. The value of k given Exhibit 3 is the coefficient of surface heat exchange for the same date in the record and provides a convenient method of computing surface heat exchange in the far- and near-field models as $k(T-T_r)$, where T is the water surface temperature (Edinger, et al., 1974).

Maximum Station waste heat discharge

The maximum Station waste heat discharge for 100% load was given in an earlier report (Edinger Associates, 1992a) as 1.97×10^9 W (6.713×10^9 Btu h^{-1}), with a pumping rate of 42.4 m^3 s^{-1} (1497 cfs), yielding a station temperature rise of 11.1°C (20°F). These values were used directly in the far- and near-field models to account for the Station's contribution to temperature for both the worst and typical case conditions.

Minimum dilution and flushing

The conditions for minimum dilution and flushing include minimum North Fork and Salt Creek inflows and minimum Clinton Lake pool elevations. For the purposes of the worst and typical plume predictions, North Fork and Salt Creek inflows were considered to be zero and lake elevations considered to be below the spillway, or at an elevation of 210.3 m (690 ft).

Far-Field Modelling Methodology

The far-field modelling is performed using the GLVHT model discussed in Edinger Associates, 1992a. The Clinton Lake map with the GLVHT segments is shown in Exhibit 4. The model was run for each of the worst case and typical case conditions outlined in Exhibit 3. It was initialized at the response temperature, Tr, and run to steady-state with the Station heat load. Surface heat exchange was computed from k(T-Tr) (Edinger, et. al, 1974). Running the model to steady-state conditions essentially assumes that the meteorological conditions do not change over a period of days, and this assumption is conservative.

Near-Field Modelling Methodology

In order to simulate the behavior of the plume in the near-field region, a hydrodynamic longitudinal-lateral-vertical (three-dimensional) model (GLLVHT) similar in construction to the GLVHT longitudinal-vertical model was applied to this region. Based on information from the longitudinal-vertical simulations presented here and observations of the plume presented in 106.102(c)(1) Actual Plume Studies (Edinger Associates, 1992b), a region of Clinton Lake covering 3000 m (10,000 ft) in the longitudinal was chosen for modelling. This region is approximately twice the length of the region shown in the presentation of actual plume data.

An outline of the three-dimensional model as it is applied around the discharge is shown in Exhibit 5. The three-dimensional model is essentially imbedded in the GLVHT model segments 17, 16 and 15. These segments are further subdivided into the 152 meter (down lake) by 56 meter (across lake) computational cells of the three-dimensional model. The centers of the cells are shown in Exhibit 5. The vertical scale for the near-field model is the same as for the far-field model, 1.1 m (3.6 ft).

The widths and depths for the near-field model was taken from the segment widths and depths used in the GLVHT longitudinal-vertical far-field model. Boundary conditions for the three-dimensional model taken from each of the seasonal GLVHT simulations were (a) elevation gradients and (b) up- and down-lake temperature profiles. These were applied to the ends of the three-dimensional model. The near-field simulations were thus an exact reproduction of the far-field simulations scaled to the discharge region.

Theoretical Plume Results

Predicted far-field and near-field plume results are presented in tabular and graphical formats based on the far-field plume results as computed from GLVHT and the near-field plume results as computed from GLLVHT. They are first presented for the worst case conditions and then for the typical conditions.

Far-field and near-field simulations for worst case conditions

The worst case conditions are defined as those which would have occurred under conditions of maximum ambient temperature, full load and minimum dilution and flushing by season. These results are shown in Exhibit 6 to Exhibit 9 for the winter, spring, summer and fall cases. These exhibits show the warmest temperatures in the vicinity of the discharge (surface layer of segment 16), with rapid fall off in temperature within one or two 1520 m segment lengths (5000 ft), and a more gradual fall off in temperature to the intake (segment 5). Also apparent is the surface-to-bottom stratification of 4 to 5°C in the vicinity of the discharge.

Results for the near-field simulations for the four seasonal cases are shown in Exhibits 10 through 13. These exhibits show a slight down-lake movement of the plume, consistent with the condition of no freshwater inflow, but with Station pumping. The isotherms for the near-field model show temperatures somewhat higher than the corresponding far-field model results. This is due to the additional detail supplied by the near-field model.

The diagrams also show stratification to mid-depth of several degrees C, consistent with the far-field model results as well as the observations. Furthermore, stratification is greater adjacent to the discharge, as would be expected.

<u>Far-field and near-field simulations for typical conditions</u>

The typical condition far-field plumes are shown in Exhibits 14 to 17. The typical condition ambient temperature in the winter is low enough that the lake can cool to temperatures less than 4°C which is the temperature at which the density of water is a maximum. As shown in Exhibit 14, the 4°C water begins to sink to lower levels beginning at Segment 8 and results in temperature inversions further up the North Fork Salt Creek

Arm toward the Station intake.

The near-field predictions in Exhibits 18 to 21. The plumes are essentially the same configuration as those found for the worst case predictions.

Summary

The difference between the worst case conditions and the typical case conditions is mostly reflected in the differences in ambient temperatures used for each case as given in Exhibit 3. For the winter conditions the worst case ambient was 7.1°C higher than the typical conditions; for spring, the worst case was 11.1°C higher; for the summer, the worst case was only 2.7°C higher; and for the fall the worst case was 10.2°C higher. It is typical for the summer mean conditions and maximum conditions to be within a few degrees celsius of each other.

The excess temperatures due to the Station operations would be the difference in the predicted temperatures and the ambient temperature as discussed in Edinger Associates (1992b) Section 3. The excess temperatures tend to be higher in the winter than in the summer and tend to be less for the worst case than the typical case in the same season. These differences in excess temperature are due to the fact that the rate of evaporative cooling increases with increasing temperature.

The worst case predicted plume gives a maximum temperature of 107.6 F (42 C), as shown in Exhibit 12. Note that this temperature corresponds to 110.7 F at the end of the discharge flume. The predicted plume is essentially for the worst day of ambient temperatures in 37 years. The 42 C isotherm of the plume extends out on the surface of the lake with a radius of about 220 meters (centered about the mouth of the discharge flume canal) or less than half-way across the lake. At mid-depth, however, the maximum plume temperature is 41 C and the 42 C isotherm would be found back up the discharge canal. Within 1.2 km (3937 feet) above and below the point of the flume discharge, surface water temperatures would be expected to have cooled to approximately 39 C (102.2 F). Mid-depth temperatures at these distances would be expected to fall to approximately 37 C (98.6 F). The distribution of temperatures and the extent of the area bounded by these temperatures are not expected to be exceeded for any anticipated Station operating conditions or any meteorological conditions that would occur more frequently than 1 day in 30 years.

References

Edinger Associates. 1992a. Clinton Lake Hydrothermal Modeling Verification for 1989, 1990, 1991 and Determination of Adequacy of Variance Limits for Clinton Station. Exhibit X of Clinton Station Condenser Cooling Water and Cooling Lake Discharge Temperature Evaluations. Document 92-121. September 22.

Edinger Associates. 1992b. Actual Plume Studies for Heated Effluent Demonstration Section 106.102(c)(1). Exhibit APS of Clinton Station Heated Effluent Demonstration. J.E.Edinger Associates Document Number 92-122, September 22.

Edinger, J. E., D. K. Brady and J. C. Geyer. 1974. Heat Exchange and Transport in the Environment. Cooling Water Studies for the Electric Power Research Institute, Research Project RP-49, Report 14. Palo Alto, California. EPRI Publication Number 74-049-00-3. November.

Exhibit 1. **Maximum of the daily average response temperature in the month and year.** **Underlined numbers indicate conditions adopted for the worst case plume predictions. Note that the worst case comes from the maxima of the daily average response temperature.**

