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Mathematical Modeling of Ultimate Heat Sink Cooling Ponds

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Prepared for
U.S. Nuclear Regulatory Commission

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MATHEMATICAL MODELING OF
ULTIMATE HEAT SINK
COOLING PONDS

ABSTRACT

A general treatment of ultimate heat sink (UHS) cooling pond thermal performance is proposed through the application of a three-dimensional grid model. Validation of the model has been shown through comparisons of predictions with data from a field and laboratory pond. The advantage of the model lies in its ability to determine the detailed character of the flow field whether it be one, two, or three dimensional. Existing models require a priori knowledge of the character and dimensionality of the flow field in such ponds.

Application of the model to a prototype UHS pond revealed that the balance of physical mechanisms involved in the thermal hydraulics of these ponds is quite different than for ponds used in normal cooling. The small, heavily-loaded, irregularly-shaped nature of the UHS pond should, in many cases, lead to a vertically mixed pond with only a one-dimensional (longitudinal) variation in pond temperature.

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Ultimate Heat Sink
Model Evaluation

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The authors would like to thank Dr. Richard Codell whose interest in this problem at NRC made this project possible. His considerable contributions to this field of research provided us with a good start in our investigations. We would also like to thank Dr. John Paul of the U.S. EPA who gave us a great deal of his time providing us with advice on the application of his model. We also appreciate the assistance of Dr. Eric Adams of MIT who provided us with the Cerco laboratory data and advice on the application of the MITEMP model. Finally, we would like to thank Mr. David Herlong and Ms. Carolyn Anderson of the Carolina Power & Light Company who provided us with the H.B. Robinson field data.

EXECUTIVE SUMMARY

A three-dimensional numerical model is proposed for the analysis of ultimate heat sink (UHS) cooling pond thermal performance. This model is able to determine the detailed character of the flow field whether it be one, two, or three-dimensional. Without such a model, it is not possible to predict with any reasonable certainty the character of the flow field in such ponds. This computer model was developed by J. Paul of the U.S. EPA and was modified for UHS applications at ANL as part of this present work. The Paul Model was improved to include the Ryan-Harleman surface heat transfer formulas for UHS applications. These latter formulas are shown to correctly represent the surface heat transfer rates for the artificial hot ponds at Raft River, Idaho. The model is tested with laboratory and field data on heated cooling ponds and is shown to correctly represent the thermal-hydraulics of such ponds. A methodology is presented in which zero, one, and three-dimensional models may be used in combination for analyzing UHS pond thermal performance.

Application of the Paul Model to a prototype UHS pond revealed that the balance of physical mechanisms involved in the thermal-hydraulics of these ponds is quite different than for ponds used in normal power plant cooling. The small heavily-loaded, irregularly-shaped nature of the UHS pond should, in many cases, lead to a vertically-mixed pond with only a one-dimensional (longitudinal) variation in pond temperature. Strong circulations resulting from the buoyancy of the discharge and the strong discharge/intake flow are supplemented by the strong removal of heat from the surface leading to a breakdown in vertical stratification.

1. INTRODUCTION

The U.S. NRC has set forth stringent safety standards (Ref. 1) on the design of cooling ponds used as ultimate heat sinks (UHS). Three basic requirements are: (a) the UHS must be capable of dissipating reactor decay heat of a design basis accident of one unit plus the safe shutdown and cooldown of all other units it serves, (b) the UHS must provide a 30-day supply of cooling water at a temperature low enough that the design basis temperature of all safety-related equipment is not exceeded, and (c) the UHS must be capable of performing under two sets of meteorological conditions selected from the historical climatological data, the first leading to the worst cooling performance and the second leading to the greatest water loss. Thus, an adequate UHS pond model must be able to reliably predict the intake temperature and water loss of the 30-day design basis conditions given the heat rejection rate of the plant.

A typical UHS cooling pond is irregularly shaped with 30-60 acres surface area with an average depth of 6-20 feet. It is commonly formed by damming up a section of a natural lake used for normal cooling of the plant. The UHS pond would also be heavily loaded during operation running as much as 15-20 MW_t per acre of surface area.

A model for a UHS has two basic components: one involves prediction of the manner in which thermal effluent from the plant mixes into the pond (the treatment of pond hydrodynamics) and the second relates to the prediction of the net radiative, evaporative, and convective heat exchange across the pond surface (the treatment of surface heat exchange). Models currently being used to determine thermal performance of these ponds use very simple treatments of mixing with large factors of conservatism built into the treatment of surface heat transfer. Such oversimplified theoretical development of these models underscores two basic issues which require resolution:

(1) are the commonly used engineering formulas for surface heat transfer applicable to small hot ponds that can reach temperatures as high as 150°F during their operation?, and

(2) are such hot ponds strongly stratified as is commonly assumed? In addition, what are the relative contributions of wind stress, discharge/intake flow, and buoyant convective motions to the thermal-hydraulics of these ponds. Does short-circuiting cut off large sections of the pond from removing heat from the surface?

It is the purpose of this report to provide a resolution to the above two questions and to provide a general mathematical modeling methodology that can be used in future UHS problems.

The lack of field data on UHS cooling pond operation is the major drawback towards improving the state-of-the art of modeling. As a result, alternative data must be used to improve model predictive capabilities. Given these facts, the procedure for model improvement we use follows three steps:

(a) We apply the field data on the artificial hot pond at Raft River, Idaho to evaluate alternative surface heat transfer formulations. Since the Raft River hot pond was completely mixed during the experiments, only the surface heat transfer formulation can realistically be tested for any model (0,1,2, or 3 dimensional). It was found that the Ryan-Harleman (Ref. 2) surface heat transfer formulation provided excellent predictions of pond heat loss at those hot pond temperatures.

(b) Now that the surface heat transfer formulation is finalized, our attention is turned to the thermal-hydraulics within UHS ponds. Here, we tested the Paul three-dimensional numerical model (Ref. 3) in related pond applications (Cerco laboratory data (Ref. 4) and the H.B. Robinson (Ref. 5) pond field data) to verify that the Paul Model could predict the correct flow patterns and thermal performance of these ponds. An evaluation of the literature revealed that the Paul Model was a good practical tool in hydrothermal modeling problems. It has been developed over a period of ten years and had verification in similar power plant thermal discharge problems. In our view, it represented the state-of-the-art in problems requiring three-dimensional numerical solutions, and its computer code could be modified without much difficulty for UHS cooling pond applications.

The Cerco lab data were chosen for verification because the laboratory pond had a simple design and contained the basic features of a UHS pond: single surface discharge, bottom intake, stratified and unstratified portions to the pond, some short-circuiting, surface heat transfer, etc. The H.B. Robinson field case was chosen due to its hot surface temperatures, multiple intakes and discharges, unstratified and stratified portions to the pond, etc. As will be seen in Chapters 5 and 6, the Paul Model predicted the flow structure and intake temperatures quite well. The model was determined to be an ideal candidate for application to a prototype UHS pond.

(c) The Paul Model is then applied to the Catawba UHS pond, a typical representative of UHS ponds, to determine the response to question (2) posed above. It was found that the Catawba UHS pond has a one-dimensional longitudinal temperature structure (full mixing occurs laterally and vertically). It does not have any short-circuiting problem and is dominated by buoyant convective motions along with the action of the momentum of the discharge/intake flow. For those UHS ponds that have similar geometry, pond depths and heat loading to the Catawba UHS pond, a similar flow structure would be anticipated.

(d) Finally, alternative zero and one-dimensional models are applied to the Catawba UHS case and predictions are compared. The discussion in Chapter 8 proposes a plan for the future application of these 0, 1, and 3-dimensional models to new UHS cases.

This report to follow is organized as follows. Chapter 2 provides an evaluation of the surface heat transfer formulas for hot pond application. Chapter 3 provides a review of the theory of the Paul three-dimensional model. Chapter 4 provides a discussion of the input/output of the Paul Model in a user's manual format. Chapters 5 and 6 present the validation results of the Paul Model with the Cerco laboratory and H.B. Robinson field data. The input to the Paul Model for these runs is also given. Chapter 7 provides the Paul Model run for the Catawba UHS case along with zero and one-dimensional model predictions. The detailed input to the Paul Model for the Catawba case is described. Chapter 8 summarizes the results of the report and presents a plan for the future use of models in UHS applications.

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2. EVALUATION OF SURFACE HEAT TRANSFER FORMULATIONS FOR HOT PONDS

A series of experiments have been carried out at Battelle Northwest Laboratory (Ref. 1-3) aimed at obtaining field data with which to characterize the thermal performance of cooling ponds at elevated temperatures. Field data were taken at Raft River, Idaho and East Mesa, California where hot ponds are used to cool geothermally heated water before reinjection into the ground. The ponds were shallow and found to be completely mixed so that at any time, a single temperature would be adequate to represent the entire pond. These data are best used to test surface heat transfer formulas. Data were acquired as these ponds cooled from an initial hot temperature. Complete mixing was observed at each time during the cooling process.

Only the results of the Raft River data comparisons are presented here since comparisons with the data from East Mesa lead to substantially the same conclusions. More details on both comparisons are given by Codell (Ref. 4). Table 2-1 lists the basic characteristics of the Raft River pond. Table 2-2 lists instrumentation present to measure the major thermal-hydraulics and meteorological variables during the Raft River experiments. Raft River experiments 1, 2 and 3 represent the best data available for model testing.

Two surface heat transfer formulations were tested with these data. Method 1 is described by Codell and Nuttle (Ref. 5). Method 2 employs the surface heat transfer relations of Ryan and Harleman (Ref. 6). Method 1 is representative of the equilibrium temperature approach, whereas Method 2 provides nonlinear expressions for and represents a direct balance of the individual components comprising the surface heat transfer. A summary of the methods appears in Tables 2-3 and 2-4, respectively.

Mathematical models were set up to predict Raft River pond temperatures as a function of time assuming complete pond mixing. The models are termed zero-dimensional models since there is no spatial variation assumed within the pond at any time. The differences between the two models related only to their treatment of surface heat transfer, from either Method 1 or Method 2. In neither case is conduction to the ground included. However, Hadlock et al. (Refs. 1-3) measured the temperature profile using burried thermistors and found that the heat flux to the ground was negligible. The wind speed reported in the field studies was taken at a height of 1.5 m not the 2 m value required in the application of the Ryan and Harleman formulas. An adjustment is thus necessary based on an assumed power law wind profile.

Results of model predictions are summarized in Figs. 2-1 to 2-4 for Experiment No. 1; Figs. 2-5 to 2-9 for Experiment No. 2; and Figs. 2-10 to 2-14 for Experiment No. 3. In all figures, time is measured relative to the first field measurement of pond temperature. Figs. 2-1, 2-6, and 2-11 compare predicted and measured pond temperatures using Method 1. Significant overprediction (by as much as 20°F) is observed in all three experiments.

Figs. 2-2, 2-7, and 2-12 compare measured pond temperatures with the predictions of Method 2. Here, a slight tendency to underpredict pond temperature for hours 4 through 16 is observed. For greater times, overprediction of as much as 3°F is seen. These comparisons reveal that the pond did not exhibit as large a diurnal swing in temperature as the models predict perhaps due to some uncertainties in the solar loading.

The surface heat transfer coefficient, K, the equilibrium temperature E and the net surface heat transfer rate, Q, all show the large diurnal temperature variations. The equilibrium temperature is defined as the pond temperature at which surface heat exchange is zero. The surface heat transfer coefficient is defined as the ratio of the actual surface heat transfer rate to the difference between the pond temperature and the pond equilibrium temperature.

In summary, Method 2 based on the surface heat transfer analysis of Ryan and Harleman gives predictions within the uncertainty of the data, considering both the uncertainty in the measured pond temperatures and the uncertainty in the meteorological input data. Method 1, based on the method of Codell and Nuttle, consistently overpredicts pond temperature. The method of Ryan and Harleman is used to simulate pond heat transfer in the spray pond model of Codell (Ref. 7). The performance of Method 2 is sufficiently accurate with these hot pond data that its use may be recommended without modification in future UHS cooling pond calculations.

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Table 2-1. Physical Description of the Artificial Cooling Pond at Raft River, Idaho ... adapted from Reference 2

Area:	Nominal 2840 m^2
Volume:	Nominal 3864 m^3
Depth:	Nominal 1.7 m
Change in volume per cm change in depth:	Nominal 27.6 m^3; 28.4 m^3 at 1.70 m depth, 26.7 m^3 at 1.50 m depth
Altitude (msl):	1480 m
Atmospheric pressure:	Nominal 840-860 mb

Table 2-2. Instrumentation Present at Raft River Experiments
... adapted from Reference 3

Item	Comments
Pond Thermistors (Yellow Springs Instruments 44006)	9 to 12 thermistors in water at 3 levels (bottom, mid and near surface and at 3 to 4 locations)
Under-Liner Thermistors (YSI 44006)	5 in vertical line over 50 cm, top thermistor in contact with liner
Hook Gauges/Stilling Wells (Science Associates)	3 along pond centerline
Pyranometers (Eppley)	On roof of mobile laboratory, adjacent to pond
Net Radiometers (Fritschen type)	Over pond surface, between pond corner and pond center (1 m height), or on boom from raft
Aspirated Wet and Dry Thermistors (YSI 44006)	7 or 8; 2 on reference tower (1.5 m and 10 m), 2 on raft (1.5 m and 3 m). 3 or 4 pond edges (1.5 m)
3-Component Wind Speed (Direction) Sensors (R.M. Young, Gill)	6 or 7; 2 on reference tower (1.5 m and 10 m), 1 on raft (1.5 m), 3 or 4 pond edges (1.5 m)
Monostatic Acoustic Sounder (Radian)	50 meters from pond, stability indication to 600 m above ground
Rain Gauges (Various manufacturers)	4 wedges at pond corners, 2 tipping buckets, other large gauges
Barometer	High-resolution digital display in mobile laboratory or microbarograph
Whole-Sky Camera	Recording of cloud cover
Logging/Recording System (Metrodata/Digidata/Kennedy)	All electrical signals continuously digitized and tape recorded at 2 or 5-second intervals

Table 2-3. Summary of Surface Heat Transfer Formulas Used in Method 1

Atmospheric Radiation to and Back Radiation from Pond, H_{AN} and H_{BR} (after Codell and Nuttle [4])

$$H_{AN} - H_{BR} = 0,$$

i.e., these terms are assumed to be equal in magnitude and hence to make no net contribution to surface heat transfer.

Solar Radiation to Pond, Evaporative and Convective Heat Transfer from Pond, H_{SN}, H_E, and H_C (after Codell and Nuttle [4])

$$(H_{SN} - H_E - H_C)\ (\text{Btu/hr-ft}^2) = K(E - T).$$

K(Btu/hr-ft²-F) = surface heat transfer coefficient
$= 0.6542 + (\beta + 0.26\ T_A)/(\beta + 0.26)$

E(F) = pond equilibrium temperature
$= H_{SN}/K + (\beta T_D + 0.26\ T_A)/(\beta + 0.26)$

T(F) = pond temperature

$f(w)$ (Btu/hr-ft²-mm Hg) = wind speed function
$= 2.92 + 0.0292\ w^2$

β(mm Hg/F) = function relating water vapor pressure difference to temperature difference
$= 0.255 - 0.0085\ T_* + 0.000204\ T_*^2$

T_*(F) $= (T + T_D)/2$

H_{SN}(Btu/hr-ft²) = solar irradiation taken from input meteorological data; total absorption at water surface assumed

T_A(F) = ambient dry-bulb temperature taken from input meteorological data

T_D(F) = ambient dewpoint temperature taken from input meteorological data

w(mph) = wind speed taken from input meteorological data

Table 2-4. Summary of Surface Heat Transfer Formulas Used in Method 2

- Solar Radiation to Pond, H_{SN}

  H_{SN} taken as solar irradiation given in meteorological data; total absorption at water surface assumed.

- Atmospheric Radiation to Pond, H_{AN} (after Ryan and Harleman [5])

  $H_{AN}(Btu/hr\text{-}ft^2) = 4.85 \times 10^{-15} (1 + 0.17 C^2) T_A^6$,

  $T_A(R)$ = ambient temperature taken from meteorological data

  C = cloudiness fraction

- Back Radiation from Pond, H_{BR} (after Ryan and Harleman [5])

  $H_{BR}(Btu/hr\text{-}ft^2) = 1.68 \times 10^{-19} T^4$,

  T(R) = pond temperature

- Evaporative Heat Transfer from Pond, H_E (after Ryan and Harleman [5])

  $H_E(Btu/hr\text{-}ft^2) = f(w)(e_s - e_A)$,

  e_S, e_A (mm Hg) = water vapor pressure at pond surface and in ambient air, respectively

  $f(w)(Btu/hr\text{-}ft^2\text{-}mm\ Hg)$ = wind speed function $= 0.9333 (\Delta T_V)^{1/3} + 0.5833\ w$

  $\Delta T_V(R)$ = virtual temperature difference $= T/(1 - 0.378\ e_S/P) - T_A/(1 - 0.378\ e_A/P)$

  P(mm Hg) = atmospheric pressure taken from meteorological data

  w(mph) = wind speed taken from meteorological data

- Convective Heat Transfer from Pond, H_C (after Ryan and Harleman [5])

  $H_C(Btu/hr\text{-}ft^2) = B\ f(w)(T - T_A)$,

  B(mm Hg/R) = Bowen ration = 0.255

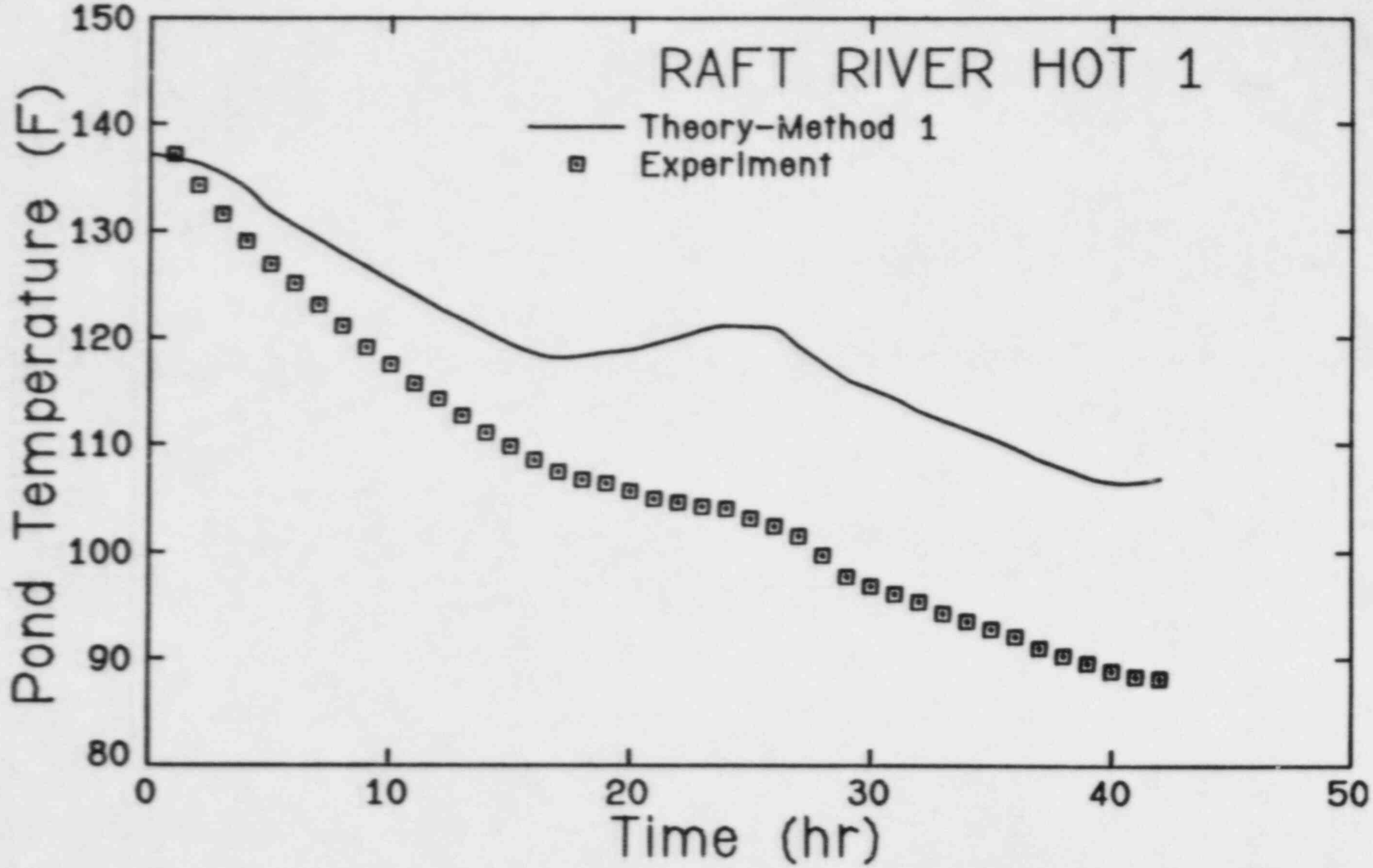


Figure 2-1. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 1 (Method 1).

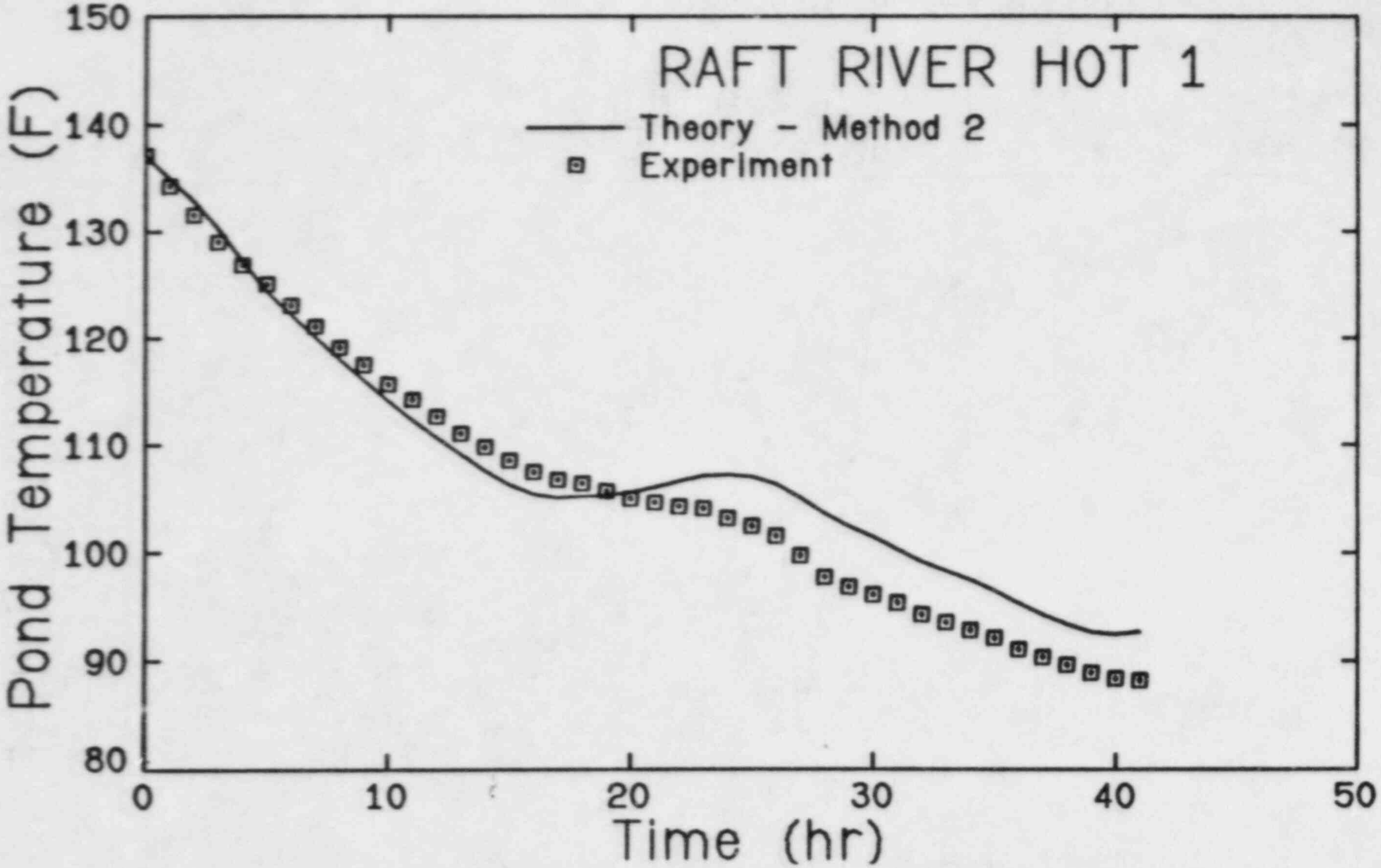


Figure 2-2. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 1 (Method 2).

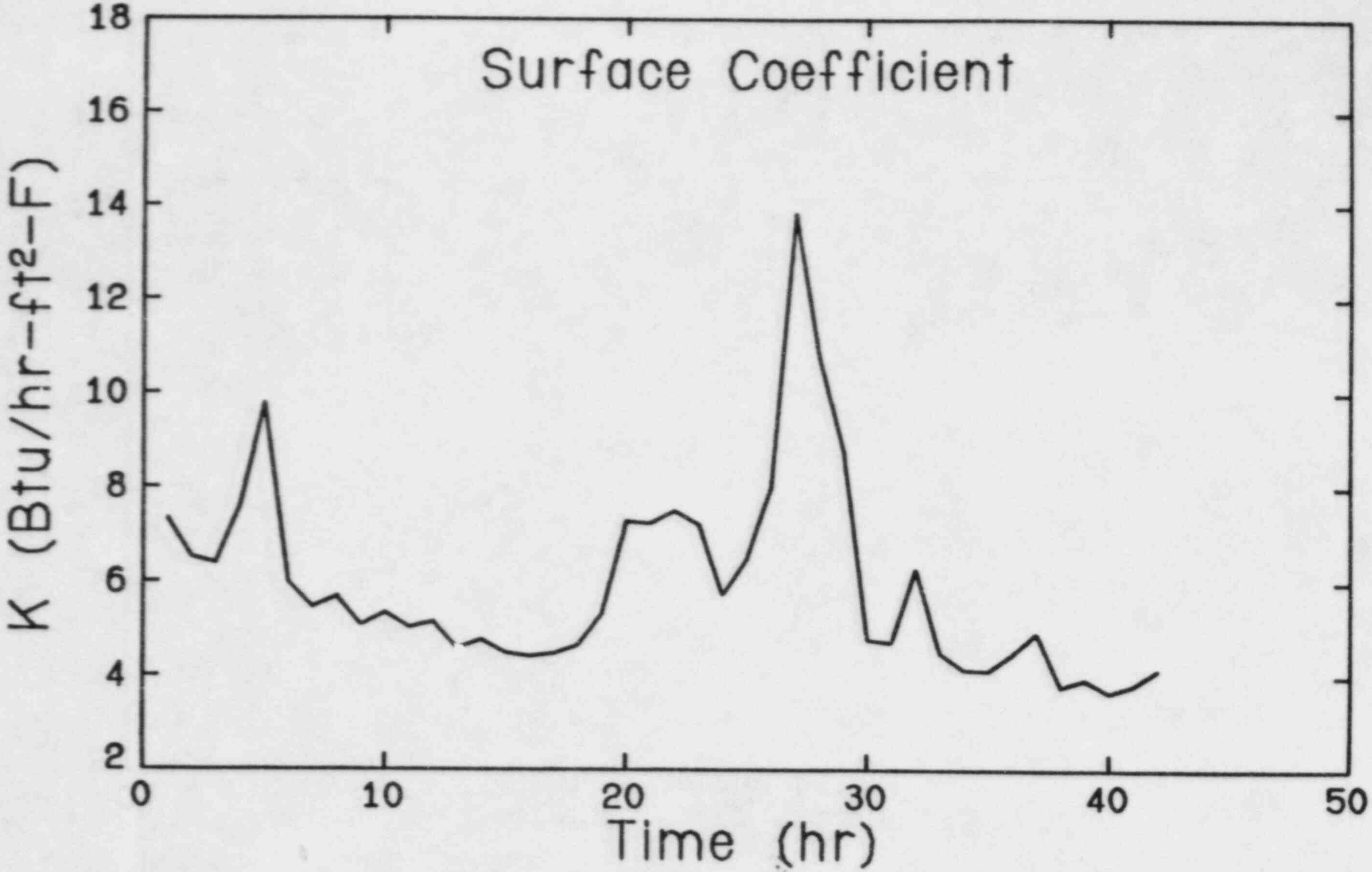


Figure 2-3. Variation of Surface Heat Transfer Coefficient for Raft River Hot Pond Experiment No. 1 (Method 1).

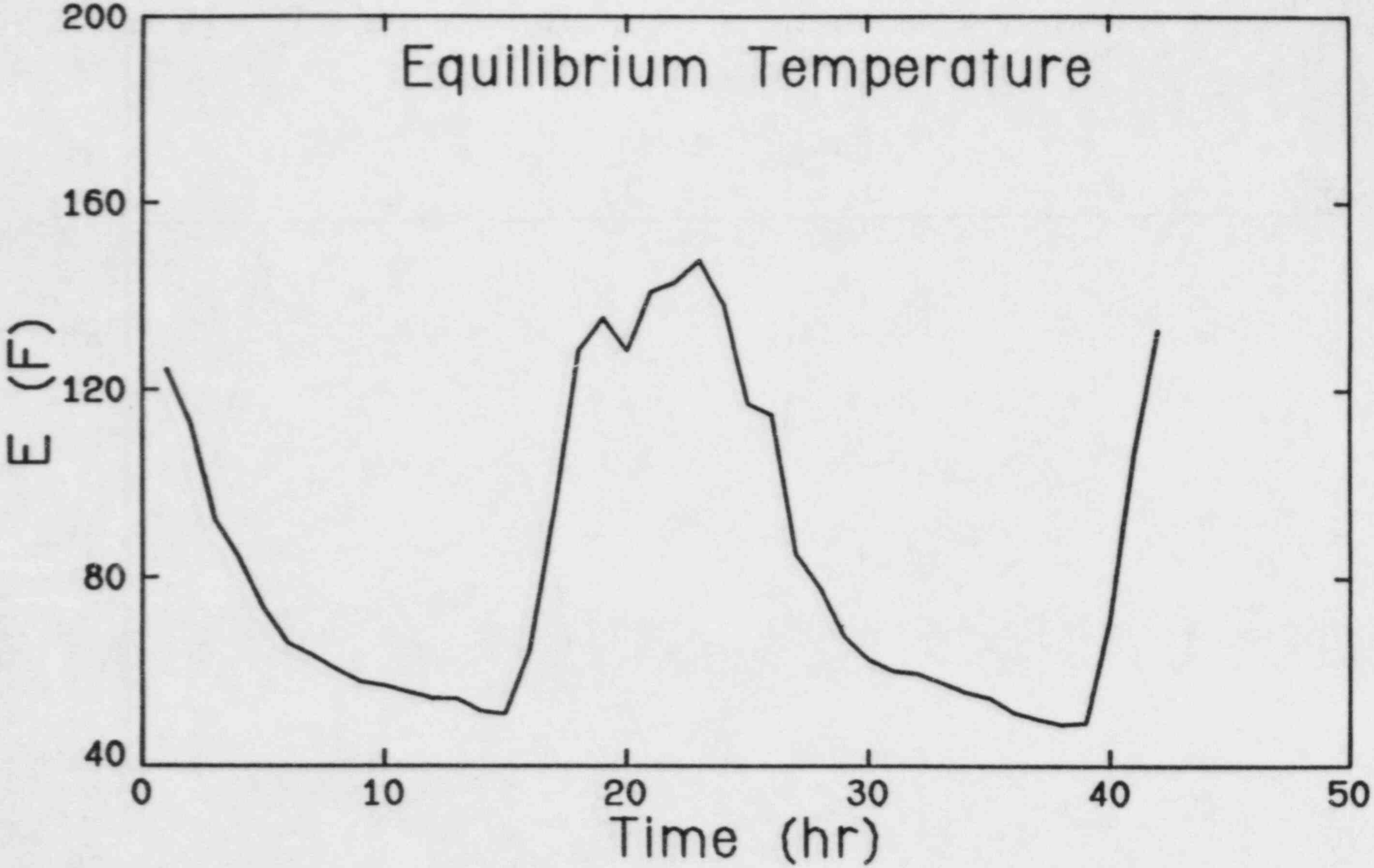


Figure 2-4. Variation of Equilibrium Temperature for Raft River Hot Pond Experiment No. 1 (Method 1).

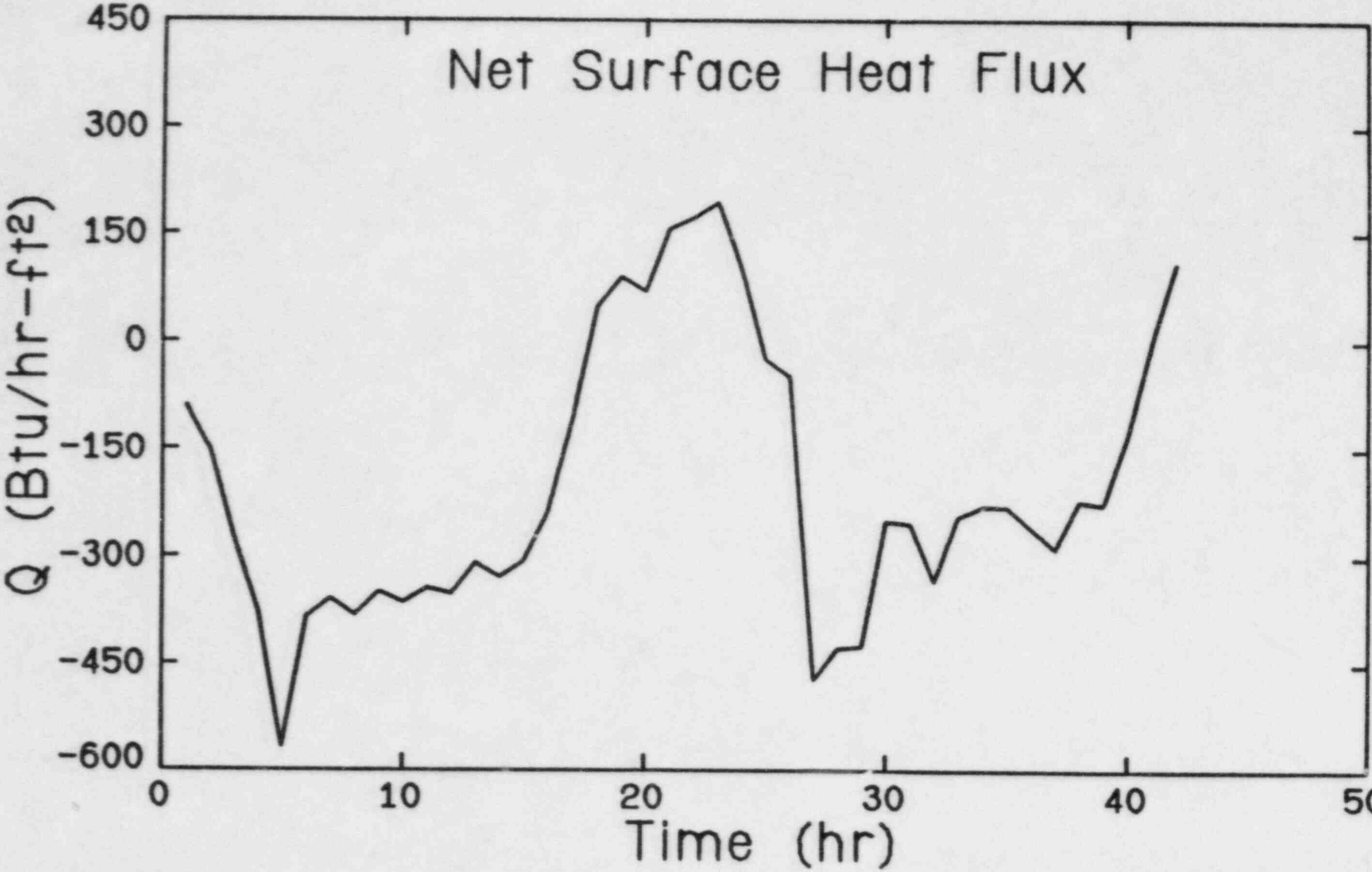


Figure 2-5. Variation of Net Surface Heat Flux for Raft River Hot Pond Experiment No. 1 (Method 1).

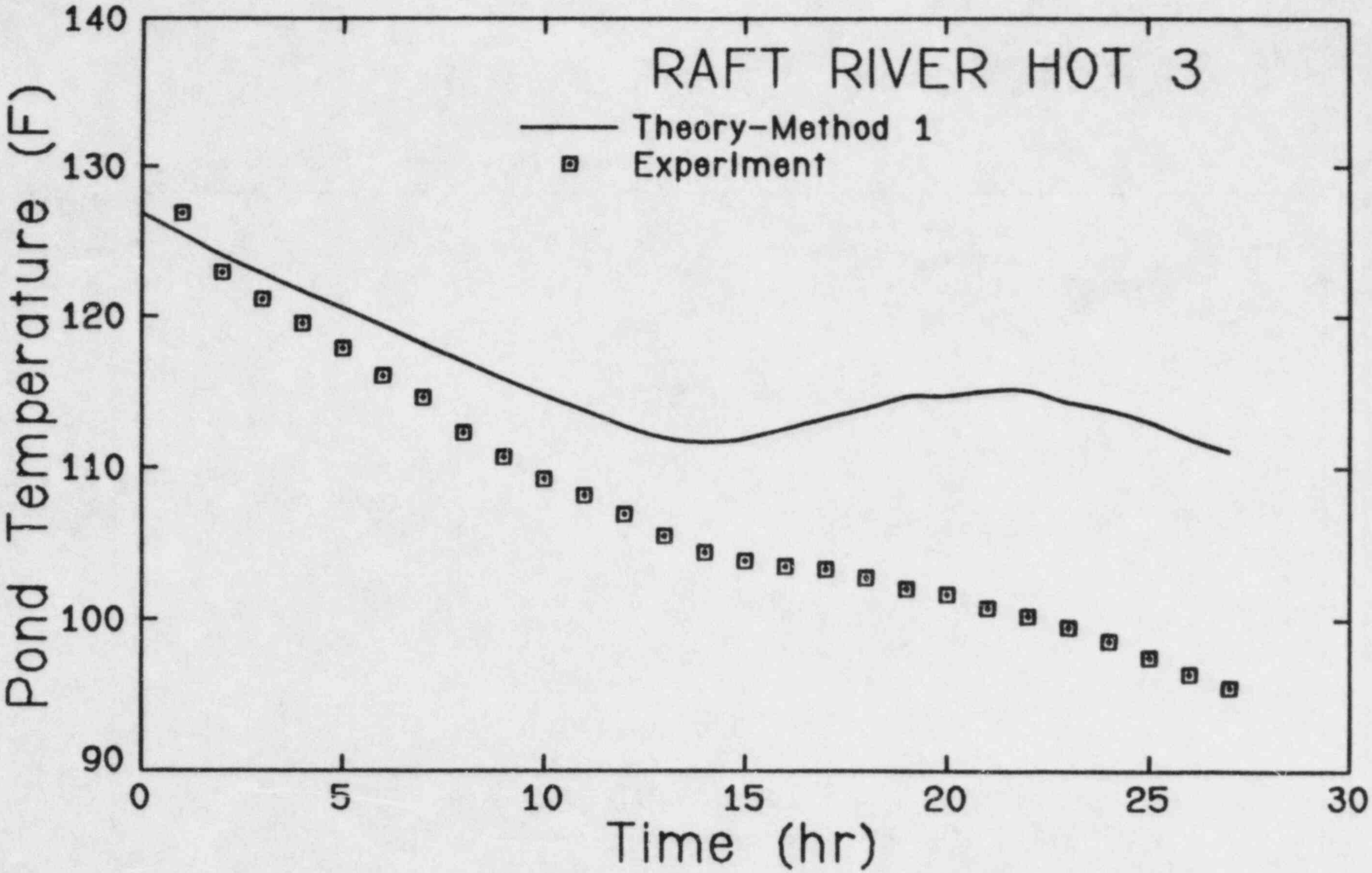


Figure 2-6. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 3 (Method 1).

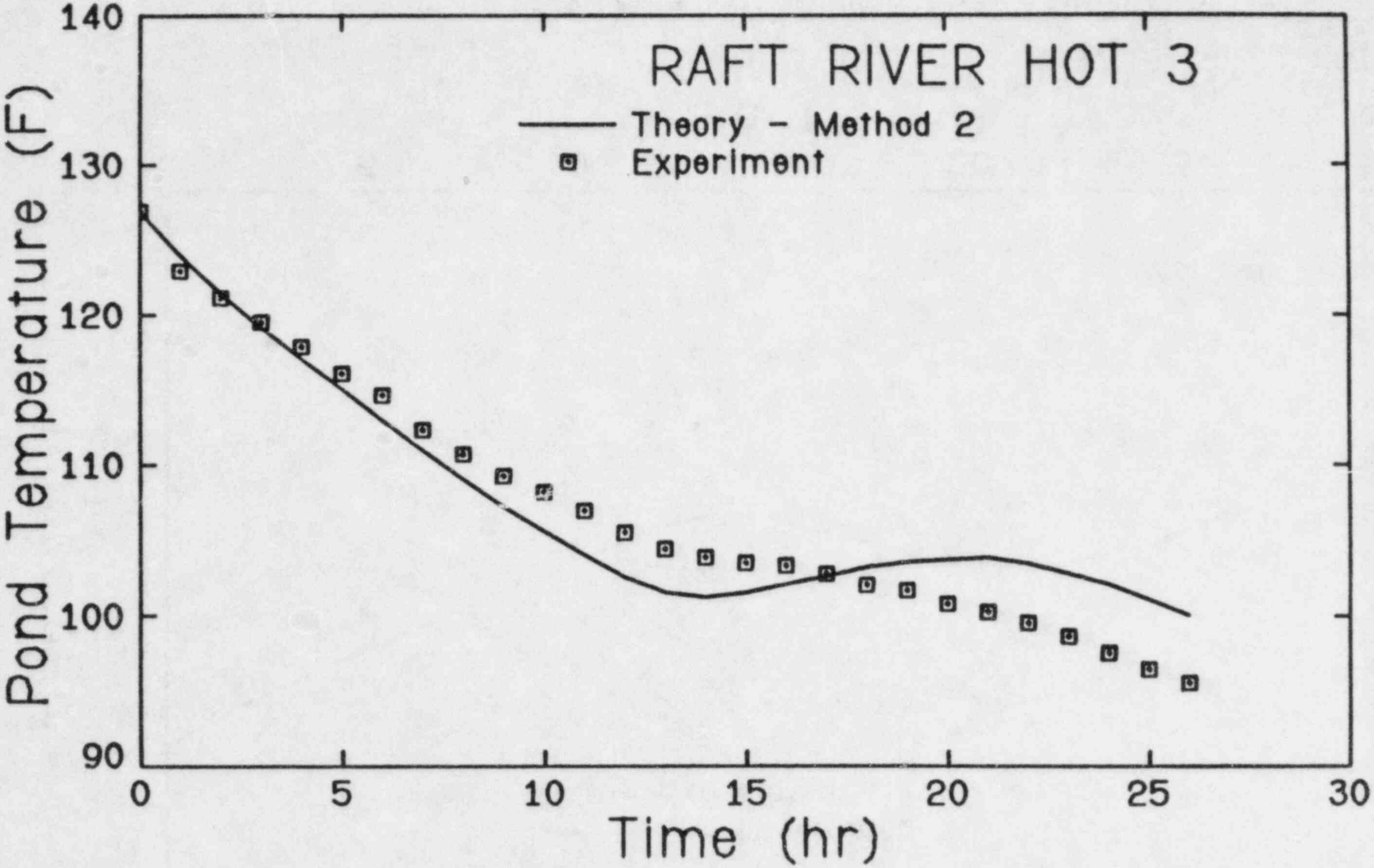


Figure 2-7. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 3 (Method 2).

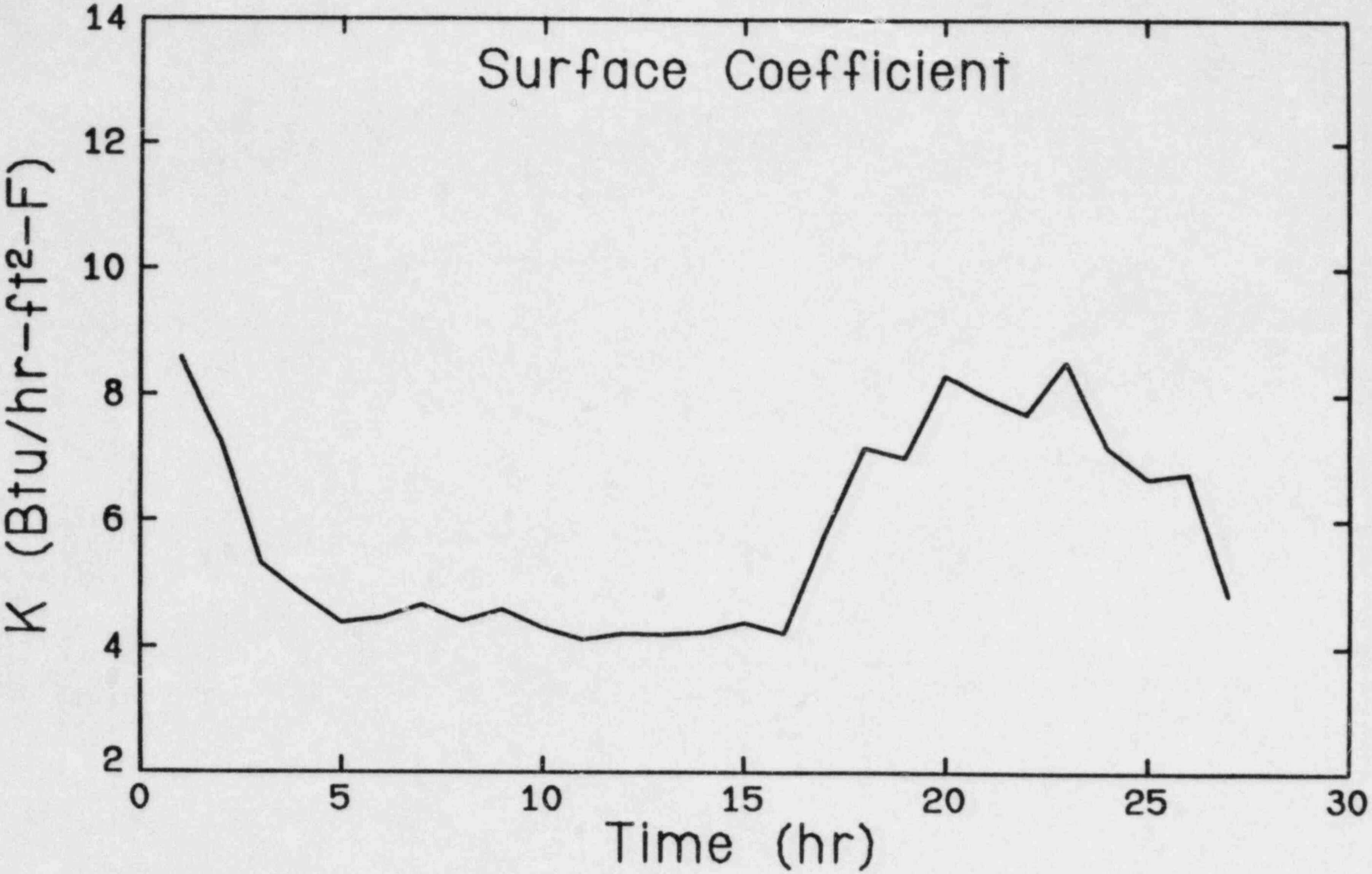


Figure 2-8. Variation of Surface Heat Transfer Coefficient for Raft River Hot Pond Experiment No. 3 (Method 1).