year	1	2	3	4	5	6	7	8	9	10	11	12
	month											
55	2.9	3.0	8.4	17.8	22.2	24.8	31.1	31.4	25.6	20.1	10.1	1.3
56	0.4	2.0	7.0	12.2	22.3	28.5	28.1	28.8	25.2	19.3	15.0	3.0
57	2.2	3.3	6.1	17.5	21.1	25.9	29.5	29.7	27.6	19.1	10.1	3.3
58	0.7	4.0	4.6	14.1	20.2	23.7	26.7	29.8	25.2	18.8	13.1	3.0
59	0.9	2.6	7.8	15.0	23.0	26.5	27.6	29.3	27.7	20.1	11.0	3.2
60	3.3	0.6	5.7	17.6	19.6	24.0	29.4	29.0	29.6	21.0	11.3	4.7
61	0.5	4.3	8.1	13.1	18.4	25.5	29.0	29.8	28.3	18.9	13.3	5.7
62	0.6	1.0	7.2	17.7	25.2	27.0	28.2	26.7	25.2	20.0	10.7	5.0
63	0.5	0.6	11.1	14.9	19.8	26.9	28.9	29.0	24.3	18.9	13.9	5.3
64	3.2	1.2	5.4	16.0	23.7	28.9	29.4	28.7	25.5	18.1	13.3	2.0
65	3.8	2.2	3.4	14.9	23.0	26.2	28.3	27.5	24.0	18.8	11.9	5.3
66	4.3	3.0	9.4	13.9	21.4	26.6	30.1	26.9	26.0	16.3	9.4	4.4
67	4.2	1.8	11.9	16.5	20.2	26.0	27.2	28.0	22.0	18.6	9.4	2.2
68	2.5	3.6	10.5	14.0	18.4	26.6	28.2	28.3	23.8	19.5	10.8	3.7
69	0.9	0.6	5.5	14.9	21.1	25.1	28.9	26.7	26.6	20.3	9.0	2.4
70	1.1	1.1	5.1	18.8	23.2	24.6	26.9	27.8	26.4	19.6	12.0	6.1
71	0.3	3.9	6.0	14.8	17.4	28.3	27.5	26.0	26.7	22.3	16.3	4.4
72	2.0	2.0	7.8	14.4	24.1	24.6	28.2	28.7	26.5	18.7	9.8	1.6
73	2.2	2.0	10.0	15.4	19.3	26.1	27.8	27.5	27.5	22.1	13.2	8.3
74	2.1	2.5	10.8	15.8	21.1	23.9	29.3	26.7	24.2	17.0	15.3	3.1
75	2.1	1.1	6.4	15.3	23.8	28.7	29.8	28.7	26.9	17.9	14.7	5.5
76	0.3	7.3	10.8	17.2	20.0	25.5	27.9	26.8	24.2	18.9	7.8	0.7
77	0.0	3.6	11.6	18.5	25.0	25.4	29.8	27.3	26.3	20.4	14.4	2.4
78	0.2	0.2	6.0	13.4	23.8	27.6	28.5	27.1	26.5	20.5	12.3	3.2
79	0.0	0.7	8.8	14.5	19.9	25.2	27.4	29.8	26.9	21.3	12.9	3.4
80	1.8	0.8	5.9	14.3	23.3	27.4	31.3	29.8	27.4	22.0	10.5	5.1
81	1.5	5.6	11.3	18.0	20.4	26.2	30.3	27.2	25.3	18.8	12.9	4.6
82	0.3	2.1	8.5	13.5	22.5	25.2	28.5	29.0	24.2	20.2	12.7	8.6
83	2.5	3.6	8.4	12.8	19.6	28.5	30.4	29.7	27.7	19.7	12.3	3.9
84	0.2	4.5	3.3	14.9	20.7	27.4	28.6	29.2	26.2	19.0	14.6	4.9
85	4.2	3.7	11.2	19.3	22.4	26.4	27.9	27.3	27.2	16.8	13.3	4.0
86	1.5	1.7	11.6	16.6	22.8	27.9	31.0	29.5	24.0	23.1	13.5	3.2
87	0.7	2.1	8.3	17.3	25.0	28.6	30.7	31.6	24.9	19.5	12.3	4.5
88	2.4	2.5	9.1	13.8	24.6	28.8	30.4	30.4	25.1	21.2	8.7	4.0
89	3.0	3.5	11.1	17.9	22.1	26.8	29.2	28.0	26.5	19.1	12.9	3.5
90	2.7	4.9	12.4	18.1	18.9	26.1	28.5	27.9	28.0	19.2	12.6	8.3
91	0.2	2.0	12.8	16.6	26.3	28.4	29.6	27.9	26.8	19.4	-9.0	-9.0

Exhibit 2. Mean of the daily average response temperature in the month and year. The average of the seasonal mean values was adopted for the typical case plume predictions. For example, the mean of 1.4 C (December), 0.4 C (January) and 0.9 C (February), or 0.9 C was used as the ambient for the typical winter plume prediction.

	month											
year	1	2	3	4	5	6	7	8	9	10	11	12
55	.8	.8	5.5	12.9	19.9	22.0	28.2	28.6	22.9	15.8	5.8	.3
56	.1	.6	4.8	9.9	18.1	25.6	26.9	26.8	22.1	16.8	8.7	.7
57	.2	1.1	4.5	9.7	18.8	23.7	27.3	28.3	23.3	15.1	6.1	1.7
58	.1	.6	2.7	10.4	17.3	22.4	25.6	27.4	23.0	16.6	10.0	.6
59	.1	.5	4.2	11.1	19.6	24.9	26.4	27.5	23.4	15.4	4.9	1.0
60	.9	.1	.7	11.5	16.3	22.4	26.9	27.5	25.6	17.1	7.5	1.3
61	.1	1.6	6.1	8.7	16.0	23.0	26.2	28.4	24.7	15.4	8.1	1.5
62	.1	.4	2.0	9.9	21.6	24.4	27.1	25.5	22.1	16.9	6.8	1.2
63	.1	.1	4.5	13.0	17.7	24.3	27.2	26.7	22.3	18.1	9.5	1.2
64	.6	.3	3.8	10.4	20.2	24.1	27.0	25.2	22.5	13.6	9.8	.4
65	1.0	1.0	1.2	10.3	20.5	23.9	26.8	25.9	22.4	15.3	9.2	3.4
66	.9	1.1	4.7	9.4	16.6	22.9	28.2	25.6	21.5	13.3	7.4	1.7
67	.8	.4	4.0	14.2	15.6	23.1	25.4	25.5	20.9	13.9	5.4	1.1
68	.4	.9	3.3	11.8	16.3	23.6	26.6	26.4	21.1	15.2	6.6	.9
69	.1	.3	2.3	11.4	17.6	21.3	27.7	26.4	22.7	15.0	5.6	.5
70	.1	.4	2.9	10.0	20.4	23.0	25.5	26.0	23.5	15.5	6.9	2.4
71	.0	1.3	3.7	10.6	15.3	24.2	25.8	24.5	23.5	18.1	9.2	2.8
72	.5	.3	5.1	10.3	18.5	23.4	25.5	26.0	23.4	14.4	5.7	.3
73	.8	.9	6.9	10.7	16.6	24.1	26.9	26.4	23.4	18.7	9.3	2.4
74	.5	1.0	6.5	11.3	17.8	22.3	27.6	25.4	20.9	14.1	9.2	.8
75	.4	.4	2.2	8.6	19.6	24.3	27.8	27.6	21.8	15.7	9.9	2.2
76	.1	3.2	8.3	14.0	16.7	23.9	26.8	25.0	21.4	13.6	4.1	.1
77	.0	1.3	7.2	14.6	21.3	23.5	28.2	25.8	23.4	14.3	9.0	.5
78	.0	.0	1.4	11.8	16.1	24.2	27.3	26.1	24.8	14.4	8.5	.6
79	.0	.1	3.4	10.5	17.6	23.3	25.5	27.0	23.7	15.2	8.5	2.0
80	.6	.1	2.7	10.2	18.4	24.4	29.4	28.5	24.7	16.3	7.2	1.9
81	.3	1.7	5.9	15.3	16.3	24.2	27.9	25.6	22.1	14.2	9.1	1.5
82	.0	.6	4.1	10.0	19.7	23.3	27.1	26.5	22.1	15.6	7.9	4.4
83	.4	1.3	5.3	8.1	16.6	23.7	28.8	28.5	23.4	15.4	8.7	.8
84	.0	2.3	1.4	8.9	17.5	25.0	26.9	27.8	22.0	16.6	8.3	2.6
85	.5	.9	6.1	13.5	19.9	23.3	27.2	26.2	22.8	15.4	9.0	.3
86	.4	.6	4.5	13.9	20.1	25.7	29.2	26.7	22.5	17.1	7.3	.9
87	.1	.9	5.6	11.6	21.3	26.7	28.1	28.4	23.1	13.0	8.5	2.3
88	.3	.6	4.6	12.8	19.9	27.1	28.7	28.7	22.5	14.7	6.8	1.4
89	.7	.4	3.9	11.5	17.4	24.0	27.0	26.9	22.7	15.3	8.0	.6
90	1.5	3.1	7.4	11.1	17.0	23.0	26.3	26.5	24.1	14.9	10.0	3.3
91	.0	1.1	6.2	13.9	20.5	27.1	28.5	26.6	23.8	15.3	-9.0	-9.0
Mean	.4	.9	4.3	11.3	18.3	23.9	27.2	26.7	22.9	15.4	7.8	1.4
Stdev	.4	.7	1.8	1.8	1.8	1.3	1.0	1.1	1.1	1.3	1.6	1.0
Max	1.5	3.2	8.3	15.3	21.6	27.1	29.4	28.7	25.6	18.7	10.0	4.4
Min	.0	.0	.7	8.1	15.3	21.3	25.4	24.5	20.9	13.0	4.1	.1

Exhibit 3. Meteorological and ambient conditions for worst case and typical case.

Worst Case

season	response temperature (T_r), C	rate of surface heat exchange (k), W m^{-2} °C^{-1}
winter (December, January, February)	8.6	35.0
spring (March, April, May)	26.3	45.3
summer (June, July, August)	31.6	35.5
fall (September, October, November)	29.6	31.9

Typical Case

season	response temperature (T_r), C	rate of surface heat exchange (k), W m^{-2} °C^{-1}
winter	0.9	21.5
spring	11.3	31.0
summer	25.9	34.8
fall	15.4	28.1

Exhibit 4. GLVHT model segments and bi-monthly sampling sites, Clinton Lake, Clinton, Illinois.

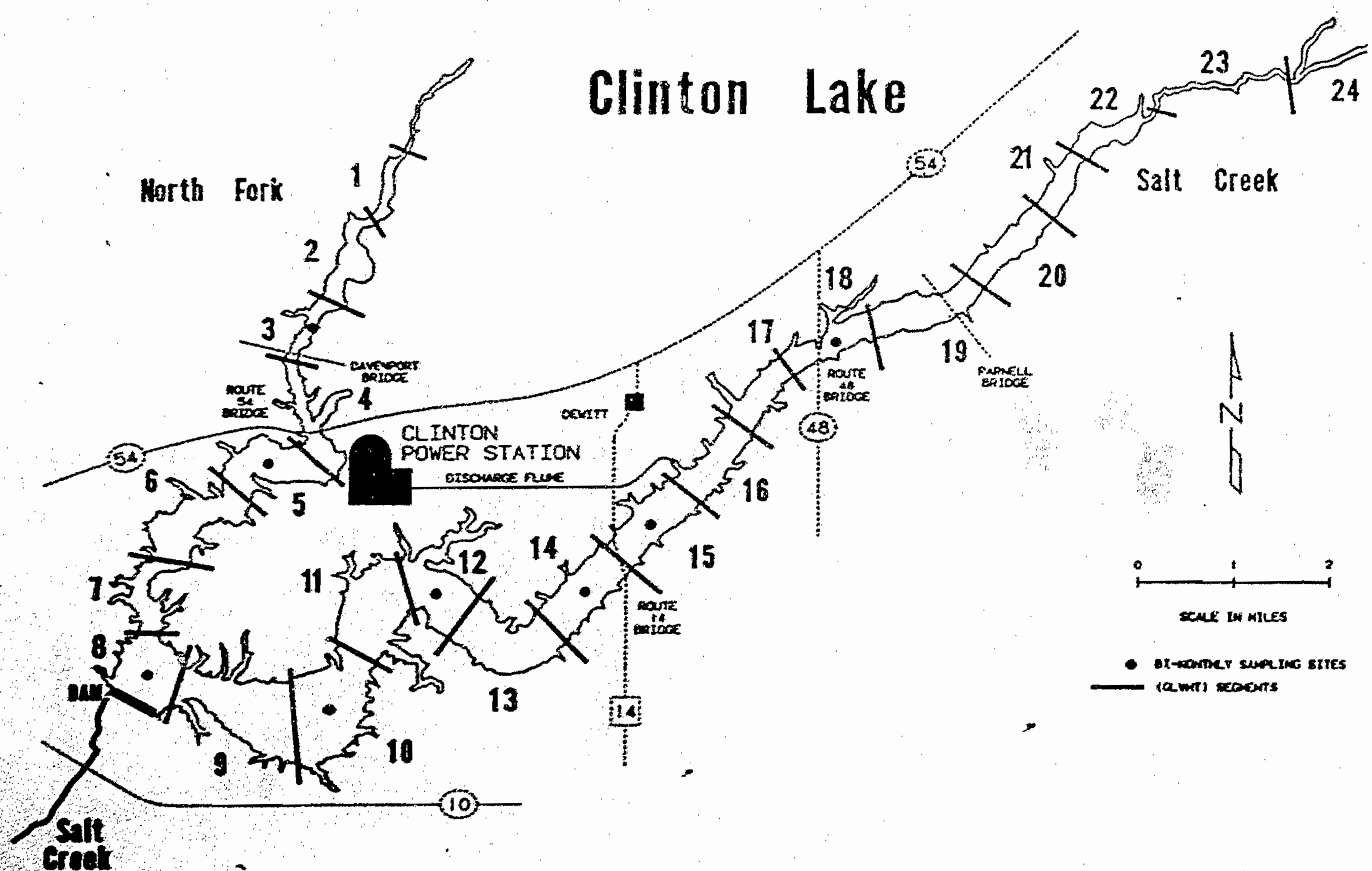


Exhibit 5. Three-dimensional model outline of computational region and reference points. Note that the lateral scale is expanded relative to the predicted plume diagrams shown later.

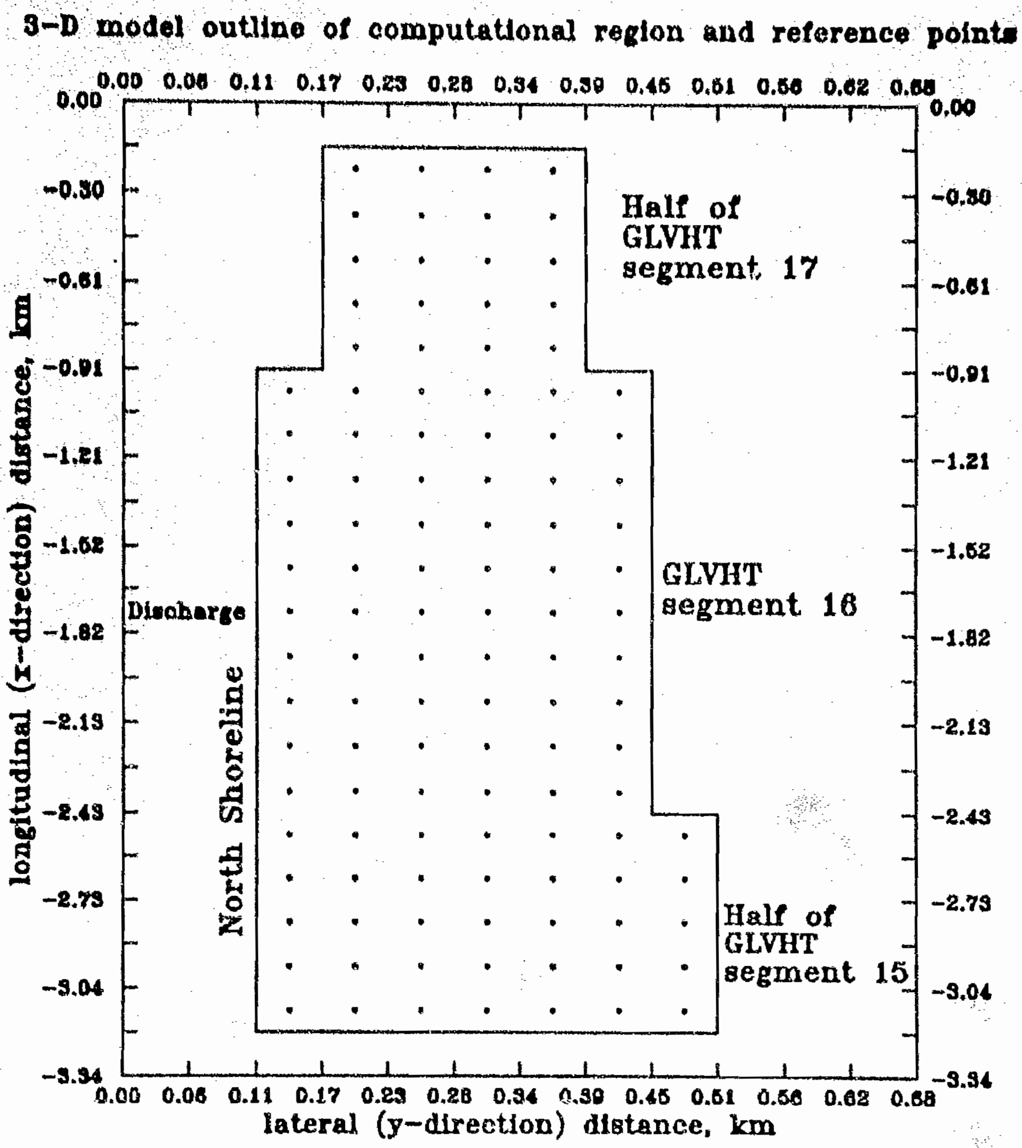


Exhibit 6. Winter far-field temperature distribution for worst case conditions. Temperatures are measured in C. Layer elevations are shown in the second part of this exhibit; segments are identified in Exhibit 4.

	segment																
layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
5	8.7	9.0	9.4	9.6	9.9	10.3	10.6	11.0	11.4	12.2	13.1	14.3	15.8	18.3	13.5	10.1	8.6
6	8.7	9.1	9.6	9.8	10.1	10.5	10.8	11.1	11.6	12.3	13.1	14.3	15.6	17.3	13.3	10.1	8.6
7	8.8	9.1	9.7	10.0	10.2	10.5	10.8	11.1	11.6	11.9	12.4	13.5	15.1	16.3	13.0	10.1	8.7
8	8.8	9.1	9.8	10.1	10.2	10.5	10.7	10.9	11.1	11.5	12.0	12.9	14.3	15.4	12.6	10.1	8.7
9	8.9	9.1	9.8	10.2	10.2	10.5	10.7	10.8	10.9	11.3	11.6	12.4	13.7	14.6	12.3	10.1	8.7
10	8.9	9.1	9.8	10.2	10.2	10.5	10.6	10.7	10.8	11.0	11.3	11.7	13.0	14.0	12.3		
11	9.0	9.1	9.7	10.2	10.2	10.5	10.5	10.6	10.6	10.7	10.9	11.0					
12	9.0	9.1	9.7	10.2	10.2	10.4	10.4	10.5	10.5	10.5	10.6	10.7					
13			9.9	10.2	10.2	10.4	10.4	10.4	10.4	10.5	10.5						
14			9.9	10.2	10.2	10.3	10.4	10.4	10.4	10.4							
15					10.2	10.3	10.3	10.4									

Exhibit 6 (continued).