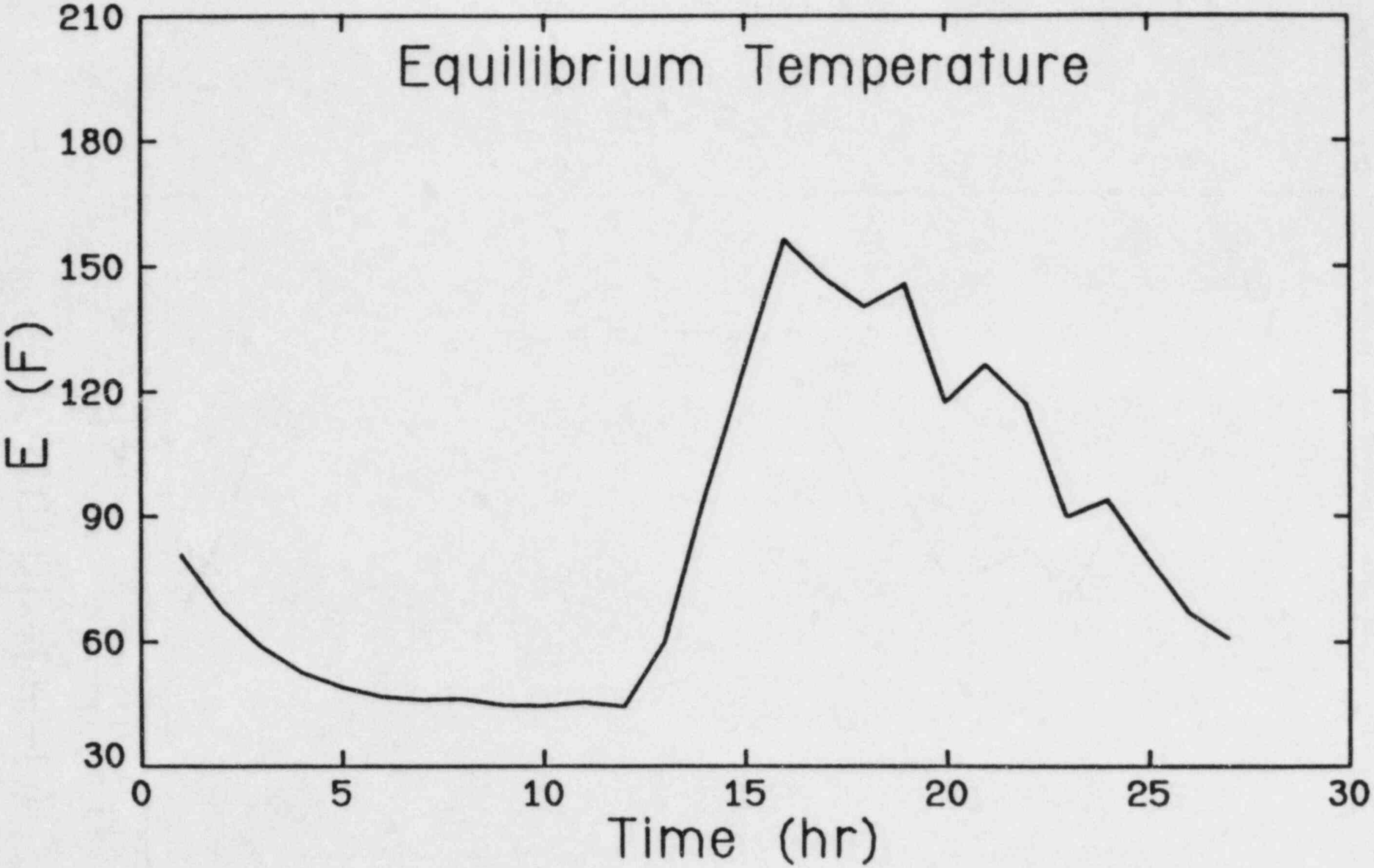


Figure 2-9. Variation of Equilibrium Temperature for Raft River Hot Pond Experiment No. 3 (Method 1).

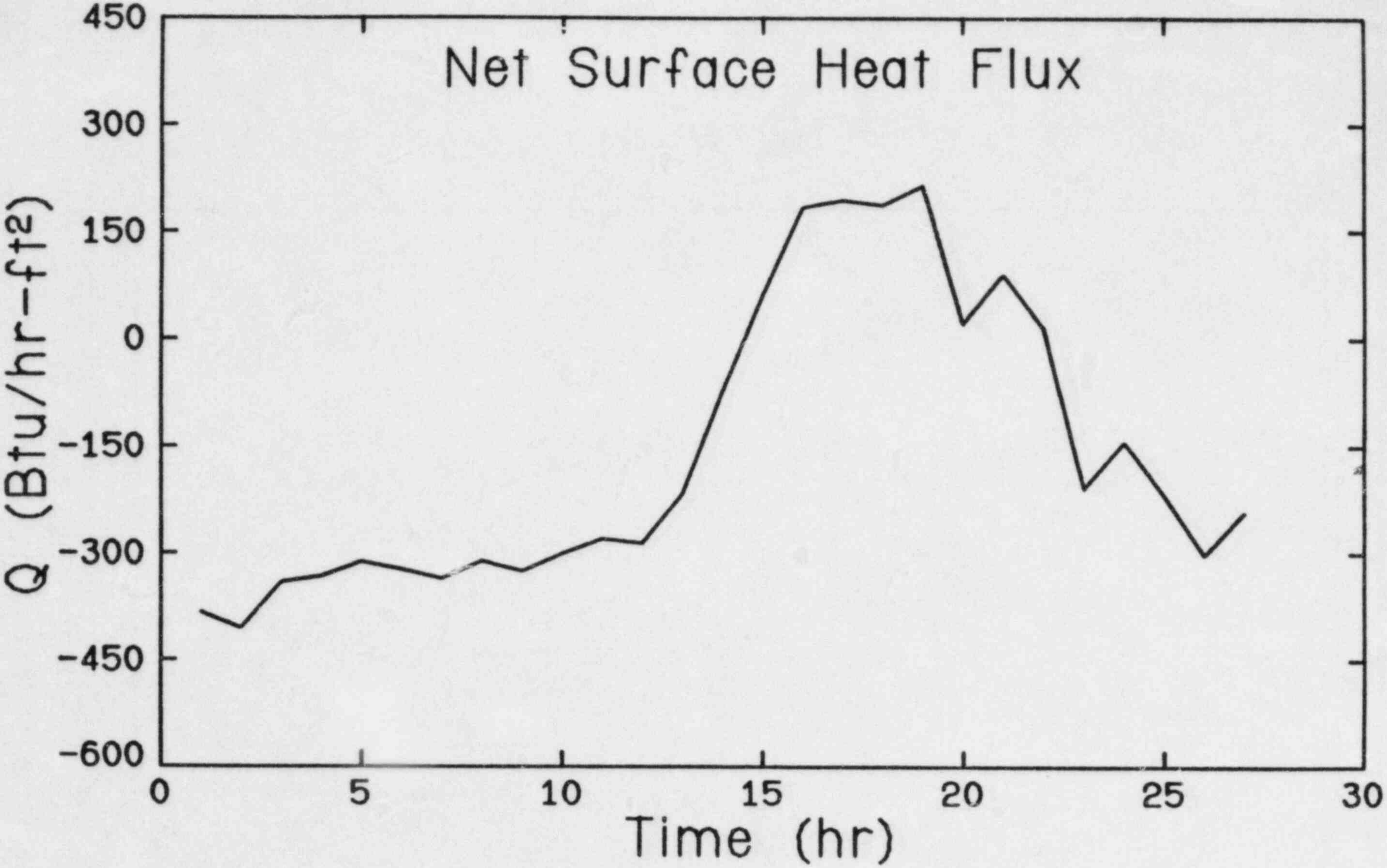


Figure 2-10. Variation of Net Surface Heat Flux for Raft River Hot Pond Experiment No. 3 (Method 1).

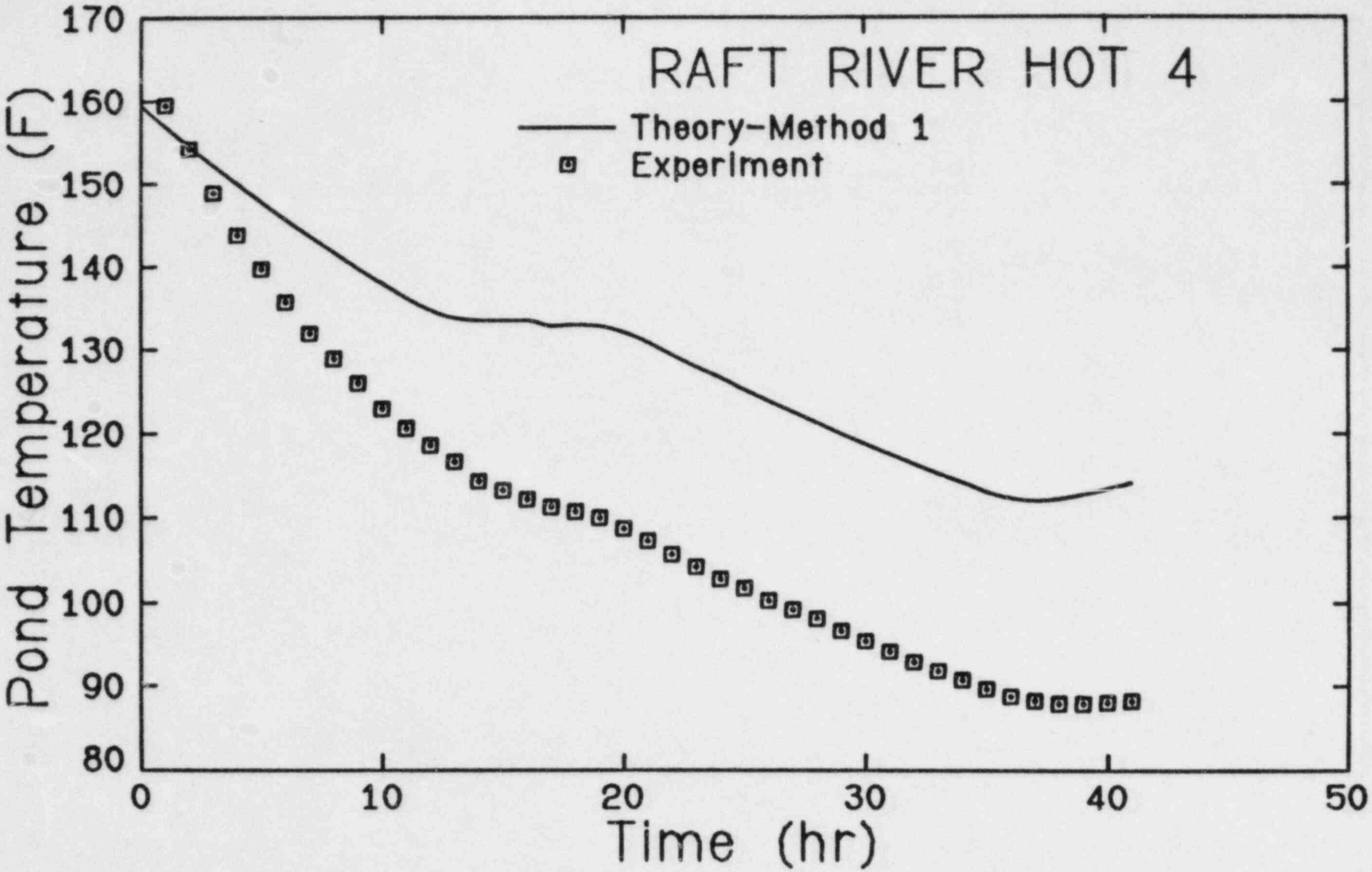


Figure 2-11. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 4 (Method 1).

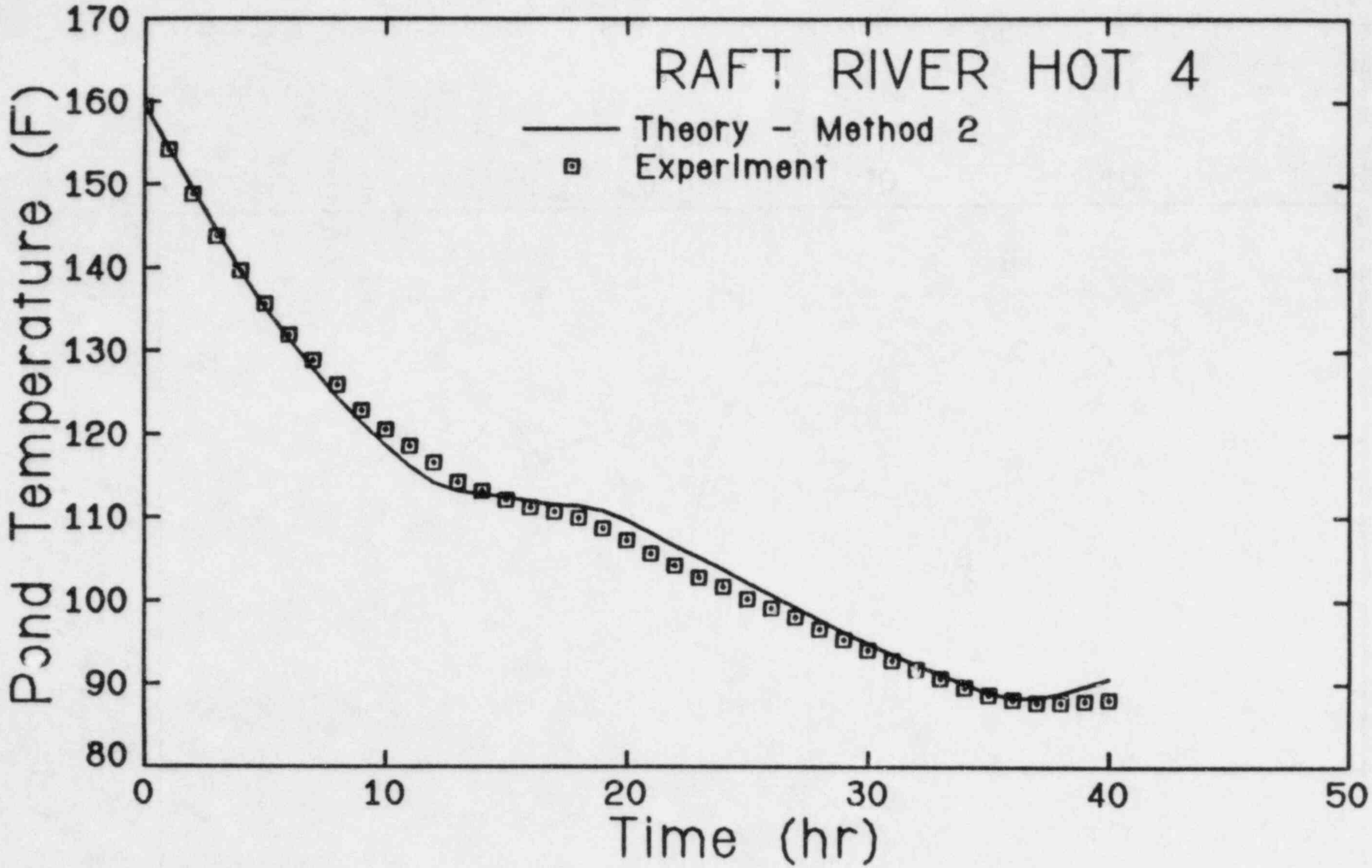


Figure 2-12. Comparison of Predicted and Measured Pond Temperatures for Raft River Hot Pond Experiment No. 4 (Method 2).

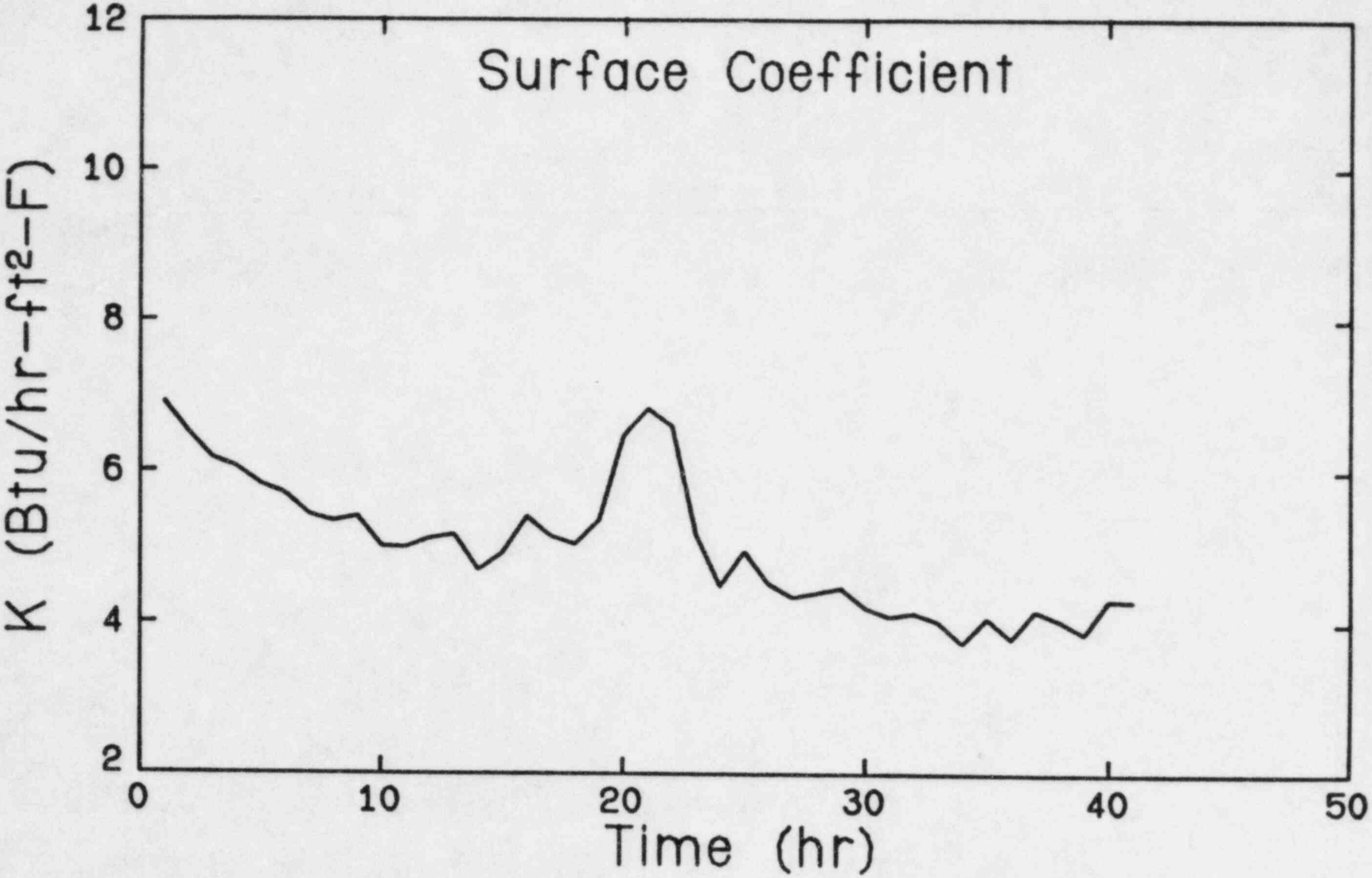


Figure 2-13. Variation of Surface Heat Transfer Coefficient for Raft River Hot Pond Experiment No. 4 (Method 1).

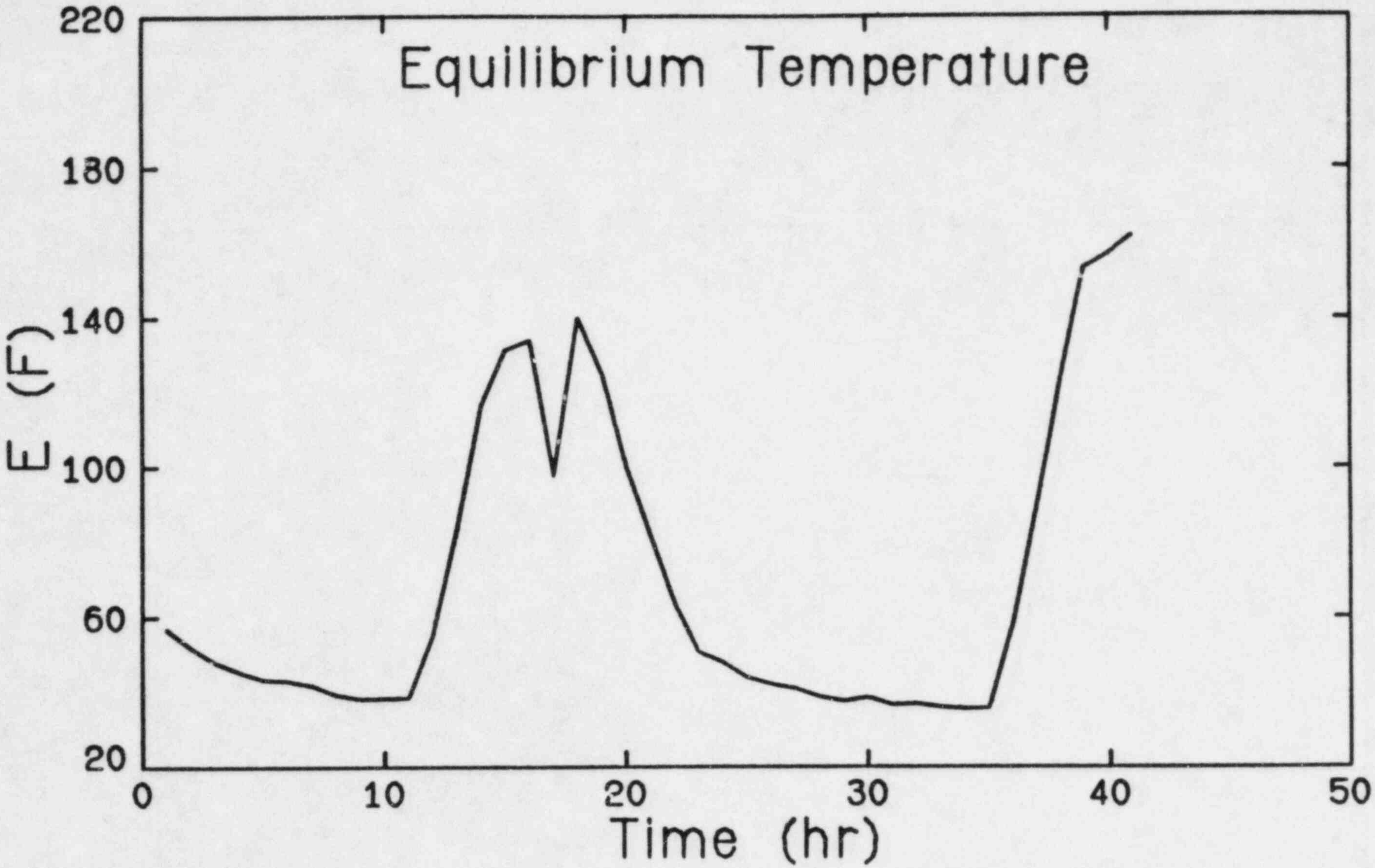


Figure 2-14. Variation of Equilibrium Temperature for Raft River Hot Pond Experiment No. 4 (Method 1).

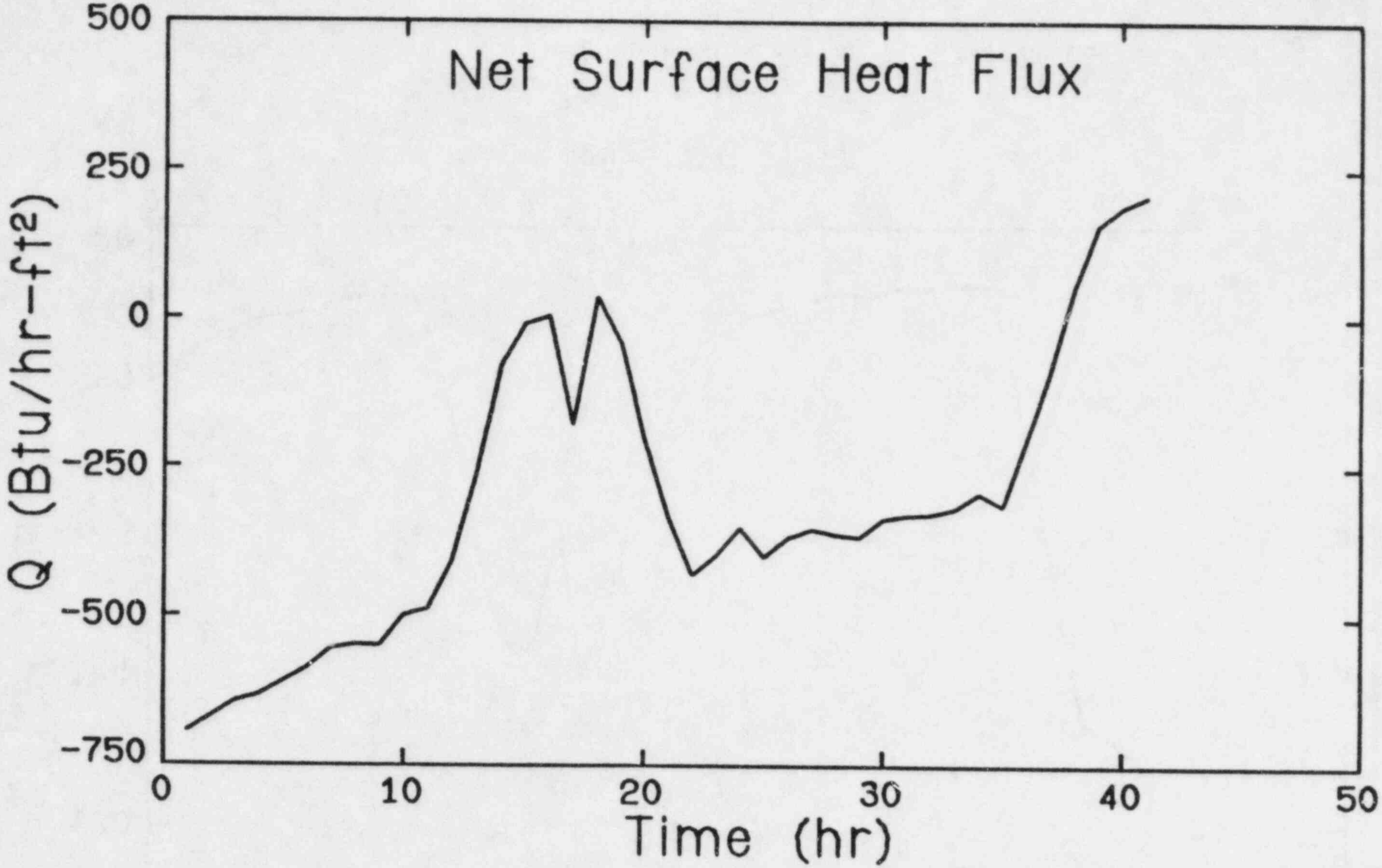


Figure 2-15. Variation of Net Surface Heat Flux for Raft River Hot Pond Experiment No. 4 (Method 1).

3. THEORETICAL FORMULATION OF PAUL MODEL

The basic equations for the Paul numerical model are derived from the time-dependent, three-dimensional equations of motion for a viscous, heat-conducting fluid. The geometry for the problem is shown in Figure 3-1. The horizontal coordinates are x and y. The vertical coordinate is z and is positive downward from the undisturbed free surface. The velocities are, respectively, u, v, and w. The following assumptions are made:

1. The pressure is assumed to vary hydrostatically, and therefore

$$\frac{\partial P}{\partial z} = \rho g.$$

2. The Boussinesq approximation is made. This assumes that the density variations are small and can be neglected except in the gravitational acceleration term.

3. Heat sources and/or sinks in the water are neglected.

4. Eddy coefficients are used to account for the turbulent and molecular diffusion effects in both the momentum and energy equations. The horizontal coefficients are assumed to be constant, but the vertical coefficients are assumed to be variable and dependent on the local vertical temperature gradient and surface wind stress.

5. The variations in the bottom topography are assumed to be gradual.

6. Density is assumed to be a function of the temperature only.

In ultimate heat sink applications, the free surface option in the model is used. The model also has the possibility for a rigid-lid computation. If the rigid lid approximation is made, $w(z = 0) = w_o$ where w_o is a specified value. By specifying non-zero values for w_o, mass transfer at the water surface and associated evaporation can be incorporated. The rigid-lid approximation is used to damp out the surface gravity waves that would otherwise be present. Run times using the free-surface version of the model are only slightly greater than the rigid-lid form and so, for UHS applications, the free surface form of the model is preferred.

The hydrostatic approximation is valid in UHS applications because variations in the vertical velocity are small enough so that the neglected terms in the vertical momentum equation are small compared to the gravitational acceleration term.

The Boussinesq approximation allows the water to be treated as incompressible. The density differences that are encountered in normal and UHS cooling pond applications of the model are relatively small, and therefore this approximation is valid. The coupling between the momentum and energy equation is retained. A consequence of the Boussinesq approximation is that the energy equation reduces to a balance between convection and diffusion.

All heat inputs and outputs to the model are assumed to occur at the boundaries of the model. As a consequence of this, heat transfer by radiation to the water is treated as a surface heat flux. This condition could be modified for a particular application if desired.

The present model allows for variations in topography of the system modeled. The procedure used is to stretch the vertical coordinate with respect to the local depth. The equations are transformed according to

$$x \leftrightarrow x$$

$$y \leftrightarrow y$$

$$\sigma \leftrightarrow z/h(x,y).$$

The details of the coordinate transformation appear in Reference 1. The equations to be solved appear more complicated due to the presence of the depth in the equations, but they are solved for a basin of constant depth in the transformed system. Also, there is no loss of resolution in the shallow areas because the same number of vertical points is used at every horizontal location. The coordinate transformation greatly reduces the programming complexities associated with the model and makes the inclusion of topographic variations quite straight forward.

The equations, in non-dimensional form, which represent the model are the following:

$$\frac{1}{h}\frac{\partial hu}{\partial x} + \frac{1}{h}\frac{\partial hv}{\partial y} + \frac{\partial \Omega}{\partial \sigma} = 0, \qquad (1)$$

$$\frac{\partial u}{\partial t} + Re\,[\frac{1}{h}\frac{\partial hu^2}{\partial x} + \frac{1}{h}\frac{\partial huv}{\partial y} + \frac{\partial \Omega u}{\partial \sigma}] + R_o v = -\frac{\partial Ps}{\partial x}$$

$$-\frac{Re}{Fr^2}[\frac{\partial}{\partial x}(h\int_o^\sigma \rho d\sigma) - \sigma\frac{\partial h}{\partial x}\rho]$$

$$+\frac{1}{h}\frac{\partial}{\partial x}[h\frac{\partial u}{\partial x}] + \frac{1}{h}\frac{\partial}{\partial y}[h\frac{\partial u}{\partial y}] - (\frac{b_o}{h_o})^2\frac{1}{h^2}\frac{\partial}{\partial \sigma}[\gamma\frac{\partial u}{\partial \sigma}] \quad , \qquad (2)$$

$$\frac{\partial v}{\partial t} + Re\,[\frac{1}{h}\frac{\partial huv}{\partial x} + \frac{1}{h}\frac{\partial hv^2}{\partial y} + \frac{\partial \Omega v}{\partial \sigma}] - R_o u = -\frac{\partial Ps}{\partial y}$$

$$-\frac{Re}{Fr^2}[\frac{\partial}{\partial y}(h\int_o^\sigma \rho d\sigma) - \sigma\frac{\partial h}{\partial y}\rho]$$

$$+\frac{1}{h}\frac{\partial}{\partial x}[h\frac{\partial v}{\partial x}] + \frac{1}{h}\frac{\partial}{\partial y}[h\frac{\partial v}{\partial y}] + (\frac{b_o}{h_o})^2\frac{1}{h^2}\frac{\partial}{\partial \sigma}[\gamma\frac{\partial v}{\partial \sigma}] \; , \qquad (3)$$

$$Pr\,[\frac{\partial T}{\partial t} + Re\,[\frac{1}{h}\frac{\partial hut}{\partial x} + \frac{1}{h}\frac{\partial hvT}{\partial y} + \frac{\partial \Omega T}{\partial \sigma}]] =$$

$$\frac{1}{h}\frac{\partial}{\partial x}[h\frac{\partial T}{\partial x}] + \frac{1}{h}\frac{\partial}{\partial y}[h\frac{\partial T}{\partial y}] + (\frac{b_o}{h_o})^2\frac{1}{h^2}\frac{\partial}{\partial \sigma}[\beta\frac{\partial T}{\partial \sigma}] \; , \qquad (4)$$

$$\rho = f(T), \qquad (5)$$

where

$$Re = \frac{u_o b_o}{A_H} \; ,$$

$$Ro = \frac{f_o b_o^2}{A_H} ,$$

$$Fr^2 = \frac{u_o^2}{g\ h_o} ,$$

$$Pr = \frac{A_H}{B_H} ,$$

$$\gamma = \frac{A_V}{A_H} ,$$

$$\beta = \frac{B_V}{B_H} ,$$

x,y = transformed horizontal coordinates,

σ = transformed vertical coordinate,

u,v = fluid velocities in x and y-directions,

Ω = fluid velocity in σ-direction,

$$= \frac{d\sigma}{dt} = \frac{1}{h} \left(w - \sigma\left(u \frac{\partial h}{\partial x} + v \frac{\partial h}{\partial y}\right)\right) ,$$

w = fluid velocity in z-direction,

t = time,

h = local depth,

P_s = surface pressure; it arises as the integration constant resulting from vertical integration of hydrostatic pressure equation; it is a function of only x and y,

$$P_s = P - gh \int_0^\sigma \rho d\sigma,$$

P = pressure,

g = gravitational acceleration,

ρ = density,

T = temperature,

f_o = Coriolis parameter,

A_H = horizontal eddy viscosity,

A_V = vertical eddy viscosity,

B_H = horizontal eddy conductivity,

B_V = vertical eddy conductivity,

b_o = reference horizontal dimension,

h_o = reference depth,

ρ_o = reference density,

$f(T)$ = equation-of-state, and

u_o = reference horizontal velocity.

Note that the reference time is b_o^2/A_H, reference vertical velocity is $u_o h_o/b_o$, and the reference pressure is $\rho_o gh\, Fr^2/Re$.

3.1. Boundary Conditions

For a closed water basin application of the model, the horizontal boundary is assumed to be no-slip, impermeable and insulated. These conditions apply except where inflows and outflows occur. In such case, the horizontal velocities are specified along with either a heat flux or a temperature value. In the rigid-lid application of the model, it is important that when inflows and outflows are specified, the net mass flux across the boundaries of the system is zero. If this condition is not satisfied, the rigid-lid condition (if applied) cannot be satisfied and the solution could be meaningless. Surface heat transfer is treated according to the equilibrium temperature method. The equilibrium temperature is defined as that temperature at the water surface for which there would be no net flux through the surface; it is a function of the meteorological conditions above the water surface and can vary with time. In this method, the surface heat transfer coefficient and equilibrium temperature must be specified on input (Ref. 2). An alternative surface heat transfer formulation (Ref. 3) was added to the model and is described in Chapter 2 and Section 3.5. A summary of boundary conditions used by the model is given in Table 3-1.

3.2. Model Parameters

The parameters in the model fall into two categories: those which relate directly to some physical characteristic of the system and those which do not. The first category includes such items as a characteristic length (the maximum distance in the x-direction covered by the grid, b_o), characteristic depth (maximum pond depth, h_o), and characteristic velocity (usually arbitrarily chosen as 1 or 10 cm/s, u_o), etc., and the second category includes the diffusivities, heat transfer coefficients, etc. The first set of parameters are helpful in nondimensionalizing the input and in interpreting the model output. Discussion will focus only on the second category.

As mentioned earlier, the horizontal eddy coefficients are constant and the vertical ones are variable. The magnitude of the horizontal values can be approximated from known values for a similar system. The magnitudes of these horizontal values should be chosen based on successful runs of the model for similar situations. They can vary considerably depending upon the scale of the geophysical problem under study.

The variability of the vertical eddy coefficient can be associated with the vertical water velocity and temperature gradients, the magnitude of the local wind stress, and the local depth of the water. The vertical gradients are important in determining the local vertical stability of the water and hence the effective vertical mixing. The local wind stress is important because it is an important mechanism for the generation of vertical mixing in geophysical application. The local depth is important to the extent that it controls the size of the vertical eddies which are possible. Table 3-1 gives the functional forms for the vertical eddy diffusivity used in the model for UHS applications. The particular form used in a specific application depends on the spatial scales of the problem.

If the surface heat transfer is taken proportional to a temperature difference, references are available to aid in the determination of the parameters from meteorological conditions (Ref. 2). The equation-of-state has been obtained from a least-squares curve fit of the density vs. temperature data using a polynomial of sufficient degree to cover a wide temperature range. An especially accurate form was chosen to handle the high pond temperatures encountered in UHS cooling ponds.

It should be mentioned again that because some of the parameters to be used in the model will not be known precisely, it is always good practice to do some sort of sensitivity analysis on them. Of course, as usually happens, the investigator does not always have the time or computer resources to do extensive testing. However, some testing will add some reliability to the results and also help the investigator to interpret the significance and relative importance of the various processes going on in the model.

The most sensitive parameters in the Paul Model are the lateral and vertical eddy viscosity and diffusivity coefficients. A sensitivity study covering the reasonable ranges of possible variation of these parameters would provide one estimate of the possible inaccuracies in the model predictions. The user should determine if the model has been run for a similar problem (similar spatial and temporal scales) in the past. Assuming the model was run successfully, the eddy diffusitivities and viscosities used in the case might provide a guide for the coefficients to be used in the case at hand.

3.3. Numerical Scheme

The basic procedure used to discretize the differential equations is the following:

(a) the dependent variables are defined in a grid lattice to fit the geometry of the particular system modeled,

(b) grid cells are defined around each variable in the grid lattice,

(c) the differential equation for a particular variable is integrated over the volume of its respective grid cell, and

(d) the resulting integrals are evaluated and/or approximated as required to give the difference equations.

This particular procedure for discretization is one of several methods discussed by Varga (Ref. 4) and has the advantage that irregular boundaries and non-uniform grids can be easily treated. Another advantage is that if the differential equations to be discretized are written in conservative form, the discretization process preserves the basic conservation properties of the differential equations. The rationale for the placement of particular variables in the grid lattice with respect to the other variables depends in part on one's preference but more in part on which arrangement lends itself to better use of the integral evaluations.

Arrangement of the grid lattice used is presented in Figure 3-2. Table 3-2 indicates the grid indices associated with each variable. Boundaries lie along integral values of the grid indices. Some typical grid cells are shown in Figure 3-3 and they indicate the relative arrangement of the variables in three dimensions. Details of the method of space and time discretization appear in Reference 1.

This solution procedure is a modification to the simplified marker and cell method (SMAC) of Amsden and Harlow (Ref. 5). The method involves the separation of the velocities into two components: one component satisfies the momentum equations with some prescribed pressure field (u,v) and the second component is the gradient of some scalar field which when added to the first component satisfies the full equations (u' and v'). Amsden and Harlow (Ref. 5) developed the method for explicit-time, free-surface, moving boundary problems; a version of the procedure is used in the Paul model and uses a rigid-lid or free surface solution with some terms treated implicitly. The vertical terms are treated implicitly.

The modified SMAC solution scheme solves for the flow variables in the following steps.

1. Assume that values for all variables are available for the previous time step,

2. Solve for temperature and density,

3. Solve for u^* and v^*,

4. Calculate the vertical velocity from the vertically summed continuity equation,

5. Calculate the pressure from a Poisson's equation,

6. Calculate u' and v' (corrections to u^* and v^*),

7. Correct the vertical velocity from the vertically summed continuity equation.

3.4. Modifications to Paul Model for UHS Applications

The Paul Model can treat open as well as closed waterbodies in its original form (Ref. 1). The treatment, however, did not handle directly several aspects required in an application to ultimate heat sink ponds. Extensions to the model were made and they are

(a) addition of a time-dependent heat loading to the pond,

(b) addition of an option to employ the time-dependent surface heat transfer using the Ryan-Harleman method (Ref. 3). This version is discussed in Chapter 2. It determines the net surface heat transfer on a cell by cell basis (surface cells only). Computed were the solar, atmospheric, back radiation, evaporation and conduction contributions to each cell. The meteorological variables of wind speed, dry-bulb temperature, dew-point temperature, short-wave solar flux, and atmospheric pressure are used in the formulations along with the surface cell temperature. The equilibrium concept is still maintained in the Paul model but only as an option,

(c) boundary conditions at the intake had to be chosen to represent specified intake velocities which varied with time. In addition, the circulation between discharge and intake due to power plant operation had to be included based on a known loading to the pond as a function of time,

(d) inclusion of updated formulation of surface wind stress as a function of wind speed from Wu (Ref. 6), and

(e) addition of subroutines to the computer code aimed at verifying that heat is being conserved by the model on a step by step basis in time.

References

1. J.F. Paul and W.J. Lick, "Numerical Model for Three-Dimensional Variable-Density Rigid-lid Hydrodynamic Flows: Volume 1. Details of the Numerical Model (Draft)." Environmental Research Laboratory, U.S. Environmental Protection Agency. Duluth, Minnesota. 1981.

2. D.K. Brady, W.L. Graves, and J.C. Geyer. "Surface Heat Exchange at Power Plant Cooling Lakes." Report No. 5, Edison Electric Institute, EEI Publication 69-401, New York, N.Y. 1969.

3. P.J. Ryan and D.R.F. Harleman, "An Analytical and Experimental Study of Transient Cooling Pond Behavior." Report No. 161. Ralph M. Parsons Laboratory. Massachusetts Institute of Technology. Cambridge, Massachusetts. January 1973.

4. R.S. Varga, Matrix Iterative Analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1962.

5. A.A. Amsden and F.H. Harlow, "The SMAC Method: A Numerical Technique for Calculating Incompressible Fluid Flows." LA-4370. Los Alamos Scientific Laboratory. Los Alamos, New Mexico. 1970.

6. J. Wu, "Wind-Stress Coefficients over Sea Surface from Breeze to Hurricanes." Journal of Geophysical Research. Vol. 87, No. C12. p. 9704-9706. November 20, 1982.

Table 3-1. Summary of the Boundary Conditions Used in the Paul Model

	Horizontal Velocities	Vertical Velocity	Temperature
Horizontal boundaries	A. set to zero B. specify non-zero values C. open-boundary; extra-polate from interior values	Not applicable	A. specify value B. specify no net heat flux C. specify heat flux
Surface boundaries	A. specify stress B. set to zero	Specify value	A. specify value B. specify heat flux C. Newton law of cooling--flux condition
Bottom boundaries	A. set to zero B. specify stress	Set to zero	A. specify no net heat flux B. Newton law of cooling--flux condition

Table 3-2. Grid Indices for Variables in Paul Model

Variable	Grid Indices
u,v	K, M, N
w	K+1/2, M+1/2, N+1/2
T,ρ	K+1/2, M, N
P_s	M+1/2, N+1/2

K - vertical grid index
M - grid index in y-direction
N - grid index in x-direction

Boundaries are along integral values for grid indices.