Layer	Thickness m	Elevation m
2	1.1	213.36
3	1.1	212.26
4	1.1	211.16
5	1.1	210.06
6	1.1	208.96
7	1.1	207.86
8	1.1	206.76
9	1.1	205.66
10	1.1	204.56
11	1.1	203.46
12	1.1	202.36
13	1.1	201.26
14	1.1	200.16
15	1.1	199.06

Exhibit 7. Spring far-field temperature distribution for worst case conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

	segment																
Layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
5	26.4	26.7	27.0	27.2	27.4	27.5	27.7	28.0	28.3	28.8	29.5	30.5	31.8	34.7	31.0	28.5	26.4
6	26.4	26.7	27.0	27.2	27.4	27.5	27.7	28.0	28.3	28.8	29.4	30.3	31.5	33.4	30.9	28.4	26.4
7	26.4	26.6	27.0	27.2	27.4	27.5	27.7	27.9	28.1	28.4	28.8	29.5	30.8	32.0	30.3	28.2	26.4
8	26.4	26.6	27.0	27.2	27.4	27.5	27.7	27.8	27.9	28.1	28.5	29.1	30.3	31.2	29.8	28.0	26.4
9	26.4	26.6	26.9	27.2	27.4	27.5	27.6	27.7	27.8	28.0	28.2	28.7	29.7	30.6	29.5	27.8	26.4
10	26.4	26.6	26.8	27.2	27.3	27.5	27.6	27.6	27.7	27.8	28.0	28.2	29.2	30.1	29.5		
11	26.4	26.6	26.7	27.1	27.3	27.4	27.5	27.5	27.6	27.6	27.7	27.7					
12	26.4	26.6	26.7	27.0	27.3	27.4	27.4	27.4	27.5	27.5	27.5	27.6					
13			26.7	27.0	27.2	27.3	27.3	27.4	27.4	27.4	27.5						
14			26.7	26.9	27.2	27.3	27.3	27.3	27.4	27.4							
15					27.2	27.2	27.3	27.3									

Exhibit 8. Summer far-field temperature distribution for worst case conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

layer	segment 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	
5	32.0	32.3	32.8	33.0	33.2	33.4	33.6	33.9	34.2	34.9	35.7	36.6	37.9	40.6	37.1	34.5	31.6	5
6	32.0	32.3	32.8	33.0	33.2	33.4	33.6	33.9	34.2	34.8	35.5	36.4	37.4	39.2	36.8	34.3	31.6	6
7	32.0	32.3	32.8	33.0	33.2	33.4	33.6	33.8	34.1	34.5	34.8	35.4	36.7	37.9	36.4	34.1	31.6	7
8	31.9	32.3	32.7	33.0	33.2	33.4	33.5	33.7	33.9	34.1	34.5	35.0	36.2	37.1	35.9	33.8	31.6	8
9	31.9	32.3	32.6	33.0	33.2	33.4	33.5	33.6	33.7	33.9	34.2	34.6	35.6	36.5	35.5	33.6	31.6	9
10	31.9	32.2	32.5	32.9	33.1	33.3	33.4	33.5	33.6	33.7	33.8	34.1	35.0	35.8	35.5			10
11	31.9	32.2	32.4	32.8	33.1	33.2	33.3	33.4	33.4	33.4	33.5	33.5						11
12	31.9	32.1	32.3	32.7	33.0	33.1	33.1	33.2	33.2	33.3	33.3	33.4						12
13			32.3	32.6	32.9	33.0	33.1	33.1	33.1	33.2	33.2							13
14			32.3	32.5	32.8	32.9	33.0	33.0	33.1	33.1								14
15					32.8	32.9	32.9	33.0										15

Exhibit 9. Fall far-field temperature distribution for worst case conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

	segment															
layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
5	30.1	30.5	31.0	31.2	31.5	31.7	31.9	32.2	32.5	33.2	34.0	35.0	36.3	39.0	35.5	32.9	29.6
6	30.1	30.5	31.0	31.2	31.5	31.7	31.9	32.2	32.5	33.1	33.8	34.7	35.8	37.7	35.2	32.6	29.6
7	30.1	30.5	31.0	31.3	31.5	31.7	31.9	32.1	32.4	32.8	33.1	33.7	35.1	36.4	34.8	32.4	29.6
8	30.1	30.5	30.9	31.3	31.5	31.7	31.8	31.9	32.2	32.4	32.8	33.4	34.5	35.5	34.3	32.1	29.6
9	30.0	30.4	30.8	31.2	31.5	31.7	31.7	31.8	32.0	32.2	32.5	32.9	33.9	34.9	33.9	31.9	29.7
10	30.0	30.4	30.7	31.1	31.4	31.6	31.7	31.7	31.8	32.0	32.1	32.4	33.4	34.3	33.9		
11	30.0	30.3	30.6	31.0	31.3	31.5	31.6	31.6	31.7	31.7	31.8	31.8					
12	30.0	30.3	30.5	30.9	31.2	31.4	31.4	31.4	31.5	31.5	31.6	31.6					
13			30.5	30.8	31.1	31.2	31.3	31.3	31.4	31.4	31.5						
14			30.5	30.7	31.0	31.1	31.2	31.3	31.3	31.4							
15					31.0	31.1	31.2	31.2									

Exhibit 10. Winter near-field temperature distribution for worst case conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). The contours for the mid-depth diagram are 19, 18, 17 and 16 C, beginning with the discharge (approximately -1.8 km on the longitudinal diagram scale). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.

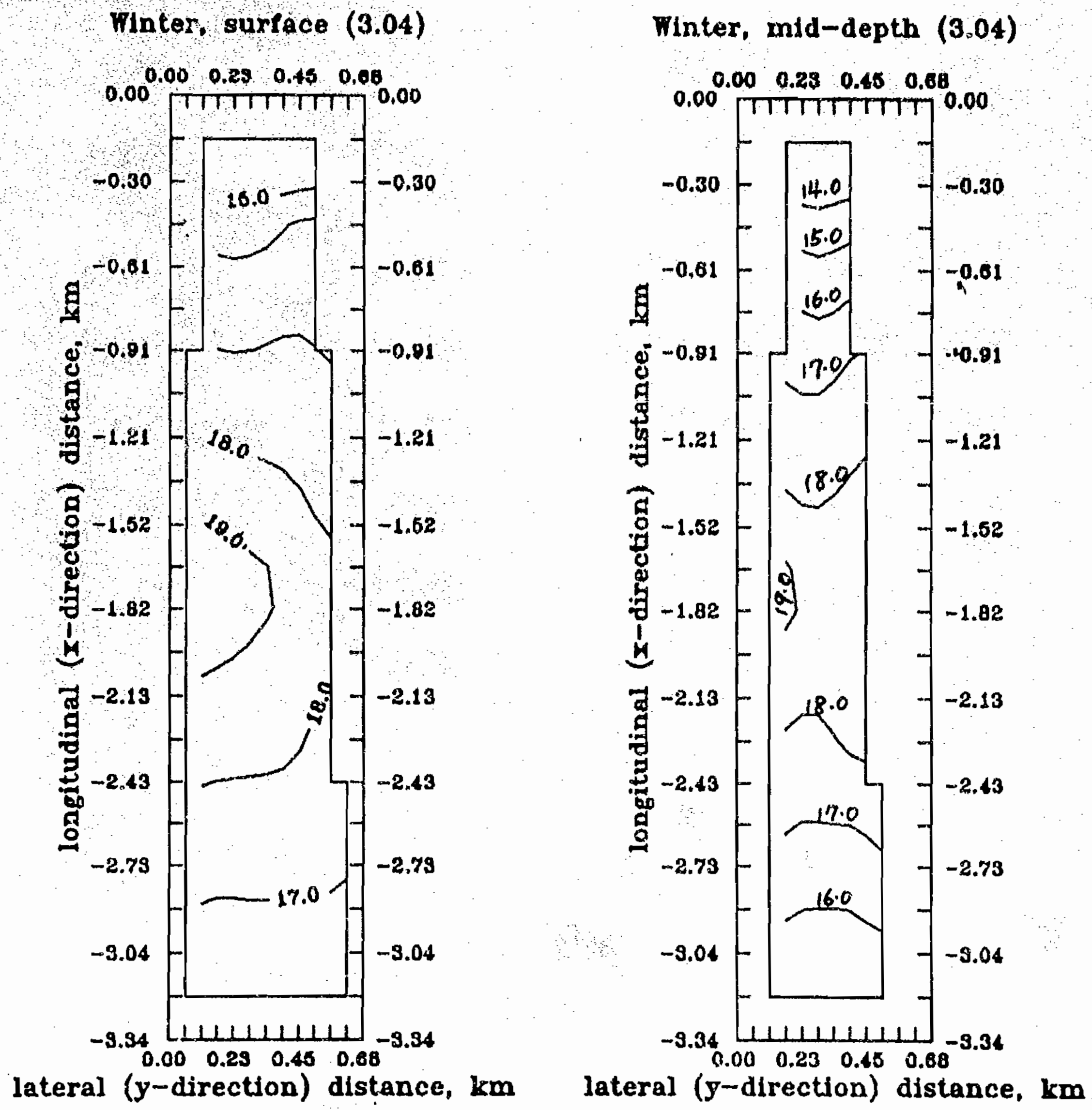
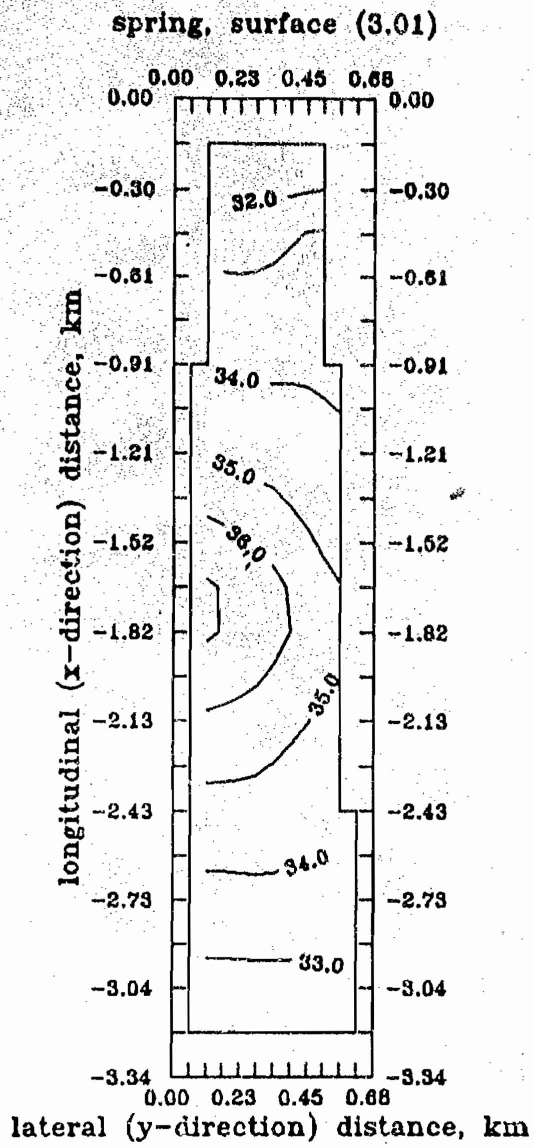


Exhibit 11. Spring near-field temperature distribution for worst case conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.



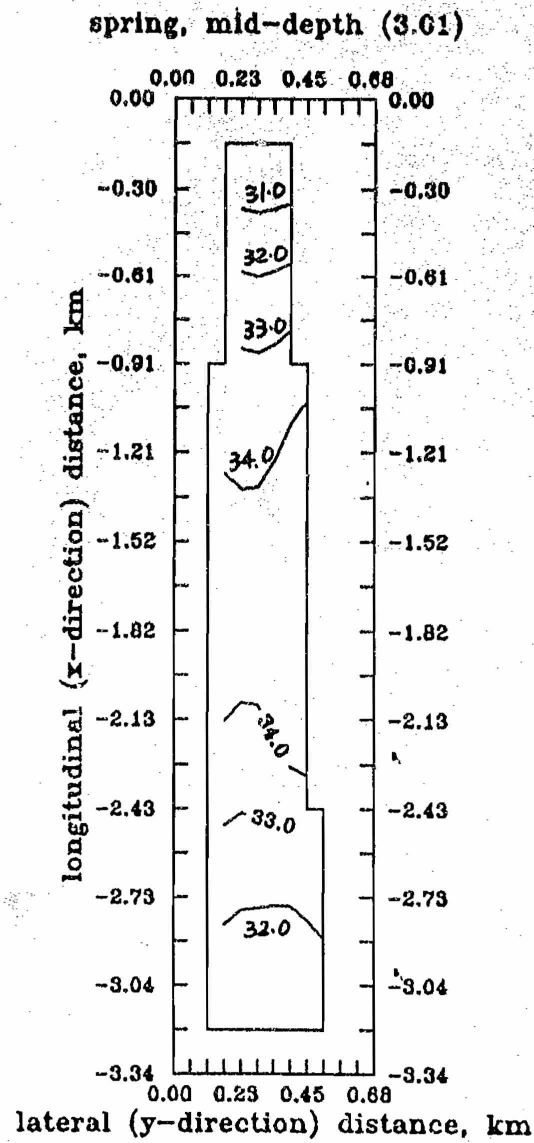
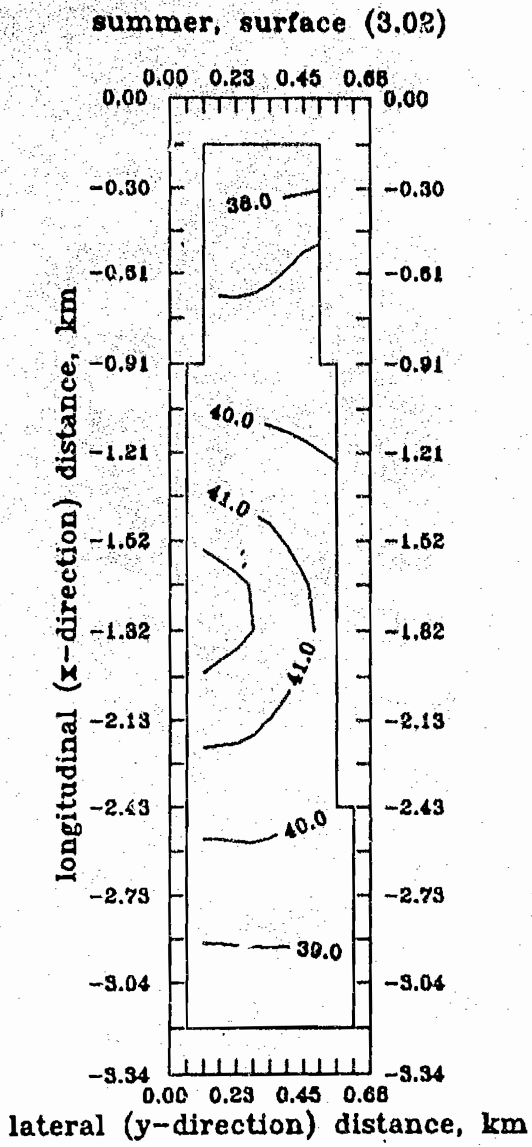


Exhibit 12. Summer near-field temperature distribution for worst case conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.



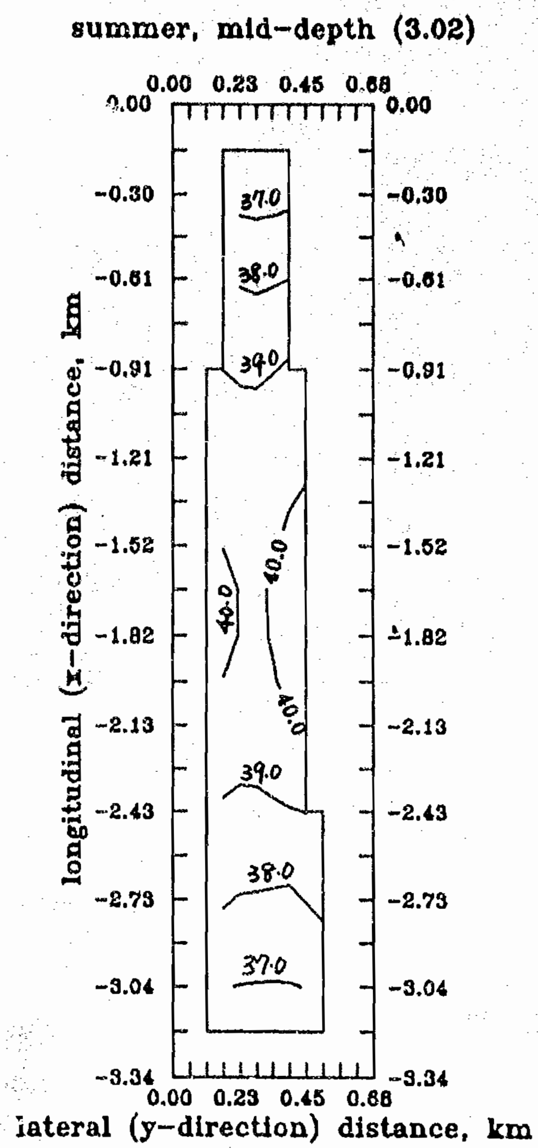


Exhibit 13. Fall near-field temperature distribution for worst case conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.