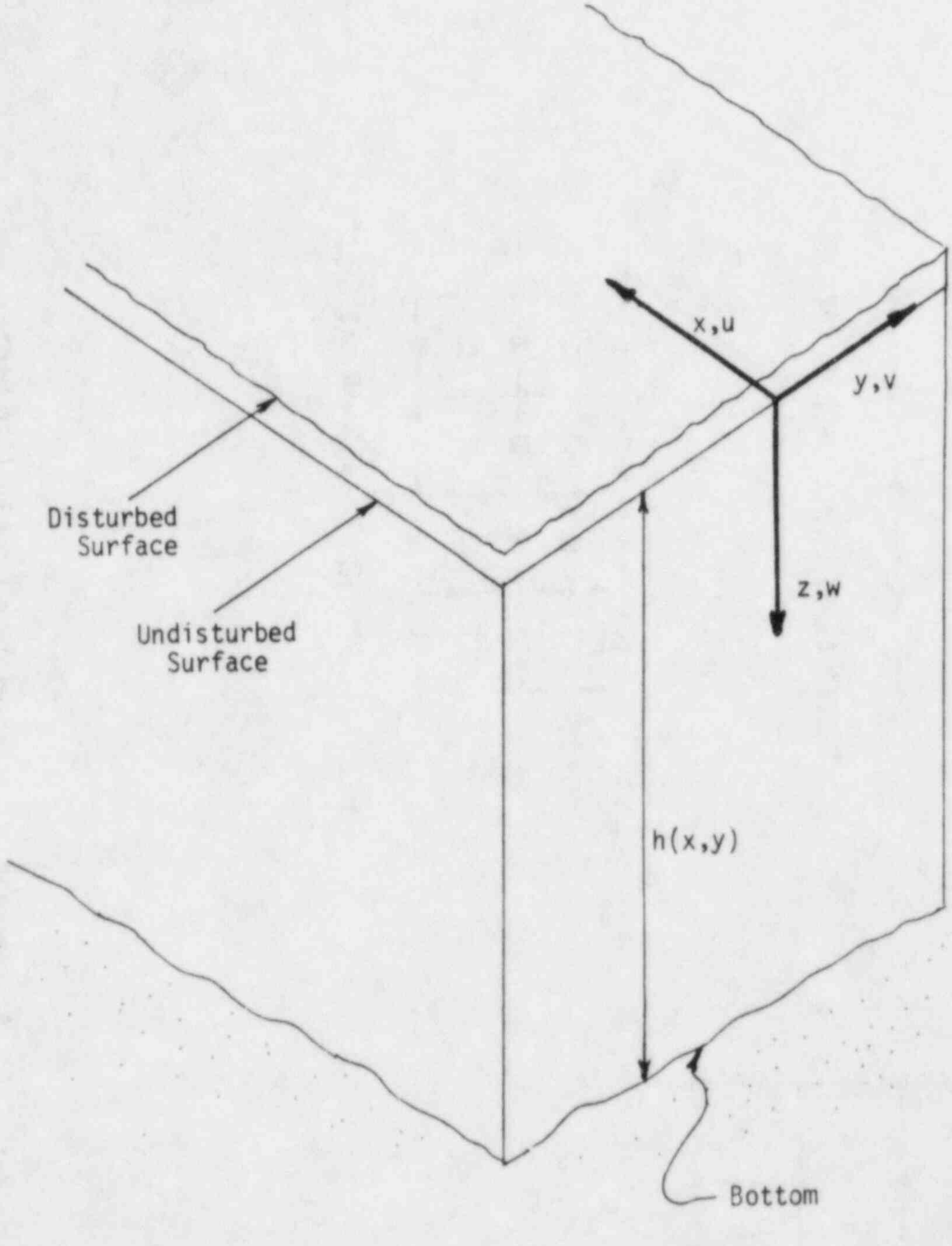


Figure 3-1. Sketch of Coordinate System Used in Paul Model ... adapted from Reference 1.

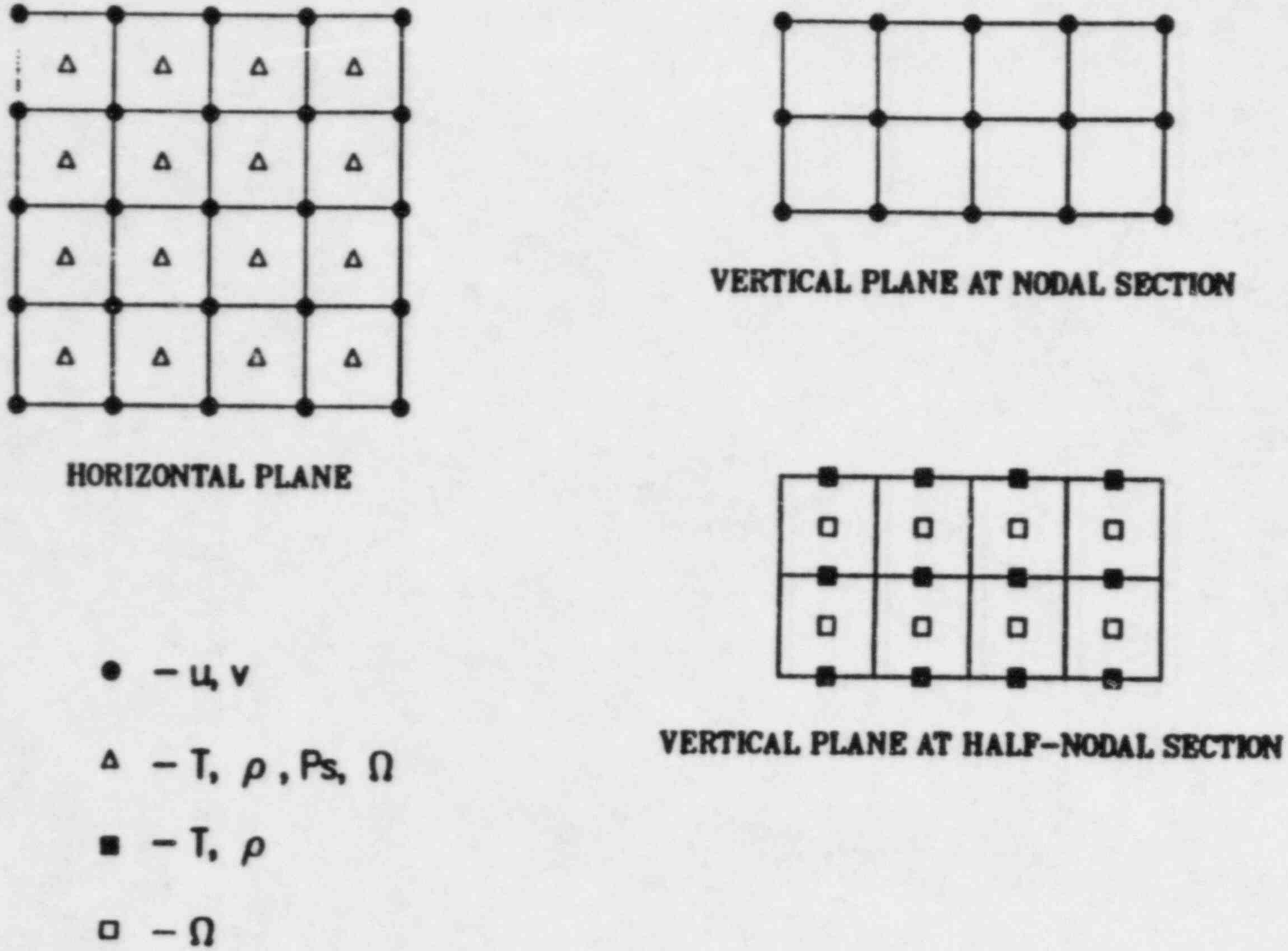
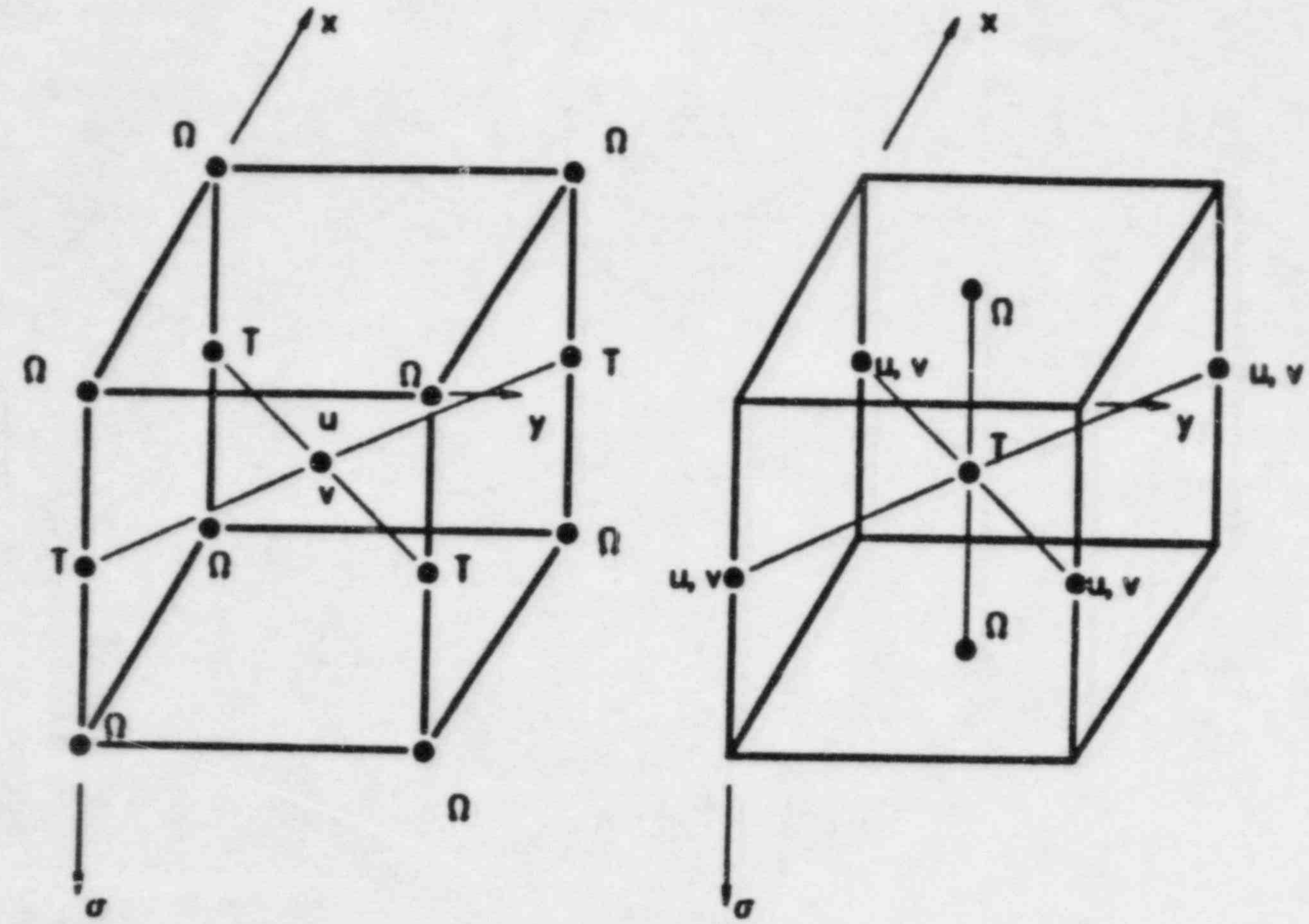


Figure 3-2. Arrangement of Variables in a Grid Lattice Used in the Paul Model ... adapted from Reference 1.



TYPICAL NODAL CELL FOR u

TYPICAL NODAL CELL FOR T

Figure 3-3. Location of Variables within Typical Nodal Cells ... adapted from Reference 1.

4. PREPARATION OF INPUT AND DISCUSSION OF OUTPUT FOR PAUL MODEL

Depending upon the application, the Paul Model requires the input of at least three data files and at most five files. The model's output requires the use of six output devices (Figure 4-1). The input data files are:

- hourly meteorological data covering the time period of the run (card image disk or tape input via logical unit 4) ... a required input file,

- model control parameters (card image disk input via logical unit II, where II is user defined in a data block) ... a required input file,

- bottom topography data (unformatted disk or tape input via logical unit ITBOT, where ITBOT is user defined and read in with control parameters) ... not required unless a variable bottom topography is present,

- restart indicator data (free formatted input/output via logical unit 98) ... a required input file, and

- model predictions for the last time step of a previous run if the new run is a continuation run (unformatted disk or tape input via logical unit ITPI, where ITPI is user defined and read in with control parameters) ... not required unless the run is a continuation of a previous run.

The output files are:

- line printer output (logical unit IO where IO is user defined in a data block),

- model predictions for the final time step (unformatted disk or tape output via logical unit ITPO, where ITPO is user defined and read in with control parameters),

- intermediate step calculations (unformatted disk or tape output via logical unit ITPO +1, where ITPO is user defined and read in with control parameters),

- user selected variables (disk or tape output defined by the user generally for plotting purposes via logical unit 12),

- temperature boundary conditions for next continuation run, if any (card-image disk output via logical unit 20). This file is defined by the user in Subroutine TSOUT, and

- dummy file needed by code for internal tracking (card image disk output via logical unit 99).

Each of the input and output files will now be discussed in turn followed by a general discussion of the hard-copy output provided by the computer code.

4.1 Meteorological Input File

The model requires hourly meteorological records to be input via logical unit 4. The data file is expected in card image, but the user may define his own input format. The model currently expects the hourly meteorological record to have the following variables and format: (4I2, 2X, 2F10.0, 20X, F10.0, 20X, 4F10.0).

Variable Name	Definition
MON	Month
IDAY	Day
IYR	Year
IHOUR	Hour
DBT	Dry bulb temperature (°F)
P	Atmospheric pressure (Hg)
DPT	Dew point temperature (°F)
WS	Wind speed (mph)
HSN	Solar radiation (Btu/ft^2-day)

ATP1	Discharge no. 1 temperature increase above intake temperature at IHOUR ... optional depending on application
ATP2	Temperature of discharge no. 2 at IHOUR ... optional depending on application

The model requires the above information. The user may rearrange the list and/or modify the format so long as the READ and FORMAT statements are changed in SUBROUTINE GETMET. This latter subroutine interpolates the hourly records of meteorological data in order to determine the meteorological variables appropriate to the time step being computed. The model expects this file via logical unit 4.

The use of ATP1 and ATP2 requires some discussion. In the Cerco laboratory case where there is only one discharge temperature and it is fixed over time, ATP1 and ATP2 are not used. In the Catawba UHS case, where the intake/discharge represented a closed circulation system, ATP1 was the increase in temperature contributed by the UHS heat load above the intake temperature on an hour by hour basis. In the H.B. Robinson pond case, ATP1 had the same meaning as in the Catawba case but ATP2 represented the discharge temperature of the Black Creek that entered the pond. The different interpretations of ATP1 and ATP2 are arranged within the code through changes made in Subroutine GETMET. More details will be presented later.

4.2 Main Card Image Input File

The following is a detailed description of the main card image input file which contains all the variables necessary to define any model run. In addition, various program options are specified through the choice of other input parameters. The logical unit number is hard-wired as 5. The user is free to change this by modifying the initialization of the variable II (input logical unit number) in the BLOCK DATA subroutine.

CARD 1

Variable List: LABEL (I), I = 1, 20
Variable Format: 20A4

Variable Name	Description
LABEL	A label (80 character maximum) for the case study used to identify output.

CARD 2

Variable List: IRUNU, ITPI, ITPO, ITBOT
Variable Format: 4I6

Variable Name	Description
IRUNU	Identifying run number of a previous run (if any). This number identifies the appropriate earlier run for which the last step is used for initialization of the current run. (Needed only if ITPI ≠ 0).
ITPI	Logical unit number used to retrieve the last step of a previous calculation. If value is 0, no input will be expected.
ITPO	Logical unit number used to write final calculations. If value is 0, there is no saving of calculations.
ITBOT	Logical unit number used to read bottom topography data. (Needed only if IBOT = 2).

CARD 3

Variable List: IDUMP(I), I = 1, 8
Variable Format: 8I6

Variable Name	Description
IDUMP(1)	If 1, print forcing terms in CLFH subroutine. If 0, do not print them
IDUMP(2)	If 1, print coefficients calculated in CLF4 subroutine. If 0, do not print them.
IDUMP(3)	If 1, print coefficients calculated in CLF4A subroutines. If 0, do not print them.
IDUMP(4)	If 1, print terms calculated in CLFL subroutine. If 0, do not print them.
IDUMP(5)	If 1, print GAM array calculated in CLF subroutine. If 0, do not print the array.
IDUMP(6)	If 1, print arrays in CLF subroutine. If 0, do not print the arrays.

IDUMP(7)	If 1, print implicit arrays in CLF subroutine. If 0, do not print the arrays.
IDUMP(8)	If 1, print arrays in CLFGA subroutine. If 0, do not print the arrays.

CARD 4

Variable List: IRUN, MML, NNL, KKL
Variable Format: 4I6

Variable Name	Description
IRUN	Identification number for the present run
MML	Number of cells in the Y-direction, representing the horizontal axis. (Note: the number of grid points along the Y-axis is MML + 1).
NNL	Number of cells in the X-direction, representing the vertical axis. (Note: the number of grid points along the X-axis is NNL + 1).
KKL	Number of intervals in the σ-direction, representing the Z-axis. (Note: the number of grid points along the Z-axis is KKL + 1).

CARD 5

Variable List: INIT, IBOT, IINPUT, ITMAX, ICMAX, INLET, IIPRT, ITTPRT, IPPRT, IBC, IPPPRT, ITPRT, IBET
Variable Format: 13I6

Variable Name	Description
INIT	Control switch for determining which initial conditions to use. If 1, the run starts without an initial estimate of temperatures and velocities. Default temperatures and velocities however, will be arranged through control switches such as INLET and IOPT(6) that are identified later in the current input stream. If 2, this run is a continuation run that will be initialized with values calculated at the last step of the previous run which had identification number, IRUNU. The values were output previously through logical unit ITPO, and

will be currently read in through logical unit ITPI.

IBOT Control switch for determining which bottom topography to use.
If 1, read in from standard input data file, i.e., further on in this file
If 2, read in from logical unit number ITBOT which contains an unformatted FORTRAN file defining the bottom topography.
If 3, use a constant depth.
If 4, use depths read in on logical unit number ITPI.

IINPUT Control switch for printing of initial conditions.
If 1, print initial conditions.
If 0, do not print.

ITMAX Maximum number of time steps.

ICMAX Number of passes to make in static stability check.
If 0, no check will be made.

INLET Control switch for determining if inflow/outflow boundary conditions are to be read in.
If 1, no boundary conditions to read in because this case study does not have any inflow or outflow channels.
If 2, read in boundary conditions.

IIPRT Control switch for printing of changes (from previous step) and relative changes of variables (within same step) at every IIPRT'th time step*.

ITTPRT* Control switch for printing of dependent variables at every ITTPRT'th time step.

IPPRT* Control switch for printing of pressure iterations at every IPPRT'th time step.

IBC Control switch for setting boundary conditions for special cases.

If 1, no boundary conditions to set.
If 2 or 3, read values for outer X-boundary. (Note: if value is 3, velocity values along M = M1 and M = ML will be set to values at N = NNL).
If 4, read pressure values along 3

	outer boundaries and temperatures along outer X-boundary.
IPPPRT*	Control switch for printing of changes (from previous step) and relative changes of pressure (within same step) at every IPPPRT'th iteration.
ITPRT*	Control switch for printing of pressure solution at every ITPRT'th time step.
IBET	Number of iterations to increase relaxation for pressure iterations.

CARD 6

Variable List: IPMAX
Variable Format: I6

Variable Name	Description
IPMAX	Maximum number of pressure iterations attempted to attain convergence at each time step.

CARD 7

Variable List: IOPT(L), L = 1, 9
Variable Format: 10I6

Variable Name	Description
IOPT(1)	Control switch to specify form for equation of state

Values	Equation of State Form
1	$\rho - \rho_o$ = RA(1)*T
2	$\rho - \rho_o$ = RA(1)*T*T*(1+RA(2)*T)
3	$\rho - \rho_o$ = RA(1)*T*(1+RA(2)*T*(1+RA(3)*T))

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*The values for these parameters are at the discretion of the user and depend on the value of the time step and the total number of time steps. For example, if the time step is 15 minutes and the run is over a period of six hours, the maximum number of time steps will be 24. The user may choose to print out information at the end of each hour, thus giving these parameters (ITTPRT, IPPRT, IPPPRT, and ITPRT) the value of 4. Or the user may wish to see the pressure solution at every time step by making ITPRT = 1. If no output is desired for any step, make all these parameters equal to zero.

$$4 \quad \rho - \rho_o = 0.001^* \ \ RA(1) - \frac{(T+RA(2))^*(T+RA(3))^2}{RA(4)^*(T+RA(5))}$$

RA(1), ..., RA(5) are constants that are input later.

IOPT(2) — Control switch to specify which surface boundary conditions are to be used for temperature

Values	Surface Boundary Conditions
1.	$\rho_o C_p B_v \frac{\partial T}{\partial z} = K\ (T-T_E)$ at surface
	or, equivalently,
	$\frac{B_v}{B_H} - \frac{\partial T}{\partial \sigma} \alpha = \alpha\ (T-T_E),\ \alpha = \frac{K\ h_o}{\rho_o C_p B_H}$
2	$\rho_o C_p B_v \frac{\partial T}{\partial z} = Q$ at surface
	or, equivalently,
	$\frac{B_v}{B_H} \frac{1}{h} \frac{\partial T}{\partial \sigma} = \alpha,\ \alpha = \frac{Qh_o}{T_o \rho_o C_p B_H}$

The value IOPT(2) = 2 represents the Ryan-Harleman method of computing surface heat transfer (see Chap. 2).

IOPT(3) — Control switch to specify the form to use for vertical eddy viscosity and diffusivities (IOPT(3) = 2 is the suggested form to use for UHS applications).

Values	Forms
1	$Av = Av_o$ = constant $Bv = Bv_o^o$ = constant

2 $$Av = Av_o \left(1 + Av_1 \frac{1}{h} \frac{\partial T}{\partial \sigma}\right)$$

$$Bv = Bv_o \left(1 + Bv_1 \frac{1}{h} \frac{\partial T}{\partial \sigma}\right)$$

3 $$Av = Av_o (1 + Av_1 \cdot h)$$
$$Bv = Bv_o (1 + Bv_1 \cdot h)$$

See Table 1 for details on the option IOPT(3) = 2 which is the preferred method.

IOPT(4) Control switch to specify what type of grid to use.

Values	Grid Definition
0	Δx = 1.0/NNL $\Delta y = \Delta x$ * DEL where DEL = $\Delta X/\Delta Y$
1	Δx and Δy are read in from a data input file and are to be used when variable grid spacings are required.

IOPT(5) Control switch to specify what type of wind stress variations to use.

Values	Wind Stress Type
0	τ_{wx} = TWX = constant τ_{wy} = TWY = constant
1	τ_{wx} = TWX*HD2(M,N,1) τ_{wy} = TWY*HD2(M,N,1)

IOPT(6) Control switch to specify whether initial temperature conditions are to be read in.

Values	Definitions
0	Zero initial temperature conditions.
N	Initial temperature conditions are to be read in on logical unit N.

IOPT(7) Control switch to specify order of sequencing through indices for pressure iterations.

Values	Sequencing Order
1	N = N1, NLM M = M1, MLM
2	N = N1, NLM M = MLM, M1, -1
3	N = NLM, N1, -1 M = M1, MLM
4	N = NLM, NL, -1 M = MLM, M1, -1

IOPT(8) — Control switch to specify whether any intermediate velocity calculations are to be saved.

Values	Definitions
0	do not save any intermediate calculations
N	save intermediate velocity calculations on logical unit ITPO+1 every N'th time step.

IOPT(9) — Control switch to specify if free surface calculation is to be done.

Values	Definitions
0	rigid-lid form of model is to be used.
1	free surface form of model is to be used.

CARD 8

Variable List: DT, DEL, EPST, EPS
Variable Format: 4F10.0

Variable Name	Description
DT	Non-dimensional time step.

$$DT = \frac{TS}{b_o^2 / A_H}$$

where TS is the time step in seconds. TS should be less than 0.5 * ($\Delta x/U_{max}$), where U_{max} is the largest velocity specified for any inflow/outflow channel, and Δx is the increment in the horizontal grid. If Δx varies, then choose an estimate of the maximum value of $\Delta x/u$ throughout the pond.

	It is common to set TS to a round number that is less than its calculated value to more easily interpret the real time associated to any time step.
DEL	Ratio of ΔY to ΔX. (Useful only when IOPT(4) = 0).
EPST	Convergence criteria for time steps. (usually chosen as 10^{-5}).
EPS	Convergence criteria for pressure iterations (usually chosen as 10^{-6}).

CARD 9

Variable List: RA(I), I=1,5
Variable Format: 5F10.0

Variable Name	Description
RA	Coefficients for equation of state.

CARD 10

Variable List: RE, RO, FR, PR, RATIO, TWX, TWY, PLEV
Variable Format: 8F10.0

Variable Name	Description
RE	Turbulent Reynolds number $RE = U_o b_o / A_H$
RO	Nondimensional Coriolis parameter $RO = f_o b_o^2 / A_H$
FR	Froude number $FR = U_o / \sqrt{g h_o}$
PR	Turbulent Prandtl number $PR = A_H / B_H$
RATIO	Ratio of horizontal to vertical reference lengths $RATIO = b_o / h_o$
TWX	Non-dimensional wind stress in x-direction $TWX = \tau_{wx} h_o / \rho_o A_H U_o$ (τ_{wx} = 1 dyne/cm^2)
TWY	Non-dimensional wind stress in y-direction $TWY = \tau_{wy} h_o / \rho_o A_H U_o$ (τ_{wy} = 1 dyne/cm^2)
PLEV	Specified non-dimensional pressure level

CARD 11

Variable List: AH, AVO, AV1, BH, BVO, BV1, ALPHA, TE
Variable Format: 8F10.0

Variable Name	Description
AH	Horizontal eddy viscosity (cm^2/s)
AV0,AV1	Coefficients in vertical eddy viscosity formulation (see Table 1)
BH	Horizontal eddy thermal diffusivity (cm^2/s)
BV0,BV1	Coefficients in vertical eddy thermal diffusivity formulation (see Table 1).
ALPHA	Non-dimensional surface heat transfer coefficient if IOPT(2) = 1 Non-dimensional surface heat flux if IOPT(2) = 2
TE	Equilibrium temperature (needed only if IOPT(2) = 1 and ALPHA ≠ 0)

CARD 12

Variable List: THU, THP, THC, THT, BET, BET1
Variable Format: 6F10.0

Variable Name	Description
THU	Theta value for implicit vertical viscous terms (usually chosen as 1.0)
THP	Theta value for implicit pressure terms (usually chosen as 0.55)
THC	Theta value for implicit Coriolis terms (usually chosen as 0.5)
THT	Theta value for implicit vertical conductivity terms (usually chosen as 1.0)
BET	Maximum value to use for relaxation in pressure iterations (BET = 0.0 for no relaxation) (usually chosen as 0.0)
BET1	Percent of BET to use at first iteration when IBET = 1 (usually chosen as 1.0)

CARD 13

Variable List: COF1, COF2, COFD, HOO
Variable Format: 4F10.0

Variable Name	Description
COF1	Coefficient in vertical eddy diffusivity formulation, c_1, (see Table 1)
COF2	Coefficient in vertical eddy diffusivity formulation, c_2 (see Table 1)

COFD	Exponential decay depth (D) for the wind-induced turbulence in cm (see Table 4-1)
HOO	Reference depth in cm (see Table 4-1)

CARD SET 14

Variable List: H(M,N), M = 1 ..., ML, N = 1 ..., NL
Variable Format: 8F10.0

Variable Name	Description
H	Non-dimensional depths at grid points needed only if IBOT = 1 $H = h/h_o$ where h_o is any reference depth. It is recommended that h_o be set to the largest depth in the pond.

CARD SET 15

Variable List: DX(N), N = N1P, NL
Variable Format: 8F10.0

Variable Name	Description
DX	Non-dimensional grid spacings in x-direction (horizontal axis) needed only if IOPT(4) = 1 $DX = \Delta X(N)/b_o$

CARD SET 16

Variable List: DY(M), M = M1P, ML
Variable Format: 8F10.0

Variable Name	Description
DY	Non-dimensional grid spacings in y-direction (horizontal axis) needed only if IOPT(4) = 1 $DY = \Delta Y(M)/b_o$

CARD SET 17

Variable List: HD2(M,N), M = M1, ..., ML, N = N1, ..., NL
Variable Format: 8F10.0

Variable Name	Description
HD2	Non-dimensional wind stress factor; nondimensionality assumes τ = 1.0 dynes/

cm², when the magnitude of wind stress is a function of space and/or time. (Needed only if IOPT(5) = 1)

$HD2 = \tau h_o/\rho_o A_h U_o$

CARD SET 18

Variable List: TA(1, M, N), M = M1, ML, N = N1, NLM
Variable Format: 8F10.0

Variable Name	Description
TA	Initial cell temperatures (deg. C) on a cell by cell basis in the horizontal plane. The temperatures are assumed to be vertically uniform. (Needed only if IOPT(6) = N ≠ 0 where N is the logical unit number for temperature input and INIT = 1).

CARD 19

Variable List: I1
Variable Format: I6

Variable Name	Description
I1	Total number of discharge and intakes for which velocities are to be specified. The number I1 refers to the total number of grid points for which velocity boundary conditions are to be specified (in x-y plane). (Needed only if INLET = 2).

CARD SET 20

Variable List: I2(1,L), I2(2,L), L = 1, I1
Variable Format: 26I3

Variable Name	Description
I2 (1,L)	M-index (y-coordinate) of coordinate pair designating grid point at which a velocity is to be specified.
I2 (2,L)	N-index (x-coordinate) of coordinate pair designating grid point at which a velocity is to be specified.
	Note: There should be I1 pairs of coordinates presented in Card set 20. In this card, the (M,N) coordinates of all discharges and inlets are presented.

CARD SET 21

Variable List: UB (K,M,N), K = K1, KLM
VB (K,M,N), K = K1, KLM
Variable Format: 8F10.0

Variable Name	Description
UB (K,M,N)	Specified U-velocities for a vertical column of grid points with surface coordinates (M,N) where M = I2(1,L) and N = I2(2,L)
VB (K,M,N)	Specified V-velocities for a vertical column of grid points with surface coordinates (M,N) where M = I2(1,L) and N = I2(2,L)

Note: There should be I1 pairs of input cards specifying velocities. For each (M,N) pair presented in order, the arrays UB(K,M,N) and VB(K,M,N) are specified for each K, as K varies from surface to bottom.

The remaining cards 22-24 are not used in cases where discharge temperatures are read in (and used) as a function of time as part of the meteorological input file. In such cases (H.B. Robinson and Catawba UHS cases), these cards are read in here yet overridden within the computer code.

CARD 22

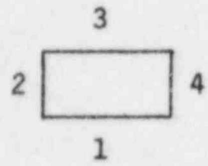
Variable List: I3
Variable Format: I6

Variable Name	Description
I3	Number of specified temperature boundary values to be read in. These are the number of cells in the x-y plane for which temperatures are known and fixed with time (for at least one depth).

CARD 23

Variable List: IA, IB
Variable Formt: 2I3

Variable Name	Description
IA	Identifies character of boundary for which the user is inputting a temperature. IA can have only four values 1-4 with meanings corresponding to the position of the discharge or intake wall.



1 = bottom wall
2 = left side wall
3 = top wall
4 = right side wall

IB — Designates coordinate position of the boundary with respect to direction. If IA = 1 or 3, IB is the M index of the coordinate pair locating the cell. If IA = 2 or 4, IB is the N index of the coordinated pair locating the cell. This variable IB locates the discharge or inlet that contains either fixed temperature (discharge) or fixed flux (intake) with respect to the M or N coordinate system.

CARD SET 24

Variable List: TTN (IA, K, IB) K = K1, KL
Variable Format: 8F10.0

Variable Name	Description
TTN (IA, K, IB)	Specified vertical column of temperatures at the discharges (fluxes for the intakes) along boundary IA with appropriate coordinate index, IB, for the entire vertical column of cells. Note: There must be I3 sets of 'Card Set 23 + Card set 24' input cards

4.3 Bottom Topography Input File

If the parameter, IBOT, in card number 5 of the main input stream (see Section 4.2) was set equal to 2, then the model expects an unformatted FORTRAN data set consisting of non-dimensionalized depths for each pond grid point. The logical unit number for the reading of this file is defined by the variable, ITBOT, in card number 2 of the main input stream (see Section 4.2).

4.4 Restart Indicator File

A dataset containing only one record needs to be created and saved on a direct access device before running the model. The model uses this file to keep track of the time steps that have been executed by writing to this file the number of the last completed step. It is useful to know what the last completed time step was in case of any abnormal terminations of the model. The model can then be restarted at the last completed step without having to rerun the model from the initial conditions.

The model accesses this file through logical unit 98. The user is free to change this. The one record on this file consists of two free-formatted variables, RESTRT and NUMIT. Initially, RESTRT should be set to 0 and NUMIT to -1.

This record is read in at the beginning of each model run. If RESTRT is non-zero, the model is put into a restart mode and resumes normal running from time step NUMIT. The model is re-initialized to where it was at the end of time step NUMIT by reading in (through logical unit ITPO + 1) a selected group of data that were written out (through logical unit ITPO + 1) in the previous run that had the abnormal termination. Note that this latter file defined by IOPT(8) saves the intermediate results from the main input stream. In order to use this restarting feature properly, IOPT(8) must always be a non-zero integer in every run and unit ITPO + 1 must be defined in the control statements section for the user's system. If IOPT(8) is set to zero, no intermediate results will be saved during the run and if there is a need for restarting the model, it will have to be from the original initial conditions.

The value of IOPT(8) does not necessarily have to be equal to 1. The user may wish to save every 5th step, 10th step, or, in general, every Nth step. It is important to keep in mind that NUMIT is a multiple of IOPT(8). For example, if IOPT(8) = 10, every 10th calculation (time step) will be written out to a file through logical unit ITPO + 1. At the same time, a record will be written to the restart indicator file with NUMIT ranging from 10 to a multiple of 10. If the model has an abnormal termination at time step 47, it will be restarted from the results saved for time step 40, not time step 46.

4.5 Previous Run/Last Step Input File

It is possible to apply the model in a series of runs instead of just one run. This may be necessary on some computer systems that have severe time and output disk space restrictions. It is also suggested that the beginning of any long run be done as a series of short runs for helping pinpoint any problems that may exist. When problems occur, they usually show up at the beginning of a run and are almost always an input error. It is easier and cheaper to identify most errors from a series of short runs: one step, then ten steps, then fifty steps, etc. Model runs employing this method of sequencing short then longer runs will be referred to below as the use of "continuation" runs.

Two unformatted input/output disk (tape) files are needed to accomplish these continuation runs. The logical unit numbers of these files are defined by the variables ITPI and ITPO in the main input stream. These files are used to read and write the results of the final time step for each continuation run. The variable, ITPI, refers to the file from the old run that is being input to the continuation whereas the variable, ITPO, refers to the last output step from the old run that is being written to disk.

For example, let the first run of a continuation run have ITMAX, the maximum number of time steps, set equal to 5. (Here, ITPI may take on any value as it will be bypassed because there is no previous run.) Also, let ITPO be 10. The variable, IRUN, which is the identification number for this run, will be 1. After the 5th time step is calculated, the model will write out, through logical unit ITPO = 10, all the appropriate variables needed to initialize the next continuation run.

For the second run of this continuation series, ITPI must be changed in the input file to a non-zero value, since we want to read in the file representing the last step created by the previous run. A logical unit number is also needed; the input value for ITPO can remain the same. The identification number of this run, IRUN, should be changed to 2 and the variable IRUNU, which is the identification number of the previous run, should be changed from 0 to 1. The model checks the value of IRUNU against the previous last step input to insure that it is reading in the correct set of data. There is also a variable, INIT, which must be changed from a 1 to a 2 to indicate to the code that this is a continuation run and not a zero condition initialization run.

4.6 Line Printer Output File

The model outputs information at the end of each time step to the printer through the logical unit defined by the variable IO, which is initialized to 6 in the BLOCK DATA subroutine. The user can change the value to whatever is defined as the printer unit number on his system.

4.7 Final-Step Calculation Output File

There is a model option to output to a disk or tape file the final step calculations of the model run. This output file is then used for initializing the next run of the model in a continuation run and also as one of the input files to the plotting program. The variable, ITPO, indicates to the model if this file should be created. A value of zero means that no file is desired, whereas a non-zero value causes the model to produce this file through logical unit ITPO. The file is unformatted and its use as initialization for a continuation run is described in Section 4.5.

4.8 Intermediate-Step Calculation Output File

The model has the capability of outputting intermediate step results to a disk or tape file for the purpose of restarting the model after an abnormal termination. These intermediate time step calculations can also be input into the plotting program for intermediate model plots.

This file is an unformatted file written out through logical unit ITPO + 1. The frequency with which these intermediate time steps are written is defined by IOPT(8) in the main input stream. If IOPT(8) is zero, no intermediate time steps will be written.

4.9 User-Selected Output File

The model is set up to write a disk or tape file to logical unit 12. The data written to this file is chosen by the user and is commonly used for some independent plotting program. For example, the user may wish to see the temperature of a particular pond cell as a function of time over the entire run. He would need to modify the write and format statements in the code with the appropriate list of arguments that would give him this information. He then would run this file using his own plotting program.

4.10 Dummy File

The model requires the use of a card image dummy file for internal usage. The user needs only to define this file and scratch it at the end of the model run. The file is never needed for any continuation run.

4.11 The Pointers and their Definitions

The treatment of boundary conditions is handled through definition of a set of pointers for each variable. Pointers are integer values which are assigned to each cell (or nodal point) which in turn define the boundary conditions on that variable for the code. The pointers define which cells or nodes are interior to the region being modeled and which are at a boundary. The pointers are most useful for defining conditions at the boundary cells or nodes. The pointers define boundary conditions such as no-slip, specified velocity, specified heat flux, specified temperature, etc. The model is very sensitive to errors in the pointers so they must be assigned with great care.

The user must assign values to six pointer arrays. The six arrays are:

JJV: pointers for calculating u- and v-velocities
JJW: pointers for calculating w-velocity
JJT: pointers for calculating temperature and density
JJTN: pointers for calculating the x-direction derivative for temperature
JJTM: pointers for calculating the y-direction derivative for temperature
JJP: pointers for calculating pressure

These arrays are stored in the code using a block data subroutine. The user has to modify the dimensions of the pointer arrays in common block ABLOCK. The pointer arrays are two-dimensional arrays with the first index representing the y-axis position and the second index the x-axis position of a cell or a grid point. For every pointer, except JJV, the index-pair, (M, N), represents a cell. Only for pointer JJV, does the index pair (M, N) represent the grid (nodal) point.

Every point/cell on the grid must have a pointer value for each pointer array. Tables 4-3 to 4-8 present the pointer values and their descriptions.

4.12 Array Dimensions

Any run of the model requires a number of changes to be made directly within the model computer code. The major modification involves changes in the dimensions of various arrays. These array dimensions are determined by the size of the grid defining the pond. Since the model requires a large amount of computer core for execution, it is more cost-effective to modify the dimensions of the arrays for each case study rather than fixing the dimensions to oversized values.

The model is currently dimensioned to handle a grid size of 20 × 46 × 21, i.e., 20 nodal points in the y-direction, 46 nodal points in the x-direction, and 21 nodal points in the z-direction. These dimensions can remain the same if the case study grid is the same size or smaller. If the case study grid is larger, the user simply edits the dimension statements to fit his grid. The arrays to be redimensioned are:

FC(z,y,x), UQ(z,y,x), VQ(z,y,x), FB(z,y,x), FA(z,y,x), A3A(z,y,x), A3B(z,y,x), PXA(y,x), PYA(y,x), PX(y,x), PY(y,x), A1(x), A2(x), A3(x), A4(x), FU(x), FV(x), F(x), G(x), ZZ1(x), ZZ2(x), ZZ3(x), ZZ4(x), JJV(y,x), JJW(y,x), JJT(y,x), JJTN(y,x), JJTM(y,x), JJP(y,x), HA1(x), HA2(y), HC1(y,x), HC2(y,x), HC5(y,x) HC5(y,x), HC6(y,x), HD1(y,x), HD2(y,x,2), HD3(y,x), HD4(y,x), HD6(y,x), UA(z,y,x), UB(z,y,x), VA(z,y,x), VB(z,y,x), W(z,y,x), PB(y,x), TA(z,y,x), TB(z,y,x), R(z,y,x), PA(y,x), HA(y,x), HB(y,x), H(y,x), X(x), Y(y), and Z(z),

where x is the index referring to the total number of grid points in the x direction,

y is the index referring to the total number of grid points in the y direction, and z is the index referring to the total number of grid points in the z direction.

One array, TTN(4,z,a) needs to be changed where z is total number of grid points in z-direction and a is max(y,x).

4.13 TTN Array Assignments

The array, TTN, contains values for the specified temperatures (°C) along the pond boundary for the discharges and fluxes for the intakes. This array has three indices, with the first index indicating which side of the cell represents the boundary with the pond. Looking at a cell in the x-y plane, a value of 1 indicates that the bottom wall of the cell is the boundary; a value of 2 points to the left side, a value of 3 points to the top of the cell, and a value of 4 indicates that the right side of the cell is the boundary. The second index refers to the z-level of the cell and the third index indicates the cell position with respect to the y- or x-axis.

For example, let a rectangular pond be defined by a 5 × 4 grid in the x-y plane as shown in Figure 4-2, with only one z-level (surface only). Cell A would be designated by TTN(2,1,2) with the first 2 indicating that the pond boundary is on the left side of the cell; the 1 refers to the first z-level and the second 2 states that the cell is two cells away along the x-axis from the origin. We know it is two cells from the x-axis (rather than y-axis) because the opening is a vertical face. If the first index is a 2 or 4, the third index is with respect to the y-axis. If the first index is 1 or 3, the third index is with respect to the x-axis. Cell B would be TTN(3,1,2), cell C would be TTN(4,1,3) and cell D would be TTN(1,1,4).

The TTN specified temperature for a cell can be either a specified value, in degrees Celsius, or a specified flux defined as temperature of cell (°C) times velocity of cell (cm/s) and normalized by 1°C and u_o (velocity scale). The general rule is to define discharge cells as specified values and intake cells as specified fluxes. When any inlet cell is defined through a specified value, the entire vertical column of cells must be defined in terms of the same specified value (temperature or flux). When the inlet is being defined in terms of a specified flux; then only the vertical cells actually defining the inlet are to have a special flux. The other cells (if any) in the vertical column that do not define the inlet should be set to zero.

When a specified flux is defined, the velocity used is the appropriate velocity component in the direction of flow from cell to inlet or from inlet to cell.

4.14 Overview of Printed Output

The control flags described earlier largely determine the frequency of printing of calculations. Abbreviated printout of meteorological data and selected pond temperatures are made at every step. A full printout at any given step includes

a) the U velocity for all nodal points in the x-y plane, one array for each vertical level

b) the V velocity for all nodal points in the x-y plane, one array for each vertical level

c) the W velocity for all nodal points in the x-y plane, one array for each vertical level

d) the temperatures (°C) for all cells in the x-y plane, one array for each vertical level,

e) the pressures for all nodal points in the x-y plane, one array for each vertical level

f) information on the relative changes in the velocity components, pressures and temperatures from the previous step

At the start of any printout, the following are listed

1) a complete listing of all input parameters read in from card sets 1-24,

2) six arrays corresponding to the six pointers,

3) inlet velocities for all intakes and discharges

4) boundary conditions for temperature at all boundaries.

As above, the frequency of printing can be adjusted by the control flags described earlier.

Table 4-1. Formulation for Vertical Eddy Viscosity and Vertical Eddy Thermal Diffusivity in IOPT(3)=2

Eddy coefficients are used to account for turbulent diffusion effects. The horizontal eddy viscosities and diffusivities are assumed constant. In the vertical direction, a simple non-linear turbulence model is used based on a stability function which depends on the local stratification. The vertical eddy viscosity is given by

$$A = \frac{A_o(c_1 + c_2 e^{-z/D})}{(1 + \sigma_1 \frac{g\alpha D^2 e^{2z/D}}{\vec{\tau}_w} \frac{\partial T}{\partial z})^{1/2}},$$

and the vertical eddy conductivity is

$$K_v = \frac{K_o(c_1 + c_2 e^{-z/D})}{(1 + \sigma_2 \frac{g\alpha D^2 e^{2z/D}}{\vec{\tau}_w} \frac{\partial T}{\partial z})^{1/2 \; 3/2}}.$$

Here A_o and K_o are the vertical eddy viscosity and diffusivity in the absence of stratification and are assumed to be equal; c_1, c_2, σ_1, σ_2, and D are empirical constants; $\vec{\tau}_w$ is the surface wind stress; and α is the coefficient of thermal expansion for water, assumed to be a function of the temperature.

For user input purposes:

AVO = A_o	AV1 = σ_1
BVO = K_o	BV1 = σ_2
COF1 = c_1	COF2 = c_2
COFD = D	

Table 4-2 contains the values used for these parameters for the three case studies presented in this manual.