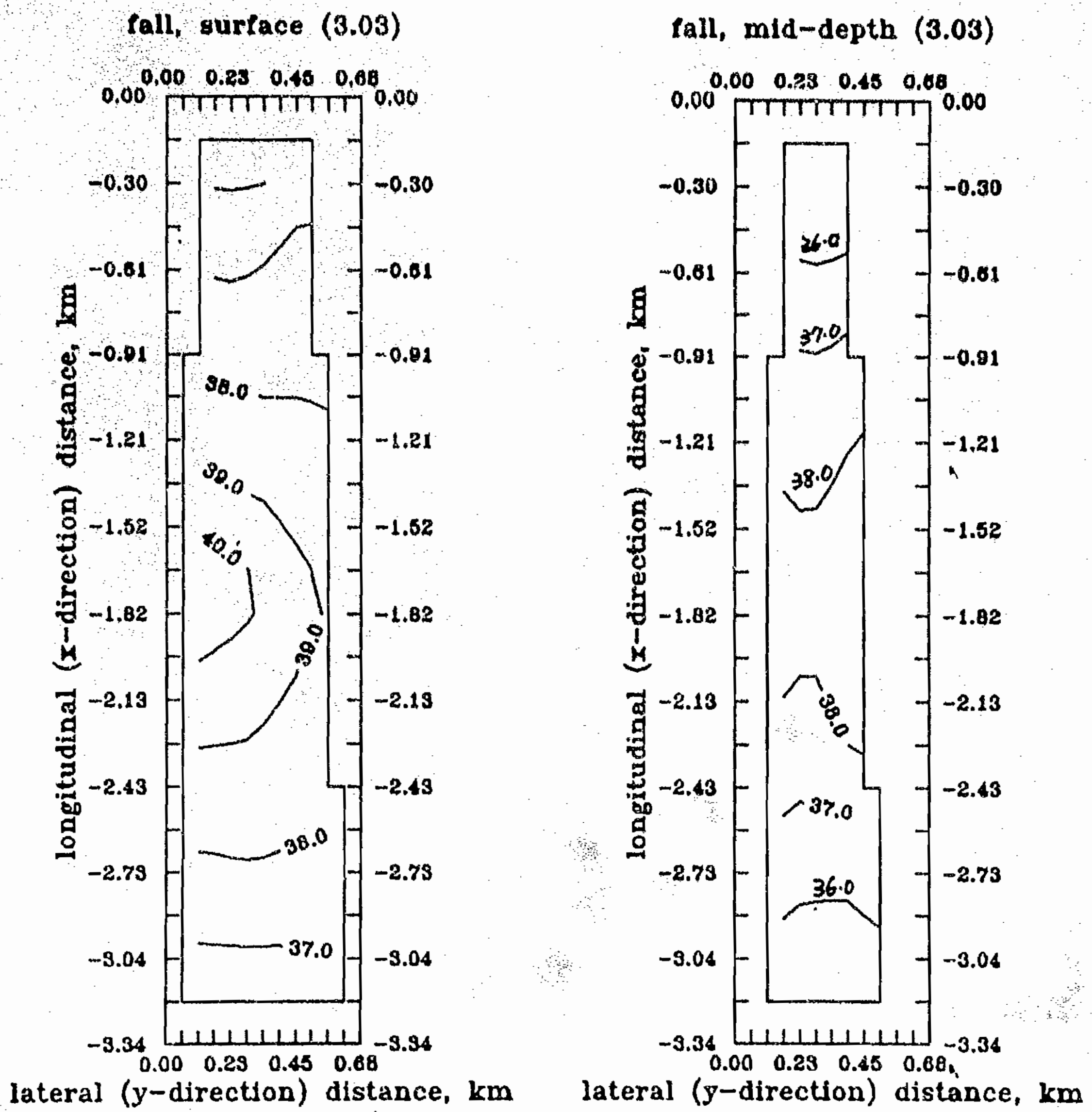


Exhibit 14. Winter far-field temperature distribution for typical conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

							segment											
layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	
5	4.2	2.6	2.7	3.2	3.6	4.6	5.1	5.6	6.2	7.2	8.2	9.4	10.9	13.0	6.6	1.8	2.3	5
6	4.2	2.6	3.1	3.6	3.9	4.8	5.3	5.8	6.4	7.4	8.3	9.5	10.7	12.0	6.6	2.1	2.3	6
7	4.0	2.7	3.5	3.9	4.2	4.8	5.3	5.7	6.1	7.1	7.8	8.8	10.2	10.9	6.6	2.6	2.2	7
8	3.8	2.8	4.0	4.2	4.4	4.9	5.2	5.5	5.8	6.6	7.1	8.0	9.5	9.8	6.6	3.4	2.2	8
9	3.6	3.0	4.3	4.4	4.5	4.8	5.1	5.3	5.5	6.2	6.6	7.4	8.9	9.0	6.6	4.1	2.1	9
10	3.7	3.4	4.4	4.5	4.6	4.8	5.1	5.2	5.3	5.7	6.1	6.7	8.2	8.4	6.6			10
11	4.0	4.0	4.5	4.5	4.6	4.8	5.0	5.1	5.2	5.3	5.5	5.6						11
12	4.1	4.1	4.5	4.6	4.7	4.8	4.9	4.9	4.9	4.9	5.0	5.2						12
13			4.6	4.6	4.7	4.8	4.8	4.8	4.8	4.8	4.9							13
14			4.6	4.6	4.7	4.8	4.8	4.8	4.8	4.8								14
15					4.7	4.8	4.8	4.8										15

Exhibit 15. Spring far-field temperature distribution for typical conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

							segment											
layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	
5	12.3	12.1	12.4	12.6	13.0	13.4	13.7	14.0	14.5	15.2	16.1	17.2	18.6	21.0	16.4	13.1	11.6	5
6	12.3	12.1	12.6	12.9	13.2	13.5	13.8	14.1	14.6	15.2	16.0	17.1	18.3	19.8	16.0	13.0	11.6	6
7	12.3	12.1	12.7	13.0	13.2	13.6	13.8	14.0	14.3	14.8	15.3	16.2	17.6	18.7	15.6	13.0	11.6	7
8	12.2	12.1	12.7	13.1	13.3	13.5	13.8	13.9	14.1	14.4	14.9	15.6	16.8	17.8	15.2	12.9	11.5	8
9	12.2	12.1	12.6	13.1	13.3	13.5	13.7	13.8	13.9	14.2	14.5	15.1	16.3	17.0	14.9	12.8	11.5	9
10	12.1	12.1	12.5	13.1	13.3	13.5	13.6	13.7	13.8	13.9	14.1	14.5	15.6	16.4	14.9			10
11	12.1	12.1	12.4	13.0	13.3	13.5	13.5	13.6	13.6	13.7	13.8	13.9						11
12	12.1	12.1	12.3	12.9	13.2	13.4	13.4	13.4	13.5	13.5	13.6	13.7						12
13			12.3	12.8	13.2	13.3	13.3	13.4	13.4	13.4	13.5							13
14			12.3	12.7	13.2	13.3	13.3	13.3	13.4	13.4								14
15					13.2	13.2	13.3	13.3										15

Exhibit 16. Summer far-field temperature distribution for typical conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

	segment																	
layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	
5	26.1	26.6	26.9	27.1	27.3	27.6	27.8	28.1	28.6	29.2	30.0	31.0	32.3	34.9	30.9	28.1	25.5	5
6	25.9	26.6	27.0	27.3	27.5	27.7	28.0	28.2	28.6	29.1	29.8	30.7	31.8	33.5	30.6	27.9	25.1	6
7	25.7	26.5	27.0	27.3	27.5	27.8	28.0	28.1	28.4	28.8	29.1	29.8	31.1	32.5	30.1	27.8	25.0	7
8	25.5	26.4	26.9	27.3	27.5	27.7	27.9	28.0	28.1	28.4	28.8	29.4	30.5	31.2	29.6	27.6	24.8	8
9	25.4	26.2	26.7	27.2	27.5	27.7	27.8	27.9	28.0	28.2	28.5	28.9	29.9	30.5	29.3	27.4	24.8	9
10	25.3	26.1	26.6	27.1	27.4	27.6	27.7	27.8	27.8	27.9	28.1	28.4	29.4	29.9	29.3			10
11	25.3	25.9	26.4	26.9	27.3	27.5	27.6	27.6	27.7	27.7	27.8	27.8						11
12	25.3	25.8	26.3	26.8	27.2	27.4	27.4	27.4	27.5	27.5	27.6	27.6						12
13			26.3	26.7	27.0	27.2	27.3	27.3	27.4	27.4	27.5							13
14			26.3	26.6	26.9	27.1	27.2	27.3	27.3	27.4								14
15					26.9	27.0	27.1	27.2										15

Exhibit 17. Fall far-field temperature distribution for typical conditions. Temperatures are measured in C. Layer elevations are shown in the second part of Exhibit 6; segments are identified in Exhibit 4.

	segment																	
Layer	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21	
5	16.1	16.5	16.9	17.2	17.5	17.9	18.2	18.5	19.0	19.7	20.6	21.7	23.0	25.4	21.0	17.9	15.6	5
6	16.1	16.5	17.1	17.4	17.7	18.0	18.3	18.6	19.0	19.7	20.4	21.4	22.6	24.0	20.7	17.7	15.6	6
7	16.1	16.5	17.2	17.5	17.8	18.1	18.3	18.5	18.7	19.2	19.7	20.5	21.9	23.0	20.2	17.5	15.6	7
8	16.1	16.5	17.1	17.6	17.8	18.0	18.2	18.3	18.5	18.9	19.2	19.9	21.1	22.0	19.7	17.3	15.6	8
9	16.1	16.5	17.0	17.5	17.8	18.0	18.1	18.2	18.3	18.6	18.9	19.4	20.5	21.2	19.3	17.1	15.6	9
10	16.1	16.5	16.8	17.4	17.7	17.9	18.0	18.1	18.2	18.3	18.5	18.8	19.9	20.6	19.3			10
11	16.1	16.4	16.7	17.2	17.6	17.9	17.9	18.0	18.0	18.1	18.1	18.2						11
12	16.1	16.4	16.6	17.1	17.5	17.7	17.7	17.8	17.8	17.9	17.9	18.0						12
13			16.6	17.0	17.4	17.6	17.6	17.7	17.7	17.8	17.8							13
14			16.6	16.9	17.3	17.5	17.6	17.6	17.7	17.7								14
15					17.3	17.4	17.5	17.5										15

Exhibit 18. Winter near-field temperature distribution for typical conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.

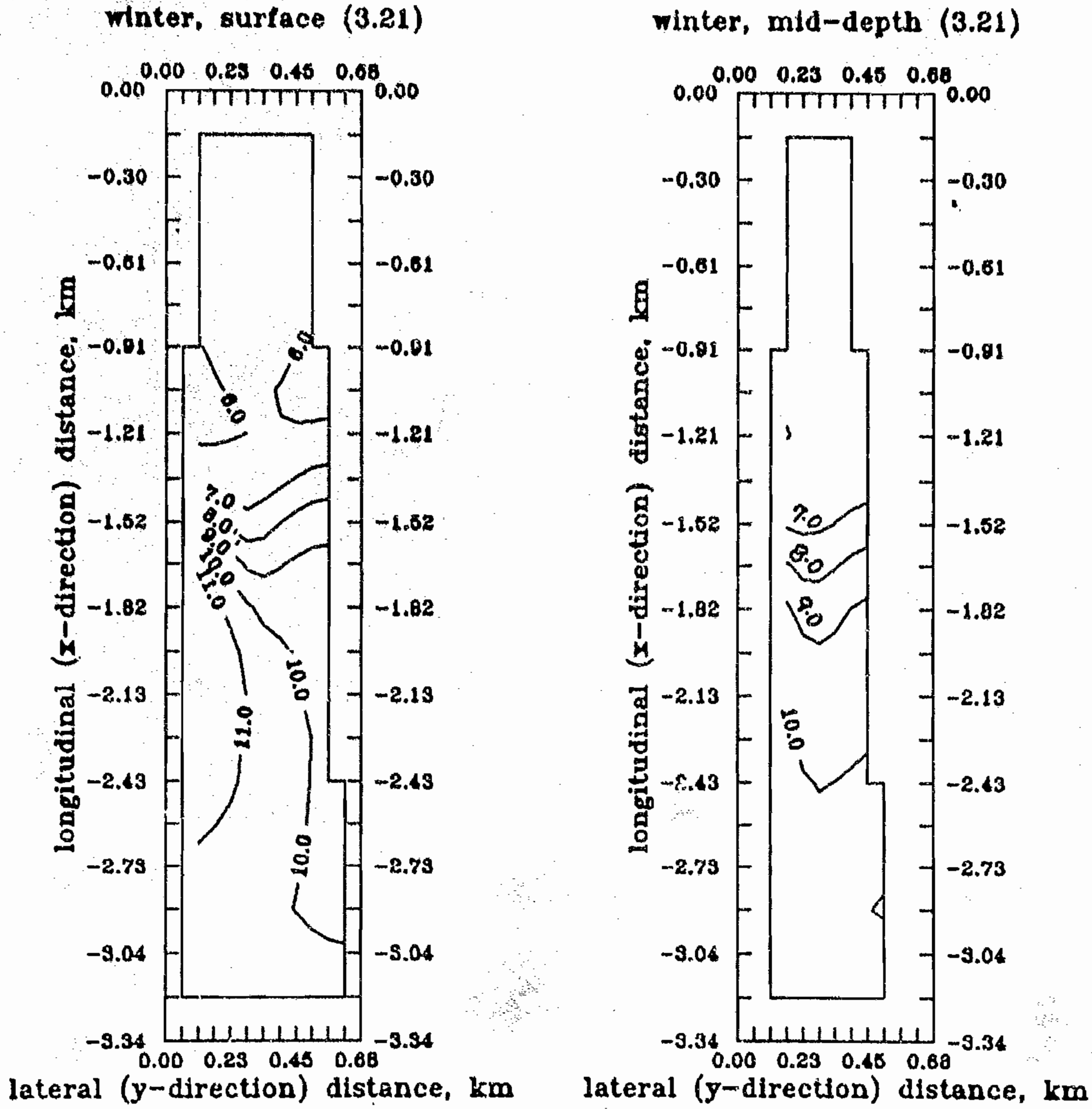


Exhibit 19. Spring near-field temperature distribution for typical conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.

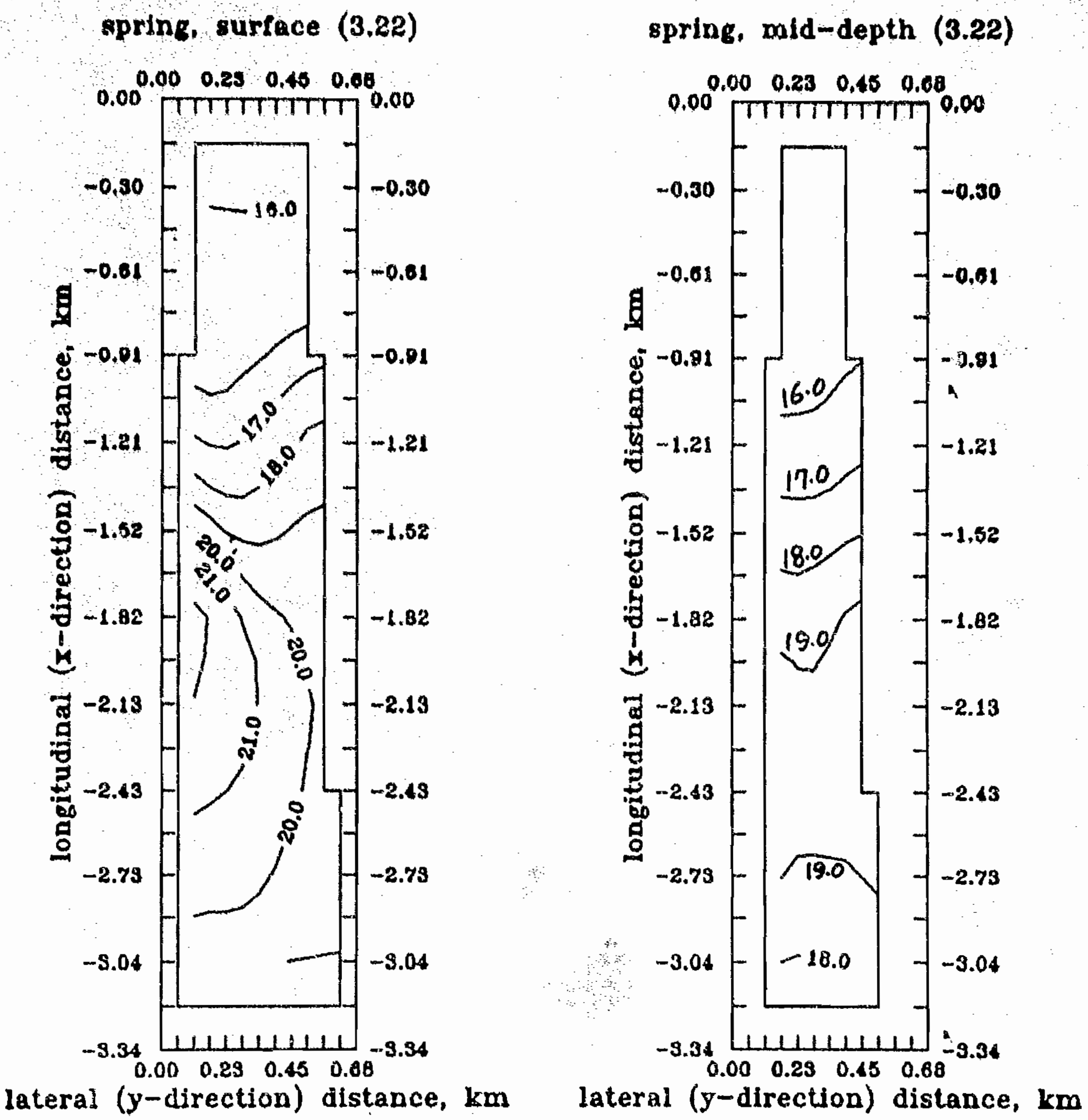


Exhibit 20. Summer near-field temperature distribution for typical conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.