Table 4-2. List of Vertical Eddy Viscosity and Vertical Eddy Thermal Diffusivity Coefficients used in Case Studies in this Report

Case	AVO	AV1	BVO	BV1	COF1	COF2	COFD
Cerco	0.1	0.00225	0.1	0.00225	1.0	1.0	3.81
Robinson	0.3	0.010125	0.3	0.003375	1.0	1.0	900.0
Catawba	10.0	0.0	10.0	0.0	1.0	1.0	900.0

Table 4-3. Values for Pointer JJV (M, N) where (M, N) Corresponds to Grid Point (M, N)

JJV	Description
1	Interior Point - Surface Stress B.C.
2	Interior Point - Ice Cover B.C.
3	None of Others
4	Extrapolated Boundary Point
5	Specified Non-Zero Boundary Point

Table 4-4. Values for Pointer JJW (M, N) where (M, N) Corresponds to Pond Surface Cell (M, N)

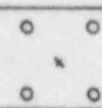
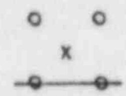
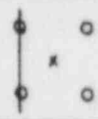
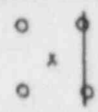
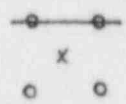
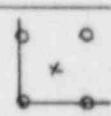
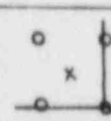
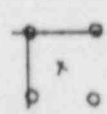
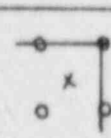
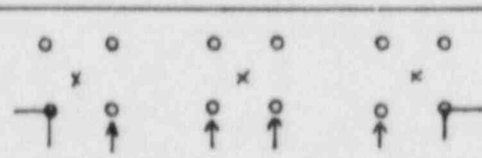
JJW	Description	
1	Interior Point	
2	Wall Behind	
3	Wall to Left	
4	Wall to Right	
5	Wall Ahead	
6	Outside Grid - No Calculation	
7	Wall Behind and to Left	
8	Wall Behind and to Right	
9	Wall Ahead and to Left	
10	Wall Ahead and to Right	
11	Inlet Behind	

Table 4-4. Continued

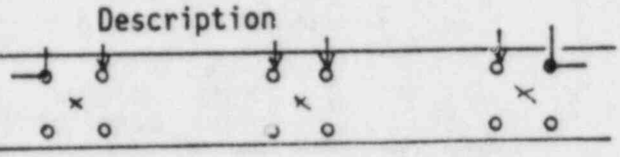
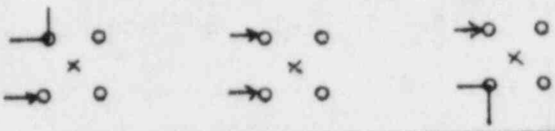
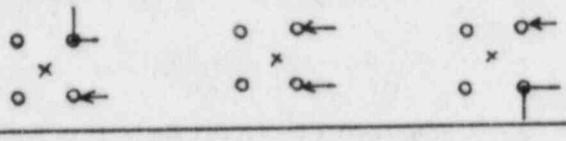
JJW	Description	
12	Inlet Ahead	
13	Inlet to Left	
14	Inlet to Right	

Table 4-5. Values for Pointer JJT (M, N) where (M, N) Corresponds to Pond Surface Cell (M, N)

JJT	Description
1	Interior Point - Surface Heat Flux B.C.
2	Interior Point - Specified Surface Temperature
3	Outside Grid - No Calculation
4	Extrapolated Boundary - Surface Heat Flux B.C.
5	Extrapolated Boundary - Specified Surface Temperature

Table 4-6. Values for Pointer JJTN (M, N) where (M, N) Corresponds to Pond Surface Cell (M, N)

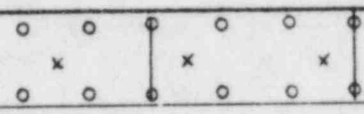
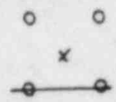
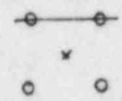
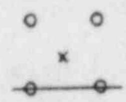
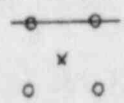
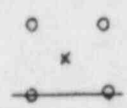
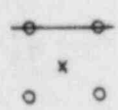
JJTN	Description	
1	Interior Point	
2	Insulated Wall Behind	
3	Insulated Wall Ahead	
4	Outside Grid - No Calculation	
5	Specified Value Behind	
6	Specified Value Ahead	
7	Specified Flux Behind	
8	Specified Flux Ahead	

Table 4-7. Values for Pointer JJTM (M, N) where (M, N) Corresponds to Pond Surface Cell (M, N)

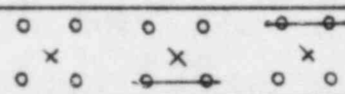
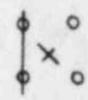
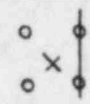
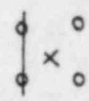
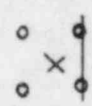
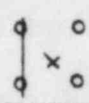
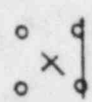
JJTM	Description
1	Interior Point 
2	Insulated Wall Behind 
3	Insulated Wall Ahead 
4	Outside Grid - No Calculation
5	Specified Value Behind 
6	Specified Value Ahead 
7	Specified Flux Behind 
8	Specified Flux Ahead 

Table 4-8. Values for Pointer JJP (M, N) where (M, N) Corresponds to Pond Surface Cell (M, N)

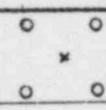
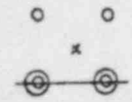
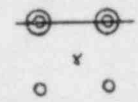
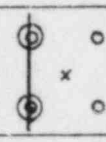
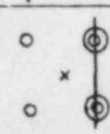
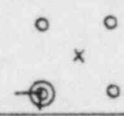
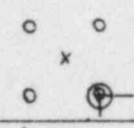
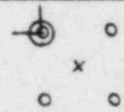
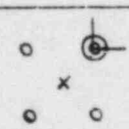
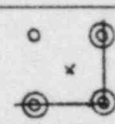
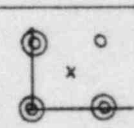
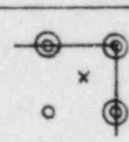
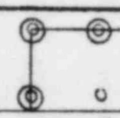
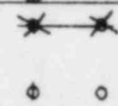
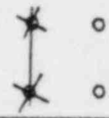
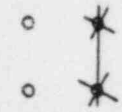
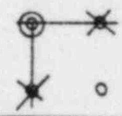
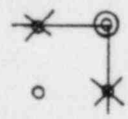
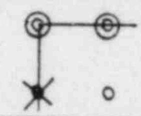
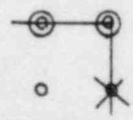
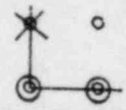
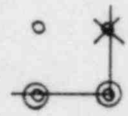
JJP	Description	
1	Interior Point	
2	Specified Values Behind	
3	Specified Values Ahead	
4	Specified Values to Left	
5	Specified Values to Right	
6	Specified Value Behind and to Left	
7	Specified Value Behind and to Right	
8	Specified Value Ahead and to Left	
9	Specified Value Ahead and to Right	
10	Specified Values Behind and Right	
11	Specified Values Behind and Left	
12	Specified Values Ahead and Right	

Table 4-8. Continued

JJP	Description	
13	Specified Values Ahead and Left	
14	Extrapolated Values Ahead	
15	Extrapolated Values to Left	
16	Extrapolated Values to Right	
17	Extrapolated Values Ahead and Left	
18	Extrapolated Values Ahead and Right	
19	Specified Values Ahead, Extrapolated Value to Left	
20	Specified Values Ahead, Extrapolated Value to Right	
21	Specified Values Behind, Extrapolated Value to Left	
22	Specified Values Behind, Extrapolated Value to Right	
23	Outside Grid - No Calculation	

o interior velocity point

× extrapolated velocity point

◎ specified velocity point

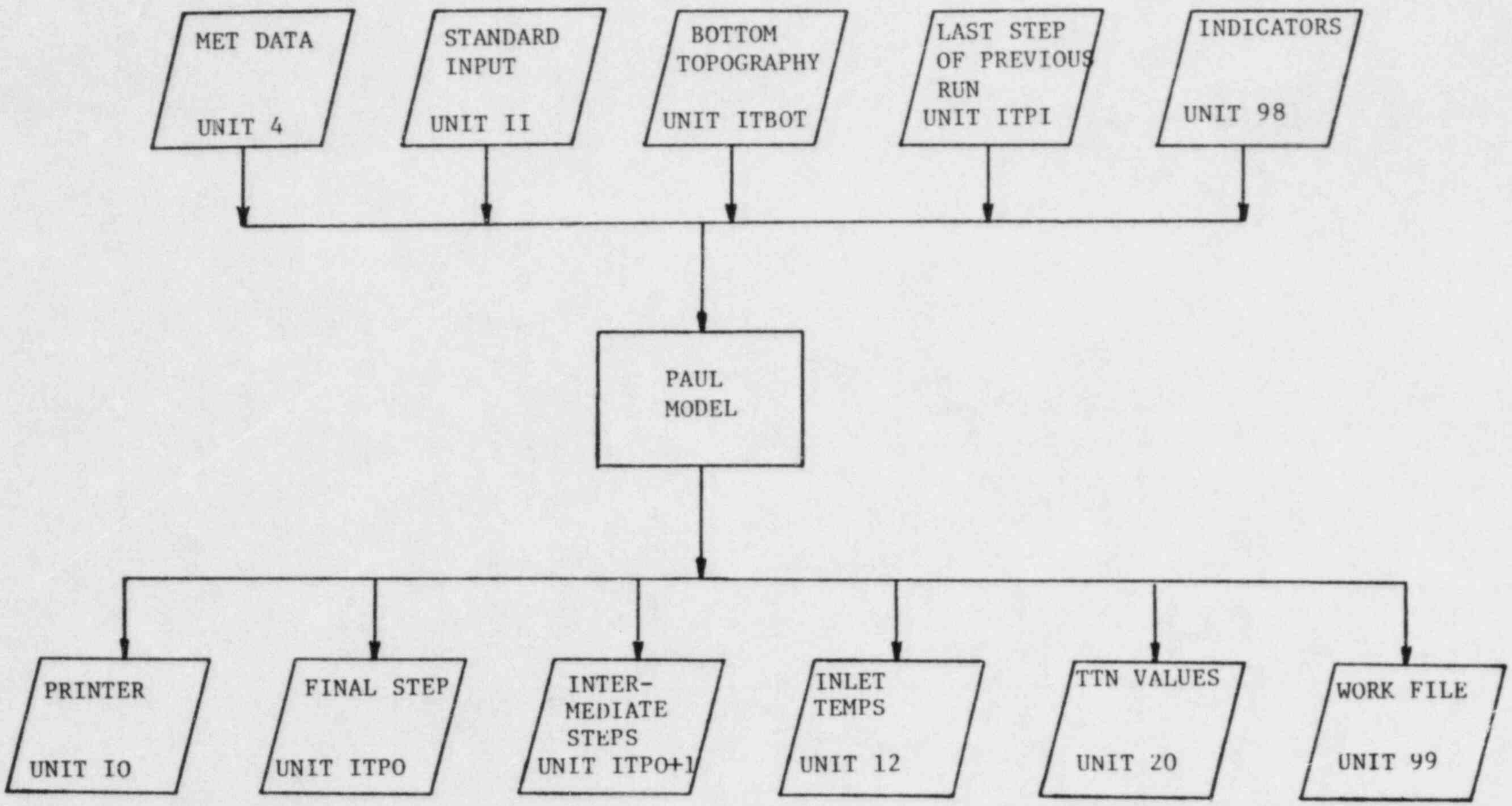
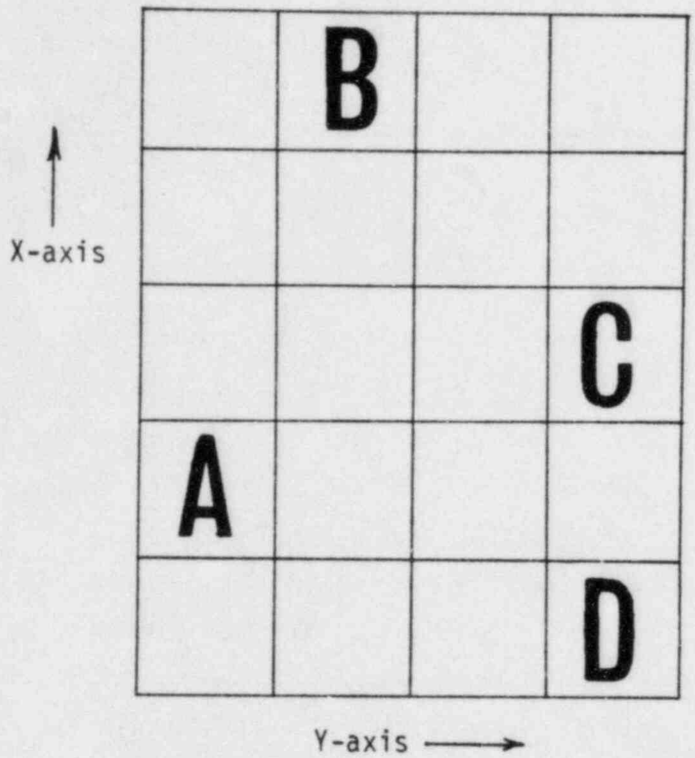


Fig. 4-1. Schematic Diagram Showing Input and Output for Paul Model.



Cell	TTN Indices
A	(2,1,2)
B	(3,1,2)
C	(4,1,3)
D	(1,1,4)

Fig. 4-2. Example for TTN Indices for a 5×4 Rectangular Pond with Only One Z-Level (Surface).

5. VERIFICATION OF PAUL MODEL WITH CERCO LABORATORY DATA

The Paul Model is tested here with laboratory data on cooling pond thermal performance. In general, existing cooling ponds cannot be scaled successfully in the laboratory, due to contradictory similarity requirements for hydrodynamic mixing and surface heat transfer. The laboratory data used here were taken for diagnostic purposes in studying cooling pond design. Present in the laboratory simulation are the same physical processes that are operational in prototype UHS cooling ponds. To be tested is the model's ability to correctly predict the coupling of flow and surface heat transfer in a partially stratified environment.

The data used for model testing was taken from Cerco (Ref. 1). In this work, an experimental study was carried out to analyze the flow patterns possible in different designs of cooling ponds. Care was taken in the laboratory to assure that the thermal structure, as indicated by the vertical temperature gradient, is similar to actual shallow field cooling ponds. The important scaling requirement was found to be a nondimensional parameter, the "pond number," which includes the effects of pond shape, pond depth, the circulating water flow rate, exit temperature rise, entrance mixing, and interfacial friction. A rectangular pond of dimensions 17.7 × 35.7 × 0.2 ft was instrumented with approximately 60 temperature probes shown in Fig. 5-1. Figs. 5-2 and 5-3 show the surface isotherms and vertical temperature profiles at specific points in the pond. The data represent the steady-state temperature field for a rectangular pond with discharge and intake at opposite corners of the pond. For a steady discharge temperature of 127.9°F, the intake temperature was measured to be 103.1°F. The observed plume was stratified just outside the discharge yet was nearly fully-mixed at further locations in the pond. The upper left-hand section of the pond was less effective in dispersing the heat due to some short-circuiting.

Paul Model predictions for this case were made using a grid 19 × 39 × 6 cells where $\Delta x = \Delta y = 11$ inches and $\Delta z = 0.5$ inches. The horizontal grid layout is presented in Fig. 5-4. The same intake and discharge flow was maintained in the model simulation as in the lab; in the model, the discharge temperature was held constant at 127.9°F. The simulation of the discharge and intake is given in Fig. 5-5. In the laboratory simulation, the discharge dimensions were 11" wide by 2" deep. In the Paul simulation, the discharge was 11" wide × 1.75" deep. Discharge flow and rejected heat were maintained equal between lab and model simulation. In the lab, the intake was near the bottom and of dimensions 11" wide × 0.5" deep. In the Paul simulation, this intake was also 11" × 0.5". Flow into the pond and out were identical between lab and model simulation.

Equilibrium temperatures were measured directly in the lab using a shallow insulated tank filled with approximately 1 inch of water. Cerco measured an equilibrium temperature for this case at 76.0°F. A surface heat transfer coefficient K = 157.8 Btu/ft^2.day °F was predicted based on measured ambient air data (Ref. 1).

Table 5-1 lists the constants used in Paul Model simulation. Discussions with J. Paul motivated the choice of lateral and vertical eddy viscosity and eddy thermal diffusivity constants. Figures 5-6 and 5-7 present Paul model predictions at steady state. The predicted intake temperature was excellent at 102.9°F compared with a measured value of 103.1°F. The surface isotherms (see Fig. 5-6) showed more lateral diffusion than was apparent in the experimental data. Based on the comparison of model predictions with the data, it appears that a choice of smaller values for the eddy viscosities and diffusivities would have improved the predictions. Predicted vertical profiles are presented in Fig. 5-7. All are good representations of the data (Fig. 5-5) except for positions A and B. Here temperatures below ambient were predicted, a problem indicative of large temperature gradients unresolved in a coarse grid system. A more refined grid system close to the discharge should provide more accurate predictions near the discharge.

Model predictions and data may be compared on a point by point basis by examining Figs. 5-2 and 5-6 (surface isotherms) and Figs. 5-3 and 5-7 (vertical isotherms). Difference between predictions and observations are small or large depending upon the relative lateral and vertical spreading that has taken place. In spite of the point by point differences that exist between model and data in the lab tank, the predicted temperature compares very well with the observed data at the intake end of the pond.

A listing of the detailed input to the model is provided in Tables 5-2 to 5-7. The model predictions were made through five continuation runs. Table 5-2 presents input for the initial run of 15 minutes real time (i.e., 15 minutes in the physical model). Table 5-3 presents input for the next 15 minutes using the output of the last step of the first run as initial conditions for the second run. Table 5-4 provides the next set of input continuing the second run from 30 to 45 minutes. Table 5-5 provides input for the next 15 minute period. Finally, Table 5-6 provides input for the final 15 minutes at which steady state was achieved. In total, 75 minutes of tank time was run. The code was, therefore, run for increments of 15 minutes of tank time; the differences in predictions between the 60 and 75 minute runs were very small indicating that steady state conditions were effectively reached at 75 minutes of tank time. Tables 5-7, 5-8, and 5-9 present the pointer arrays for JJV, JJW, JJT, JJTM, JJTN, and JJP.

References

1. C. Cerco, "Experimental and Analytical Study of the Design of Shallow Cooling Ponds." M.S. Thesis. Department of Civil Engineering. Massachusetts Institute of Technology. May 1977.

Table 5-1. Values of Parameters Chosen in Paul Model Run for Cerco Lab Case

b_o = reference length = maximum length of pond in x-direction = 530.9 cm

h_o = reference depth = 3 in. = 7.62 cm

u_o = reference velocity = 1.0 cm/s

T_s = time step $< \frac{1}{2} \frac{\Delta x}{u_{max}}$ = 0.873 sec ~ 0.5 sec

DT = 2.661×10^{-5}	RE = 35.39	BV1 = 2.25×10^{-3}
DEL = 1.0	RO = 1.88	THV = 1.0
EPST = 10^{-5}	FR = 1.16×10^{-2}	THP = 0.55
EPS = 10^{-6}	RATIO = 69.7	THC = 0.5
RA(1) = 1000.0	TWX = 10^{-8}	THT = 1.0
RA(2) = 283.0	TWY = 10^{-8}	BET = 0.0
RA(3) = -3.98	PLEV = 1000.	BET1 = 1.0
RA(4) = 503.4	AH = 15.0	
RA(5) = 67.3	AVO = 0.1	
RA(6) = 0.0	AV1 = 2.25×10^{-3}	
RA(7) = 0.0	BH = 3.0	
RA(8) = 0.0	BVO = 0.1	

Table 5-2. Main Input to Paul Model for First Run, 15 Minutes Tank Time

```
     20
CERCO POND STUDY: CASE NUMBER 44  -- GRID 39 X 19 X 6,  DS = .2794 METERS
      0     0    09     0
      2     2     2     2     2     2     2     2     2     2
      1    39    19    06
      1     3     2  0450     0     2     1   150  1000     1  1000  1000     1
    200
      4     1     2     0     0     5     0   000     0     0
0.000026611.0       .00001     .000001
1000.0     283.0     -3.98      503.37     67.26
35.39066671.878748930.011568365.0          69.6667   0.000000010.000000011000.
015.0      0.1       0.00225   003.0      0.1       0.00225    .00215397924.44
1.0        0.55      0.50      1.0        0.0       1.0
1.0        1.0       3.81      7.62
   50.55554  50.55554  50.55554  50.55554  50.55554  50.55554  47.77777  47.77777
   47.77777  47.22221  47.22221  46.66666  44.99998  43.33333  43.33333  42.77777
   42.22221  42.22221  42.22221  42.22221  41.66666  41.66666  41.11110  41.11110
   40.55554  39.99998  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
   38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  50.55554
   50.55554  50.55554  50.55554  50.55554  50.55554  47.77777  47.77777  47.77777
   47.22221  47.22221  46.66666  46.66666  44.99998  43.88887  43.33333  42.77777
   42.77777  42.77777  42.22221  42.22221  42.22221  41.66666  42.77777  39.99998
   39.99998  39.99998  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
   38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  50.55554  50.55554
   50.55554  50.55554  50.55554  50.55554  47.77777  47.77777  47.77777  47.77777
   47.22221  46.66666  46.66666  46.66666  46.11110  44.99998  44.99998  44.99998
   43.33333  42.77777  42.77777  42.77777  42.77777  42.77777  42.22221  41.66666
   40.55554  39.99998  39.44443  38.88887  38.88887  38.88887  38.88887  38.88887
   38.88887  38.88887  38.88887  38.88887  38.88887  50.55554  50.55554  50.55554
   50.55554  50.55554  50.55554  50.55554  50.55554  47.77777  47.77777  47.22221
   46.66666  46.66666  46.66666  46.66666  46.66666  46.11110  45.55554  44.99998
   44.44443  43.88887  42.77777  42.77777  42.77777  42.77777  42.77777  41.66666
   41.11110  40.55554  39.99998  39.99998  39.99998  39.99998  38.88887  38.88887
   38.88887  38.88887  38.88887  38.88887  43.33333  43.33333  43.33333  43.33333
   47.77777  47.77777  47.77777  47.77777  47.77777  47.22221  47.22221  46.66666
   46.66666  46.66666  46.66666  46.66666  46.66666  46.11110  45.55554  45.55554
   45.55554  44.99998  43.88887  43.33333  43.33333  43.33333  43.33333  43.33333
   41.66666  41.66666  41.66666  41.11110  41.11110  39.99998  39.44443  38.88887
   38.88887  38.88887  38.88887  37.77777  37.77777  37.77777  38.33333  43.33333
   47.77777  43.88887  46.66666  46.66666  46.66666  46.66666  46.66666  46.66666
   46.66666  46.66666  46.66666  46.66666  46.11110  45.55554  45.55554  45.55554
   44.99998  44.44443  43.88887  43.33333  43.33333  43.33333  43.33333  42.77777
   41.66666  41.66666  41.66666  41.66666  41.11110  39.99998  38.88887  38.88887
   38.88887  38.88887  37.77777  37.77777  37.77777  38.33333  38.88887  39.44443
   45.55554  44.44443  44.99998  44.99998  45.55554  46.11110  46.11110  46.11110
   46.11110  46.11110  46.11110  46.11110  45.55554  45.55554  45.55554  44.99998
   44.44443  44.44443  43.88887  43.33333  43.33333  43.33333  43.33333  42.77777
   41.66666  41.66666  41.66666  41.11110  39.99998  38.88887  38.88887  38.88887
   38.88887  37.77777  37.77777  37.77777  38.33333  38.88887  38.88887  38.88887
   43.88887  43.33333  43.33333  43.88887  44.44443  44.99998  44.99998  44.99998
   44.99998  44.99998  44.99998  44.99998  44.99998  44.99998  44.99998  44.44443
   44.44443  44.44443  43.88887  43.33333  43.33333  43.33333  42.77777  42.22221
   41.66666  41.66666  41.11110  39.99998  38.88887  38.88887  38.88887  38.88887
   37.77777  37.77777  37.77777  38.33333  38.88887  38.88887  38.88887  38.88887
   38.88887  40.55554  42.77777  43.33333  43.88887  43.88887  43.33333  43.88887
   43.33333  43.88887  44.44443  44.44443  44.44443  44.44443  44.44443  44.44443
   44.44443  43.88887  43.33333  43.33333  43.33333  43.33333  42.22221  41.66666
```

Table 5-2 (continued)

```
41.66666  41.11110  39.99998  38.88887  38.88887  38.88887  38.88887  38.33333
38.33333  38.33333  38.33333  38.88887  38.88887  38.88887  38.88887  38.88887
38.88887  39.44443  42.77777  42.77777  42.77777  41.66666  42.22221  42.22221
42.77777  43.88887  43.88887  43.88887  43.88887  43.88887  43.88887  43.88887
43.88887  43.33333  43.33333  43.33333  43.33333  42.22221  41.66666  41.11110
40.55554  39.99998  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
38.88887  39.44443  41.11110  41.11110  41.66666  41.66666  41.66666  42.22221
42.22221  42.22221  42.22221  42.77777  42.77777  42.77777  43.33333  43.33333
43.33333  43.33333  42.77777  42.77777  42.22221  41.66666  40.55554  39.99998
39.99998  39.99998  39.44443  39.44443  39.44443  38.88887  38.88887  38.88887
38.88887  38.88887  39.44443  39.44443  39.44443  38.88887  38.88887  38.88887
39.44443  39.99998  40.55554  41.11110  41.66666  41.66666  41.66666  41.66666
42.22221  42.22221  42.22221  42.22221  42.22221  42.22221  42.22221  42.22221
42.22221  42.22221  42.22221  41.66666  41.11110  40.55554  39.99998  39.99998
39.99998  39.99998  39.99998  39.99998  38.88887  38.88887  38.88887  38.88887
38.88887  39.44443  39.44443  39.44443  38.88887  38.88887  39.44443  39.44443
39.99998  40.55554  40.55554  41.11110  41.66666  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  42.22221  42.22221  42.22221  42.22221  42.22221
42.22221  41.66666  41.66666  41.66666  41.11110  40.55554  39.99998  39.99998
39.99998  39.99998  39.99998  38.88887  38.88887  38.88887  38.88887  38.88887
39.44443  39.44443  39.44443  38.88887  39.44443  39.44443  39.99998  39.99998
40.55554  40.55554  40.55554  41.11110  41.11110  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  41.11110  40.55554  39.99998  39.99998  39.99998
39.99998  39.99998  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
38.88887  38.88887  39.44443  39.44443  39.99998  39.99998  39.99998  39.99998
40.55554  40.55554  40.55554  40.55554  41.11110  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  41.11110  40.55554  39.99998  39.99998  39.99998
39.99998  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
38.88887  39.44443  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998
39.99998  40.55554  40.55554  40.55554  41.11110  41.11110  41.11110  41.66666
41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666  41.66666
41.66666  41.66666  41.66666  41.11110  40.55554  39.99998  39.99998  39.99998
38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887
39.44443  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998
39.99998  39.99998  39.99998  40.55554  40.55554  40.55554  40.55554  41.11110
41.11110  41.11110  41.11110  41.11110  41.66666  41.66666  41.66666  41.66666
41.66666  41.66666  41.11110  40.55554  39.99998  39.99998  39.99998  38.88887
38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  38.88887  39.44443
39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998
39.99998  39.99998  39.99998  39.99998  39.99998  40.55554  40.55554  40.55554
40.55554  40.55554  40.55554  40.55554  41.11110  41.11110  41.66666  41.66666
41.66666  41.11110  40.55554  39.99998  39.99998  39.99998  38.88887  38.88887
38.88887  38.88887  38.88887  38.88887  38.88887  39.44443  39.99998  39.99998
39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998
39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998  39.99998
39.99998  39.99998  39.99998  40.55554  40.55554  41.11110  41.11110  41.11110
41.11110  40.55554  39.99998  39.99998  39.99998
000002
001002040019
0.0       0.0       0.0       0.0       0.0       0.0       0.0
4.572     4.572     4.572     4.572     0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       16.00     0.0
000004
002001
53.277777853.277777853.277777853.27777780.0       0.0       0.0
002002
53.277777853.277777853.277777853.27777780.0       0.0       0.0
004018
0.0       0.0       0.0       0.0       0.0       0.0       0.0
004019
0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Table 5-3. Main Input to Paul Model for Continuation Run, 15-30 Minutes Tank Time

```
    20
CERCO POND STUDY: CASE NUMBER 44  -- GRID 39 X 19 X 6,  DS = .2794 METERS
     1    8   09    0
     2    2    2    2    2    2    2    2    2    2
     2   39   19   06
     2    3    2 0450    0    2    1  150 1000    1 1000 1000    1
   200
     4    1    2    0    0    5    0  000    0    0
0.000026611.0       .00001    .000001
1000.0    283.0     -3.98     503.37    67.26
35.39066671.878748930.011568365.0       69.6667   0.000000010.000000011000.
015.0     0.1       0.00225   003.0     0.1       0.00225   .00215397924.44
1.0       0.55      0.50      1.0       0.0       1.0
1.0       1.0       3.81      7.62
000002
001002040019
0.0       0.0       0.0       0.0       0.0       0.0       0.0
4.572     4.572     4.572     4.572     0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       16.00     0.0
000004
002001
53.277777853.277777853.277777853.27777780.0       0.0       0.0
002002
53.277777853.277777853.277777853.27777780.0       0.0       0.0
004018
0.0        0.0        0.0        0.0        0.0        0.0        0.0
004019
0.0        0.0        0.0        0.0        0.0        0.0        0.0
```

Table 5-4. Main Input to Paul Model for Continuation Run, 30-45 Minutes Tank Time

```
      20
CERCO POND STUDY: CASE NUMBER 44  -- GRID 39 X 19 X 6,  DS = .2794 METERS
       2     8    09     0
       2     2     2     2     2     2     2     2     2     2
       3    39    19    06
       2     3     2  0450     0     2     1   150  1000     1  1000  1000     1
     200
       4     1     2     0     0     5     0   000     0     0
0.000026611.0       .00001     .000001
1000.0    283.0     -3.98      503.37     67.26
35.39066671.878748930.011568365.0       69.6667   0.000000010.000000011000.
015.0     0.1       0.00225    003.0      0.1       0.00225   .00215397924.44
1.0       0.55      0.50       1.0        0.0       1.0
1.0       1.0       3.81       7.62
000002
001002040019
0.0       0.0       0.0        0.0        0.0       0.0       0.0
4.572     4.572     4.572      4.572      0.0       0.0       0.0
0.0       0.0       0.0        0.0        0.0       0.0       0.0
0.0       0.0       0.0        0.0        0.0       16.00     0.0
000004
002001
53.277777853.277777853.277777853.27777780.0     0.0       0.0
002002
53.277777853.277777853.277777853.27777780.0     0.0       0.0
004018
0.0        0.0       0.0        0.0        0.0       0.0       0.0
004019
0.0        0.0       0.0        0.0        0.0       0.0       0.0
```

Table 5-5. Main Input to Paul Model for Continuation Run, 45-60 Minutes Tank Time

```
     20
   CERCO POND STUDY: CASE NUMBER 44  -- GRID 39 X 19 X 6,  DS = .2794 METERS
      3     8    09     0
      2     2     2     2     2     2     2     2     2     2
      4    39    19    06
      2     3     2  0450     0     2     1   150  1000     1  1000  1000     1
    200
      4     1     2     0     0     5     0   000     0     0
   0.000026611.0      .00001    .000001
   1000.0    283.0    -3.98     503.37    67.26
   35.39066671.878748930.011568365.0      69.6667   0.000000010.000000011000.
   015.0     0.1      0.00225   003.0     0.1      0.00225    .00215397924.44
   1.0       0.55     0.50      1.0       0.0      1.0
   1.0       1.0      3.81      7.62
   000002
   00100204 0019
   0.0       0.0      0.0       0.0       0.0      0.0       0.0
   4.572     4.572    4.572     4.572     0.0      0.0       0.0
   0.0       0.0      0.0       0.0       0.0      0.0       0.0
   0.0       0.0      0.0       0.0       0.0      16.00     0.0
   000004
   002001
   53.277777853.277777853.277777853.27777780.0     0.0       0.0
   002002
   53.277777853.277777853.277777853.27777780.0     0.0       0.0
   004018
   0.0        0.0       0.0       0.0       0.0      0.0       0.0
   004019
   0.0        0.0       0.0       0.0       0.0      0.0       0.0
```

Table 5-6. Main Input to Paul Model for Continuation Run, 60-75 Minutes Tank Time

```
    20
CERCO POND STUDY: CASE NUMBER 44  -- GRID 39 X 19 X 6,  DS = .2794 METERS
     4    8   09    0
     2    2    2    2    2    2    2    2    2    2
     5   39   19   06
     2    3    2 0450    0    2    1  150 1000    1 1000 1000    1
   200
     4    1    2    0    0    5    0  000    0    0
0.000026611.0      .00001    .000001
1000.0    283.0    -3.98     503.37    67.26
35.39066671.878748930.011568365.0      69.6667   0.000000010.000000011000.
015.0     0.1      0.00225   003.0     0.1       0.00225   .00215397924.44
1.0       0.55     0.50      1.0       0.0       1.0
1.0       1.0      3.81      7.62
000002
0010020400019
0.0       0.0      0.0       0.0       0.0       0.0       0.0
4.572     4.572    4.572     4.572     0.0       0.0       0.0
0.0       0.0      0.0       0.0       0.0       0.0       0.0
0.0       0.0      0.0       0.0       0.0       16.00     0.0
000004
002001
53.277777853.277777853.277777853.27777780.0    0.0       0.0
002002
53.277777853.277777853.277777853.27777780.0    0.0       0.0
004018
0.0        0.0       0.0       0.0       0.0       0.0       0.0
004019
0.0        0.0       0.0       0.0       0.0       0.0       0.0
```

Table 5-7. Array of JJV and JJW Pointers in Paul Model Input for Cerco Laboratory Study

JJV POINTERS

3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

JJW POINTERS

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	14	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	8	0

Table 5-8. Array of JJT and JJTM Pointers in Paul Model Input for Cerco Laboratory Study

JJT POINTERS

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

JJTM POINTERS

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0

Table 5-9. Array of JJTN and JJP Pointers in Paul Model Input for Cerco Laboratory Study

JJP POINTERS

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	12	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	[illegible]	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	0
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	10	0

JJTN POINTERS

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0

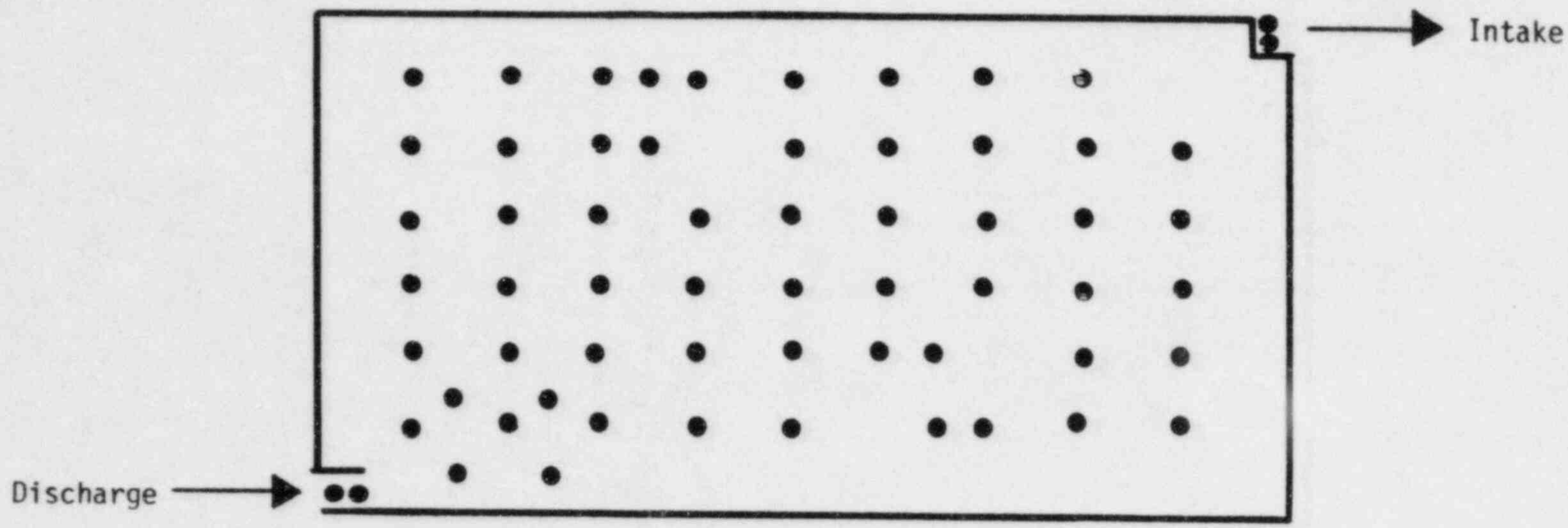


Fig. 5-1. Plan View of Temperature Probe Locations for Cerco Laboratory Study ... adapted from Reference 1.

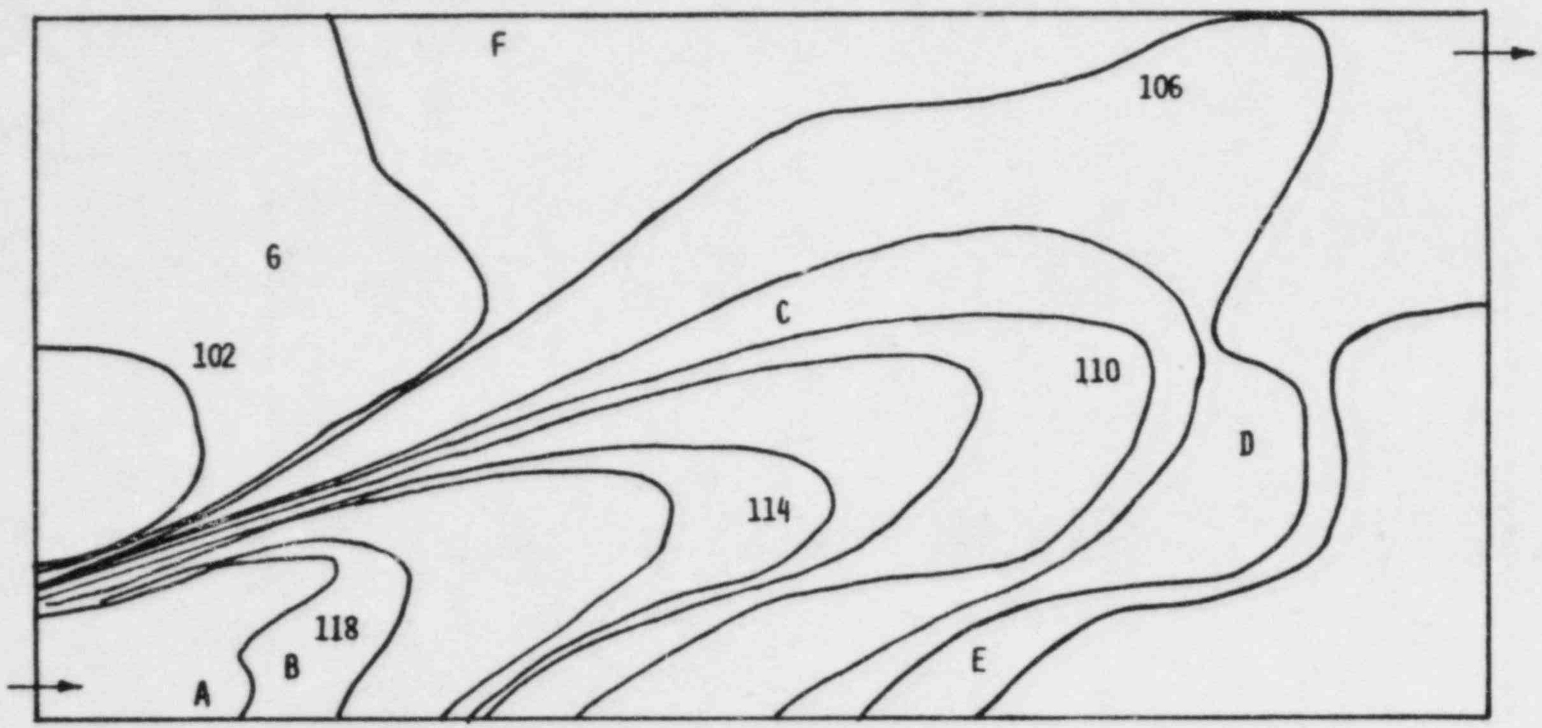


Fig. 5-2. Measured Surface Isotherms for Cerco Lab Case
... adapted from Reference 1.

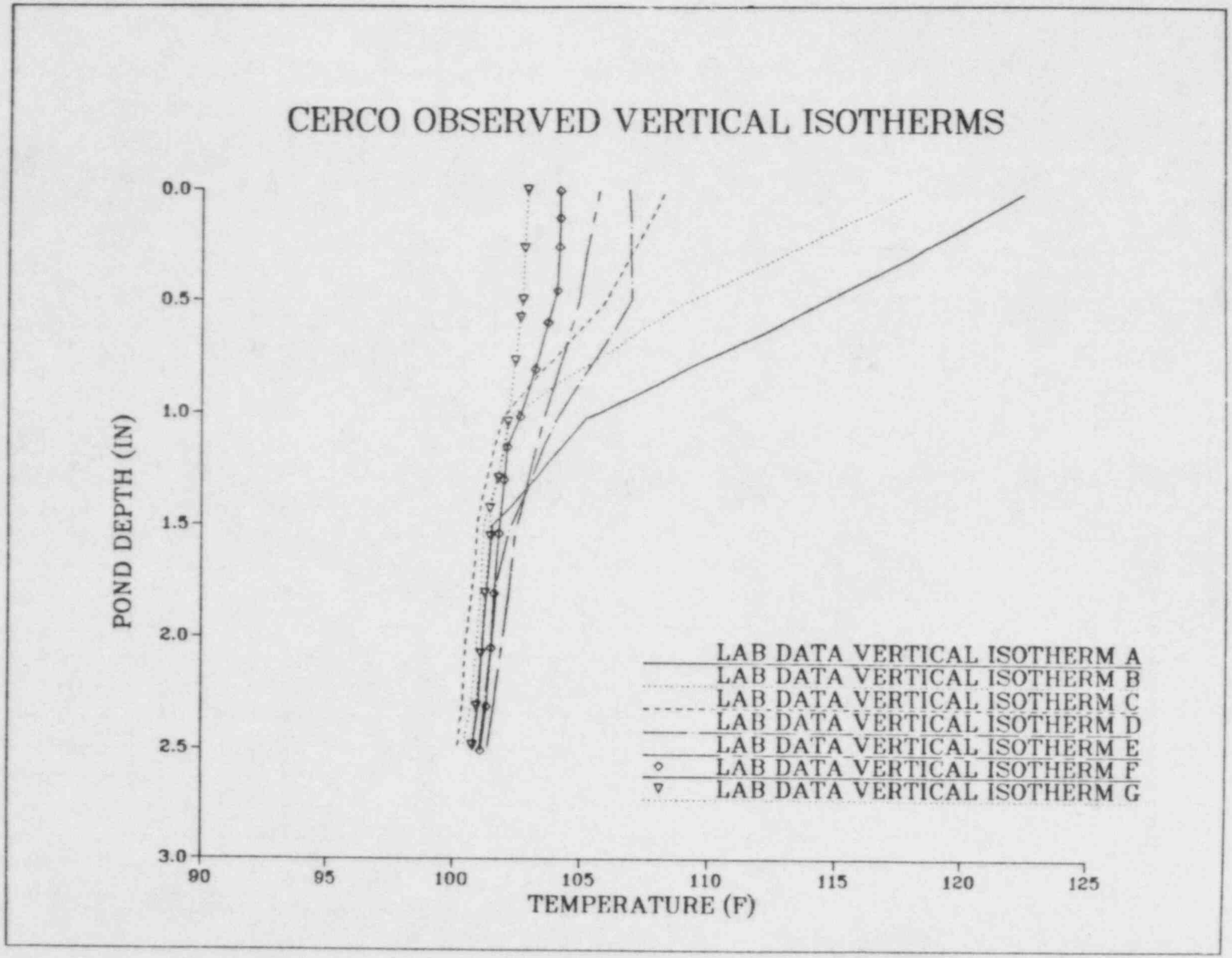


Fig. 5-3. Measured Vertical Temperature Profiles for Cerco Lab Case ... adapted from Reference 1.

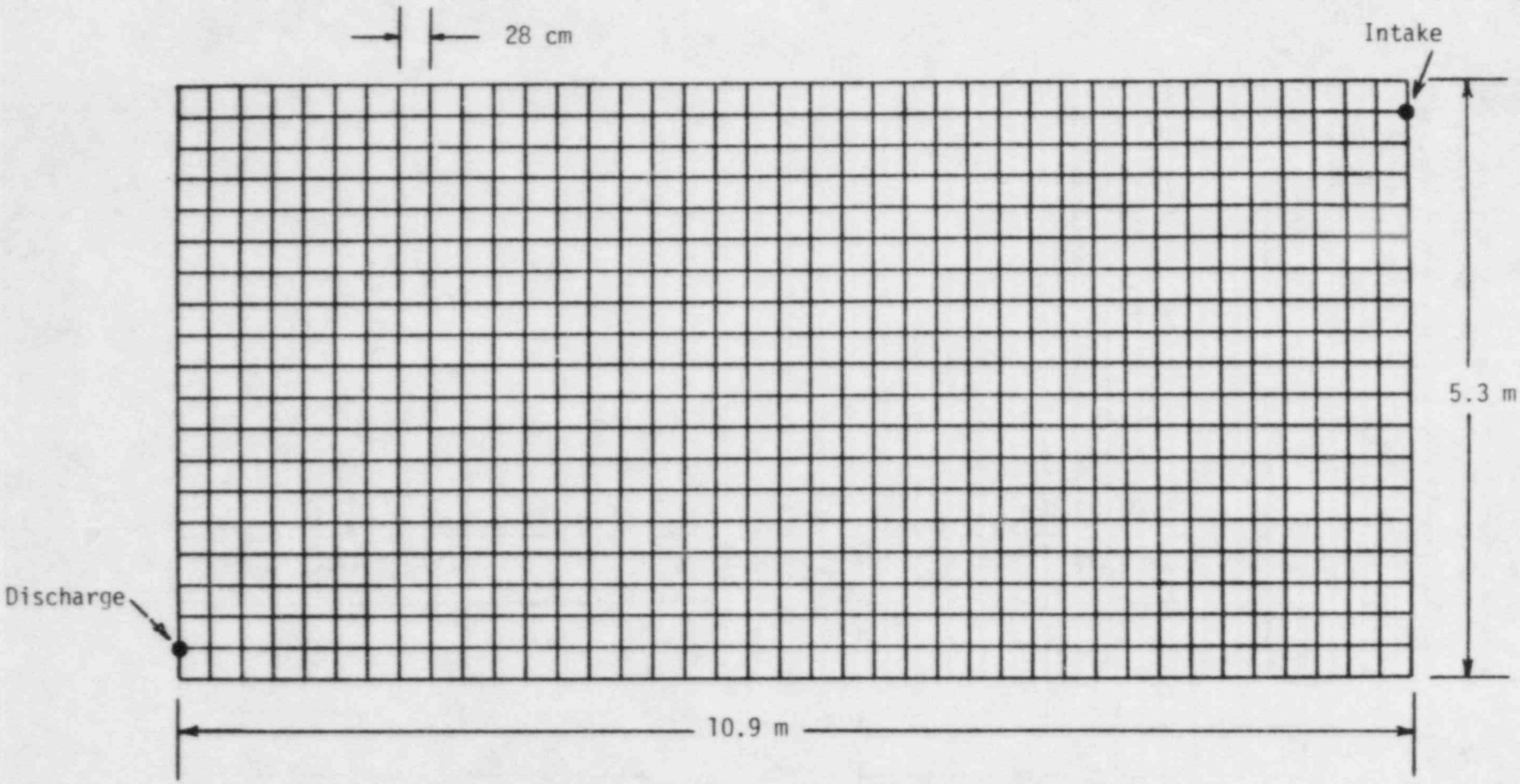
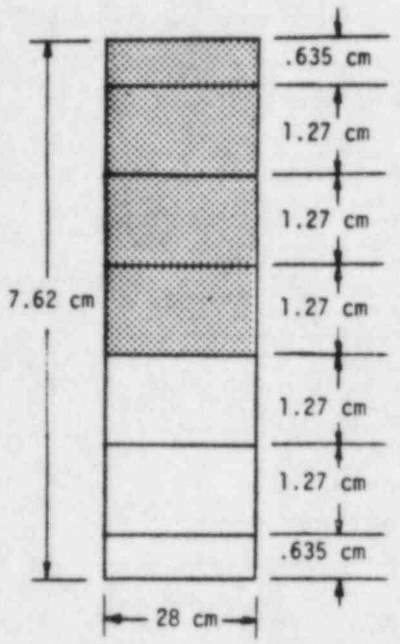
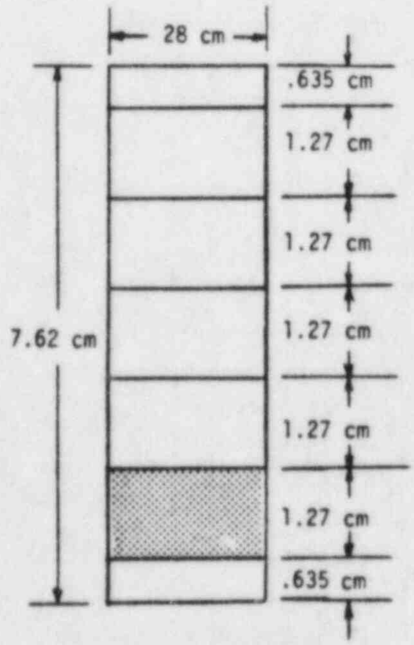


Fig. 5-4. Horizontal Grid System Used in Paul Model Run for Cerco Lab Data.

Fig. 5-5. Simulation of Discharge and Intake in Paul Model Run for Cerco Lab Data



Discharge configuration for Cerco study. Top four cells used with an exit velocity of 4.57 cm/s.



Intake configuration for Cerco study. Sixth cell used with an intake velocity of 16.0 cm/s.

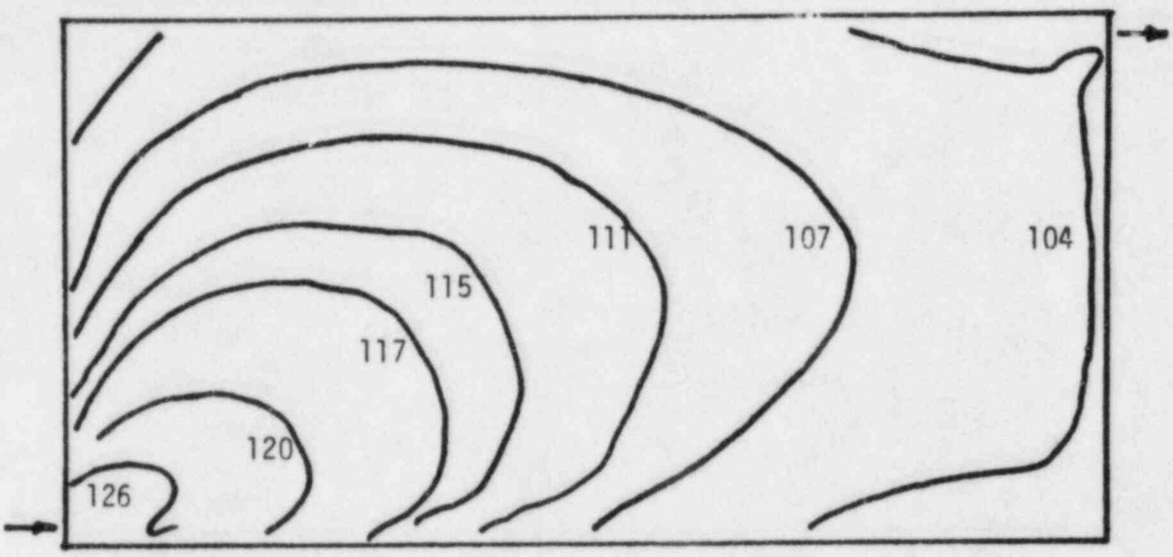


Fig. 5-6. Predictions of Surface Isotherms from Paul Model for Cerco Lab Case

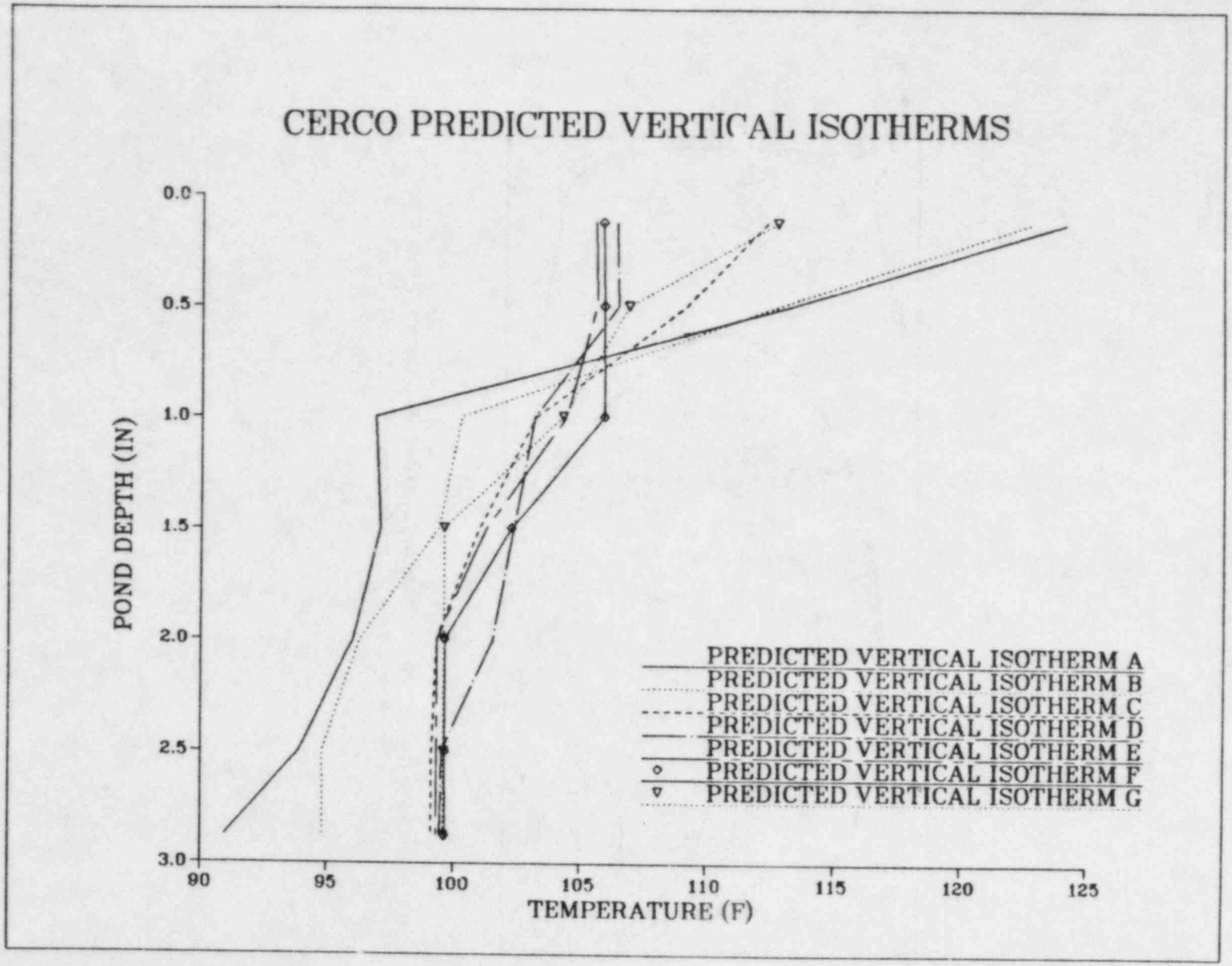


Fig. 5-7. Predictions of Vertical Temperature Isotherms from Paul Model for Cerco Lab Case.

6. APPLICATION OF PAUL MODEL TO H.B. ROBINSON COOLING POND

The purpose of this validation exercise is to test the Paul model's performance with field data representing hot ponds. The Raft River data provided only a test of the surface heat transfer formulation since the pond is fully mixed. The Paul model should be tested in cases with observed stratification as well as hot pond conditions to assure that the model could handle complex flows at the same time as strong surface heat transfers. The most closely related pond to a UHS case was found to be the H.B. Robinson pond located in South Carolina (Refs. 1-4). The H.B. Robinson plant has one coal-fired unit (155 MWe) and one nuclear unit (722 MWe). Both units discharge through a 4.2 mile long discharge channel into the middle of Lake Robinson (see Fig. 6-1).

The impoundment may be divided into three sections for purposes of discussion.

1. Lower impoundment - from the dam extending approximately 5.6 km (3.5 mi) north

2. Middle impoundment - from approximately 5.6 km (3.5 mi) north of the dam to State Route 346 (see Fig. 6-1).

3. Upper impoundment - from State Route 346 northward.

The data of August 14, 1978 were chosen for model testing. On this date, pond temperatures were measured by boat along five transects (A-E) with several vertical locations measured at each position along a transect. The positions of these transects is given in Figs. 6-1. Bathymetry of the pond represented in the grid simulation is given in Fig. 6-2. All discharges and intake locations are presented in Fig. 6-2. The surface isotherms and vertical cross sectional temperature distributions are presented in Figs. 6-3 to 6-5. The August 14 date was chosen because it had the warmest pond temperatures recorded during the 1976-1979 period in which intensive measurements were made at the pond.

Some characteristics of the pond thermal structure follows which may be evidenced by the field data measurements on August 14.

Upper Impoundment

The limited effects of thermal discharge on the upper impoundment area is due in part to the construction associated with the relocation of the SR 346 road bed. During the creation of the impoundment, SR 346 was relocated by constructing a 305 m (1000 ft) earthen dike through the impoundment area and a 61 m (200 ft) supported bridge. This relatively small bridge opening has limited the amount of warmed discharge water which could move northward and has created an area in the impoundment which is generally protected from the thermal effluent. Only during periods when southerly or south-easterly winds predominate and/or during periods of low flow will discharge waters move a substantial distance above the SR 346 bridge. However, even during these periods, warmed discharge waters stratify over cooler bottom waters and large volumes of water which are not affected by plant discharge exist; with a shift in wind direction, warmed discharge waters, because they are on the surface, tend to follow the wind and/or flow currents. This creates changing thermal conditions in the top 2 m (6.6 ft) of water in many areas of the upper impoundment.

Middle Impoundment

The effects of the plant discharge were most evident in the middle impoundment area and this area is warmer than the remainder of the impoundment. The natural flow of the impoundment results in the flow of warmed discharge waters from the middle impoundment area to the plant intake and spillway.

Lower Impoundment

As warmed discharge waters move southward, cooling occurs and water temperatures in the lower impoundment area are cooler than those recorded in the middle impoundment areas. Generally, some mixing of discharge waters with bottom waters occurred, but stratification was still evident, especially during the warmer summer months. This area is deeper than the other two impoundment areas and is usually rather stratified as is the case in the August 14 measurements.

In order to prepare the Paul model predictions for August 14, 1978, the following data were obtained from Carolina Power and Light* for the period July-August 1978,

a) discharge temperature as a function of time (daily averages provided),

b) discharge flow rate (constant in time at 593,000 gpm),

c) flow rate and temperature as a function of time for the Black Creek inflow into H.B. Robinson pond,

d) flow rate exiting the pond through the dam as a function of time, and

e) meteorological data on an hour by hour basis from an on-site tower.

The meteorological data were taken at ~15 m above the pond surface and were scaled downward using a 1/7-power law to provide estimated winds at 2 m, the elevation required for measured wind data using the Ryan-Harleman treatment of surface heat transfer. The remaining data such as pond bathymetry, water level of pond, etc., were obtained from References 1-4.

The grid system chosen for the H.B. Robinson pond is given in Fig. 6-6. It is 45 cells (in x) by 25 cells (in y) by 10 cells (in z). Sample grid spacings are shown in Fig. 6-7. A variable grid was chosen in such a way that smaller grid cells could be positioned near the plant discharge and intake. Larger grid cells could be positioned in the region between the discharge and intake where temperature gradients are not expected to be very large.

The two discharges to the pond (from plant and Black Creek) were irregular in shape and were simulated as shown in Figs. 6-8 and 6-9. Flow rates and heat fluxes were conserved in the schematization.

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*Personal Communication from C. Anderson and D. Herlong at Carolina Power and Light Company, July 1983.

The actual discharge channel is trapezoidal in shape covering 27.4 m across the surface and 6.1 m wide at its bottom. The depth of the discharge was 3.7 m. Due to the grid size chosen, the discharge was simulated from a slot 160.9 m wide and 3.48 m deep. The exit velocity was adjusted in the simulation to conserve the exit flow and heat flux into the pond.

The actual plant intake encompasses three round pipes located near the bottom on the west shore of the lower impoundment. The simulated intake encompasses three cells near the bottom in the same location. The simulated intake velocity is chosen to provide equal flow rates between actual and simulated intakes.

The dam has an open weir of dimensions 3 m deep by 22.4 m wide representing a surface intake. In the Paul model, this open weir was represented by a half-cell at the surface 160.9 m wide by 0.55 m deep. The intake velocity was adjusted to assure conservation of mass flow for both model and actual dam representations.

The Black Creek discharge into the pond is simulated from a 160.9 m wide by 0.87 m deep opening. The Black Creek discharge temperature was typically about 23.3°C whereas the plant discharge temperature was generally between 39-40°C. The plant discharge/intake flow rate was about 35 m^3/s whereas the Black Creek discharge was varied from 4.8 to 6.2 m^3/s. The dam outlet flow rate varied from 4.5 to 8.3 m^3/s during the period of calculation. The Black Creek temperature was determined at each time step as a linear interpolated (in time) value between a measurement made in July and one in August. Those two measurement values were the only relevant data available on Black Creek temperatures during the period of computation.

Paul Model calculations were made for the period August 6-August 14. A weighted average between the July 14 and August 14 pond temperature measurements (appropriate to August 6) provided initial cell temperatures. The method involved a simple linear interpolation in time on a cell-by-cell basis to determine these initial temperatures for the computer run. Time steps of 12 minutes were used in the simulation based on the criterion that $\Delta t < \min(\Delta x/u)$ on a cell by cell basis. The results of the calculations for the day of August 14 (6 p.m.) are presented in Figs. 6-10 to 6-15. Fig. 6-10 provides a sketch of the predicted surface velocity field at 6 p.m. on August 14. Note the plant discharge flow directed largely towards the plant intake and dam to the south. Fig. 6-11 presents the return flow at the bottom of the pond. Figs. 6-12 and 6-13 present the surface and bottom isotherms respectively, indicating that pond vertical stratification is present. Fig. 6-14 presents cross-sectional velocity distributions in the north-south (N=24) and east-west directions (M=14). Significant eddying motions are apparent. Fig. 6-15 presents the vertical temperature profiles at transects A-E for comparison with field data in Fig. 6-4. It may be seen from the predictions that

(a) the upper impoundment is nearly fully mixed as represented by the model predictions. However, only surface isotherm data were measured for the impoundment on that day. Temperatures were measured to be about 33°C or so, but these temperatures represent only a very thin warm water layer created by wind induced spreading of the plume to the south. Beneath this thin layer, however, temperatures were several degrees cooler according to D. Herlong of Carolina Power and Light. If such vertical temperature data were available, it would be expected to indicate much better agreement with model predictions.

(b) in the middle impoundment, the predicted and observed temperature distributions are highly stratified. Model/data discrepancies are generally less than 2°C.

(c) in the lower impoundment there is observed at least a 2°C stratification between surface and bottom (Transect B). Predictions reveal similar temperatures measured and a 2.5°C stratification.

(d) the mean daily temperature at the dam intake on August 14 was 32.0°C. The predicted value is 31.1°C.

Overall, the Paul model predictions compared reasonably well with the data in a qualitative and quantitative sense. It is encouraging that the model was able to predict an unstratified flow field in the upper portion of the pond and a stratified system in the remainder of the pond, both in general agreement with the data. The results are good considering the uncertainties inherent in the data themselves.

Summary of Model Input to Paul Model for Robinson Pond Case

The key input parameters to the model are listed in Table 6-1. There were three continuation runs encompassing the run period August 6-14, 1978. These three continuation runs were needed in order to implement the change in Black Creek flow rate (through specified Black Creek discharge velocities) over time.

The pointers for the runs are given in Figs. 6-16 to 6-18. A listing of the main input file and meteorological input file is given in Tables 6-2 to 6-7 as follows:

Continuation Run No. 1: Tables 6-2 and 6-3
Continuation Run No. 2: Tables 6-4 and 6-5
Continuation Run No. 3: Tables 6-6 and 6-7.

References

1. U.S. Nuclear Regulatory Commission. Final Environmental Statement related to the operation of the H.B. Robinson Nuclear Steam-Electric Plant Unit 2 NUREG-75/024. April 1975.

2. C.W. Anderson, G.W. Bigelow, W.T. Bryson, J.J. Donaghy, D.D. Herlong, D.H. Schiller, and W.H. Tarpee. H.B. Robinson Steam Electric Plant Environmental Monitoring Program, 1979 Annual Report. Environmental Technology Section, Carolina Power & Light Company. August 1980.

3. Carolina Power & Light Company. H.B. Robinson Steam Electric Plant 316 Demonstration. Volume II. June 30, 1976.

4. Carolina Power & Light Company. H.B. Robinson Steam Electric Plant 1976-78 Environmental Monitoring Program Results. Volume II. 1979.

Table 6-1. Parameters used in Paul Model Run of H.B. Robinson Pond

b_o = maximum distance in x direction = 9865 m

h_o = reference depth = 9.14 m

u_o = reference velocity = 10 cm/s

DT = 3.6989×10^{-5}	RE = 197.31	BH = 5×10^{4}
DEL = 0.0	RO = 1946.47	BVO = 1.0
EPST= 10^{-5}	FR = 1.056×10^{-2}	BVI = 1.88×10^{-3}
EPS = 10^{-6}	RATIO = 1078.9	THV = 1.0
RA(1) = 1000.0	PR = 1.0	THP = 0.55
RA(2) = 283.0	TWX = 1.83×10^{-3}	THC = 0.5
RA(3) = -3.98	TWY = 1.83×10^{-3}	THT = 1.0
RA(4) = 503.4	PLEV = 1000.0	BET = 0.0
RA(5) = 67.3	AH = 5×10^{4}	BET1 = 1.0
RA(6) = 0.0	AVO = 1.0	
RA(7) = 0.0	AV1 = 1.88×10^{-3}	
RA(8) = 0.0		

Table 6-2. Main Input File for Continuation Run No. 1 in Paul Model Simulation, H.B. Robinson Case.