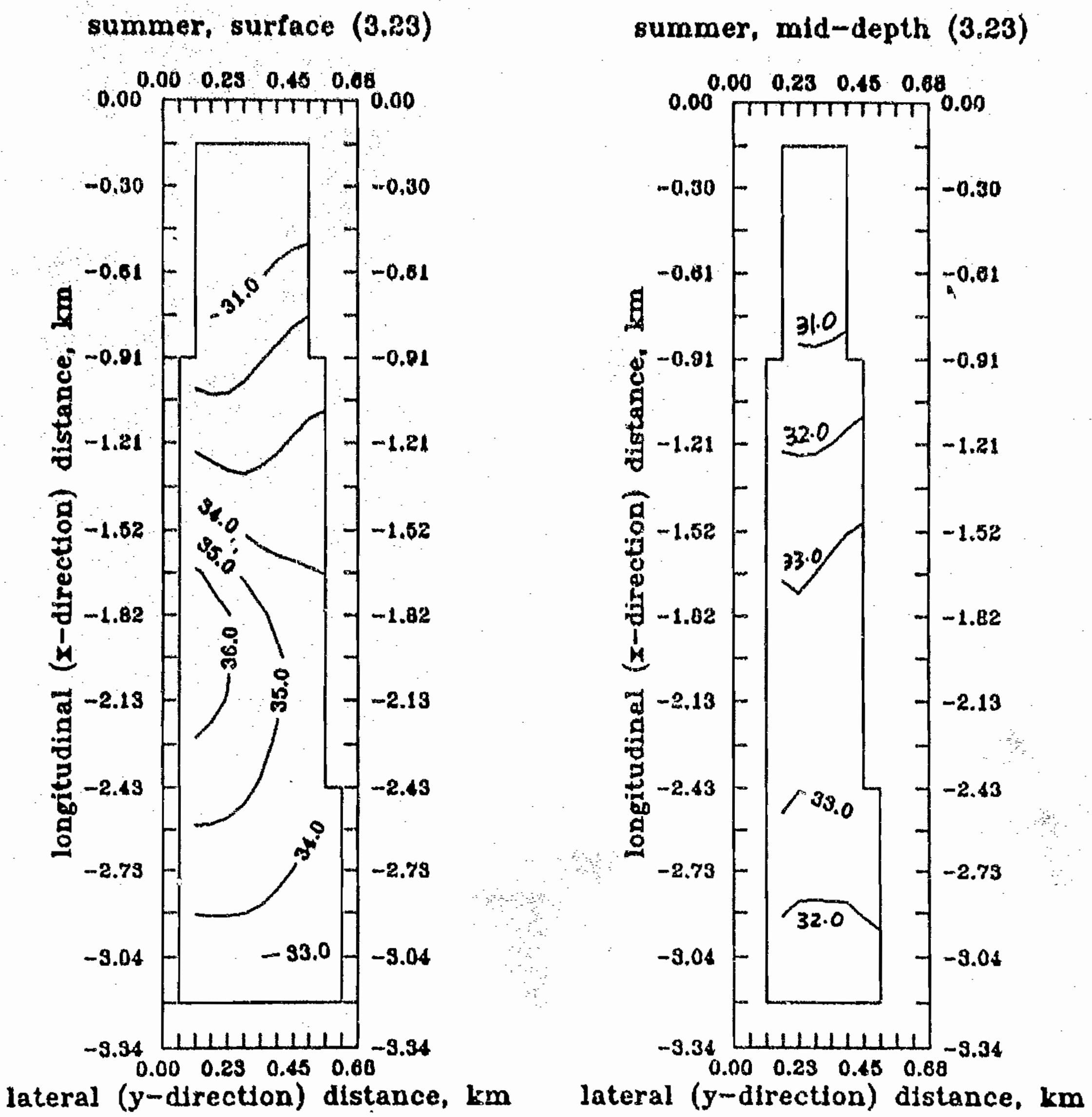
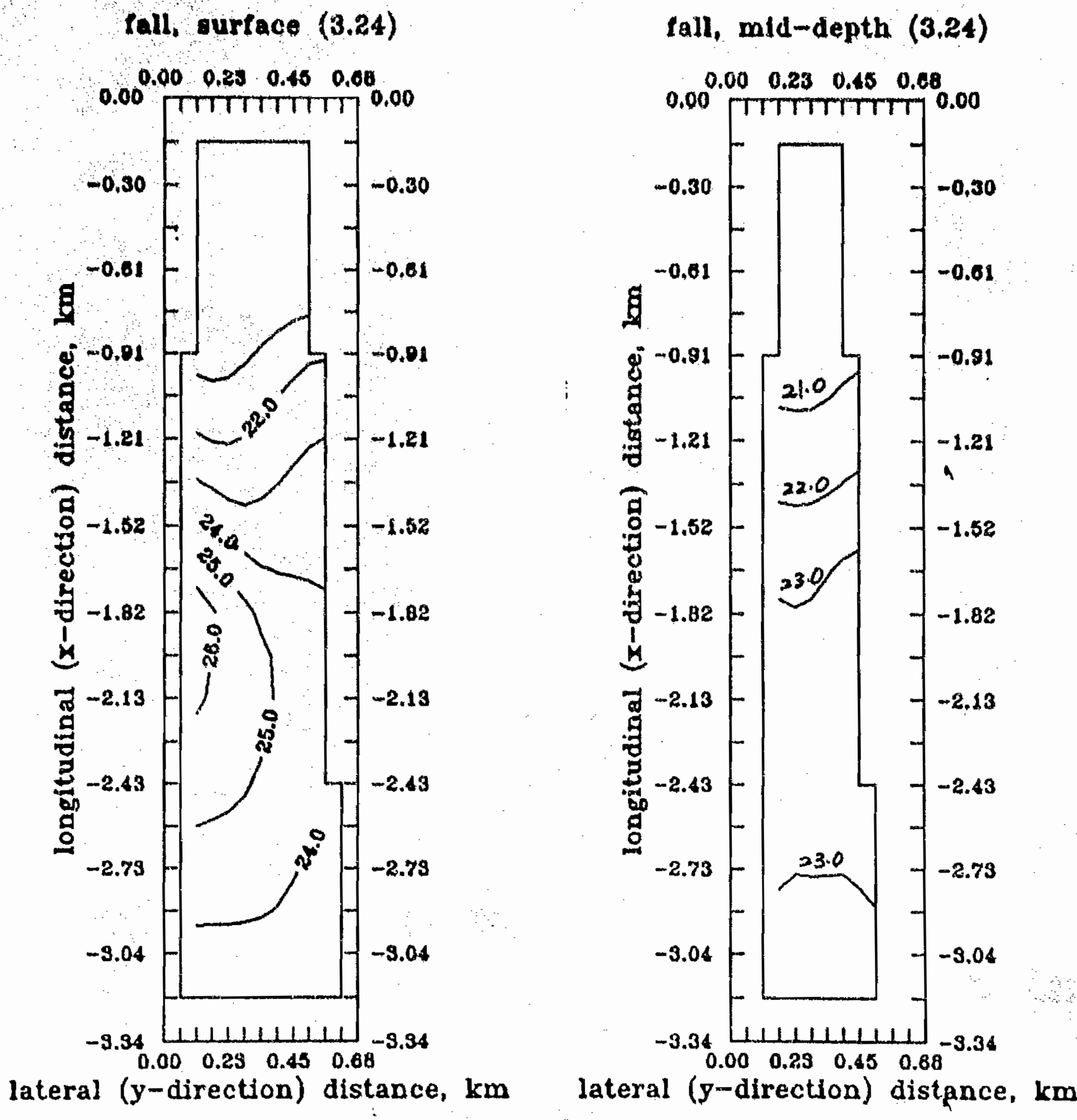


Exhibit 21. Fall near-field temperature distribution for typical conditions for the surface and for mid-depth. At the top of each diagram is the up-lake (Salt Creek) direction and at the bottom is the down-lake (plant intake direction). Location relative to reference points are shown in Exhibit 5. The number in parenthesis is the simulation number.



BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

ILLINOIS POWER COMPANY (Clinton Power Station), **Petitioner,** **v.** **ILLINOIS ENVIRONMENTAL PROTECTION AGENCY,** **Respondent.**	)	PCB No. 92-______ (§ 302.211(f) Hearing)

SUPPLEMENTAL AFFIDAVIT OF JAMES A. SMITHSON

I, James A. Smithson, on oath do depose and state:

1. I am the Director - Outreach and Assessment, in the Environmental Affairs Department of Illinois Power Company ("Illinois Power").

2. As part of my responsibilities as Director - Outreach and Assessment, I was involved in preparing Illinois Power's Petition for Hearing on Heated Effluent Demonstration Pursuant to 35 Ill. Adm. Code § 302.211(f) ("Petition"), and certain of the Exhibits submitted therewith. Specifically, I was involved in coordinating the information which is presented in paragraphs 4 through 7 of the Petition. In addition, Illinois Power employees working under my supervision provided J.E. Edinger Associates, Inc. ("Edinger") with the lake temperature data referenced in paragraphs 4 through 7 of the Petition, which data was used by Edinger in preparing Exhibits HE-1 and HE-2.

3. To the best of my knowledge, the information presented in paragraphs 4 through 7 of the Petition, as well as the lake temperature information provided to Edinger, is true and correct.

Certain of this information was provided to me from individuals employed by Illinois Power who have personal knowledge of the truth and correctness of the information so provided, and I myself have personal knowledge of the truth and correctness of certain of this information.

FURTHER AFFIANT SAYETH NOT.

James A. Smithson

James A. Smithson

Subscribed and sworn to before me
this 7 day of Oct, 1992

William H. Witts

Notary Public

My Commission Expires: 8/4/93

"OFFICIAL SEAL"
William H. Witts
Notary Public, State of Illinois
My Commission Expires 8/4/93

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

ILLINOIS POWER COMPANY (Clinton Power Station),	)	
Petitioner,	)	PCB No. 92-_______
v.	)	(§ 302.211(f) Hearing)
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY,	)	
Respondent.	)	

AFFIDAVIT OF JOHN E. EDINGER

I, John E. Edinger, on oath do depose and state:

1. I am President and Principal Scientist at J.E. Edinger Associates, Inc., 37 West Avenue, Wayne, Pennsylvania ("Edinger Associates").

2. I received a Bachelors of Civil Engineering from Union College in 1960 and a PhD in Water Resources and Physical Oceanography from The Johns Hopkins University in 1965. My area of expertise is environmental hydrology with particular emphasis on waterbody dynamics and hydrothermal analysis. I started the consulting firm of Edinger Associates in 1974.

3. For the present proceeding, Illinois Power retained Edinger Associates to perform actual plume studies and predicted plume studies for the heated effluent demonstration for Clinton Lake, using lake temperature data and Station operating data for the years 1989-1991.[1] Edinger Associates has prepared two reports encompassing these two studies. The actual plume studies are presented in the report submitted as Exhibit HE-1 to Illinois Power's Petition for Hearing on Heated Effluent Demonstration Pursuant to 35 Ill. Adm. Code § 302.211(f) ("Petition"). The

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[1] The Station operating data used in preparing the two reports is the same as that used in preparing Exhibit 4 to Illinois Power's Petition for Hearing to Determine Specific Thermal Standards Pursuant to 35 Ill. Adm. Code § 302.211(j).

predicted plume studies are presented in the report submitted as Exhibit HE-2 to the Petition. The two Edinger Associates reports also are referenced at various places in the Petition.

4. To the best of my knowledge, the information presented or depicted in Exhibits HE-1 and HE-2, the two Edinger Associates reports, is true and correct. Certain of this information was provided to Edinger Associates from individuals employed by Illinois Power who have personal knowledge of the truth and correctness of the information so provided. In addition, I myself have, or my associate Edward Buchak has, personal knowledge of the truth and correctness of certain of this information.

FURTHER AFFIANT SAYETH NOT.

John E. Edinger

John E. Edinger

Subscribed and sworn to before me
this 9th day of October, 1992.

Martha A Collins
Notary Public

My Commission Expires: 9-4-94

OFFICIAL SEAL
MARTHA A. COLLINS
NOTARY PUBLIC STATE OF ILLINOIS
MY COMMISSION EXP. SEPT. 4,1994