```
      20
    ROBINSON NUCLEAR POWER PLANT  -- RUN 1 - BLOCK A:  360 STEPS
       0     0    09     5
       2     2     2     2     2     2     2     2     2     2
       1    19    45    10
       1     1     0   360     0     2     1   036  1200     1   100   100     1
     100
       4     2   002     1     2     5     0   036    01     0
    .0000369890.0      .00001    .000001
    1000.0    283.0     -3.98     503.37    67.26
    197.3056  1946.4749 0.010560421.0       1078.88   .0018288  .0018288  1000.
    50000.    0.3       0.010125  50000.    0.3       0.003375  0.000155  15.0
    1.0       0.55      0.50      1.0       0.0       1.0
    1.0       1.0       900.0     914.36
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       1.20000
       1.20000   1.20000   1.20000   1.20000   0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.86667   0.76667   0.93333   0.83333   0.50000
       0.26667   0.26667   0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.86667
       0.80000   0.73333   0.86667   1.00000   0.33333   0.26667   0.30000   0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.73333   0.76667   0.76667   0.90000   1.10000
       0.40000   0.40000   0.43333   0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.66667
       0.66667   0.73333   0.90000   1.10000   0.83333   0.46667   0.56667   0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.66667   0.70000   0.73333   0.93333   1.13333
       0.96667   0.90000   0.66667   0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.70000
       0.80000   0.73333   0.93333   1.13333   0.83333   0.86667   0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.70000   0.73333   0.96667   1.00000
       0.70000   0.60000   0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.70000
       0.70000   0.73333   1.00000   0.90000   0.56667   0.46667   0.30000   0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.66667   0.66667   0.70000   0.73333   0.66667   0.73333   0.60000
       0.43333   0.33333   0.26667   0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.66667   0.66667   0.76667   0.66667
       0.56667   0.50000   0.36667   0.30000   0.40000   0.33333   0.26667   0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.80000   0.86667   0.60000   0.60000   0.50000   0.43333   0.33333   0.23333
       0.23333   0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.10000   0.10000   0.36667   0.46667
       0.60000   0.66667   0.50000   0.30000   0.26667   0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.10000   0.10000   0.26667   0.36667   0.56667   0.63333   0.43333
       0.33333   0.43333   0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.10000   0.10000
       0.20000   0.36667   0.73333   0.66667   0.56667   0.53333   0.0       0.0
       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0       0.10000   0.10000   0.26667   0.66667   0.63333
       0.60000   0.56667   0.0       0.0       0.0       0.0       0.0       0.0
```

Table 6-2. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.10000	0.16667	0.60000	0.60000	0.50000	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61.	0.0	0.0	0.0	0.0	0.10000	0.23333	0.56667	0.56667
62.	0.43333	0.43333	0.43333	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.33333
64.	0.33333	0.26667	0.53333	0.53333	0.50000	0.46667	0.43333	0.0
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.36667	0.36667	0.33333	0.30000	0.53333	0.53333
67.	0.50000	0.46667	0.43333	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.0	0.0	0.0	0.0	0.40000	0.40000	0.43333
69.	0.43333	0.40000	0.46667	0.56667	0.53333	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.40000	0.40000	0.43333	0.46667	0.46667	0.36667	0.50000	0.56667
72.	0.53333	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73.	0.0	0.0	0.0	0.43333	0.43333	0.40000	0.40000	0.43333
74.	0.46667	0.50000	0.50000	0.53333	0.50000	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.0	0.0	0.0	0.40000	0.43333
76.	0.43333	0.40000	0.40000	0.33333	0.40000	0.43333	0.33333	0.33333
77.	0.30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.33333	0.40000	0.40000	0.36667	0.33333	0.36667
79.	0.36667	0.40000	0.36667	0.30000	0.30000	0.30000	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.30000	0.33333
81.	0.33333	0.33333	0.36667	0.40000	0.36667	0.0	0.33333	0.30000
82.	0.26667	0.26667	0.0	0.0	0.0	0.0	0.0	0.0
83.	0.0	0.0	0.26667	0.30000	0.33333	0.33333	0.30000	0.33333
84.	0.33333	0.0	0.30000	0.26667	0.23333	0.26667	0.0	0.0
85.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.23333	0.26667
86.	0.33333	0.33333	0.26667	0.26667	0.30000	0.0	0.0	0.23333
87.	0.23333	0.23333	0.0	0.0	0.0	0.0	0.10000	0.10000
88.	0.26667	0.20000	0.23333	0.26667	30000	0.30000	0.30000	0.26667
89.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.10000	0.26667	0.26667	0.16667	0.20000	0.10000
91.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.26667
93.	0.13333	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
94.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.	0.0	0.10000	0.10000	0.26667	0.10000	0.10000	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97.	0.0	0.0	0.0	0.0	0.0	0.10000	0.23333	0.10000
98.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.10000	0.20000	0.10000	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.10000	0.16667	0.10000
103.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.10000	0.10000	0.16667	0.10000	0.10000	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.10000
108.	0.13333	0.10000	0.10000	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.10000	0.10000	0.13333	0.13333	0.10000	0.10000
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
113.	0.13333	0.13333	0.13333	0.10000	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
116.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

118.	0.0	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
119.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
121.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
122.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
123.	0.10000	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
124.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
126.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
127.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
128.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.02039	0.02546
131.	0.03182	0.03979	0.04974	0.06198	0.06198	0.04974	0.03979	0.03182
132.	0.02546	0.02039	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
133.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
134.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
135.	0.01631	0.01631	0.01631	0.01631	0.01631			
136.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
137.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
138.	0.01631	0.01631	0.01631					
139.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
141.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
142.	0.0	0.0	0.0	0.0	0.0	0.0	30.14285	30.14285
143.	30.14285	30.14285	0.0	0.0	0.0	0.0	0.0	0.0
144.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
145.	0.0	31.14285	31.14285	31.14285	31.37631	31.42856	31.42856	0.0
146.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
147.	0.0	0.0	0.0	0.0	32.37685	32.37849	32.37523	32.27071
148.	32.31290	32.34854	32.34854	0.0	0.0	0.0	0.0	0.0
149.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.38229
150.	32.38066	32.37468	32.26527	32.28841	32.30853	32.32187	0.0	0.0
151.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
152.	0.0	0.0	32.14285	32.14285	32.14285	32.19614	32.19804	32.24757
153.	32.03671	0.0	0.0	0.0	0.0	0.0	0.0	0.0
154.	0.0	0.0	0.0	0.0	0.0	32.69330	32.68758	32.66663
155.	32.07536	32.07645	32.08461	0.0	0.0	0.0	0.0	0.0
156.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157.	0.0	32.68758	32.66472	32.07698	32.08298	32.09386	0.0	0.0
158.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
159.	0.0	0.0	0.0	0.0	32.69330	32.66090	32.07971	32.09114
160.	32.10475	0.0	0.0	0.0	0.0	0.0	0.0	0.0
161.	0.0	0.0	0.0	0.0	0.0	0.0	32.69521	32.69521
162.	32.39235	31.80434	31.81631	32.08406	32.09822	0.0	0.0	0.0
163.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.45847
164.	33.41139	32.57143	32.57143	32.24869	32.25305	32.25740	32.52243	32.79836
165.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
166.	0.0	33.44894	33.45303	33.17821	32.57143	32.57143	32.25903	32.26556
167.	32.26665	0.0	0.0	0.0	0.0	0.0	0.0	0.0
168.	0.0	0.0	0.0	0.0	33.57143	33.57143	33.28571	33.28571
169.	33.28571	32.96841	32.92188	32.94092	0.0	0.0	0.0	0.0
170.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
171.	34.54965	34.53223	34.51590	34.21385	34.11179	32.89330	32.92378	0.0
172.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
173.	0.0	0.0	0.0	0.0	34.55292	34.54094	34.23671	34.11670
174.	32.85901	32.88568	33.14854	0.0	0.0	0.0	0.0	0.0
175.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176.	35.24896	35.47235	35.35561	34.93301	34.71803	33.87044	0.0	0.0
177.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

178.	0.0	0.0	0.0	0.0	36.08080	35.71834	35.55096	35.32376
179.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.08406
181.	35.72923	35.57137	35.34853	0.0	0.0	0.0	0.0	0.0
182.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
183.	0.0	0.0	36.05141	35.72650	35.58771	35.35561	35.37683	35.38391
184.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
185.	0.0	0.0	0.0	0.0	36.68976	36.70609	36.39806	35.63071
186.	35.35207	35.36621	35.38037	0.0	0.0	0.0	0.0	0.0
187.	0.0	0.0	0.0	0.0	0.0	0.0	36.66527	36.66527
188.	36.41574	36.06363	35.71997	35.68297	0.0	0.0	0.0	0.0
189.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190.	38.34356	37.95888	36.76895	36.42174	36.08759	35.71997	35.71344	0.0
191.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
192.	0.0	0.0	40.11618	38.83046	38.72977	37.12787	36.73956	36.04185
193.	35.68568	35.68297	0.0	0.0	0.0	0.0	0.0	0.0
194.	0.0	0.0	0.0	0.0	40.04379	40.11563	39.71344	38.71643
195.	37.77711	37.40976	36.41275	35.74609	35.72105	0.0	0.0	0.0
196.	0.0	0.0	0.0	0.0	0.0	0.0	39.58852	39.66663
197.	39.53223	38.80815	38.50121	38.43970	37.42772	36.69440	36.05576	35.75644
198.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199.	0.0	38.91968	38.70146	38.48950	38.15997	38.41574	38.41220	0.0
200.	0.0	35.77223	35.76189	35.76460	0.0	0.0	0.0	0.0
201.	0.0	0.0	0.0	0.0	37.99508	37.98364	38.47345	38.16595
202.	38.42282	38.41928	0.0	0.0	35.75916	35.77005	35.77277	0.0
203.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.72649
204.	37.70609	37.77005	38.49086	38.76139	38.75644	0.0	0.0	0.0
205.	35.77821	35.77821	0.0	0.0	0.0	0.0	0.0	36.50201
206.	36.76460	36.76323	37.04488	37.69521	37.75372	38.69058	38.76732	0.0
207.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
208.	0.0	35.50201	35.46120	36.46120	36.47343	36.75916	36.79454	0.0
209.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210.	0.0	0.0	0.0	0.0	35.48161	35.45711	35.50066	36.50201
211.	36.51018	0.0	0.0	0.0	0.0	0.0	0.0	0.0
212.	0.0	0.0	0.0	0.0	0.0	0.0	34.80814	35.48161
213.	34.76323	35.51836	0.0	0.0	0.0	0.0	0.0	0.0
214.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
215.	0.0	34.49303	34.46854	34.51126	0.0	0.0	0.0	0.0
216.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
217.	0.0	0.0	0.0	0.0	34.17711	34.17711	0.0	0.0
218.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
219.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.15616
220.	34.15616	0.0	0.0	0.0	0.0	0.0	0.0	0.0
221.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
222.	0.0	0.0	33.18663	33.17249	33.18663	0.0	0.0	0.0
223.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
224.	0.0	0.0	0.0	0.0	0.0	33.18446	33.16759	32.46527
225.	32.47943	0.0	0.0	0.0	0.0	0.0	0.0	0.0
226.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
227.	0.0	32.18446	32.16759	32.15915	32.17603	0.0	0.0	0.0
228.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
229.	0.0	0.0	0.0	0.0	0.0	32.14353	32.12894	31.44487
230.	31.46175	0.0	0.0	0.0	0.0	0.0	0.0	0.0
231.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
232.	31.15834	31.14853	31.14853	31.15834	0.0	0.0	0.0	0.0
233.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
234.	0.0	0.0	0.0	0.0	0.0	31.15181	31.15181	0.0
235.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
236.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
237.	30.15834	30.87262	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

238.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
239.	0.0	30.15834	30.15834	30.15834	30.15834	0.0	0.0	0.0
240.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
241.	0.0	0.0	0.0	0.0	30.15834	30.15834	30.15834	30.15834
242.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
243.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
244.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
245.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
246.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
247.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
248.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
249.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250.	30.14285	30.14285	0.0	0.0	0.0	0.0	30.14285	30.14285
251.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
252.	0.0	31.14285	31.14285	31.14285	31.21956	31.42856	31.42856	0.0
253.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
254.	0.0	0.0	0.0	0.0	32.22173	32.22826	32.21519	31.79718
255.	31.96591	32.10851	32.10851	0.0	0.0	0.0	0.0	0.0
256.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.24350
257.	32.23697	32.21303	31.77541	31.86795	31.94849	32.00183	0.0	0.0
258.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
259.	0.0	0.0	32.14285	32.14285	32.14285	31.49892	31.50653	31.70465
260.	31.71831	0.0	0.0	0.0	0.0	0.0	0.0	0.0
261.	0.0	0.0	0.0	0.0	0.0	32.20181	32.17894	32.09512
262.	31.87288	31.87724	31.90990	0.0	0.0	0.0	0.0	0.0
263.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
264.	0.0	32.17894	32.02751	31.87941	31.90337	31.94690	0.0	0.0
265.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
266.	0.0	0.0	0.0	0.0	32.20181	32.07227	31.89030	31.93602
267.	31.99045	0.0	0.0	0.0	0.0	0.0	0.0	0.0
268.	0.0	0.0	0.0	0.0	0.0	0.0	32.20943	32.20943
269.	31.85513	31.64595	31.69385	31.90771	31.96432	0.0	0.0	0.0
270.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.11965
271.	32.93134	32.57143	32.57143	32.13765	32.15508	32.17250	32.37547	32.62199
272.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
273.	0.0	33.03156	33.09789	32.85571	32.57143	32.57143	32.17903	32.20515
274.	32.20950	0.0	0.0	0.0	0.0	0.0	0.0	0.0
275.	0.0	0.0	0.0	0.0	33.57143	33.57143	33.28571	33.28571
276.	33.28571	32.87372	32.68756	32.76376	0.0	0.0	0.0	0.0
277.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
278.	34.48433	34.41466	34.34935	33.99832	33.59010	32.57326	32.69518	0.0
279.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
280.	0.0	0.0	0.0	0.0	34.49739	34.44949	34.08977	33.60970
281.	32.43610	32.54279	32.73706	0.0	0.0	0.0	0.0	0.0
282.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
283.	35.13875	35.17517	34.70818	33.87491	33.87222	33.48181	0.0	0.0
284.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
285.	0.0	0.0	0.0	0.0	35.89465	35.30196	34.63249	34.58081
286.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
287.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.90771
288.	35.34550	34.71413	34.67987	0.0	0.0	0.0	0.0	0.0
289.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
290.	0.0	0.0	35.77708	35.33461	34.77943	34.70818	34.79308	34.82138
291.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
292.	0.0	0.0	0.0	0.0	36.18765	36.25298	35.87799	34.95143
293.	34.69403	34.75063	34.80724	0.0	0.0	0.0	0.0	0.0
294.	0.0	0.0	0.0	0.0	0.0	0.0	36.08969	36.08969
295.	35.94876	35.39742	35.30849	35.16045	0.0	0.0	0.0	0.0
296.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
297.	38.10852	37.40697	36.50444	35.97270	35.49323	35.30849	35.28236	0.0

Table 6-2. Continued

298.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
299.	0.0	0.0	40.03616	38.75046	38.34769	37.03298	36.38687	35.31035
300.	35.17134	35.16045	0.0	0.0	0.0	0.0	0.0	0.0
301.	0.0	0.0	0.0	0.0	39.74661	40.03398	39.28236	38.29434
302.	37.53709	36.92480	35.93678	35.41299	35.31285	0.0	0.0	0.0
303.	0.0	0.0	0.0	0.0	0.0	0.0	38.78270	39.09512
304.	39.41466	38.66119	38.29057	38.04456	36.99664	36.20616	35.79451	35.45436
305.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
306.	0.0	38.25021	38.23447	38.24376	37.78278	37.94276	37.93460	0.0
307.	0.0	35.51750	35.47614	35.48701	0.0	0.0	0.0	0.0
308.	0.0	0.0	0.0	0.0	37.55501	37.50603	38.17952	37.80672
309.	37.97705	37.96291	0.0	0.0	35.46524	35.50879	35.51967	0.0
310.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.33461
311.	37.25298	37.50879	38.24921	38.47614	38.45436	0.0	0.0	0.0
312.	35.54144	35.54144	0.0	0.0	0.0	0.0	0.0	36.29382
313.	36.48701	36.48157	36.75096	37.20943	37.44348	38.19093	38.49791	0.0
314.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
315.	0.0	35.29382	35.13054	36.13054	36.17952	36.46524	36.60677	0.0
316.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
317.	0.0	0.0	0.0	0.0	35.21219	35.11421	35.28839	36.29382
318.	36.32649	0.0	0.0	0.0	0.0	0.0	0.0	0.0
319.	0.0	0.0	0.0	0.0	0.0	0.0	34.66119	35.21219
320.	34.48157	35.35915	0.0	0.0	0.0	0.0	0.0	0.0
321.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
322.	0.0	34.25790	34.15993	34.33084	0.0	0.0	0.0	0.0
323.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
324.	0.0	0.0	0.0	0.0	33.85136	33.85136	0.0	0.0
325.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
326.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.76753
327.	33.76753	0.0	0.0	0.0	0.0	0.0	0.0	0.0
328.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
329.	0.0	0.0	32.88945	32.83286	32.88945	0.0	0.0	0.0
330.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
331.	0.0	0.0	0.0	0.0	0.0	32.88075	32.81326	32.14688
332.	32.20348	0.0	0.0	0.0	0.0	0.0	0.0	0.0
333.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
334.	0.0	31.88075	31.81326	31.77951	31.84702	0.0	0.0	0.0
335.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
336.	0.0	0.0	0.0	0.0	0.0	31.73706	31.65869	31.06523
337.	31.13272	0.0	0.0	0.0	0.0	0.0	0.0	0.0
338.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
339.	30.77626	30.73706	30.73706	30.77626	0.0	0.0	0.0	0.0
340.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
341.	0.0	0.0	0.0	0.0	0.0	30.75012	30.75012	0.0
342.	0.0	0.0	0.0	0.0	0.0	0.0	0.[illegible]	0.0
343.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
344.	29.77625	30.49052	0.0	0.0	0.0	0.0	0.0	0.0
345.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
346.	0.0	29.77625	29.77625	29.77625	29.77625	0.0	0.0	0.0
347.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
348.	0.0	0.0	0.0	0.0	29.77625	29.77625	29.77625	29.77625
349.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
350.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
351.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
352.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
353.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
354.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
355.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
356.	0.0	0.0	0.0	0.0	0.0	0.0	29.90169	29.89299
357.	29.88428	29.94089	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

358.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
359.	0.0	30.63409	31.00620	30.98878	31.01054	31.42856	31.42856	0.0
360.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
361.	0.0	0.0	0.0	0.0	31.37520	31.74077	31.86084	32.15303
362.	31.75647	31.78847	31.78847	0.0	0.0	0.0	0.0	0.0
363.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.63644
364.	31.80173	31.85213	32.18787	31.79565	31.46843	31.57512	0.0	0.0
365.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
366.	0.0	0.0	31.84142	31.76305	31.48872	31.79681	31.18741	31.17268
367.	31.18593	0.0	0.0	0.0	0.0	0.0	0.0	0.0
368.	0.0	0.0	0.0	0.0	0.0	31.54649	31.50076	31.48285
369.	31.22159	30.99785	31.22644	0.0	0.0	0.0	0.0	0.0
370.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
371.	0.0	31.50076	31.47195	31.25424	31.18073	31.48552	0.0	0.0
372.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
373.	0.0	0.0	0.0	0.0	31.54649	31.45018	31.30867	31.40933
374.	31.79033	0.0	0.0	0.0	0.0	0.0	0.0	0.0
375.	0.0	0.0	0.0	0.0	0.0	0.0	31.60393	31.47733
376.	31.26244	31.70807	31.57143	31.67259	31.78580	0.0	0.0	0.0
377.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.70575
378.	32.41133	32.22696	32.37065	31.97404	32.02444	32.05928	32.17953	32.38687
379.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
380.	0.0	32.64479	32.67091	32.51314	32.46645	32.57143	32.07234	32.12459
381.	32.13330	0.0	0.0	0.0	0.0	0.0	0.0	0.0
382.	0.0	0.0	0.0	0.0	33.57143	33.57143	33.28571	33.28571
383.	33.27652	32.74744	32.37514	32.52754	0.0	0.0	0.0	0.0
384.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
385.	34.39725	34.25790	34.12727	33.70425	32.85934	32.14655	32.39038	0.0
386.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
387.	0.0	0.0	0.0	0.0	34.42337	34.32758	33.89381	32.94843
388.	31.90874	32.08557	32.18843	0.0	0.0	0.0	0.0	0.0
389.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
390.	34.99179	34.77893	33.84494	32.76553	32.87222	32.96365	0.0	0.0
391.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
392.	0.0	0.0	0.0	0.0	35.64645	34.74680	33.46913	33.59976
393.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
394.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.67259
395.	34.83388	33.59976	33.78833	0.0	0.0	0.0	0.0	0.0
396.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
397.	0.0	0.0	35.41133	34.81210	33.70425	33.84494	34.01476	34.07137
398.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
399.	0.0	0.0	0.0	0.0	35.51819	35.64882	35.18457	34.04575
400.	33.81664	33.92984	34.04306	0.0	0.0	0.0	0.0	0.0
401.	0.0	0.0	0.0	0.0	0.0	0.0	35.32224	35.32224
402.	35.32610	34.50916	34.75986	34.46376	0.0	0.0	0.0	0.0
403.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
404.	37.78848	36.67110	36.15173	35.37398	34.70074	34.75986	34.70259	0.0
405.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
406.	0.0	0.0	39.92949	38.64377	37.83823	37.02310	35.91661	34.33499
407.	34.48553	34.46376	0.0	0.0	0.0	0.0	0.0	0.0
408.	0.0	0.0	0.0	0.0	39.35037	39.92513	38.70760	37.73154
409.	37.21706	36.27818	35.30214	34.96886	34.76857	0.0	0.0	0.0
410.	0.0	0.0	0.0	0.0	0.0	0.0	37.70828	38.33313
411.	39.25790	38.46524	38.00972	37.51768	36.42189	35.55519	35.44617	35.05159
412.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
413.	0.0	37.35759	37.61180	37.91611	37.27986	37.32610	37.29779	0.0
414.	0.0	35.17787	35.09514	35.11690	0.0	0.0	0.0	0.0
415.	0.0	0.0	0.0	0.0	36.96718	36.86922	37.78764	37.32776
416.	37.38269	37.35440	0.0	0.0	35.07336	35.16045	35.18222	0.0
417.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.81210

Table 6-2. Continued

418.	36.64822	37.16045	37.92699	38.09514	38.05159	0.0	0.0	0.0
419.	35.22575	35.22575	0.0	0.0	0.0	0.0	0.0	36.01625
420.	36.11690	36.10602	36.35907	36.56174	37.02932	37.52472	38.13867	0.0
421.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
422.	0.0	35.01625	34.68967	35.68967	35.78764	36.07335	36.35638	0.0
423.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
424.	0.0	0.0	0.0	0.0	34.85297	34.65701	35.00536	36.01625
425.	36.08156	0.0	0.0	0.0	0.0	0.0	0.0	0.0
426.	0.0	0.0	0.0	0.0	0.0	0.0	34.46524	34.85297
427.	34.10602	35.14688	0.0	0.0	0.0	0.0	0.0	0.0
428.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
429.	0.0	33.94440	33.74844	34.09027	0.0	0.0	0.0	0.0
430.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
431.	0.0	0.0	0.0	0.0	33.41702	33.41702	0.0	0.0
432.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
433.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.24937
434.	33.24937	0.0	0.0	0.0	0.0	0.0	0.0	0.0
435.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
436.	0.0	0.0	32.49323	32.38000	32.49323	0.0	0.0	0.0
437.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
438.	0.0	0.0	0.0	0.0	0.0	32.47581	32.34082	31.72232
439.	31.83554	0.0	0.0	0.0	0.0	0.0	0.0	0.0
440.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
441.	0.0	31.47581	31.34082	31.27333	31.40831	0.0	0.0	0.0
442.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
443.	0.0	0.0	0.0	0.0	0.0	31.18842	31.03166	30.55904
444.	30.69403	0.0	0.0	0.0	0.0	0.0	0.0	0.0
445.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
446.	30.26680	30.18842	30.18842	30.26680	0.0	0.0	0.0	0.0
447.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
448.	0.0	0.0	0.0	0.0	0.0	30.21454	30.21454	0.0
449.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
450.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
451.	29.26680	29.98108	0.0	0.0	0.0	0.0	0.0	0.0
452.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
453.	0.0	29.26680	29.26680	29.26680	29.26680	0.0	0.0	0.0
454.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
455.	0.0	0.0	0.0	0.0	29.26680	29.26680	29.26680	29.26680
456.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
457.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
458.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
459.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
460.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
461.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
462.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
463.	0.0	0.0	0.0	0.0	0.0	0.0	29.85713	29.85713
464.	29.85713	29.85713	0.0	0.0	0.0	0.0	0.0	0.0
465.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
466.	0.0	30.06767	30.63971	30.54826	30.66257	31.30280	31.42856	0.0
467.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
468.	0.0	0.0	0.0	0.0	30.33044	31.01027	31.15952	30.70287
469.	31.84900	31.46843	31.46843	0.0	0.0	0.0	0.0	0.0
470.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.52611
471.	31.12782	31.12033	30.48079	31.35059	31.30280	31.14839	0.0	0.0
472.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
473.	0.0	0.0	31.04785	30.93030	30.78195	30.84280	30.92397	30.85713
474.	30.42174	0.0	0.0	0.0	0.0	0.0	0.0	0.0
475.	0.0	0.0	0.0	0.0	0.0	30.89117	30.83740	30.89771
476.	30.66591	30.63173	30.85713	0.0	0.0	0.0	0.0	0.0
477.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

478.	0.0	30.83740	30.87811	30.70509	30.71010	30.85713	0.0	0.0
479.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
480.	0.0	0.0	0.0	0.0	30.89116	30.83891	30.77042	30.80807
481.	31.25693	0.0	0.0	0.0	0.0	0.0	0.0	0.0
482.	0.0	0.0	0.0	0.0	0.0	0.0	31.04877	30.64458
483.	30.77208	31.57759	31.57143	31.57143	31.60727	0.0	0.0	0.0
484.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.34435
485.	32.04556	31.26901	31.48454	31.60393	32.10616	32.05391	32.00819	32.15173
486.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
487.	0.0	32.17090	32.29210	32.34116	31.62825	31.98747	31.91417	32.04404
488.	32.05710	0.0	0.0	0.0	0.0	0.0	0.0	0.0
489.	0.0	0.0	0.0	0.0	33.21121	33.15244	32.89124	32.52214
490.	32.48622	32.15562	32.06271	32.29132	0.0	0.0	0.0	0.0
491.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
492.	34.31017	34.10115	33.71565	32.84212	31.93188	31.59976	32.08557	0.0
493.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
494.	0.0	0.0	0.0	0.0	34.34935	34.20566	33.66507	32.42264
495.	31.50595	31.73456	31.79987	0.0	0.0	0.0	0.0	0.0
496.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
497.	34.84482	34.38269	33.03806	32.14832	32.30833	32.44550	0.0	0.0
498.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
499.	0.0	0.0	0.0	0.0	35.39827	34.02576	32.48941	32.68535
500.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
501.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.43745
502.	34.24782	32.68535	32.95967	0.0	0.0	0.0	0.0	0.0
503.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
504.	0.0	0.0	35.04556	34.19231	32.84212	33.03806	33.27319	33.35158
505.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
506.	0.0	0.0	0.0	0.0	34.84871	35.04466	34.47400	33.40465
507.	33.29695	33.38840	33.47983	0.0	0.0	0.0	0.0	0.0
508.	0.0	0.0	0.0	0.0	0.0	0.0	34.56543	34.56543
509.	34.70239	33.78674	33.83391	33.63478	0.0	0.0	0.0	0.0
510.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
511.	37.27965	35.77347	35.56461	34.67313	33.98915	33.83391	33.69676	0.0
512.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
513.	0.0	0.0	39.42805	38.29681	37.05917	36.52214	35.44633	33.99998
514.	33.67397	33.63478	0.0	0.0	0.0	0.0	0.0	0.0
515.	0.0	0.0	0.0	0.0	38.63060	39.44856	38.16063	37.22191
516.	36.86269	35.66507	34.69774	34.42995	34.18341	0.0	0.0	0.0
517.	0.0	0.0	0.0	0.0	0.0	0.0	36.69765	37.63242
518.	38.94829	38.25290	37.72887	36.99414	35.93050	34.96317	35.09782	34.64882
519.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
520.	0.0	36.46495	36.99081	37.58844	36.77693	36.71428	36.70607	0.0
521.	0.0	34.83823	34.71413	34.74680	0.0	0.0	0.0	0.0
522.	0.0	0.0	0.0	0.0	36.37935	36.23261	37.39575	36.84879
523.	36.78833	36.74588	0.0	0.0	34.68147	34.81210	34.84476	0.0
524.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.28958
525.	36.04466	36.81210	37.60477	37.71413	37.64882	0.0	0.0	0.0
526.	34.91008	34.91008	0.0	0.0	0.0	0.0	0.0	35.73866
527.	35.74680	35.73045	35.96719	35.91403	36.61617	36.85851	37.77945	0.0
528.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
529.	0.0	34.73866	34.24879	35.24879	35.39575	35.68147	36.10602	0.0
530.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
531.	0.0	0.0	0.0	0.0	34.49373	34.19981	34.72234	35.73866
532.	35.83662	0.0	0.0	0.0	0.0	0.0	0.0	0.0
533.	0.0	0.0	0.0	0.0	0.0	0.0	34.26930	34.49373
534.	33.73045	34.93460	0.0	0.0	0.0	0.0	0.0	0.0
535.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
536.	0.0	33.63089	33.33698	33.84969	0.0	0.0	0.0	0.0
537.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

538.	0.0	0.0	0.0	0.0	32.98268	32.98268	0.0	0.0
539.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
540.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.73122
541.	32.73122	0.0	0.0	0.0	0.0	0.0	0.0	0.0
542.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
543.	0.0	0.0	32.09698	31.92717	32.09698	0.0	0.0	0.0
544.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
545.	0.0	0.0	0.0	0.0	0.0	32.07085	31.86838	31.29778
546.	31.46761	0.0	0.0	0.0	0.0	0.0	0.0	0.0
547.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
548.	0.0	31.07085	30.86838	30.76714	30.96962	0.0	0.0	0.0
549.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
550.	0.0	0.0	0.0	0.0	0.0	30.63979	30.40465	30.05286
551.	30.25534	0.0	0.0	0.0	0.0	0.0	0.0	0.0
552.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
553.	29.75735	29.63979	29.63979	29.75735	0.0	0.0	0.0	0.0
554.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
555.	0.0	0.0	0.0	0.0	0.0	29.67897	29.67897	0.0
556.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
557.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
558.	28.75735	29.47163	0.0	0.0	0.0	0.0	0.0	0.0
559.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560.	0.0	28.75735	28.75735	28.75735	28.75735	0.0	0.0	0.0
561.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
562.	0.0	0.0	0.0	0.0	28.75735	28.75735	28.75735	28.75735
563.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
564.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
565.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
566.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
567.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
568.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
569.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
570.	0.0	0.0	0.0	0.0	0.0	0.0	29.85713	29.85713
571.	29.85713	29.85713	0.0	0.0	0.0	0.0	0.0	0.0
572.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
573.	0.0	29.85713	29.90057	29.85713	29.93105	31.16563	31.39223	0.0
574.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
575.	0.0	0.0	0.0	0.0	29.91679	30.10892	29.87935	29.85713
576.	31.01312	31.34851	31.14839	0.0	0.0	0.0	0.0	0.0
577.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.09096
578.	30.26567	29.85713	29.85713	30.34888	31.16563	30.72168	0.0	0.0
579.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
580.	0.0	0.0	30.58920	30.51953	30.55891	30.05815	30.16905	30.85713
581.	30.52028	0.0	0.0	0.0	0.0	0.0	0.0	0.0
582.	0.0	0.0	0.0	0.0	0.0	30.50212	30.44986	30.25142
583.	29.79190	30.05815	30.59576	0.0	0.0	0.0	0.0	0.0
584.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
585.	0.0	30.44986	30.22964	29.88335	30.31943	30.85713	0.0	0.0
586.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
587.	0.0	0.0	0.0	0.0	30.50212	30.18610	30.03574	30.60124
588.	30.85713	0.0	0.0	0.0	0.0	0.0	0.0	0.0
589.	0.0	0.0	0.0	0.0	0.0	0.0	30.57799	30.40262
590.	30.36278	30.62727	31.28542	31.57143	31.57143	0.0	0.0	0.0
591.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.22603
592.	31.03944	30.68684	30.81747	31.21306	32.23679	32.16711	32.10616	32.02779
593.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
594.	0.0	30.79930	30.98218	31.46986	30.90456	31.26901	31.64748	31.99993
595.	31.99998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
596.	0.0	0.0	0.0	0.0	32.66258	32.58418	32.42642	31.74382
597.	31.69759	31.39796	31.82166	32.05510	0.0	0.0	0.0	0.0

Table 6-2. Continued

598.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
599.	34.22307	33.83322	33.04945	31.97997	31.12161	30.99016	31.68684	0.0
600.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
601.	0.0	0.0	0.0	0.0	34.27533	34.08374	33.07724	31.82321
602.	31.03018	31.40799	31.49507	0.0	0.0	0.0	0.0	0.0
603.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
604.	34.69788	33.98645	32.24123	31.33017	31.63496	31.89622	0.0	0.0
605.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
606.	0.0	0.0	0.0	0.0	35.15007	33.08197	31.59142	31.80914
607.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
608.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.20232
609.	33.37805	31.80914	32.13672	0.0	0.0	0.0	0.0	0.0
610.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
611.	0.0	0.0	34.67981	33.30403	31.98331	32.24123	32.55473	32.65924
612.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
613.	0.0	0.0	0.0	0.0	34.21492	34.45876	33.72723	32.77763
614.	32.82451	32.94643	33.06836	0.0	0.0	0.0	0.0	0.0
615.	0.0	0.0	0.0	0.0	0.0	0.0	33.84915	33.84915
616.	34.03203	33.28708	32.87379	32.79875	0.0	0.0	0.0	0.0
617.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
618.	36.37286	34.69795	34.80043	33.80228	33.36649	32.87379	32.68591	0.0
619.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
620.	0.0	0.0	38.09456	37.44337	35.98367	35.74382	34.97609	33.99998
621.	32.85100	32.79875	0.0	0.0	0.0	0.0	0.0	0.0
622.	0.0	0.0	0.0	0.0	37.55510	38.35999	37.69035	36.91493
623.	36.43596	35.07726	34.12079	33.76373	33.53027	0.0	0.0	0.0
624.	0.0	0.0	0.0	0.0	0.0	0.0	35.93021	37.03371
625.	38.21677	37.86101	37.35925	36.65886	35.66925	34.71278	34.62422	34.24605
626.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
627.	0.0	35.75067	36.46394	37.39391	36.87437	36.71428	36.60811	0.0
628.	0.0	34.44467	34.33313	34.37668	0.0	0.0	0.0	0.0
629.	0.0	0.0	0.0	0.0	35.79152	35.78432	36.87862	36.65164
630.	36.55418	36.53676	0.0	0.0	34.31738	34.46376	34.50731	0.0
631.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.76707
632.	35.47701	36.30719	37.22780	37.39040	37.35556	0.0	0.0	0.0
633.	34.59439	34.59439	0.0	0.0	0.0	0.0	0.0	35.46106
634.	35.37668	35.35490	35.57530	35.27586	36.06686	36.37297	37.42522	0.0
635.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
636.	0.0	34.46106	33.80792	34.80792	35.00383	35.28958	35.85565	0.0
637.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
638.	0.0	0.0	0.0	0.0	34.13451	33.74261	34.43930	35.46106
639.	35.59171	0.0	0.0	0.0	0.0	0.0	0.0	0.0
640.	0.0	0.0	0.0	0.0	0.0	0.0	34.07335	34.13451
641.	33.35490	34.72234	0.0	0.0	0.0	0.0	0.0	0.0
642.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
643.	0.0	33.31737	32.92549	33.60912	0.0	0.0	0.0	0.0
644.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
645.	0.0	0.0	0.0	0.0	32.54834	32.54834	0.0	0.0
646.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
647.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.21306
648.	32.21306	0.0	0.0	0.0	0.0	0.0	0.0	0.0
649.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
650.	0.0	0.0	31.70074	31.47432	31.70074	0.0	0.0	0.0
651.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
652.	0.0	0.0	0.0	0.0	0.0	31.66589	31.39594	30.87323
653.	31.09967	0.0	0.0	0.0	0.0	0.0	0.0	0.0
654.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
655.	0.0	30.66589	30.39594	30.26096	30.53093	0.0	0.0	0.0
656.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
657.	0.0	0.0	0.0	0.0	0.0	30.09114	29.77763	29.54666

Table 6-2. Continued

658.	29.81664	0.0	0.0	0.0	0.0	0.0	0.0	0.0
659.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
660.	29.24789	29.09114	29.09114	29.24789	0.0	0.0	0.0	0.0
661.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
662.	0.0	0.0	0.0	0.0	0.0	29.14340	29.14340	0.0
663.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
664.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
665.	28.24789	28.96219	0.0	0.0	0.0	0.0	0.0	0.0
666.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
667.	0.0	28.24789	28.24789	28.24789	28.24789	0.0	0.0	0.0
668.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
669.	0.0	0.0	0.0	0.0	28.24789	28.24789	28.24789	28.24789
670.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
671.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
672.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
673.	0.0.	0.0	0.0	0.0	0.0	0.0	0.0	
674.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
675.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
676.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
677.	0.0	0.0	0.0	0.0	0.0	0.0	29.68282	29.66106
678.	29.85713	29.85713	0.0	0.0	0.0	0.0	0.0	0.0
679.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
680.	0.0	29.85713	29.85713	29.85713	29.85713	30.85692	31.13315	0.0
681.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
682.	0.0	0.0	0.0	0.0	29.85713	29.85713	29.85713	29.85713
683.	30.29228	31.25708	30.82835	0.0	0.0	0.0	0.0	0.0
684.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.85713
685.	29.85713	29.85713	29.85713	29.90039	30.85692	30.42856	0.0	0.0
686.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
687.	0.0	0.0	30.24879	30.18349	30.02007	29.85713	29.85713	30.41463
688.	31.11464	0.0	0.0	0.0	0.0	0.0	0.0	0.0
689.	0.0	0.0	0.0	0.0	0.0	30.08813	30.00648	29.70714
690.	29.57143	29.67194	29.83522	0.0	0.0	0.0	0.0	0.0
691.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
692.	0.0	30.00648	29.67992	29.57143	29.80257	30.42813	0.0	0.0
693.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
694.	0.0	0.0	0.0	0.0	30.08812	29.62549	29.57143	30.12892
695.	30.85713	0.0	0.0	0.0	0.0	0.0	0.0	0.0
696.	0.0	0.0	0.0	0.0	0.0	0.0	30.11534	30.11534
697.	29.87042	29.87572	30.71393	31.53041	31.57143	0.0	0.0	0.0
698.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.16977
699.	30.14256	30.25142	30.41470	30.69490	31.79541	32.28033	32.20413	32.10616
700.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
701.	0.0	29.97928	30.06093	30.27863	30.52356	30.79570	31.38077	31.99998
702.	31.99998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
703.	0.0	0.0	0.0	0.0	32.01851	31.86610	31.63751	31.03355
704.	30.97913	30.85013	31.59850	31.87064	0.0	0.0	0.0	0.0
705.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
706.	34.13599	33.36295	32.38326	31.11781	30.58060	30.43782	31.25142	0.0
707.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
708.	0.0	0.0	0.0	0.0	34.20131	33.88547	32.48941	30.92188
709.	30.46631	30.79541	31.05667	0.0	0.0	0.0	0.0	0.0
710.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
711.	34.55092	33.61825	31.53700	30.48532	30.82942	31.15599	0.0	0.0
712.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
713.	0.0	0.0	0.0	0.0	34.90187	32.13818	30.77499	31.04713
714.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
715.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.96719
716.	32.50829	31.04713	31.42813	0.0	0.0	0.0	0.0	0.0
717.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

718.	0.0	0.0	34.28542	32.41576	31.26485	31.53700	31.86356	31.97241
719.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
720.	0.0	0.0	0.0	0.0	33.59007	33.89488	32.98047	31.64960
721.	31,83464	32.26471	32.59126	0.0	0.0	0.0	0.0	0.0
722.	0.0	0.0	0.0	0.0	0.0	0.0	33.13287	33.13287
723.	33.36148	32.78743	31.74213	31.64960	0.0	0.0	0.0	0.0
724.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
725.	35.46608	33.62245	33.90504	32.93143	32.74382	31.74213	31.46454	0.0
726.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
727.	0.0	0.0	36.76106	36.58994	34.90816	34.61076	34.28442	33.50377
728.	31.74213	31.64960	0.0	0.0	0.0	0.0	0.0	0.0
729.	0.0	0.0	0.0	0.0	36.47958	37.27142	37.22009	36.60796
730.	36.00925	34.28442	33.49423	33.09753	32.87714	0.0	0.0	0.0
731.	0.0	0.0	0.0	0.0	0.0	0.0	35.16277	36.43500
732.	37.48524	37.46913	36.98479	36.32358	35.40799	34.46242	34.10170	33.84328
733.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
734.	0.0	35.08121	35.93707	37.20668	37.05725	36.71428	36.51013	0.0
735.	0.0	34.02013	33.95213	34.00656	0.0	0.0	0.0	0.0
736.	0.0	0.0	0.0	0.0	35.20369	35.44467	36.31256	36.56456
737.	36.37131	36.34953	0.0	0.0	34.00388	34.11542	34.16985	0.0
738.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.08798
739.	34.95341	35.74113	36.78474	37.23799	37.19444	0.0	0.0	0.0
740.	34.27870	34.27870	0.0	0.0	0.0	0.0	0.0	35.18349
741.	35.00656	34.97934	34.95871	34.66628	35.40501	36.21622	37.28154	0.0
742.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
743.	0.0	34.18349	33.32196	34.31375	34.61198	34.89769	35.60527	0.0
744.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
745.	0.0	0.0	0.0	0.0	33.77527	33.18045	34.15627	35.18349
746.	35.34677	0.0	0.0	0.0	0.0	0.0	0.0	0.0
747.	0.0	0.0	0.0	0.0	0.0	0.0	33.87741	33.77527
748.	32.97934	34.51006	0.0	0.0	0.0	0.0	0.0	0.0
749.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750.	0.0	33.00388	32.51401	33.36855	0.0	0.0	0.0	0.0
751.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
752.	0.0	0.0	0.0	0.0	32.11400	32.11400	0.0	0.0
753.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
754.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.69490
755.	31.69490	0.0	0.0	0.0	0.0	0.0	0.0	0.0
756.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
757	0.0	0.0	31.30450	31.02147	31.30450	0.0	0.0	0.0
758.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
759.	0.0	0.0	0.0	0.0	0.0	31.26096	30.92349	30.44870
760	30.73174	0.0	0.0	0.0	0.0	0.0	0.0	0.0
761	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
762.	0.0	30.26096	29.92349	29.75478	30.09224	0.0	0.0	0.0
763.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
764.	0.0	0.0	0.0	0.0	0.0	29.54250	29.15060	29.04050
765.	29.37794	0.0	0.0	0.0	0.0	0.0	0.0	0.0
766.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
767.	28.73845	28.54250	28.54250	28.73845	0.0	0.0	0.0	0.0
768.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
769.	0.0	0.0	0.0	0.0	0.0	28.60780	28.60780	0.0
770.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
771.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
772.	27.73845	28.45273	0.0	0.0	0.0	0.0	0.0	0.0
773.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
774.	0.0	27.73845	27.73845	27.73845	27.73845	0.0	0.0	0.0
775.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
776.	0.0	0.0	0.0	0.0	27.73845	27.73845	27.73845	27.73845
777.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

778.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
779.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
780.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
781.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
782.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
783.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
784.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143
785.	29.65285	29.82266	0.0	0.0	0.0	0.0	0.0	0.0
786.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
787.	0.0	29.70677	29.73289	29.85713	29.85713	30.51402	30.87407	0.0
788.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
789.	0.0	0.0	0.0	0.0	29.75902	29.79820	29.85713	29.77042
790.	29.92216	31.16563	30.50832	0.0	0.0	0.0	0.0	0.0
791.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.85713
792.	29.85046	29.85713	29.71815	29.85713	30.51401	30.42856	0.0	0.0
793.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
794.	0.0	0.0	29.98428	29.90590	29.85713	29.69203	29.70509	30.14285
795.	30.57669	0.0	0.0	0.0	0.0	0.0	0.0	0.0
796.	0.0	0.0	0.0	0.0	0.0	29.62006	29.57143	29.57143
797.	29.57143	29.57143	29.60226	0.0	0.0	0.0	0.0	0.0
798.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
799.	0.0	29.57143	29.57143	29.57143	29.57143	29.82433	0.0	0.0
800.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
801.	0.0	0.0	0.0	0.0	29.62004	29.57143	29.57143	29.75902
802.	30.65672	0.0	0.0	0.0	0.0	0.0	0.0	0.0
803.	0.0	0.0	0.0	0.0	0.0	0.0	29.65271	29.65271
804.	29.57143	29.57143	30.26498	31.23650	31.57143	0.0	0.0	0.0
805.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.71802
806.	29.68536	29.81598	30.01193	30.20787	31.01164	31.63866	32.20370	32.18454
807.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
808.	0.0	29.57143	29.58739	29.84865	30.14256	30.46913	31.04543	31.99998
809.	31.99993	0.0	0.0	0.0	0.0	0.0	0.0	0.0
810.	0.0	0.0	0.0	0.0	31.16507	30.98218	30.70787	30.32599
811.	30.27319	30.53444	31.37534	31.70190	0.0	0.0	0.0	0.0
812.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
813.	34.04890	32.89270	31.62227	30.27319	30.10991	30.01111	30.81599	0.0
814.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
815.	0.0	0.0	0.0	0.0	34.12727	33.51971	31.90158	30.17522
816.	30.01193	30.01164	30.32516	0.0	0.0	0.0	0.0	0.0
817.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
818.	34.40396	33.31406	30.87297	29.86810	30.18814	30.46246	0.0	0.0
819.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
820.	0.0	0.0	0.0	0.0	34.65369	31.52611	30.14243	30.37102
821.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
822.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.73206
823.	31.78735	30.37102	30.74232	0.0	0.0	0.0	0.0	0.0
824.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
825.	0.0	0.0	33.82822	31.72205	30.55391	30.87297	31.26485	31.39548
826.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
827.	0.0	0.0	0.0	0.0	32.96524	33.33099	32.13074	30.46523
828.	30.68729	31.31766	31.70953	0.0	0.0	0.0	0.0	0.0
829.	0.0	0.0	0.0	0.0	0.0	0.0	32.31029	32.31029
830.	32.68257	31.81389	30.57625	30.46523	0.0	0.0	0.0	0.0
831.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
832.	33.80414	32.33125	32.20033	31.93799	31.68979	30.57625	30.23816	0.0
833.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
834.	0.0	0.0	34.60374	34.67239	32.86211	32.27579	32.22702	31.91881
835.	30.57625	30.46523	0.0	0.0	0.0	0.0	0.0	0.0
836.	0.0	0.0	0.0	0.0	33.84041	34.58942	35.36012	35.25912
837.	34.17517	32.22702	31.87880	31.86267	32.01970	0.0	0.0	0.0

Table 6-2. Continued

838.	0.0	0.0	0.0	0.0	0.0	0.0	33.84251	34.16113
839.	35.47519	36.65086	36.61032	35.91656	34.03496	33.79958	33.57919	33.44051
840.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
841.	0.0	34.41173	35.34013	37.01944	37.24013	36.61084	35.95297	0.0
842.	0.0	33.59560	33.57112	33.63644	0.0	0.0	0.0	0.0
843.	0.0	0.0	0.0	0.0	34.61538	35.10504	35.74651	36.47748
844.	36.18843	36.16229	0.0	0.0	33.69037	33.76707	33.83240	0.0
845.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.39130
846.	34.42979	35.17503	36.34169	37.08559	37.03334	0.0	0.0	0.0
847.	33.96301	33.96301	0.0	0.0	0.0	0.0	0.0	34.90590
848.	34.63644	34.54486	34.20758	34.05667	34.74316	36.05946	37.13785	0.0
849.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
850.	0.0	33.90590	32.55779	33.49080	34.13672	34.39464	35.27388	0.0
851.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
852.	0.0	0.0	0.0	0.0	33.40688	32.38797	33.87323	34.90590
853.	35.10184	0.0	0.0	0.0	0.0	0.0	0.0	0.0
854.	0.0	0.0	0.0	0.0	0.0	0.0	33.68147	33.40688
855.	32.55960	34.29779	0.0	0.0	0.0	0.0	0.0	0.0
856.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
857.	0.0	32.69037	32.10254	33.12796	0.0	0.0	0.0	0.0
858.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
859.	0.0	0.0	0.0	0.0	31.67966	31.67966	0.0	0.0
860.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
861.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.17674
862.	31.17674	0.0	0.0	0.0	0.0	0.0	0.0	0.0
863.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
864.	0.0	0.0	30.90826	30.56862	30.90826	0.0	0.0	0.0
865.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
866.	0.0	0.0	0.0	0.0	0.0	30.85600	30.45107	30.02415
867.	30.36380	0.0	0.0	0.0	0.0	0.0	0.0	0.0
868.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
869.	0.0	29.85600	29.45107	29.24860	29.65353	0.0	0.0	0.0
870.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
871.	0.0	0.0	0.0	0.0	0.0	28.39387	28.52359	28.53430
872.	28.93925	0.0	0.0	0.0	0.0	0.0	0.0	0.0
873.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
874.	28.22899	27.99387	27.99387	28.22899	0.0	0.0	0.0	0.0
875.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
876.	0.0	0.0	0.0	0.0	0.0	28.07224	28.07224	0.0
877.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
878.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
879.	27.22899	27.94328	0.0	0.0	0.0	0.0	0.0	0.0
880.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
881.	0.0	27.22899	27.22899	27.22899	27.22899	0.0	0.0	0.0
882.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
883.	0.0	0.0	0.0	0.0	27.22899	27.22899	27.22899	27.22899
884.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
885.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
886.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
887.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
888.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
889.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
890.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
891.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143
892.	29.57143	29.57883	0.0	0.0	0.0	0.0	0.0	0.0
893.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
894.	0.0	29.57143	29.57143	29.74646	29.82266	30.22261	30.61499	0.0
895.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
896.	0.0	0.0	0.0	0.0	29.57143	29.59792	29.79219	29.57143
897.	29.85713	30.97122	30.42856	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

898.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.70459
899.	29.65887	29.77695	29.57143	29.71599	30.32558	30.42856	0.0	0.0
900.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
901.	0.0	0.0	29.76555	29.70459	29.77695	29.57143	29.57143	30.10439
902.	30.14285	0.0	0.0	0.0	0.0	0.0	0.0	0.0
903.	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143	29.57143
904.	29.57143	29.57143	29.57143	0.0	0.0	0.0	0.0	0.0
905.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
906.	0.0	29.57143	29.57143	29.57143	29.57143	29.62839	0.0	0.0
907.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
908.	0.0	0.0	0.0	0.0	29.57143	29.57143	29.57143	29.57143
909.	30.12332	0.0	0.0	0.0	0.0	0.0	0.0	0.0
910.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143
911.	29.57143	29.57143	29.85699	30.94260	31.43788	0.0	0.0	0.0
912.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
913.	29.57143	29.57143	29.60916	29.83777	30.37102	30.95940	31.71385	32.26291
914.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
915.	0.0	29.57143	29.57143	29.57143	29.76155	30.14256	30.67204	31.99998
916.	31.99998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
917.	0.0	0.0	0.0	0.0	30.31163	30.21877	30.10446	29.95206
918.	29.91396	30.21877	31.09875	31.53317	0.0	0.0	0.0	0.0
919.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
920.	33.88547	32.42244	30.84503	29.91396	29.72346	29.58438	30.43782	0.0
921.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
922.	0.0	0.0	0.0	0.0	34.05325	33.15395	31.31377	29.79965
923.	29.60916	29.57143	29.59364	0.0	0.0	0.0	0.0	0.0
924.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
925.	34.25700	33.00925	30.31769	29.11351	29.62427	29.94431	0.0	0.0
926.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
927.	0.0	0.0	0.0	0.0	34.39972	30.97093	29.57036	29.83762
928.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
929.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.49693
930.	31.27573	29.83762	30.21100	0.0	0.0	0.0	0.0	0.0
931.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
932.	0.0	0.0	33.37102	31.19954	30.05098	30.24518	30.66614	30.81854
933.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
934.	0.0	0.0	0.0	0.0	32.20686	32.76712	31.22395	29.57640
935.	29.67154	30.35721	30.82779	0.0	0.0	0.0	0.0	0.0
936.	0.0	0.0	0.0	0.0	0.0	0.0	31.33820	31.33820
937.	31.77252	30.75908	29.30743	29.16264	0.0	0.0	0.0	0.0
938.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
939.	31.72389	31.02933	30.49564	30.90384	30.61429	29.04997	28.87309	0.0
940.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
941.	0.0	0.0	31.99010	32.16542	30.76768	29.94080	30.16962	30.33385
942.	29.04997	28.86711	0.0	0.0	0.0	0.0	0.0	0.0
943.	0.0	0.0	0.0	0.0	31.12334	31.37814	32.27730	32.44518
944.	31.56152	30.16962	30.26337	30.53026	31.09441	0.0	0.0	0.0
945.	0.0	0.0	0.0	0.0	0.0	0.0	31.74484	31.33056
946.	32.34010	33.71173	34.22247	33.52171	31.68364	32.14713	32.78949	33.03773
947.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
948.	0.0	33.02121	32.80159	34.31568	35.02022	33.64122	33.11182	0.0
949.	0.0	32.98761	33.19012	33.26633	0.0	0.0	0.0	0.0
950.	0.0	0.0	0.0	0.0	34.02805	34.23801	34.32161	35.28345
951.	34.15196	33.79390	0.0	0.0	33.37685	33.41873	33.49493	0.0
952.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.69463
953.	33.90619	33.82652	35.89865	36.93318	36.87224	0.0	0.0	0.0
954.	33.64734	33.64734	0.0	0.0	0.0	0.0	0.0	34.62831
955.	34.20908	33.96901	33.45648	33.44707	33.94290	35.90271	36.99416	0.0
956.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
957.	0.0	33.62831	31.79361	32.66785	33.58807	33.79375	34.74809	0.0

Table 6-2. Continued

958.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
959.	0.0	0.0	0.0	0.0	32.78421	31.59549	33.49478	34.62831
960.	34.85692	0.0	0.0	0.0	0.0	0.0	0.0	0.0
961.	0.0	0.0	0.0	0.0	0.0	0.0	33.48552	32.78421
962.	32.03381	34.08553	0.0	0.0	0.0	0.0	0.0	0.0
963.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
964.	0.0	32.37686	31.72539	32.88739	0.0	0.0	0.0	0.0
965.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
966.	0.0	0.0	0.0	0.0	31.25494	31.25494	0.0	0.0
967.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
968.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.65858
969.	30.65858	0.0	0.0	0.0	0.0	0.0	0.0	0.0
970.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
971.	0.0	0.0	30.51202	30.11578	30.51202	0.0	0.0	0.0
972.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
973.	0.0	0.0	0.0	0.0	0.0	30.45107	29.97862	29.59961
974.	29.99586	0.0	0.0	0.0	0.0	0.0	0.0	0.0
975.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
976.	0.0	29.45107	28.97862	28.74240	29.21484	0.0	0.0	0.0
977.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
978.	0.0	0.0	0.0	0.0	0.0	28.44522	27.89659	28.02812
979.	28.50056	0.0	0.0	0.0	0.0	0.0	0.0	0.0
980.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
981.	27.71954	27.44522	27.44522	27.71954	0.0	0.0	0.0	0.0
982.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
983.	0.0	0.0	0.0	0.0	0.0	27.53667	27.53667	0.0
984.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
985.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
986.	26.71954	27.43382	0.0	0.0	0.0	0.0	0.0	0.0
987.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
988.	0.0	26.71954	26.71954	26.71954	26.71954	0.0	0.0	0.0
989.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
990.	0.0	0.0	0.0	0.0	26.71954	26.71954	26.71954	26.71954
991.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
992.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
993.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
994.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
995.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
996.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
997.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
998.	0.0	0.0	0.0	0.0	0.0	0.0	29.30273	29.21565
999.	29.12857	29.57143	0.0	0.0	0.0	0.0	0.0	0.0
1000.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1001.	0.0	29.57143	29.57143	29.57143	29.61366	29.94829	30.42856	0.0
1002.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1003.	0.0	0.0	0.0	0.0	29.57143	29.57143	29.57883	29.52045
1004.	29.80525	30.74261	30.42856	0.0	0.0	0.0	0.0	0.0
1005.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
1006.	29.57143	29.57143	29.34628	29.57143	30.18843	30.31035	0.0	0.0
1007.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1008.	0.0	0.0	29.58920	29.57143	29.56142	29.25919	29.30273	29.69073
1009.	30.14285	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1010.	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143	29.54399
1011.	29.17210	29.25919	29.19804	0.0	0.0	0.0	0.0	0.0
1012.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1013.	0.0	29.57143	29.52658	29.30273	29.57143	29.57143	0.0	0.0
1014.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1015.	0.0	0.0	0.0	0.0	29.57143	29.49174	29.52045	29.57143
1016.	29.78079	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1017.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143

Table 6-2. Continued

1018.	29.57143	29.57143	29.69371	30.56529	31.21474	0.0	0.0	0.0
1019.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
1020.	29.57143	29.57143	29.57143	29.57143	29.91382	30.40150	31.22398	32.00777
1021.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1022.	0.0	29.57143	29.57143	29.57143	29.57143	29.81598	30.29866	31.56195
1023.	31.77097	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1024.	0.0	0.0	0.0	0.0	29.99016	29.90308	29.77245	29.59828
1025.	29.57143	29.90303	30.78635	31.36444	0.0	0.0	0.0	0.0
1026.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1027.	33.62422	31.89659	30.20787	29.57143	29.57143	29.57143	30.13303	0.0
1028.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1029.	0.0	0.0	0.0	0.0	33.93771	32.78319	30.72592	29.42410
1030.	29.20639	29.57143	29.57143	0.0	0.0	0.0	0.0	0.0
1031.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1032.	34.11003	32.70445	29.85286	28.23177	28.84137	29.36388	0.0	0.0
1033.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1034.	0.0	0.0	0.0	0.0	34.08948	30.46246	28.34572	28.99886
1035.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1036.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.22011
1037.	30.76410	28.99886	29.73094	0.0	0.0	0.0	0.0	0.0
1038.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1039.	0.0	0.0	32.91382	30.67702	29.52138	29.64755	30.11783	30.27457
1040.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1041.	0.0	0.0	0.0	0.0	31.35887	32.09373	30.31718	28.74039
1042.	28.72667	29.34700	29.90436	0.0	0.0	0.0	0.0	0.0
1043.	0.0	0.0	0.0	0.0	0.0	0.0	30.36610	30.36610
1044.	30.86247	29.76651	28.00441	27.83894	0.0	0.0	0.0	0.0
1045.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1046.	29.64363	29.92160	29.37462	29.89714	29.63588	27.40407	27.55139	0.0
1047.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1048.	0.0	0.0	29.37643	29.63845	29.20731	28.81543	29.15451	28.86711
1049.	27.40407	27.19507	0.0	0.0	0.0	0.0	0.0	0.0
1050.	0.0	0.0	0.0	0.0	29.20731	28.50284	29.19446	29.63123
1051.	28.94786	28.94604	29.07669	29.27568	30.12112	0.0	0.0	0.0
1052.	0.0	0.0	0.0	0.0	0.0	0.0	29.64717	28.78856
1053.	29.20503	30.77258	31.60120	31.12686	29.33234	30.49467	31.65738	32.30644
1054.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1055.	0.0	31.14670	30.26305	31.31973	32.00270	30.67160	30.27065	0.0
1056.	0.0	31.88379	32.63736	32.80283	0.0	0.0	0.0	0.0
1057.	0.0	0.0	0.0	0.0	32.55031	31.94548	31.79614	32.67088
1058.	31.50021	31.17262	0.0	0.0	32.56306	33.07039	33.15747	0.0
1059.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.99794
1060.	31.95900	31.47522	33.63048	35.55933	34.44797	0.0	0.0	0.0
1061.	33.33163	33.33163	0.0	0.0	0.0	0.0	0.0	34.28328
1062.	33.70833	33.39316	32.70535	32.26582	31.79189	34.21729	36.74704	0.0
1063.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1064.	0.0	33.29366	31.02945	31.84489	33.03944	33.19287	34.22232	0.0
1065.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1066.	0.0	0.0	0.0	0.0	32.16154	30.80301	32.99405	34.29366
1067.	34.61198	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1068.	0.0	0.0	0.0	0.0	0.0	0.0	33.28958	32.16154
1069.	31.50804	33.87325	0.0	0.0	0.0	0.0	0.0	0.0
1070.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1071.	0.0	32.06334	31.35962	32.60532	0.0	0.0	0.0	0.0
1072.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1073.	0.0	0.0	0.0	0.0	30.92401	30.92401	0.0	0.0
1074.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1075.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.21306
1076.	30.21306	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1077.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

1078.	0.0	0.0	30.11578	29.66293	30.11578	0.0	0.0	0.0
1079.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1080.	0.0	0.0	0.0	0.0	0.0	30.04611	29.50620	29.17506
1081.	29.62791	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1082.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1083.	0.0	29.04611	28.50620	28.23621	28.77615	0.0	0.0	0.0
1084.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1085.	0.0	0.0	0.0	0.0	0.0	27.89659	27.26956	27.52193
1086.	28.06186	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1087.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1088.	27.21010	26.89659	26.89659	27.21010	0.0	0.0	0.0	0.0
1089.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1090.	0.0	0.0	0.0	0.0	0.0	27.00108	27.00108	0.0
1091.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1092.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1093.	26.21010	26.92438	0.0	0.0	0.0	0.0	0.0	0.0
1094.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1095.	0.0	26.21010	26.21010	26.21010	26.21010	0.0	0.0	0.0
1096.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1097.	0.0	0.0	0.0	0.0	26.21010	26.21010	26.21010	26.21010
1098.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1099.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1101.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1102.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1103.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1105.	0.0	0.0	0.0	0.0	0.0	0.0	28.85713	28.85713
1106.	28.85713	29.08502	0.0	0.0	0.0	0.0	0.0	0.0
1107.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1108.	0.0	29.57143	29.57143	29.57143	29.57143	29.85713	30.42856	0.0
1109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1110.	0.0	0.0	0.0	0.0	29.57143	29.57143	29.57143	28.88908
1111.	29.62019	30.51401	30.42856	0.0	0.0	0.0	0.0	0.0
1112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
1113.	29.57143	29.57143	28.85713	29.52589	30.14285	30.18043	0.0	0.0
1114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1115.	0.0	0.0	29.57143	29.57143	29.34587	28.75235	28.85713	29.57143
1116.	29.94328	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1117.	0.0	0.0	0.0	0.0	0.0	29.57143	29.54181	29.32628
1118.	28.71317	28.85713	28.85713	0.0	0.0	0.0	0.0	0.0
1119.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1120.	0.0	29.54181	29.30669	28.77194	29.18300	29.44843	0.0	0.0
1121.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1122.	0.0	0.0	0.0	0.0	29.57143	29.24017	28.88908	29.20349
1123.	29.62839	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1124.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.57143
1125.	29.44385	29.57143	29.57143	30.15381	30.99158	0.0	0.0	0.0
1126.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
1127.	29.57143	29.57143	29.57143	29.57143	29.57143	30.00526	30.74643	31.61588
1128.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1129.	0.0	29.39923	29.57143	29.57143	29.57143	29.57143	30.02826	31.07863
1130.	31.31377	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1131.	0.0	0.0	0.0	0.0	29.68536	29.58739	29.57143	29.57143
1132.	29.57143	29.58739	30.47392	31.06975	0.0	0.0	0.0	0.0
1133.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1134.	33.36295	31.34795	29.93028	29.57143	29.57143	29.57143	29.82823	0.0
1135.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1136.	0.0	0.0	0.0	0.0	33.71565	32.42244	30.22420	29.04854
1137.	28.78221	29.48941	29.57143	0.0	0.0	0.0	0.0	0.0

Table 6-2. Continued

1138.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1139.	33.95079	32.39964	29.30946	27.74643	28.08934	28.62364	0.0	0.0
1140.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1141.	0.0	0.0	0.0	0.0	33.77924	30.07384	27.42856	27.85585
1142.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1143.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.92619
1144.	30.34816	27.85585	28.88455	0.0	0.0	0.0	0.0	0.0
1145.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1146.	0.0	0.0	32.45662	30.27959	28.44368	28.94514	29.57896	29.75533
1147.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1148.	0.0	0.0	0.0	0.0	30.51086	31.40901	29.66785	28.12671
1149.	28.06973	28.33682	28.96382	0.0	0.0	0.0	0.0	0.0
1150.	0.0	0.0	0.0	0.0	0.0	0.0	29.52159	29.52159
1151.	29.96245	28.93375	27.29666	27.23788	0.0	0.0	0.0	0.0
1152.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1153.	28.79910	29.07251	28.49287	29.08070	28.78680	26.81134	27.12032	0.0
1154.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1155.	0.0	0.0	28.51338	28.79910	28.35823	27.91734	28.56667	27.40407
1156.	26.81134	26.80153	0.0	0.0	0.0	0.0	0.0	0.0
1157.	0.0	0.0	0.0	0.0	28.35823	27.95856	28.15451	28.25247
1158.	28.34225	28.06430	28.21127	28.22084	28.81485	0.0	0.0	0.0
1159.	0.0	0.0	0.0	0.0	0.0	0.0	28.53819	28.24428
1160.	28.15451	28.44843	28.97992	28.83211	28.44022	29.23996	30.52527	31.54117
1161.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1162.	0.0	29.27217	27.84462	28.32399	28.98518	27.84462	28.08134	0.0
1163.	0.0	30.77998	31.91347	32.09961	0.0	0.0	0.0	0.0
1164.	0.0	0.0	0.0	0.0	30.70895	29.65295	29.27066	30.05832
1165.	28.84845	28.55135	0.0	0.0	31.54416	32.47191	32.65805	0.0
1166.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.60641
1167.	29.86459	29.12392	31.17357	32.96852	31.78969	0.0	0.0	0.0
1168.	33.01596	33.01596	0.0	0.0	0.0	0.0	0.0	33.76512
1169.	33.20758	32.81731	31.81487	30.45512	29.64085	31.90517	34.37614	0.0
1170.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1171.	0.0	32.81252	30.26526	31.02193	32.49080	32.59196	33.69653	0.0
1172.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1173.	0.0	0.0	0.0	0.0	31.53889	30.01053	32.49330	33.81252
1174.	34.34245	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1175.	0.0	0.0	0.0	0.0	0.0	0.0	33.09364	31.53889
1176.	30.98225	33.66098	0.0	0.0	0.0	0.0	0.0	0.0
1177.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1178.	0.0	31.77763	30.99387	32.21669	0.0	0.0	0.0	0.0
1179.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1180.	0.0	0.0	0.0	0.0	30.59308	30.59308	0.0	0.0
1181.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1182.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.95398
1183.	29.95398	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1184.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1185.	0.0	0.0	29.71954	29.44633	29.71954	0.0	0.0	0.0
1186.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1187.	0.0	0.0	0.0	0.0	0.0	29.64116	29.03374	28.79153
1188.	29.25998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1189.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1190.	0.0	28.64116	28.03374	27.82024	28.33745	0.0	0.0	0.0
1191.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1192.	0.0	0.0	0.0	0.0	0.0	27.34793	27.01776	27.10594
1193.	27.62317	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1194.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1195.	26.70064	26.34793	26.34793	26.70064	0.0	0.0	0.0	0.0
1196.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1197.	0.0	0.0	0.0	0.0	0.0	26.46550	26.46550	0.0

Table 6-2. Continued

1198.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1199.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1200.	25.70064	26.41492	0.0	0.0	0.0	0.0	0.0	0.0
1201.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1202.	0.0	25.70064	25.70064	25.70064	25.70064	0.0	0.0	0.0
1203.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1204.	0.0	0.0	0.0	0.0	25.70064	25.70064	25.70064	25.70064
1205.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1206.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1207.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1208.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1209.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1210.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1211.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1212.	0.0	0.0	0.0	0.0	0.0	0.0	28.85713	28.85713
1213.	28.85713	28.85713	0.0	0.0	0.0	0.0	0.0	0.0
1214.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1215.	0.0	29.31770	29.42383	29.21156	29.47690	29.85713	30.42856	0.0
1216.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1217.	0.0	0.0	0.0	0.0	29.52997	29.57143	29.37077	28.85713
1218.	29.57143	30.39417	30.39417	0.0	0.0	0.0	0.0	0.0
1219.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.57143
1220.	29.57143	29.31770	28.85713	29.10542	30.14285	30.14285	0.0	0.0
1221.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1222.	0.0	0.0	29.56630	29.48140	29.03198	28.58971	28.85713	29.52997
1223.	29.68855	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1224.	0.0	0.0	0.0	0.0	0.0	29.46017	29.39648	28.97891
1225.	28.57143	28.83885	28.85713	0.0	0.0	0.0	0.0	0.0
1226.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1227.	0.0	29.39648	28.92584	28.57437	28.85713	29.08102	0.0	0.0
1228.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1229.	0.0	0.0	0.0	0.0	29.46017	28.81972	28.68050	28.85713
1230.	29.57143	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1231.	0.0	0.0	0.0	0.0	0.0	0.0	29.57143	29.48140
1232.	29.29036	29.42383	29.57143	29.85373	30.81104	0.0	0.0	0.0
1233.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.45250
1234.	29.33064	29.57143	29.57143	29.57143	29.57143	29.70808	30.41577	31.32196
1235.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1236.	0.0	28.88487	29.24023	29.57143	29.57143	29.57143	29.82823	30.71614
1237.	30.97086	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1238.	0.0	0.0	0.0	0.0	29.57143	29.57143	29.57143	29.57143
1239.	29.57143	29.57143	30.25278	30.76602	0.0	0.0	0.0	0.0
1240.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1241.	33.16702	30.93646	29.72211	29.57143	29.10008	29.57143	29.59962	0.0
1242.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1243.	0.0	0.0	0.0	0.0	33.54910	32.12518	30.04051	28.73077
1244.	28.35930	29.24449	29.45676	0.0	0.0	0.0	0.0	0.0
1245.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1246.	33.80383	32.14812	28.81143	27.42856	27.78725	28.10567	0.0	0.0
1247.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1248.	0.0	0.0	0.0	0.0	33.54655	29.78238	27.42856	27.42856
1249.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1250.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.70575
1251.	30.07956	27.42856	28.11302	0.0	0.0	0.0	0.0	0.0
1252.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1253.	0.0	0.0	32.14812	30.00526	27.63542	28.29771	29.12556	29.36589
1254.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1255.	0.0	0.0	0.0	0.0	29.93414	30.89548	29.18777	27.70869
1256.	27.76602	28.02075	28.27547	0.0	0.0	0.0	0.0	0.0
1257.	0.0	0.0	0.0	0.0	0.0	0.0	28.94600	28.94600

Table 6-2. Continued

1258.	29.42360	28.30917	26.98805	26.92438	0.0	0.0	0.0	0.0
1259.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1260.	28.19901	28.43568	27.84862	28.46838	28.14998	26.75990	26.79703	0.0
1261.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1262.	0.0	0.0	27.91330	28.19901	27.72141	27.42856	28.14285	26.83420
1263.	26.75990	26.74928	0.0	0.0	0.0	0.0	0.0	0.0
1264.	0.0	0.0	0.0	0.0	27.72141	27.55034	27.76262	27.86876
1265.	27.94220	27.42856	27.56221	27.42972	27.83514	0.0	0.0	0.0
1266.	0.0	0.0	0.0	0.0	0.0	0.0	28.15446	27.83606
1267.	27.76262	28.08102	28.29329	28.47287	28.04832	28.67662	29.67618	30.96722
1268.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1269.	0.0	28.10992	27.66501	27.71808	27.77113	27.66501	27.89764	0.0
1270.	0.0	29.95212	31.37053	31.57219	0.0	0.0	0.0	0.0
1271.	0.0	0.0	0.0	0.0	29.32756	27.93355	27.37653	28.09888
1272.	27.77113	28.00378	0.0	0.0	30.77998	31.97551	32.17717	0.0
1273.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.43074
1274.	28.29378	27.36041	29.33089	31.02541	29.79596	0.0	0.0	0.0
1275.	32.58047	32.58047	0.0	0.0	0.0	0.0	0.0	33.37650
1276.	32.83203	32.38541	30.83514	29.11209	28.02759	30.17107	32.59793	0.0
1277.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1278.	0.0	32.45164	29.69298	30.40300	32.07932	32.14130	33.30220	0.0
1279.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1280.	0.0	0.0	0.0	0.0	31.07188	29.37032	32.11775	33.45164
1281.	34.08528	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1282.	0.0	0.0	0.0	0.0	0.0	0.0	32.94669	31.07188
1283.	30.58792	33.50177	0.0	0.0	0.0	0.0	0.0	0.0
1284.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1285.	0.0	31.56863	30.71954	31.92523	0.0	0.0	0.0	0.0
1286.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1287.	0.0	0.0	0.0	0.0	30.34489	30.34489	0.0	0.0
1288.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1289.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.75967
1290.	29.75967	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1291.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1292.	0.0	0.0	29.51982	29.32878	29.49117	0.0	0.0	0.0
1293.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1294.	0.0	0.0	0.0	0.0	0.0	29.33745	28.80554	28.59560
1295.	28.98402	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1296.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1297.	0.0	28.33745	27.80554	27.71002	28.00844	0.0	0.0	0.0
1298.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1299.	0.0	0.0	0.0	0.0	0.0	27.09125	26.90021	26.99573
1300.	27.29414	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1301.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1302.	26.31856	26.10272	26.10272	26.31856	0.0	0.0	0.0	0.0
1303.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1304.	0.0	0.0	0.0	0.0	0.0	26.06383	26.06383	0.0
1305.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1306.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1307.	25.31856	26.03284	0.0	0.0	0.0	0.0	0.0	0.0
1308.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1309.	0.0	25.31856	25.31856	25.31856	25.31856	0.0	0.0	0.0
1310.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1311.	0.0	0.0	0.0	0.0	25.31856	25.31856	25.31856	25.31856
1312.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1313.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1314.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1315.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1316.	000004							
1317.	0050450090240120030150002							

Table 6-2. Continued

1318.	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346
1319.	-0.346	-0.346	0.0					
1320.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1321.	0.0	0.0	0.0					
1322.	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
1323.	0.627	0.627	0.0					
1324.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1325.	0.0	0.0	0.0					
1326.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1327.	0.0	0.0	0.0					
1328.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.909
1329.	-0.909	-0.909	0.0					
1330.	-0.615	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1331.	0.0	0.0	0.0					
1332.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1333.	0.0	0.0	0.0					
1334.	000008							
1335.	003004							
1336.	0.0							
1337.	0.0							
1338.	003005							
1339.	0.0							
1340.	0.0							
1341.	001008							
1342.	0.0							
1343.	0.0							
1344.	002023							
1345.	0.0							
1346.	0.0							
1347.	002002							
1348.	0.0							
1349.	0.0							
1350.	002003							
1351.	0.0							
1352.	0.0							
1353.	001014							
1354.	0.0							
1355.	0.0							
1356.	001015							
1357.	0.0							
1358.	0.0							

Table 6-3. Meteorological Input File for Continuation Run No. 1 in Paul Model Simulation, H.B. Robinson Case.

ROBINSON-RUN1-METDATA

1.	8 678 0 0	75.5000	29.7900	72.0000	122.0000	5.4000	0.0	23.4625	40.0500-.038415280.06147738
2.	8 678 012	75.4200	29.7900	72.0600	119.6000	5.1800	0.0	23.4627	40.0492-.032728900.05761328
3.	8 678 024	75.3400	29.7900	72.1200	117.2000	4.9600	0.0	23.4629	40.0483-.027582750.05367028
4.	8 678 036	75.2600	29.7900	72.1800	114.8000	4.7400	0.0	23.4631	40.0475-.022959010.04968795
5.	8 678 048	75.1300	29.7900	72.2400	112.4000	4.5200	0.0	23.4633	40.0466-.018837620.04570351
6.	8 678 1 0	75.1000	29.7900	72.3000	110.0000	4.3000	0.0	23.4635	40.0458-.015196410.04175186
7.	8 678 112	75.0400	29.7900	72.2000	110.6000	4.2600	0.0	23.4637	40.0450-.015324040.04076897
8.	8 678 124	74.9800	29.7900	72.1000	111.2000	4.2200	0.0	23.4639	40.0442-.015436270.03979716
9.	8 678 136	74.9200	29.7900	72.0000	111.8000	4.1800	0.0	23.4642	40.0433-.015533480.03883652
10.	8 678 148	74.8600	29.7900	71.9000	112.4000	4.1400	0.0	23.4644	40.0425-.015616010.03788730
11.	8 678 2 0	74.8000	29.7900	71.8000	113.0000	4.1000	0.0	23.4646	40.0417-.015684130.03694958
12.	8 678 212	74.7000	29.7900	71.8000	110.4000	4.2400	0.0	23.4648	40.0409-.015029910.04041432
13.	8 678 224	74.6000	29.7900	71.8000	107.8000	4.3800	0.0	23.4650	40.0400-.014127930.04400351
14.	8 678 236	74.5000	29.7900	71.8000	105.2000	4.5200	0.0	23.4652	40.0392-.012960910.04770411
15.	8 678 248	74.4000	29.7900	71.8000	102.6000	4.6600	0.0	23.4654	40.0383-.011511980.05150172
16.	8 678 3 0	74.3000	29.7900	71.8000	100.0000	4.8000	0.0	23.4656	40.0375-.009765030.05530036
17.	8 678 312	74.3600	29.7900	71.7800	102.4000	4.5800	0.0	23.4658	40.0367-.010919190.04966336
18.	8 678 324	74.4200	29.7900	71.7600	104.8000	4.3600	0.0	23.4660	40.0358-.011690720.04424772
19.	8 678 336	74.4800	29.7900	71.7400	107.2000	4.1400	0.0	23.4663	40.0350-.012117910.03914669
20.	8 678 348	74.5400	29.7900	71.7200	109.6000	3.9200	0.0	23.4665	40.0341-.012233760.03437054
21.	8 678 4 0	74.6000	29.7900	71.7000	112.0000	3.7000	0.0	23.4667	40.0333-.012091130.02992666
22.	8 678 412	74.5400	29.7900	71.6000	114.4000	3.8600	0.0	23.4669	40.0325-.014586190.03215510
23.	8 678 424	74.4800	29.7900	71.5000	116.8000	4.0200	0.0	23.4671	40.0316-.017355040.03435721
24.	8 678 436	74.4200	29.7900	71.4000	119.2000	4.1800	0.0	23.4673	40.0308-.020406070.03651241
25.	8 678 448	74.3600	29.7900	71.3000	121.6000	4.3400	0.0	23.4675	40.0300-.023746370.03859919
26.	8 678 5 0	74.3000	29.7900	71.2000	124.0000	4.5000	0.0	23.4677	40.0292-.027381660.04059497
27.	8 678 512	74.1600	29.7900	71.2400	121.2000	4.2200	10.6180	23.4679	40.0284-.022112430.03651202
28.	8 678 524	74.0200	29.7900	71.2800	118.4000	3.9400	21.2360	23.4681	40.0275-.017541590.03244255
29.	8 678 536	73.8800	29.7900	71.3200	115.6000	3.6600	31.8540	23.4684	40.0267-.013628980.02844592
30.	8 678 548	73.7400	29.7900	71.3600	112.8000	3.3800	42.4720	23.4686	40.0258-.010330900.02457627
31.	8 678 6 0	73.6000	29.7900	71.4000	110.0000	3.1000	53.0900	23.4688	40.0250-.007660440.02083208
32.	8 678 612	73.6600	29.7900	71.5200	112.0000	3.1800	159.2700	23.4690	40.0242-.008782640.02173785
33.	8 678 624	73.7200	29.7900	71.6400	114.0000	3.2600	265.4497	23.4692	40.0233-.010047870.02256795
34.	8 678 636	73.7800	29.7900	71.7600	116.0000	3.3400	371.6296	23.4694	40.0225-.011396910.02336719
35.	8 678 648	73.8400	29.7900	71.8800	118.0000	3.4200	477.8096	23.4696	40.0216-.012330350.02413040
36.	8 678 7 0	73.9000	29.7900	72.0000	120.0000	3.5000	583.9900	23.4698	40.0208-.014348430.02485224
37.	8 678 712	74.2800	29.7900	72.1800	119.8000	3.6600	817.5857	23.4700	40.0200-.015675720.02737136
38.	8 678 724	74.6600	29.7900	72.3600	119.6000	3.8200	1051.1816	23.4702	40.0191-.017059110.03002947
39.	8 678 736	75.0400	29.7900	72.5400	119.4000	3.9800	1284.7776	23.4704	40.0183-.018498030.03282886
40.	8 678 748	75.4200	29.7900	72.7200	119.2000	4.1400	1518.3735	23.4706	40.0175-.019992150.03577179
41.	8 678 8 0	75.8000	29.7900	72.9000	119.0000	4.3000	1751.9697	23.4708	40.0167-.021540750.03886057
42.	8 678 812	76.5000	29.7900	73.0000	122.6000	4.8800	1858.1497	23.4710	40.0159-.031393400.04903852
43.	8 678 824	77.2000	29.7900	73.1000	126.2000	5.4600	1964.3296	23.4712	40.0150-.043851100.05991497
44.	8 678 836	77.9000	29.7900	73.2000	129.8000	6.0400	2070.5098	23.4715	40.0142-.059182670.07103324
45.	8 678 848	78.6000	29.7900	73.3000	133.4000	6.6200	2176.6897	23.4717	40.0133-.077630640.08209217

Table 6-4. Main Input File for Continuation Run No. 2 in Paul Model Simulation, H.B. Robinson Case.

```
    20
ROBINSON NUCLEAR POWER PLANT  -- RUN 2 - BLOCK A:  360 STEPS
     1     8    09     5
     2     2     2     2     2     2     2     2     2     2
     2    19    45    10
     2     1     0   360     0     2     1   036  1200     1   100   100     1
   100
     4     2   002     1     2     0     0   036    01     0
.0000369890.0         .00001      .000001
1000.0     283.0      -3.98       503.37      67.26
197.3056   1946.4749  0.010560421.0           1075.88     .0018288   .0018288   1000.
50000.     0.3        0.010125    50000.      0.3         0.003375   0.000155   15.0
1.0        0.55       0.50        1.0         0.0         1.0
1.0        1.0        900.0       914.36
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        1.20000
     1.20000    1.20000    1.20000    1.20000    0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.86667    0.76667    0.93333    0.83333    0.50000
     0.26667    0.26667    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.86667
     0.80000    0.73333    0.86667    1.00000    0.33333    0.26667    0.30000    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.73333    0.76667    0.76667    0.90000    1.10000
     0.40000    0.40000    0.43333    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.66667
     0.66667    0.73333    0.90000    1.10000    0.83333    0.46667    0.56667    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.66667    0.70000    0.73333    0.93333    1.13333
     0.96667    0.90000    0.66667    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.70000
     0.80000    0.73333    0.93333    1.13333    0.83333    0.86667    0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.70000    0.73333    0.96667    1.00000
     0.70000    0.60000    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.70000
     0.70000    0.73333    1.00000    0.90000    0.56667    0.46667    0.30000    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.66667    0.66667    0.70000    0.73333    0.66667    0.73333    0.60000
     0.43333    0.33333    0.26667    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.66667    0.66667    0.76667    0.66667
     0.56667    0.50000    0.36667    0.30000    0.40000    0.33333    0.26667    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.80000    0.86667    0.60000    0.60000    0.50000    0.43333    0.33333    0.23333
     0.23333    0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.10000    0.10000    0.36667    0.46667
     0.60000    0.66667    0.50000    0.30000    0.26667    0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.10000    0.10000    0.26667    0.36667    0.56667    0.63333    0.43333
     0.33333    0.43333    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.10000    0.10000
     0.20000    0.36667    0.73333    0.66667    0.56667    0.53333    0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.10000    0.10000    0.26667    0.66667    0.63333
     0.60000    0.56667    0.0        0.0        0.0        0.0        0.0        0.0
```

Table 6-4. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.10000	0.16667	0.60000	0.60000	0.50000	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61.	0.0	0.0	0.0	0.0	0.10000	0.23333	0.56667	0.56667
62.	0.43333	0.43333	0.43333	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.33333
64.	0.33333	0.26667	0.53333	0.53333	0.50000	0.46667	0.43333	0.0
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.36667	0.36667	0.33333	0.30000	0.53333	0.53333
67.	0.50000	0.46667	0.43333	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.0	0.0	0.0	0.0	0.40000	0.40000	0.43333
69.	0.43333	0.40000	0.46667	0.56667	0.53333	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.40000	0.40000	0.43333	0.46667	0.46667	0.36667	0.50000	0.56667
72.	0.53333	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73.	0.0	0.0	0.0	0.43333	0.43333	0.40000	0.40000	0.43333
74.	0.46667	0.50000	0.50000	0.53333	0.50000	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.0	0.0	0.0	0.40000	0.43333
76.	0.43333	0.40000	0.40000	0.33333	0.40000	0.43333	0.33333	0.33333
77.	0.30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.33333	0.40000	0.40000	0.36667	0.33333	0.36667
79.	0.36667	0.40000	0.36667	0.30000	0.30000	0.30000	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.30000	0.33333
81.	0.33333	0.33333	0.36667	0.40000	0.36667	0.0	0.33333	0.30000
82.	0.26667	0.26667	0.0	0.0	0.0	0.0	0.0	0.0
83.	0.0	0.0	0.26667	0.30000	0.33333	0.33333	0.30000	0.33333
84.	0.33333	0.0	0.30000	0.26667	0.23333	0.26667	0.0	0.0
85.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.23333	0.26667
86.	0.33333	0.33333	0.26667	0.26667	0.30000	0.0	0.0	0.23333
87.	0.23333	0.23333	0.0	0.0	0.0	0.0	0.10000	0.10000
88.	0.26667	0.20000	0.23333	0.26667	0.30000	0.30000	0.30000	0.26667
89.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.10000	0.26667	0.26667	0.16667	0.20000	0.10000
91.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.26667
93.	0.13333	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
94.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.	0.0	0.10000	0.10000	0.26667	0.10000	0.10000	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97.	0.0	0.0	0.0	0.0	0.0	0.10000	0.23333	0.10000
98.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.10000	0.20000	0.10000	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.10000	0.16667	0.10000
103.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.10000	0.10000	0.16667	0.10000	0.10000	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.10000
108.	0.13333	0.10000	0.10000	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.10000	0.10000	0.13333	0.13333	0.10000	0.10000
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
113.	0.13333	0.13333	0.13333	0.10000	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
116.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-4. Continued

118.	0.0	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
119.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
121.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
122.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
123.	0.10000	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
124.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
126.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
127.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
128.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.02039	0.02546
131.	0.03182	0.03979	0.04974	0.06198	0.06198	0.04974	0.03979	0.03182
132.	0.02546	0.02039	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
133.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
134.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
135.	0.01631	0.01631	0.01631	0.01631	0.01631			
136.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
137.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
138.	0.01631	0.01631	0.01631					
139.	000004							
140.	005045009024012003015002							
141.	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346	-0.346
142.	-0.346	-0.346	0.0					
143.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
144.	0.0	0.0	0.0					
145.	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
146.	0.627	0.627	0.0					
147.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
148.	0.0	0.0	0.0					
149.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.	0.0	0.0	0.0					
151.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.909
152.	-0.909	-0.909	0.0					
153.	-0.615	0.0	0.0	0.0	0.0	0.0	0.0	0.0
154.	0.0	0.0	0.0					
155.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
156.	0.0	0.0	0.0					
157.	000008							
158.	003004							
159.	0.0							
160.	0.0							
161.	003005							
162.	0.0							
163.	0.0							
164.	001008							
165.	0.0							
166.	0.0							
167.	002023							
168.	0.0							
169.	0.0							
170.	002002							
171.	0.0							
172.	0.0							
173.	002003							
174.	0.0							
175.	0.0							
176.	001014							
177.	0.0							
178.	0.0							
179.	001015							
180.	0.0							
181.	0.0							

Table 6-5. Meteorological Input File for Continuation Run No. 2 in Paul Model Simulation, H.B. Robinson Case.

ROBINSON-RUN2-METDATA

1.	8 978 0 0	74.7000	29.7900	69.7000	185.0000	2.5000	0.0	23.5375	40.6500-.01411552-.00123494
2.	8 978 012	74.4600	29.7900	69.7000	184.2000	2.3400	0.0	23.5377	40.6508-.01231449-.00090432
3.	8 978 024	74.2200	29.7900	69.7500	183.4000	2.1500	0.0	23.5379	40.6517-.01064065-.00063217
4.	8 978 036	73.9800	29.7900	69.7000	182.6000	2.0200	0.0	23.5381	40.6525-.00909349-.00041293
5.	8 978 048	73.7400	29.7900	69.7000	181.8000	1.8600	0.0	23.5383	40.6534-.00767236-.00024111
6.	8 978 1 0	73.5000	29.7900	69.7000	181.0000	1.7000	0.0	23.5385	40.6542-.00637645-.00011130
7.	8 978 112	73.3400	29.7900	69.5800	183.0000	1.9000	0.0	23.5337	40.6550-.00300976-.00041977
8.	8 978 124	73.1800	29.7900	69.4600	185.0000	2.1000	0.0	23.5339	40.6558-.00982725-.00035977
9.	8 978 136	73.0200	29.7900	69.3400	187.0000	2.3000	0.0	23.5392	40.6566-.01182435-.00145184
10.	8 978 148	72.8600	29.7900	69.2200	189.0000	2.5000	0.0	23.5394	40.6575-.01399499-.00221658
11.	8 978 2 0	72.7000	29.7900	69.1000	191.0000	2.7000	0.0	23.5396	40.6583-.01633162-.00317455
12.	8 978 212	72.6600	29.7900	69.1200	196.8000	2.3800	0.0	23.5398	40.6591-.01224459-.00369686
13.	8 978 224	72.6200	29.7900	69.1400	202.6000	2.0600	0.0	23.5400	40.6600-.00875181-.00364302
14.	8 978 236	72.5800	29.7900	69.1600	208.4000	1.7400	0.0	23.5402	40.6608-.00588503-.00318202
15.	8 978 248	72.5400	29.7900	69.1800	214.2000	1.4200	0.0	23.5404	40.6617-.00364495-.00247711
16.	8 978 3 0	72.5000	29.7900	69.2000	220.0000	1.1000	0.0	23.5406	40.6625-.00200345-.00168110
17.	8 978 312	72.4800	29.7900	69.2600	222.8000	1.1800	0.0	23.5408	40.6633-.00221438-.00205054
18.	8 978 324	72.4600	29.7900	69.3200	225.6000	1.2600	0.0	23.5410	40.6642-.00241429-.00246540
19.	8 978 336	72.4400	29.7900	69.3300	228.4000	1.3400	0.0	23.5413	40.6650-.00259833-.00292657
20.	8 978 348	72.4200	29.7900	69.4400	231.2000	1.4200	0.0	23.5415	40.6658-.00276144-.00343454
21.	8 978 4 0	72.4000	29.7900	69.5000	234.0000	1.5000	0.0	23.5417	40.6667-.00289845-.00398938
22.	8 978 412	72.2200	29.7900	69.3400	225.6000	1.6600	0.0	23.5419	40.6675-.00424871-.00433864
23.	8 978 424	72.0400	29.7900	69.1800	217.2000	1.8200	0.0	23.5421	40.6683-.00584616-.00443748
24.	8 978 436	71.8600	29.7900	69.0200	208.8000	1.9800	0.0	23.5423	40.6692-.00765374-.00420767
25.	8 978 448	71.6800	29.7900	68.8600	200.4000	2.1400	0.0	23.5425	40.6700-.00961464-.00357565
26.	8 978 5 0	71.5000	29.7900	68.7000	192.0000	2.3000	0.0	23.5427	40.6708-.01165282-.00247688
27.	8 978 512	71.3200	29.7900	68.5200	194.2000	2.3400	10.6180	23.5429	40.6716-.01197037-.00302897
28.	8 978 524	71.1400	29.7900	68.3400	196.4000	2.3800	21.2360	23.5431	40.6725-.01227010-.00361129
29.	8 978 536	70.9600	29.7900	68.1600	198.6000	2.4200	31.8540	23.5433	40.6733-.01255008-.00422356
30.	8 978 548	70.7800	29.7900	67.9800	200.8000	2.4600	42.4720	23.5435	40.6741-.01280338-.00486543
31.	8 978 6 0	70.6000	29.7900	67.8000	203.0000	2.5000	53.0900	23.5437	40.6750-.01304303-.00553644
32.	8 978 612	70.6200	29.7900	68.2800	204.8000	2.4400	127.4159	23.5439	40.6758-.01222822-.00565023
33.	8 978 624	70.6400	29.7900	68.7600	206.6000	2.3800	201.7418	23.5441	40.6767-.01143667-.00572706
34.	8 978 636	70.6600	29.7900	69.2400	208.4000	2.3200	276.0676	23.5444	40.6775-.01066957-.00576901
35.	8 978 648	70.6800	29.7900	69.7200	210.2000	2.2600	350.3933	23.5446	40.6783-.00992787-.00577816
36.	8 978 7 0	70.7000	29.7900	70.2000	212.0000	2.2000	424.7197	23.5448	40.6792-.00921252-.00575662
37.	8 978 712	71.4200	29.7900	70.6600	204.8000	2.3800	753.8777	23.5450	40.6800-.01161093-.00536500
38.	8 978 724	72.1400	29.7900	71.1200	197.6000	2.5600	1083.0356	23.5452	40.6808-.01419054-.00450150
39.	8 978 736	72.8600	29.7900	71.5300	190.4000	2.7400	1412.1936	23.5454	40.6817-.01687471-.00309709
40.	8 978 748	73.5800	29.7900	72.0400	183.2000	2.9200	1741.3516	23.5456	40.6825-.01957006-.00109413
41.	8 978 8 0	74.3000	29.7900	72.5000	176.0000	3.1000	2070.5098	23.5458	40.6833-.022163110.00155015
42.	8 978 812	75.4400	29.7900	72.4600	185.2000	3.2200	2452.7576	23.5460	40.6841-.02397081-.00218150
43.	8 978 824	76.5800	29.7900	72.4200	194.4000	3.3400	2835.0056	23.5462	40.6850-.02518158-.00646551
44.	8 978 836	77.7200	29.7900	72.3800	203.6000	3.4600	3217.2537	23.5465	40.6858-.02566593-.01121317
45.	8 978 848	78.8600	29.7900	72.3400	212.8000	3.5800	3599.5017	23.5467	40.6866-.02530197-.01630601

Table 6-6. Main Input File for Continuation Run No. 3 in Paul Model Simulation, H.B. Robinson Case.

```
      20
  ROBINSON NUCLEAR POWER PLANT  -- RUN 3 - BLOCK B:  360 STEPS
       2     8    09     5
       2     2     2     2     2     2     2     2     2     2
       3    19    45    10
       2     1     0   360     0     2     1   036  1200     1   100   100     1
     100
       4     2   002     1     2     0     0   036    01     0
  .0000369890.0        .00001     .000001
  1000.0    283.0      -3.98      503.37     67.26
  197.3056  1946.4749 0.010560421.0          1078.88    .0018288  .0018238  1000.
  50000.    0.3        0.010125   50000.     0.3        0.003375  0.000155  15.0
  1.0       0.55       0.50       1.0        0.0        1.0
  1.0       1.0        900.0      914.36
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        1.20000
     1.20000    1.20000    1.20000    1.20000    0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.86667    0.76667    0.93333    0.83333    0.50000
     0.26667    0.26667    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.86667
     0.80000    0.73333    0.86667    1.00000    0.53333    0.26667    0.30000    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.73333    0.76667    0.76667    0.90000    1.10000
     0.40000    0.40000    0.43333    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.66667
     0.66667    0.73333    0.90000    1.10000    0.83333    0.46667    0.56667    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.66667    0.70000    0.73333    0.93333    1.13333
     0.96667    0.90000    0.66667    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.70000
     0.80000    0.73333    0.93333    1.13333    0.83333    0.86667    0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.70000    0.73333    0.96667    1.00000
     0.70000    0.60000    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.70000
     0.70000    0.73333    1.00000    0.90000    0.56667    0.46667    0.30000    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.66667    0.66667    0.70000    0.73333    0.66667    0.73333    0.60000
     0.43333    0.33333    0.26667    0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.66667    0.66667    0.76667    0.66667
     0.56667    0.50000    0.36667    0.30000    0.40000    0.33333    0.26667    0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.80000    0.86667    0.60000    0.60000    0.50000    0.43333    0.33333    0.23333
     0.23333    0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.10000    0.10000    0.36667    0.46667
     0.60000    0.66667    0.50000    0.30000    0.26667    0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.10000    0.10000    0.26667    0.36667    0.56667    0.63333    0.43333
     0.33333    0.43333    0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.10000    0.10000
     0.20000    0.36667    0.73333    0.66667    0.56667    0.53333    0.0        0.0
     0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
     0.0        0.0        0.0        0.10000    0.10000    0.26667    0.66667    0.63333
     0.60000    0.56667    0.0        0.0        0.0        0.0        0.0        0.0
```

Table 6-6. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.10000	0.16667	0.60000	0.60000	0.50000	0.0	0.0	0.0
60.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61.	0.0	0.0	0.0	0.0	0.10000	0.23333	0.56667	0.56667
62.	0.43333	0.43333	0.43333	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.33333
64.	0.33333	0.26667	0.53333	0.53333	0.50000	0.46667	0.43333	0.0
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.36667	0.36667	0.33333	0.30000	0.53333	0.53333
67.	0.50000	0.46667	0.43333	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.0	0.0	0.0	0.0	0.40000	0.40000	0.43333
69.	0.43333	0.40000	0.46667	0.56667	0.53333	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.40000	0.40000	0.43333	0.46667	0.46667	0.36667	0.50000	0.56667
72.	0.53333	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73.	0.0	0.0	0.0	0.43333	0.43333	0.40000	0.40000	0.43333
74.	0.46667	0.50000	0.50000	0.53333	0.50000	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.0	0.0	0.0	0.40000	0.43333
76.	0.43333	0.40000	0.40000	0.33333	0.40000	0.43333	0.33333	0.33333
77.	0.30000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.33333	0.40000	0.40000	0.36667	0.33333	0.36667
79.	0.36667	0.40000	0.36667	0.30000	0.30000	0.30000	0.0	0.0
80.	0.0	0.0	0.0	0.0	0.0	0.0	0.30000	0.33333
81.	0.33333	0.33333	0.36667	0.40000	0.36667	0.0	0.33333	0.30000
82.	0.26667	0.26667	0.0	0.0	0.0	0.0	0.0	0.0
83.	0.0	0.0	0.26667	0.30000	0.33333	0.33333	0.30000	0.33333
84.	0.33333	0.0	0.30000	0.26667	0.23333	0.26667	0.0	0.0
85.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.23333	0.26667
86.	0.33333	0.33333	0.26667	0.26667	0.30000	0.0	0.0	0.23333
87.	0.23333	0.23333	0.0	0.0	0.0	0.0	0.10000	0.10000
88.	0.26667	0.20000	0.23333	0.26667	0.30000	0.30000	0.30000	0.26667
89.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.	0.0	0.0	0.10000	0.26667	0.26667	0.16667	0.20000	0.10000
91.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.26667
93.	0.13333	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
94.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.	0.0	0.10000	0.10000	0.26667	0.10000	0.10000	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97.	0.0	0.0	0.0	0.0	0.0	0.10000	0.23333	0.10000
98.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.10000	0.20000	0.10000	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.10000	0.16667	0.10000
103.	0.10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.10000	0.10000	0.16667	0.10000	0.10000	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107.	0.0	0.0	0.0	0.0	0.0	0.10000	0.10000	0.10000
108.	0.13333	0.10000	0.10000	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.10000	0.10000	0.13333	0.13333	0.10000	0.10000
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
113.	0.13333	0.13333	0.13333	0.10000	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
116.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
117.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-6. Continued

118.	0.0	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
119.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
121.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
122.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10000
123.	0.10000	0.10000	0.10000	0.10000	0.0	0.0	0.0	0.0
124.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125.	0.0	0.0	0.0	0.10000	0.10000	0.10000	0.10000	0.10000
126.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
127.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
128.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
129.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.02039	0.02546
131.	0.03182	0.03979	0.04974	0.06198	0.06198	0.04974	0.03979	0.03182
132.	0.02546	0.02039	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
133.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
134.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
135.	0.01631	0.01631	0.01631	0.01631	0.01631			
136.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
137.	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631	0.01631
138.	0.01631	0.01631	0.01631					
139.	000004							
140.	005045009024012003015002							
141.	-0.445	-0.445	-0.445	-0.445	-0.445	-0.445	-0.445	-0.445
142.	-0.445	-0.445	0.0					
143.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
144.	0.0	0.0	0.0					
145.	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
146.	0.627	0.627	0.0					
147.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
148.	0.0	0.0	0.0					
149.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.	0.0	0.0	0.0					
151.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.909
152.	-0.909	-0.909	0.0					
153.	-0.909	0.0	0.0	0.0	0.0	0.0	0.0	0.0
154.	0.0	0.0	0.0					
155.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
156.	0.0	0.0	0.0					
157.	000008							
158.	003004							
159.	0.0							
160.	0.0							
161.	003005							
162.	0.0							
163.	0.0							
164.	001008							
165.	0.0							
166.	0.0							
167.	002023							
168.	0.0							
169.	0.0							
170.	002002							
171.	0.0							
172.	0.0							
173.	002003							
174.	0.0							
175.	0.0							
176.	001014							
177.	0.0							
178.	0.0							
179.	001015							
180.	0.0							
181.	0.0							

Table 6-7. Meteorological Input File for Continuation Run No. 3 in Paul Model Simulation, H.B. Robinson Case.

ROBINSON-RUN3-METDATA

1.	81278 0 0	71.7000	29.7900	68.9000	184.0000	3.9000	0.0	23.6125	40.4000-.03600236-.00251753
2.	81278 012	71.7200	29.7900	68.9200	183.2000	3.9200	0.0	23.6127	40.3983-.03642765-.00203661
3.	81278 024	71.7400	29.7900	68.9400	182.4000	3.9400	0.0	23.6129	40.3967-.03684891-.00154442
4.	81278 036	71.7600	29.7900	68.9600	181.6000	3.9600	0.0	23.6131	40.3950-.03726577-.00104091
5.	81278 048	71.7800	29.7900	68.9600	180.8000	3.9800	0.0	23.6133	40.3933-.03767806-.00052610
6.	81278 1 0	71.8000	29.7900	69.0000	180.0000	4.0000	0.0	23.6135	40.3917-.03808555 0.00000002
7.	81278 112	71.8200	29.7900	69.0400	182.8000	3.9200	0.0	23.6137	40.3900-.03644102-.00178224
8.	81278 124	71.8400	29.7900	69.0300	185.6000	3.8400	0.0	23.6139	40.3883-.03475406-.00340775
9.	81278 136	71.8600	29.7900	69.1200	188.4000	3.7600	0.0	23.6142	40.3867-.03303799-.00487863
10.	81278 148	71.8800	29.7900	69.1600	191.2000	3.6800	0.0	23.6144	40.3850-.03130080-.00619772
11.	81278 2 0	71.9000	29.7900	69.2000	194.0000	3.6000	0.0	23.6146	40.3833-.02955323-.00736844
12.	81278 212	71.9400	29.7900	69.1800	193.8000	3.6600	0.0	23.6148	40.3816-.03063186-.00752391
13.	81278 224	71.9800	29.7900	69.1600	193.6000	3.7200	0.0	23.6150	40.3800-.03173226-.00767682
14.	81278 236	72.0200	29.7900	69.1400	193.4000	3.7800	0.0	23.6152	40.3783-.03285459-.00782705
15.	81278 248	72.0600	29.7900	69.1200	193.2000	3.8400	0.0	23.6154	40.3766-.03399887-.00797435
16.	81278 3 0	72.1000	29.7900	69.1000	193.0000	3.9000	0.0	23.6156	40.3750-.03516529-.00811854
17.	81278 312	72.0200	29.7900	69.0200	189.8000	4.1300	0.0	23.6158	40.3733-.04121744-.00711947
18.	81278 324	71.9400	29.7900	68.9400	186.6000	4.4600	0.0	23.6160	40.3717-.04772128-.00552154
19.	81278 336	71.8600	29.7900	68.8600	183.4000	4.7400	0.0	23.6163	40.3700-.05463947-.00324616
20.	81278 348	71.7800	29.7900	68.7800	180.2000	5.0200	0.0	23.6165	40.3683-.06192382-.00021617
21.	81278 4 0	71.7000	29.7900	68.7000	177.0000	5.3000	0.0	23.6167	40.3667-.06952524 0.00364369
22.	81278 412	71.6600	29.7900	68.6400	180.4000	5.3300	0.0	23.6169	40.3650-.07191128-.00050204
23	81278 424	71.6200	29.7900	68.5800	183.8000	5.4600	0.0	23.6171	40.3633-.07405446-.00492062
24.	81278 436	71.5800	29.7900	68.5200	187.2000	5.5400	0.0	23.6173	40.3617-.07602043-.00960357
25.	81278 448	71.5400	29.7900	68.4600	190.6000	5.6200	0.0	23.6175	40.3600-.07769555-.01454030
26.	81278 5 0	71.5000	29.7900	68.4000	194.0000	5.7000	0.0	23.6177	40.3583-.07905589-.01971832
27.	81278 512	71.4600	29.7900	68.4000	194.4000	5.2200	0.0	23.6179	40.3566-.06525347-.01475425
28.	81278 524	71.4200	29.7900	68.4000	194.8000	4.7400	0.0	23.6181	40.3550-.05291986-.01398203
29.	81278 536	71.3800	29.7900	68.4000	195.2000	4.2600	0.0	23.6183	40.3533-.04203016-.01141932
30.	81278 548	71.3400	29.7900	68.4000	195.6000	3.7800	0.0	23.6185	40.3517-.03252991-.00908251
31.	81278 6 0	71.3000	29.7900	68.4000	196.0000	3.3000	0.0	23.6187	40.3500-.02436465-.00693644
32.	81278 612	71.3000	29.7900	68.4200	197.2000	3.2400	42.4720	23.6189	40.3483-.02329509-.00721101
33.	81278 624	71.3000	29.7900	68.4400	198.4000	3.1800	84.9440	23.6191	40.3467-.02224642-.00740040
34.	81278 636	71.3000	29.7900	68.4600	199.6000	3.1200	127.4160	23.6194	40.3450-.02121944-.00755589
35.	81278 648	71.3000	29.7900	68.4800	200.8000	3.0600	169.8880	23.6196	40.3434-.02021483-.00767888
36.	81278 7 0	71.3000	29.7900	68.5000	202.0000	3.0000	212.3600	23.6198	40.3417-.01923324-.00777073
37.	81278 712	71.3600	29.7900	68.8200	205.8000	3.1600	233.5959	23.6200	40.3400-.02082977-.01006950
38.	81278 724	71.4200	29.7900	69.1400	209.6000	3.3200	254.8319	23.6202	40.3383-.02232107-.01268012
39.	81278 736	71.4800	29.7900	69.4600	213.4000	3.4300	276.0679	23.6204	40.3367-.02366924-.01560697
40.	81278 748	71.5400	29.7900	69.7800	217.2000	3.6400	297.3037	23.6206	40.3350-.02483465-.01885054
41.	81278 8 0	71.6000	29.7900	70.1000	221.0000	3.8000	318.5398	23.6208	40.3333-.02577650-.02240717
42.	81278 812	72.3400	29.7900	69.9400	235.0000	3.9400	806.9675	23.6210	40.3316-.02115423-.03021135
43.	81278 824	73.0800	29.7900	69.7800	249.0000	4.0800	1295.3955	23.6212	40.3300-.01423611-.03708625
44.	81278 836	73.8200	29.7900	69.6200	262.9998	4.2200	1783.8235	23.6215	40.3283-.00520227-.04236773
45.	81278 848	74.5600	29.7900	69.4600	276.9998	4.3600	2272.2515	23.6217	40.3266 0.00557727-.04542496

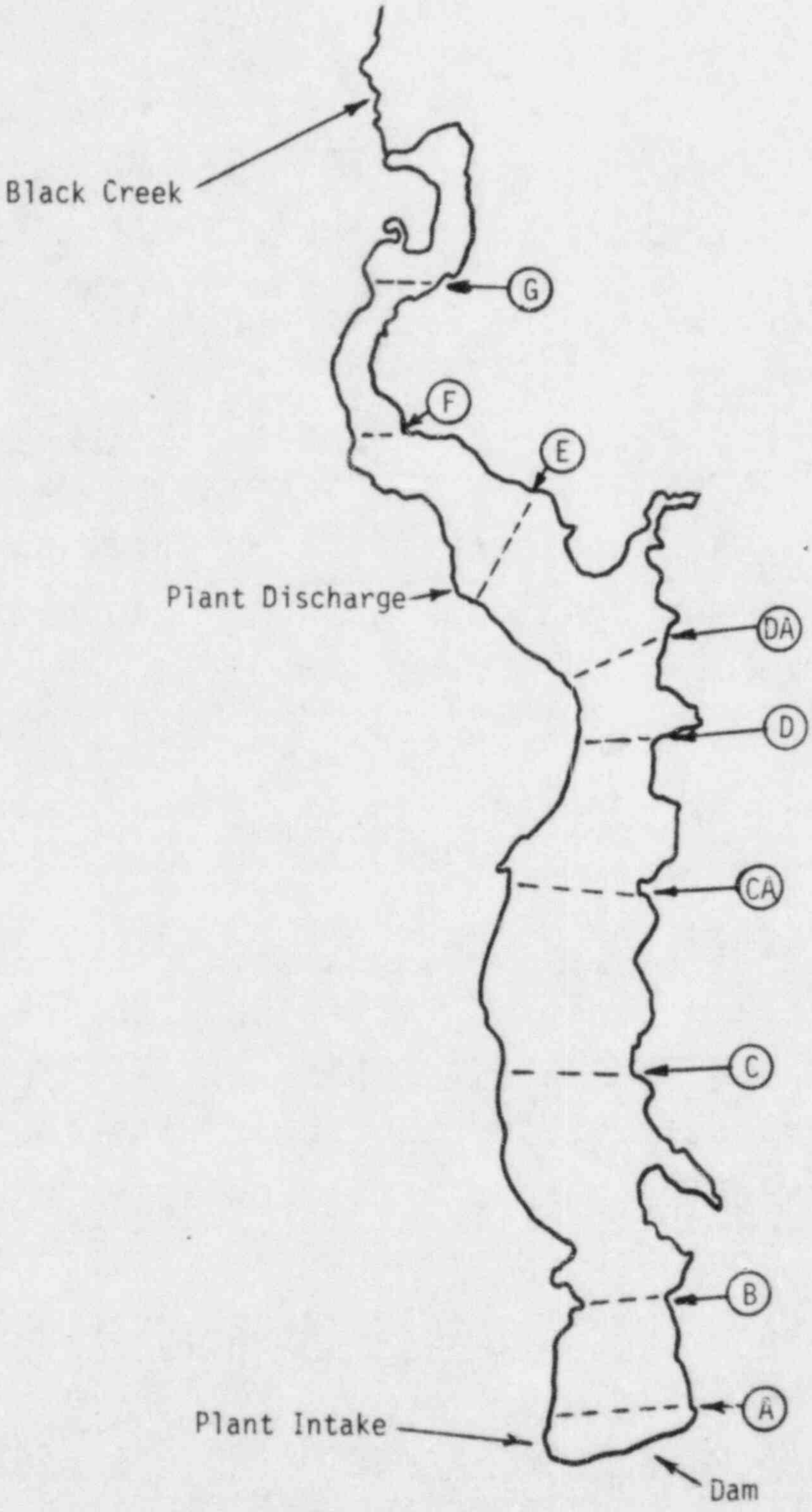


Fig. 6-1. Sketch of H.B. Robinson Pond.

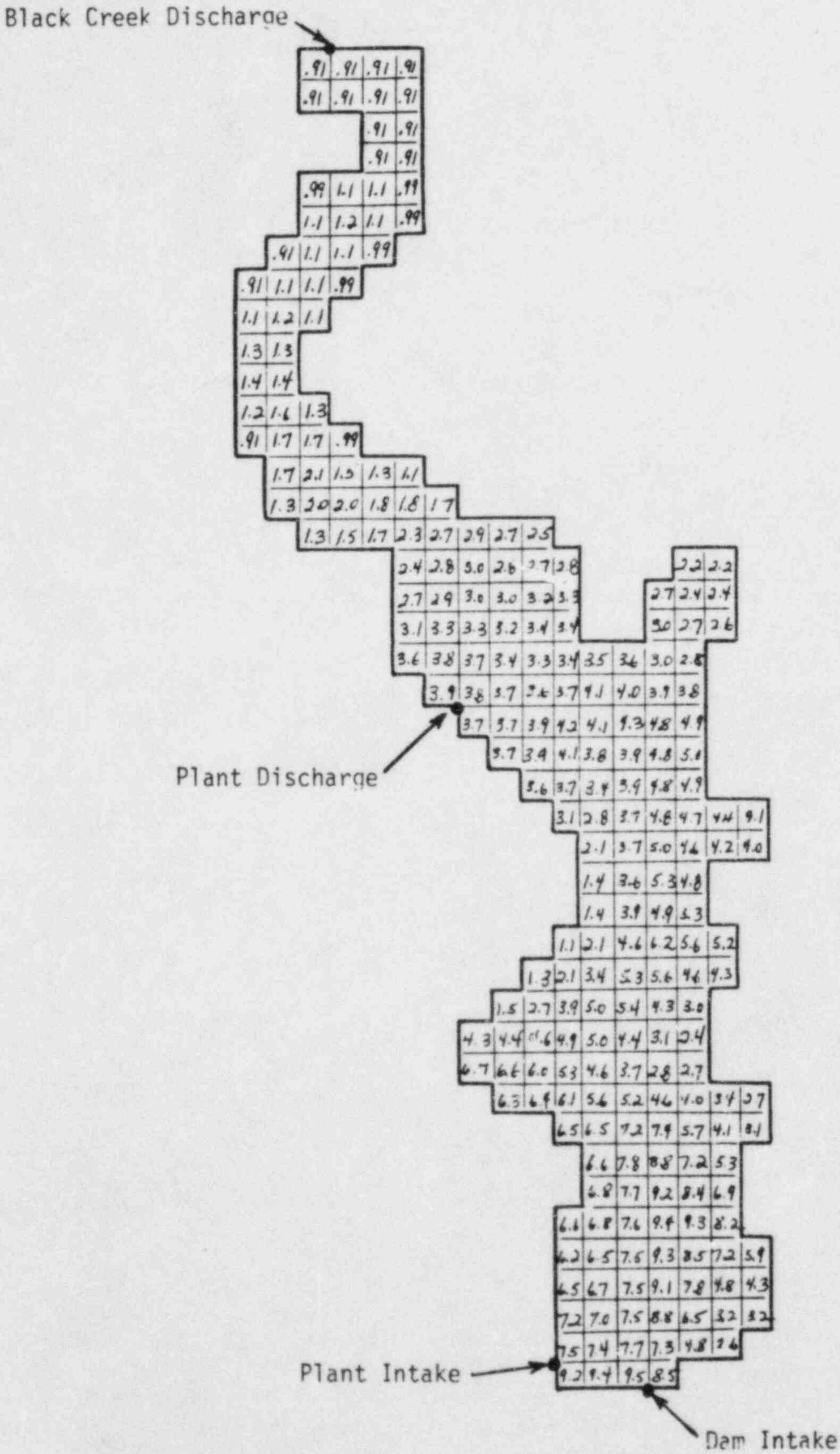


Fig. 6-2. Bottom Depths (In Meters) of Cells Representing H.B. Robinson Pond.

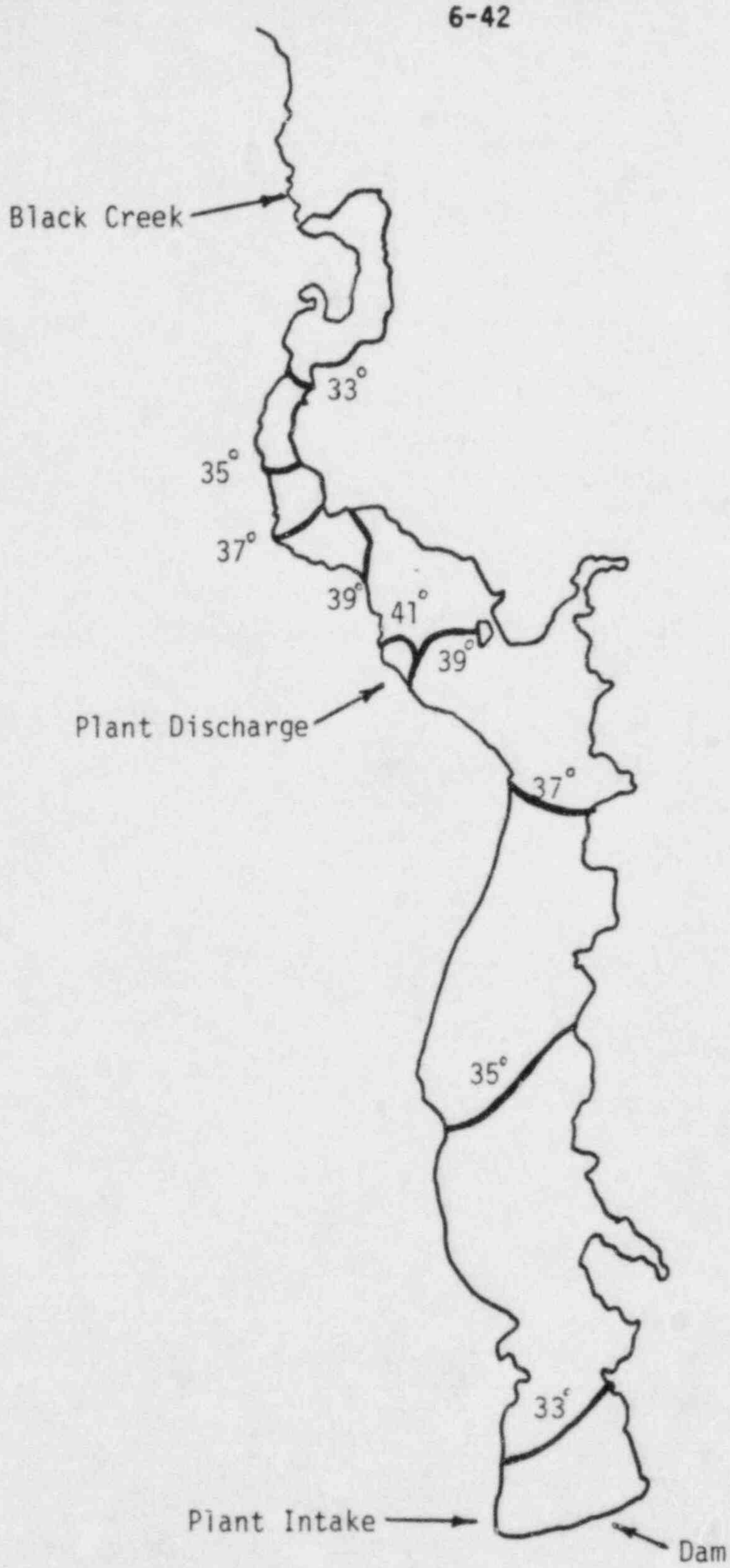


Fig. 6-3. H.B. Robinson Surface Isotherms: August 14, 1978.

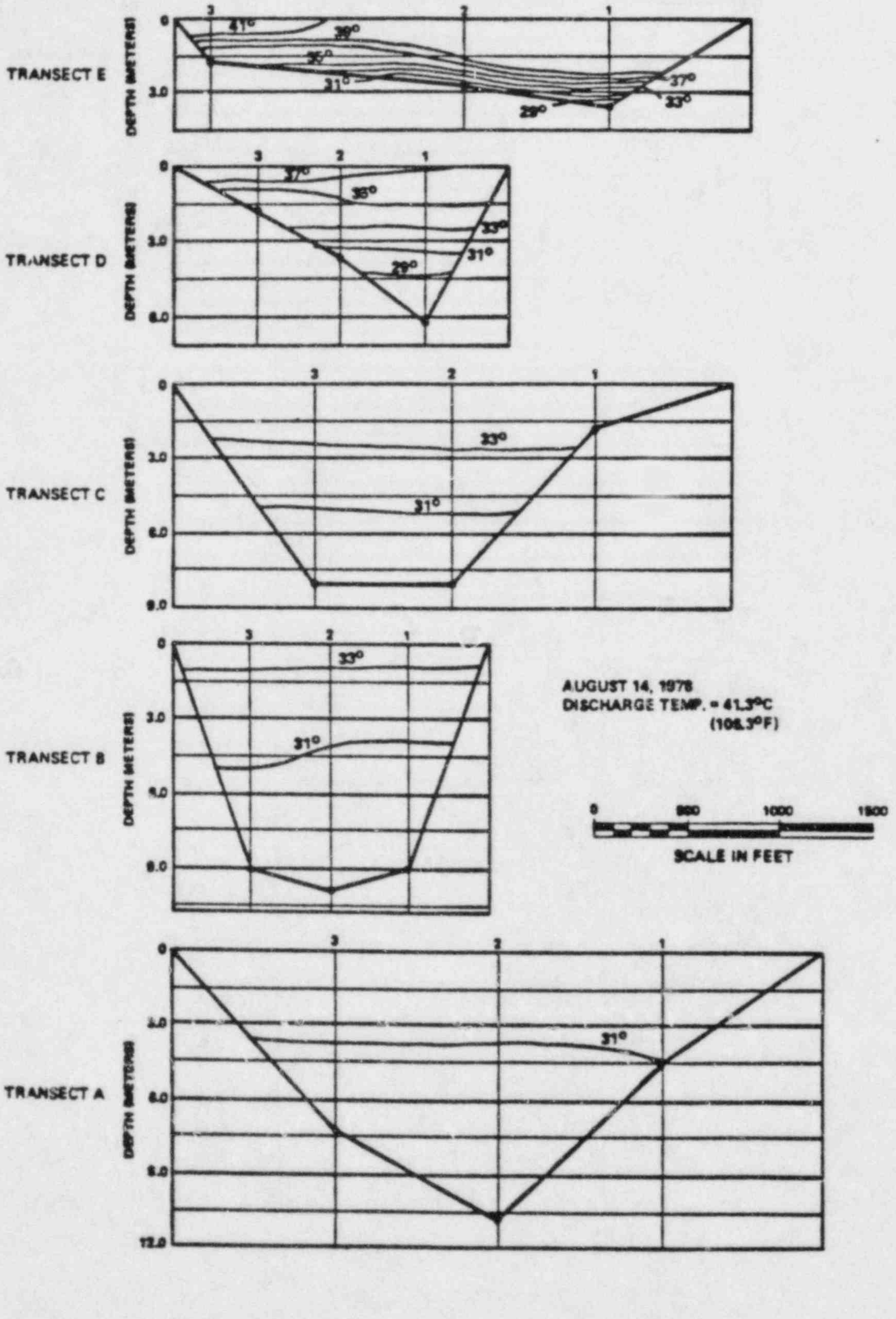


Fig 6-4. Sketch of Cross-Sectional Temperature Distributions at Transects A-E on August 14, 1978.

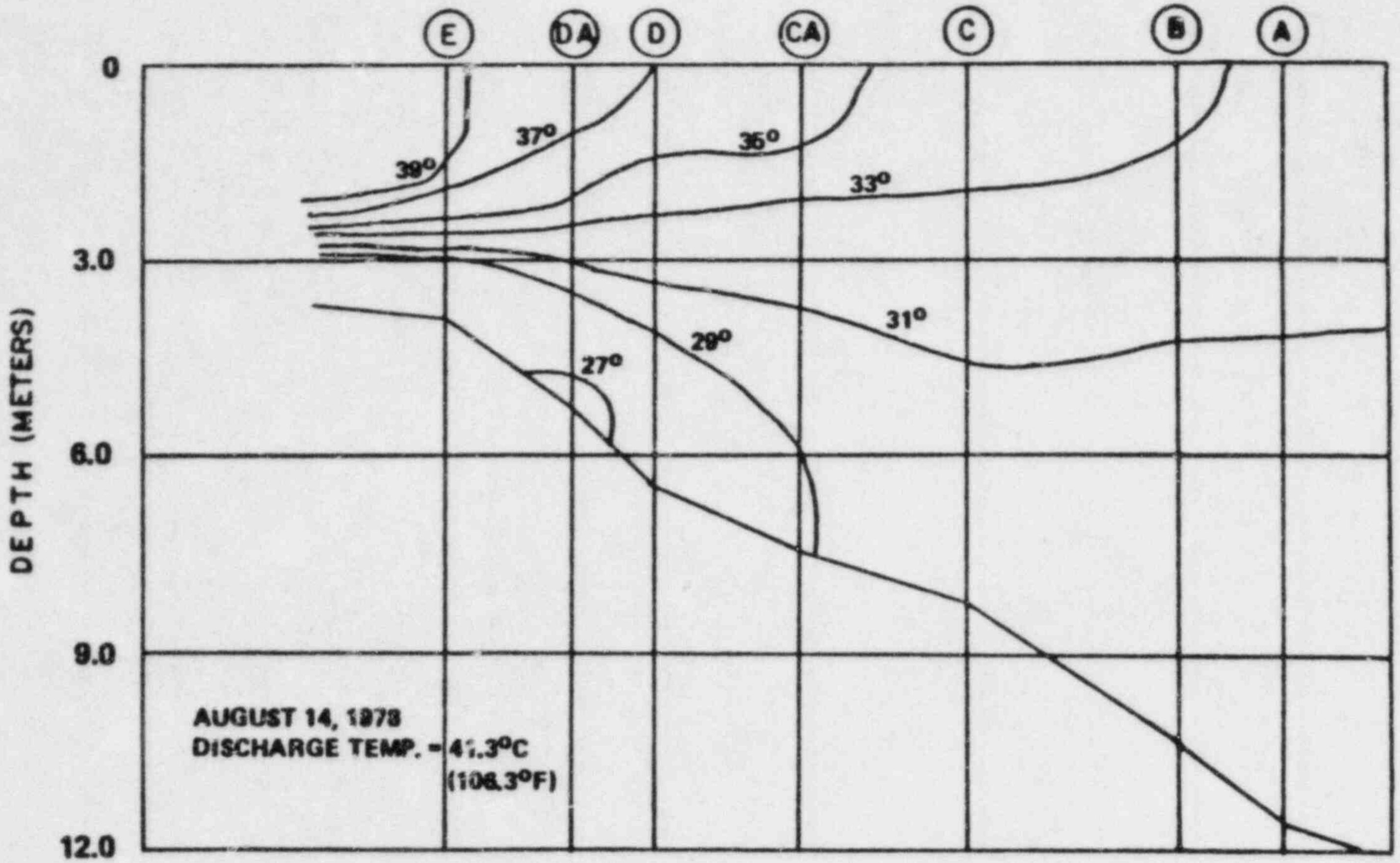


Fig. 6-5. Sketch of Temperature Isotherms of Plume Along Centerline Cross-Section of Pond on August 14, 1978.

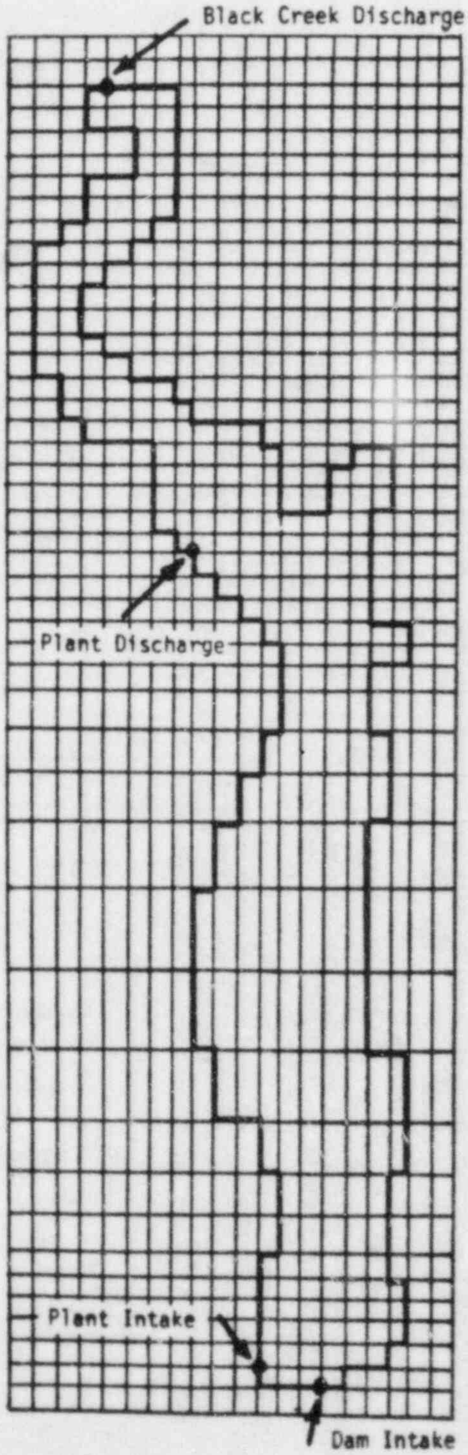


Fig. 6-6. Sketch of Grid System Used in Paul Model for H.B. Robinson Pond.

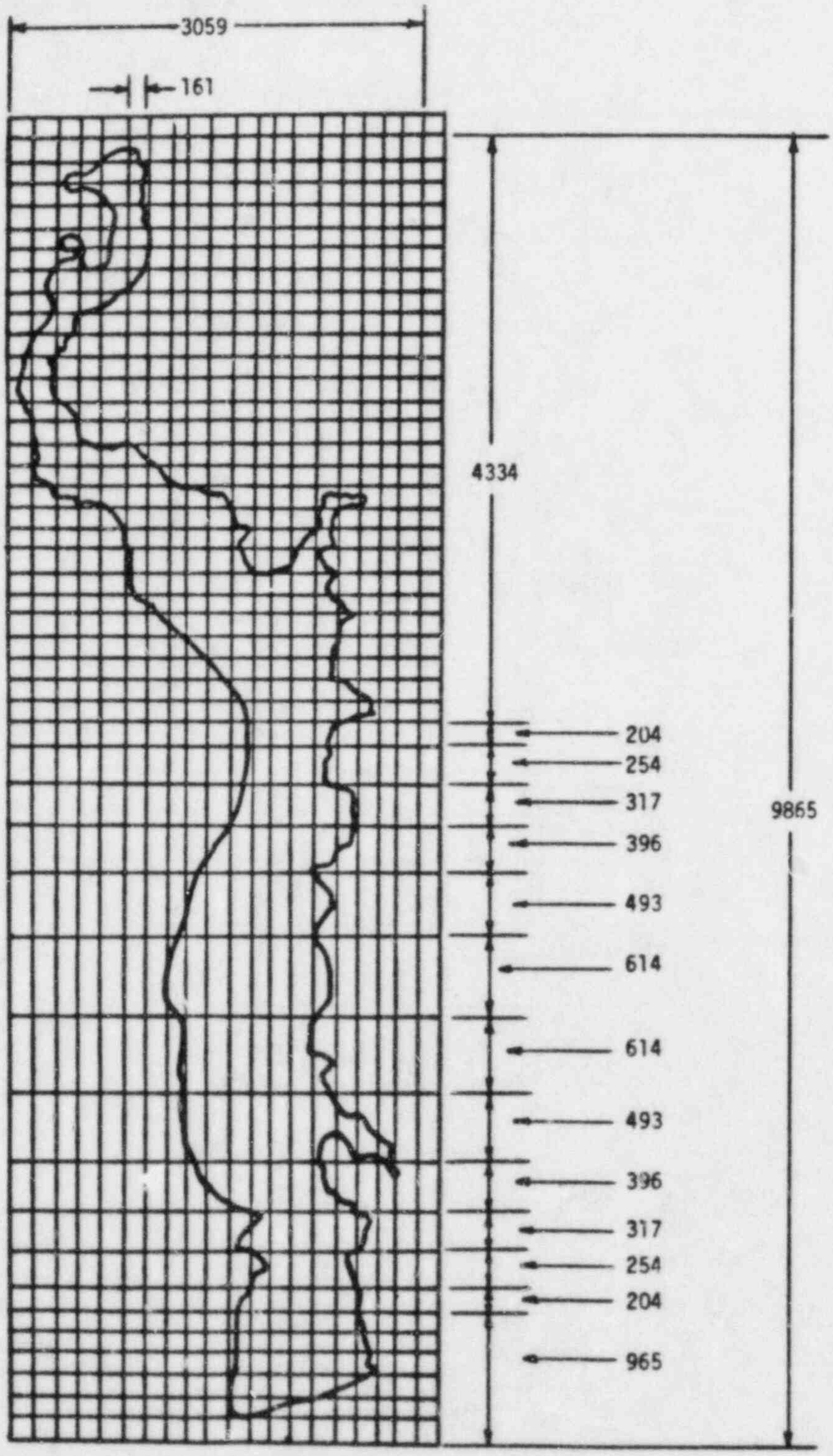


Fig. 6-7. Grid Dimensions for Paul Model Application to H.B. Robinson.

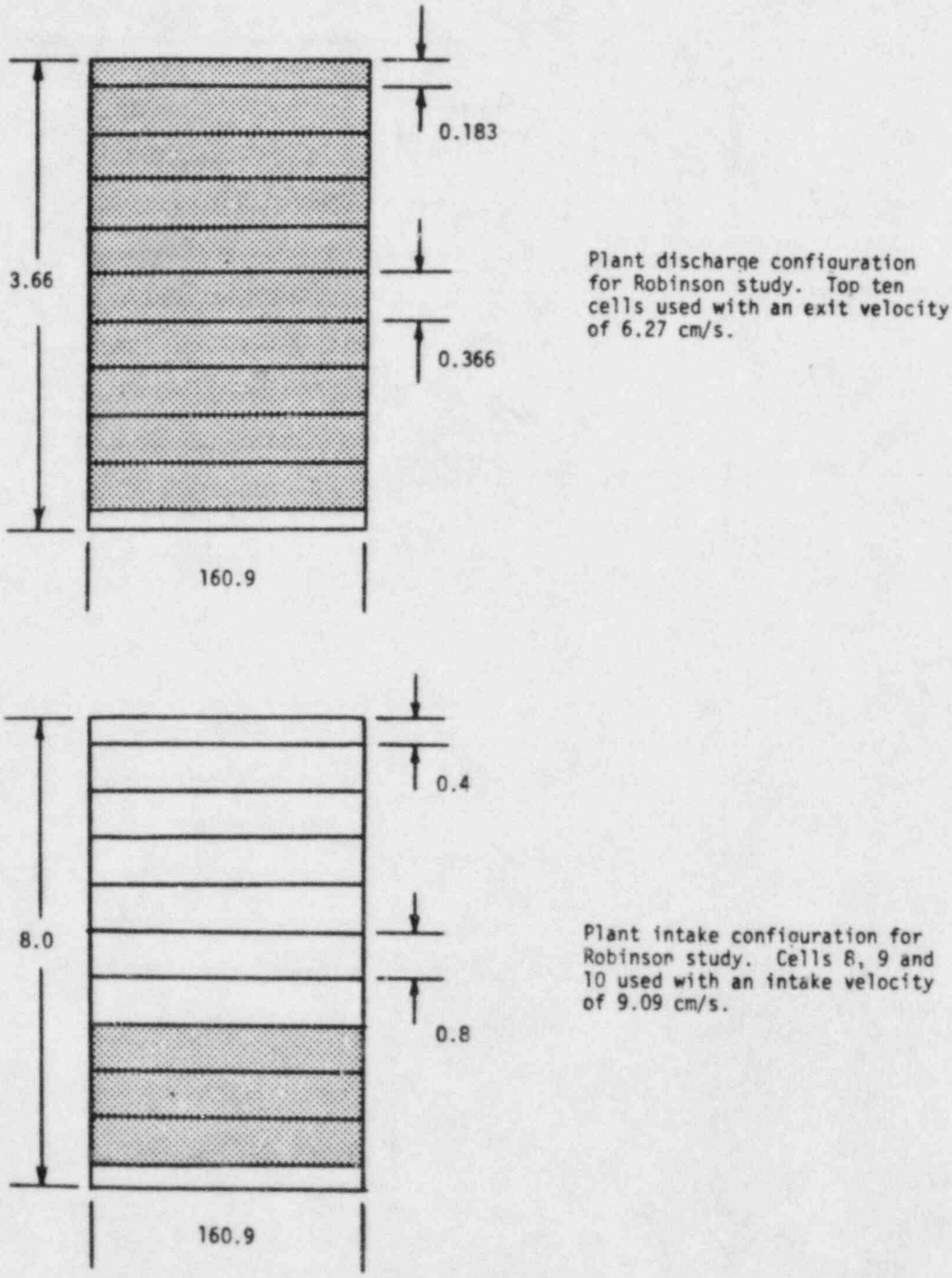


Fig. 6-8. Sketch of Plant Discharge and Intake Schematization for H.B. Robinson Pond.

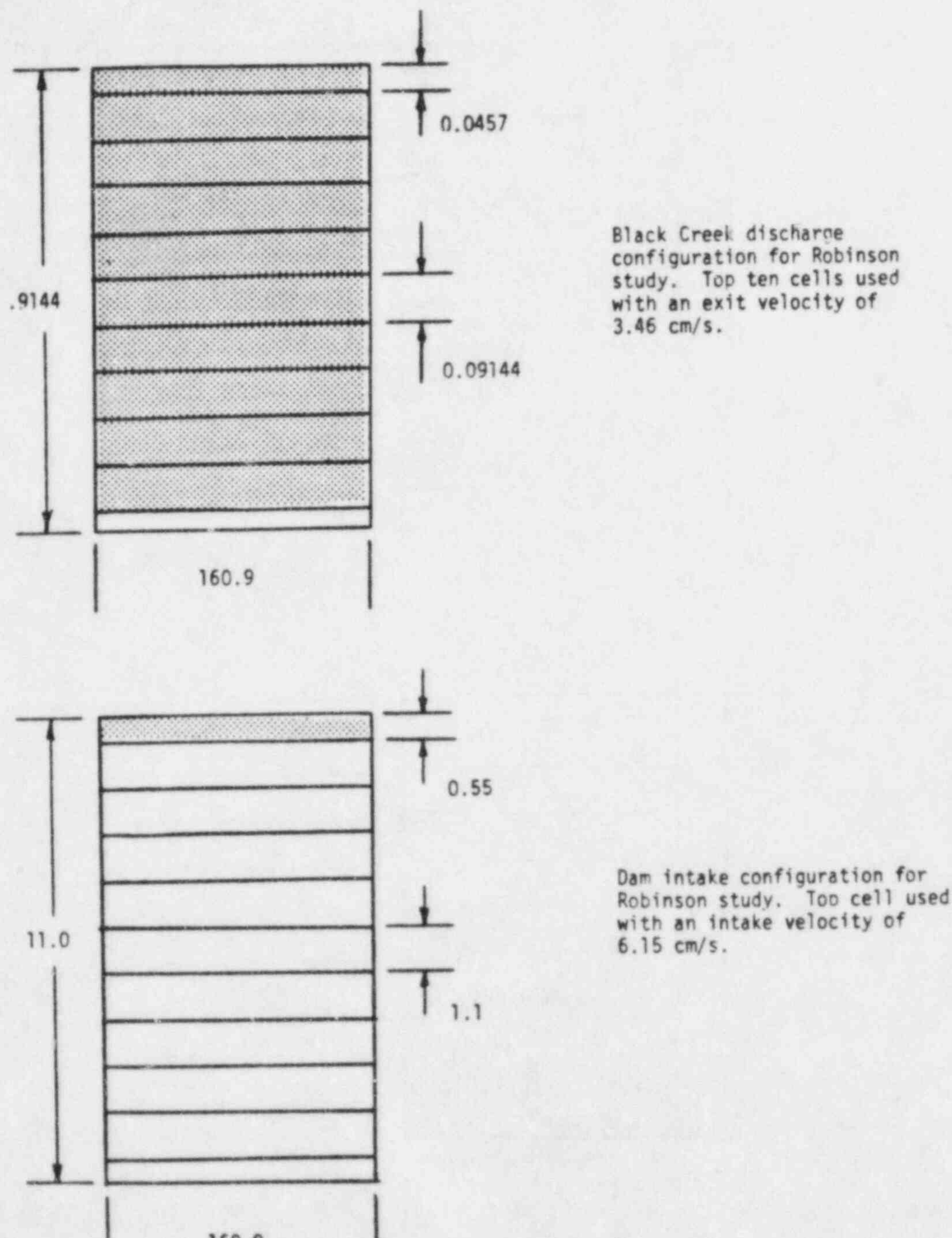


Fig. 6-9. Sketch of Schematization of Black Creek Inflow and Dam Outflow from H.B. Robinson Pond.

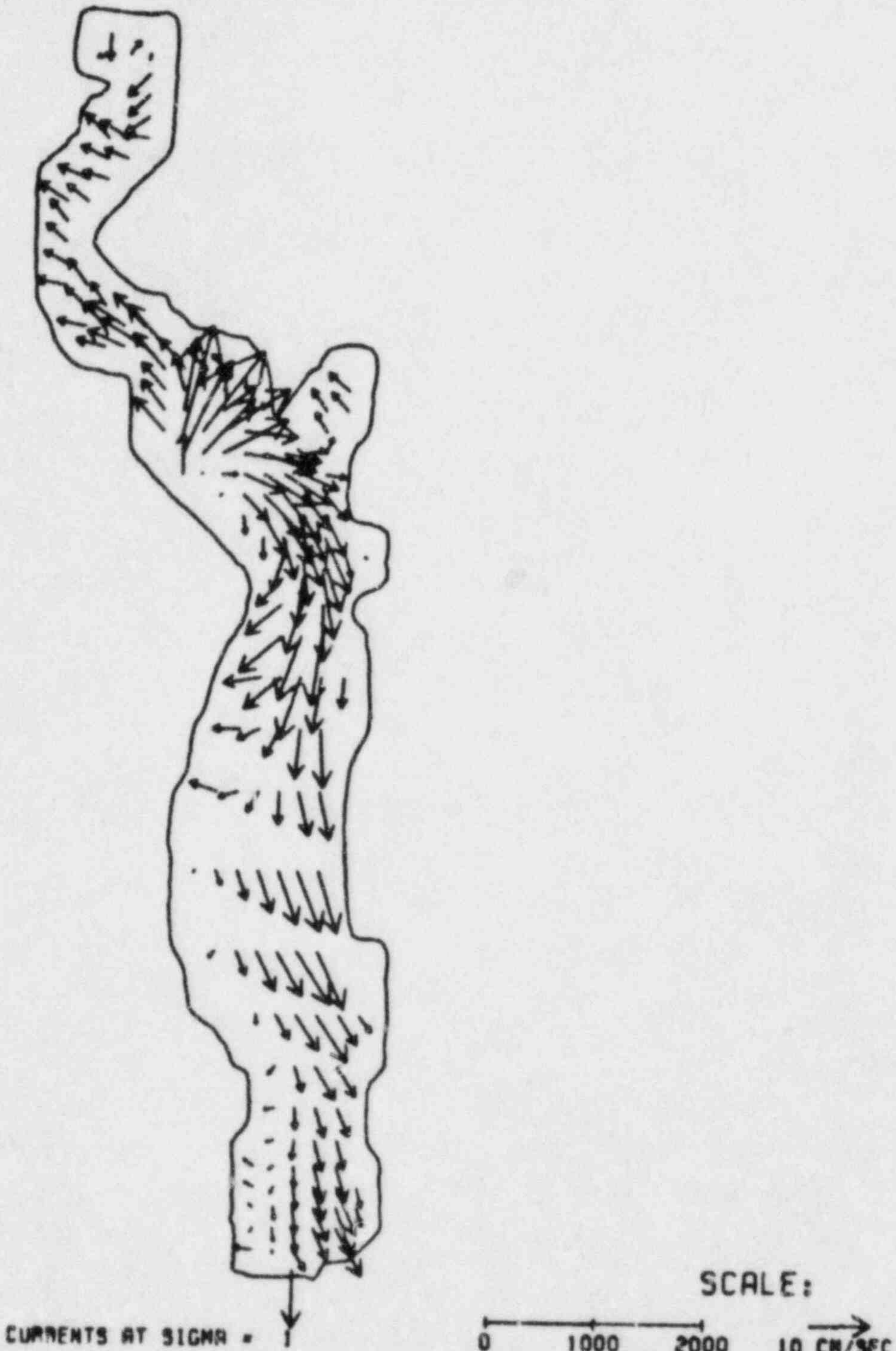


Fig. 6-10. Horizontal Velocities at Grid Points Located at Top Level (Surface) ...End of 8.75 Days.

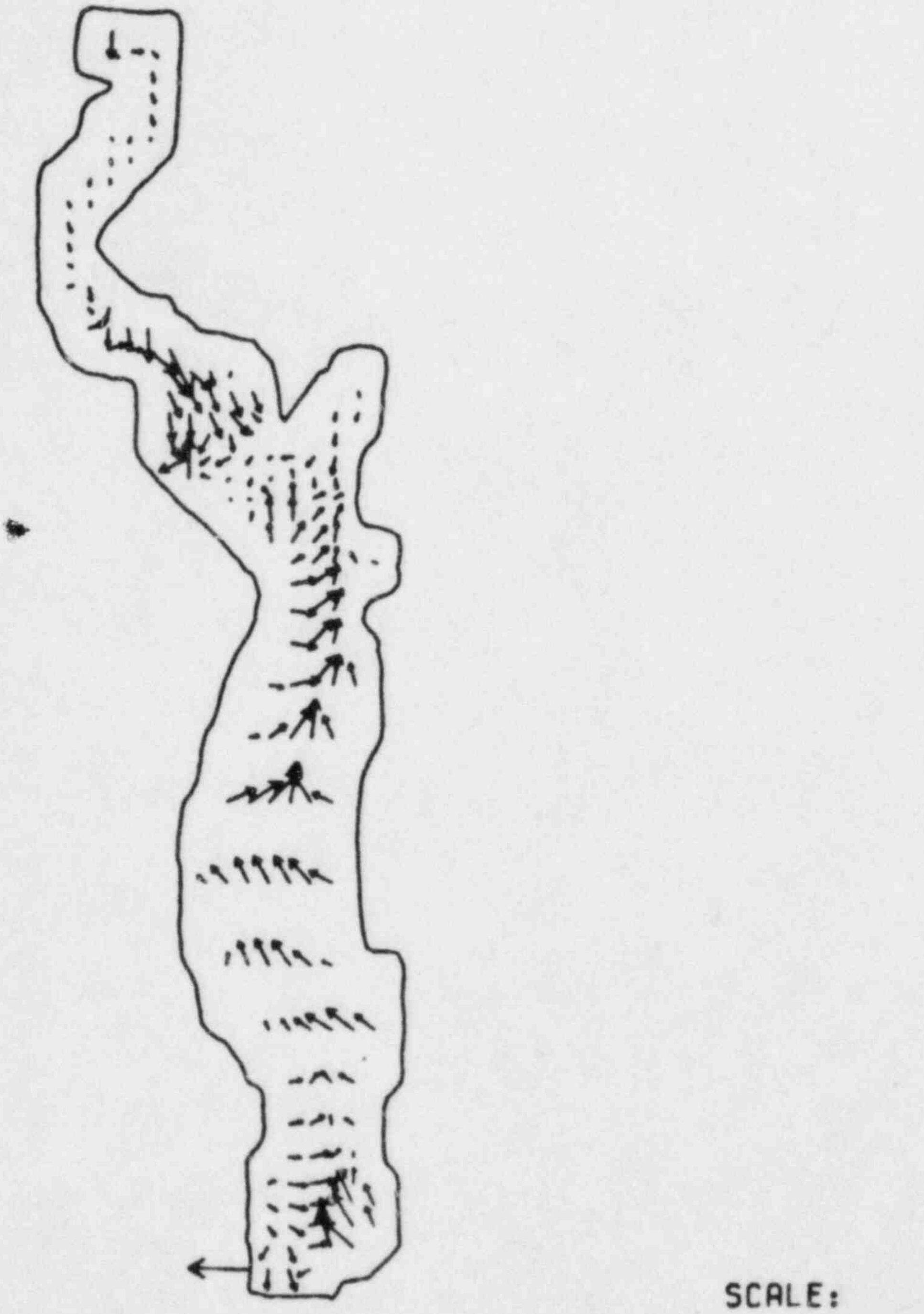


Fig. 6-11. Horizontal Velocities at Grid Points Located at Level 10 (Level Just Above Bottom) ...End of 8.75 Days.

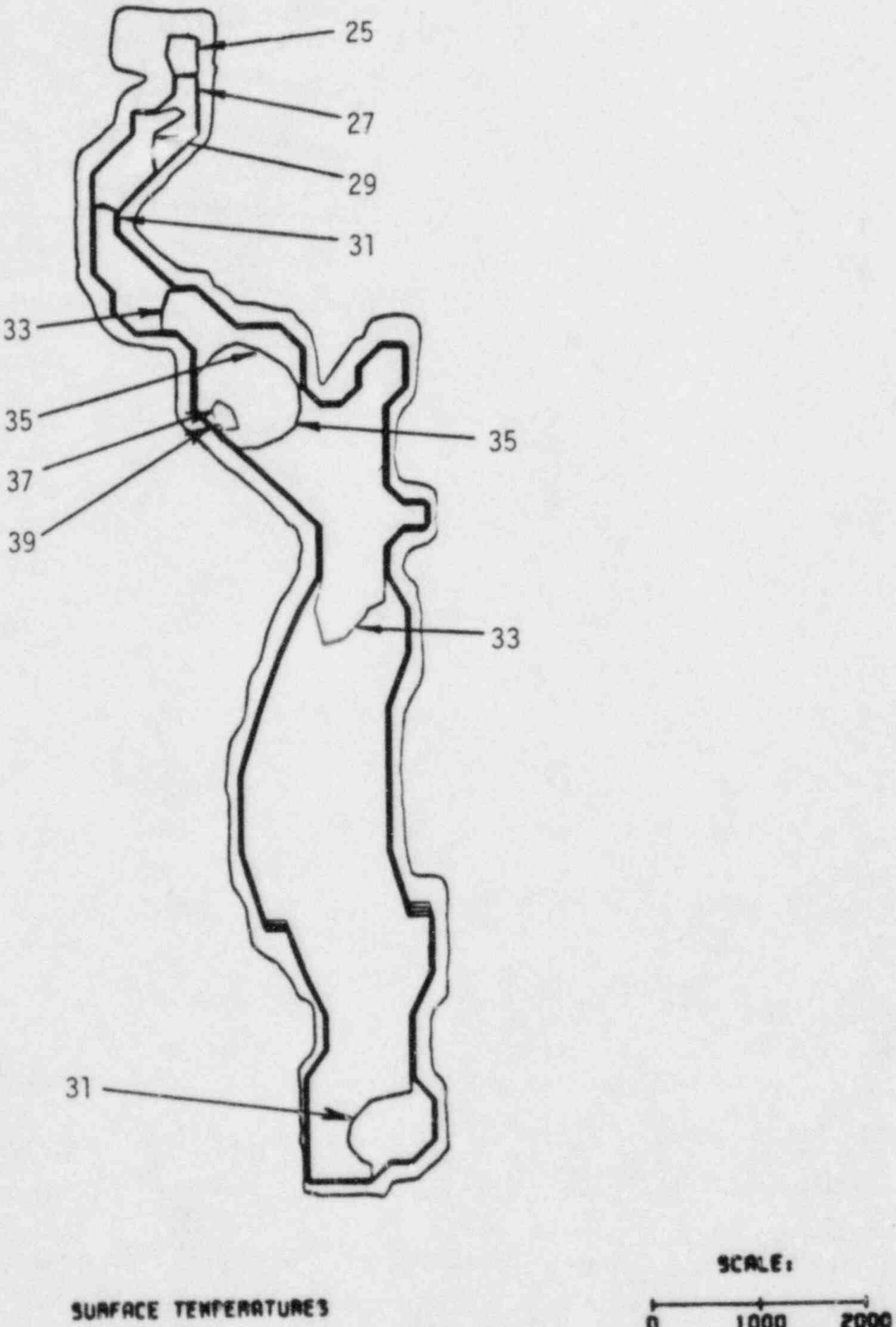


Fig. 6-12. Horizontal Isotherms Located at Top Level (Surface) ...End of 8.75 Days.

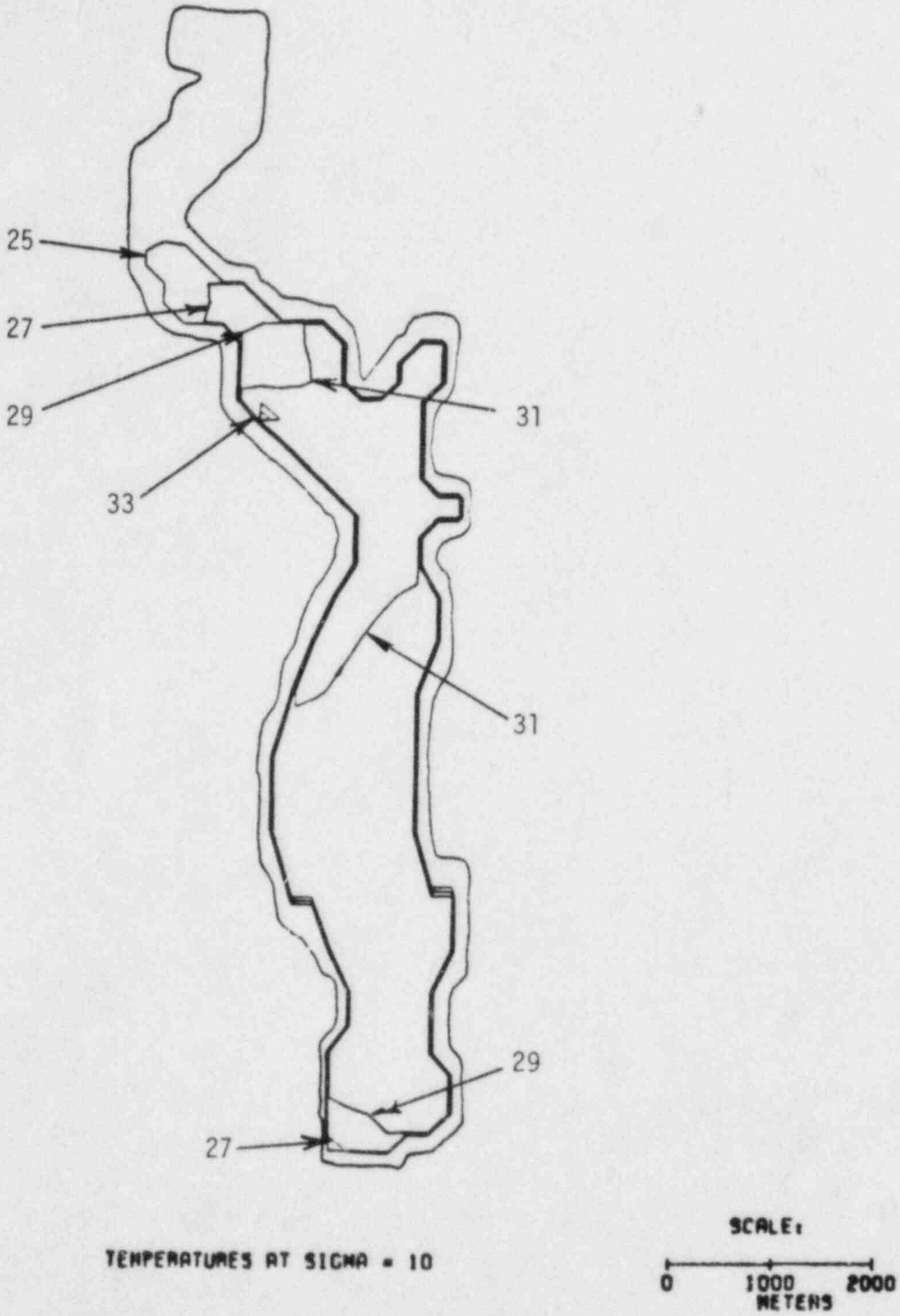


Fig. 6-13. Horizontal Isotherms Located at Level 10 (Level Just Above Bottom) ...End of 8.75 Days.

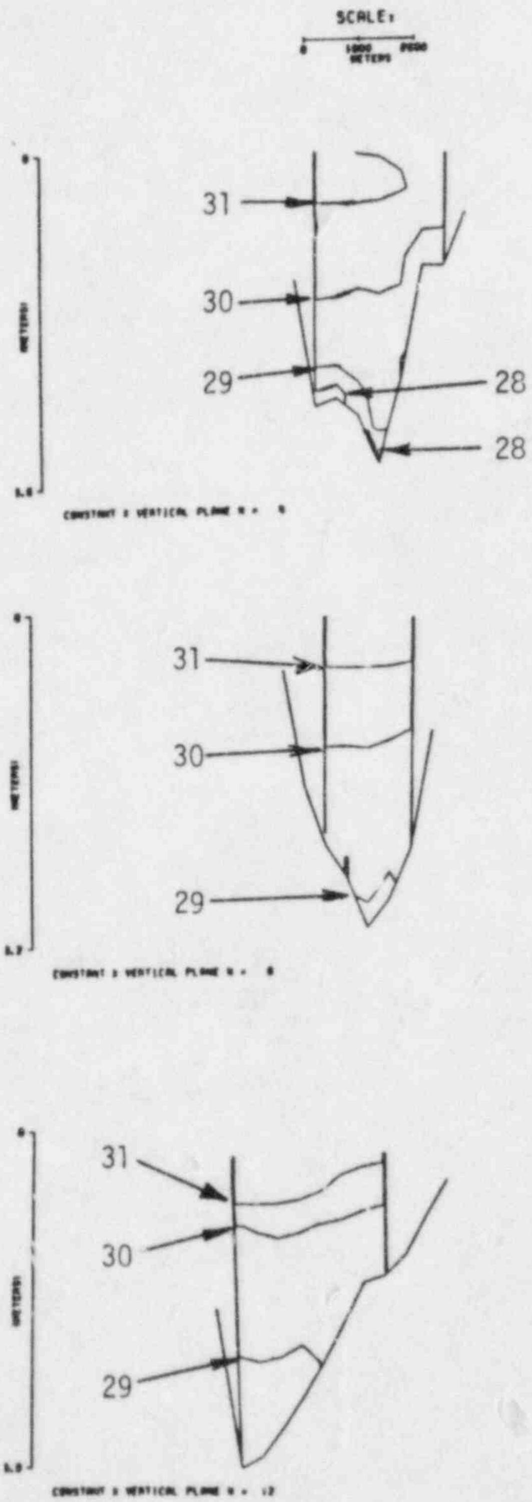


Fig. 6-14. Cross-Sectional Vertical Isotherms in Plane at (a) N=4 ...X Constant, (b) N=8 ...X Constant, and (c) N=12 ...X Constant ...End of 8.75 Days.

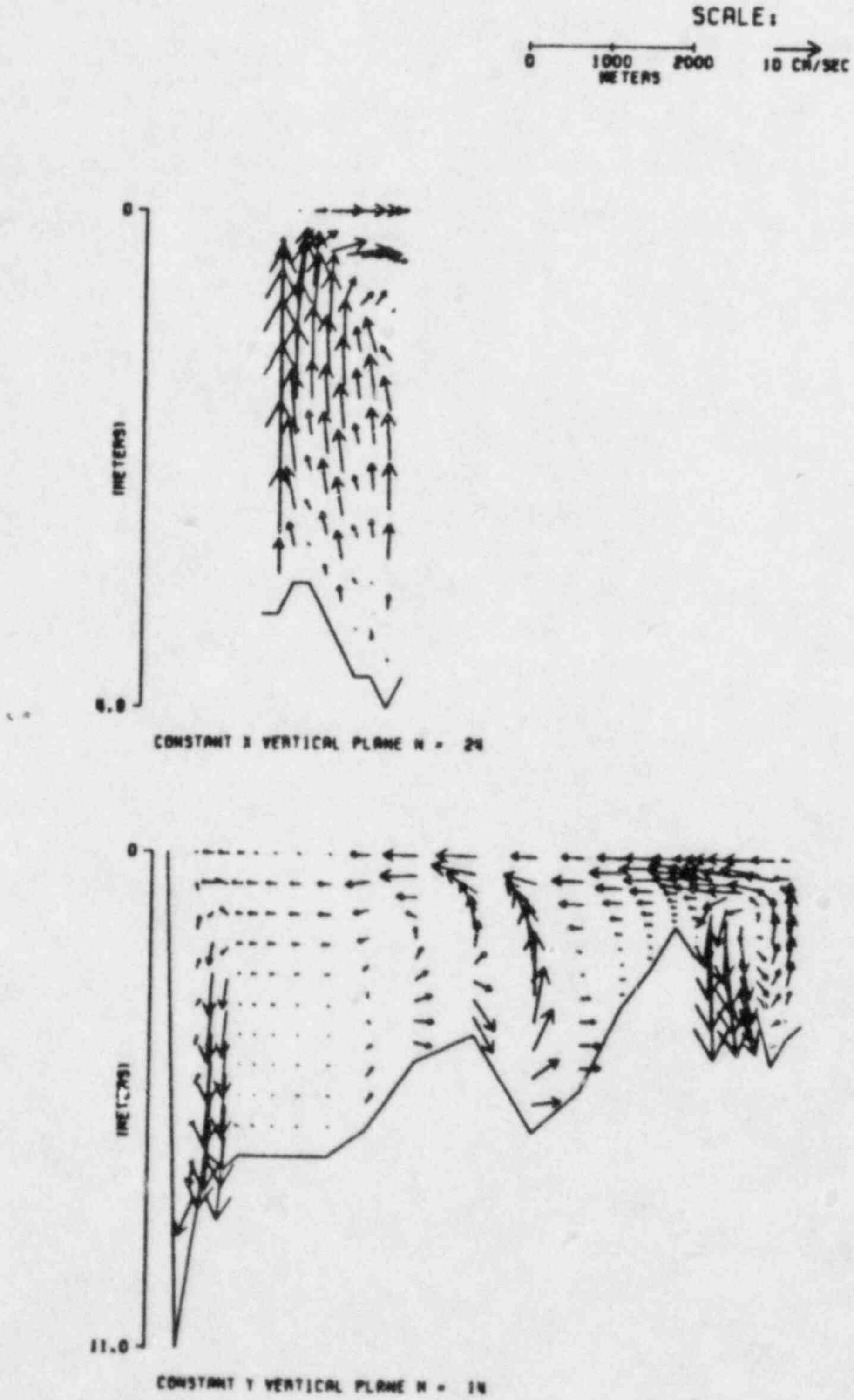


Fig. 6-15. Cross-Sectional Velocities in Plane at (a) N=24 ...X Constant, and (b) M=14 ...Y Constant ...End of 8.75 Days.

Fig. 6-16. JJV and JJW Pointers for H.B. Robinson Run of Paul Model.

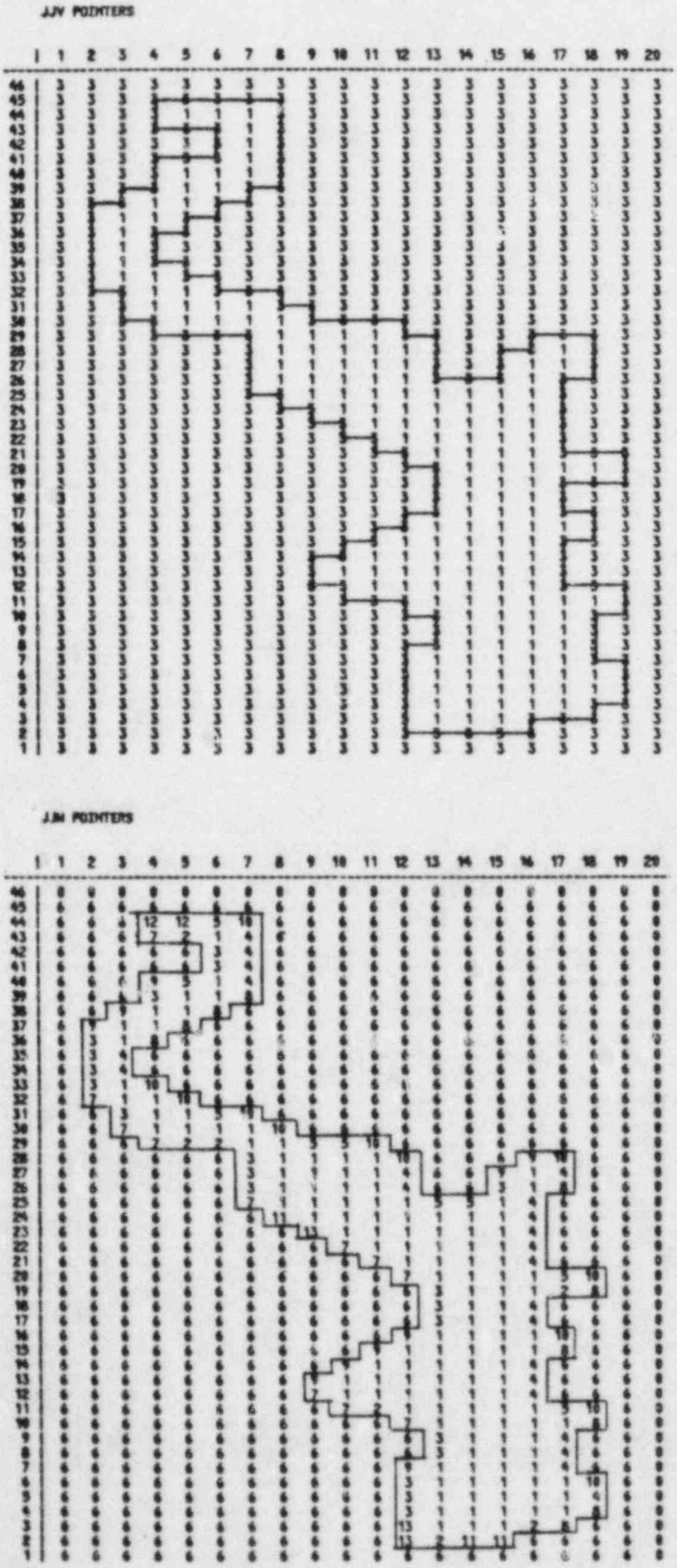


Fig. 6-17. JJT and JJTM Pointers for H.B. Robinson Run of Paul Model.

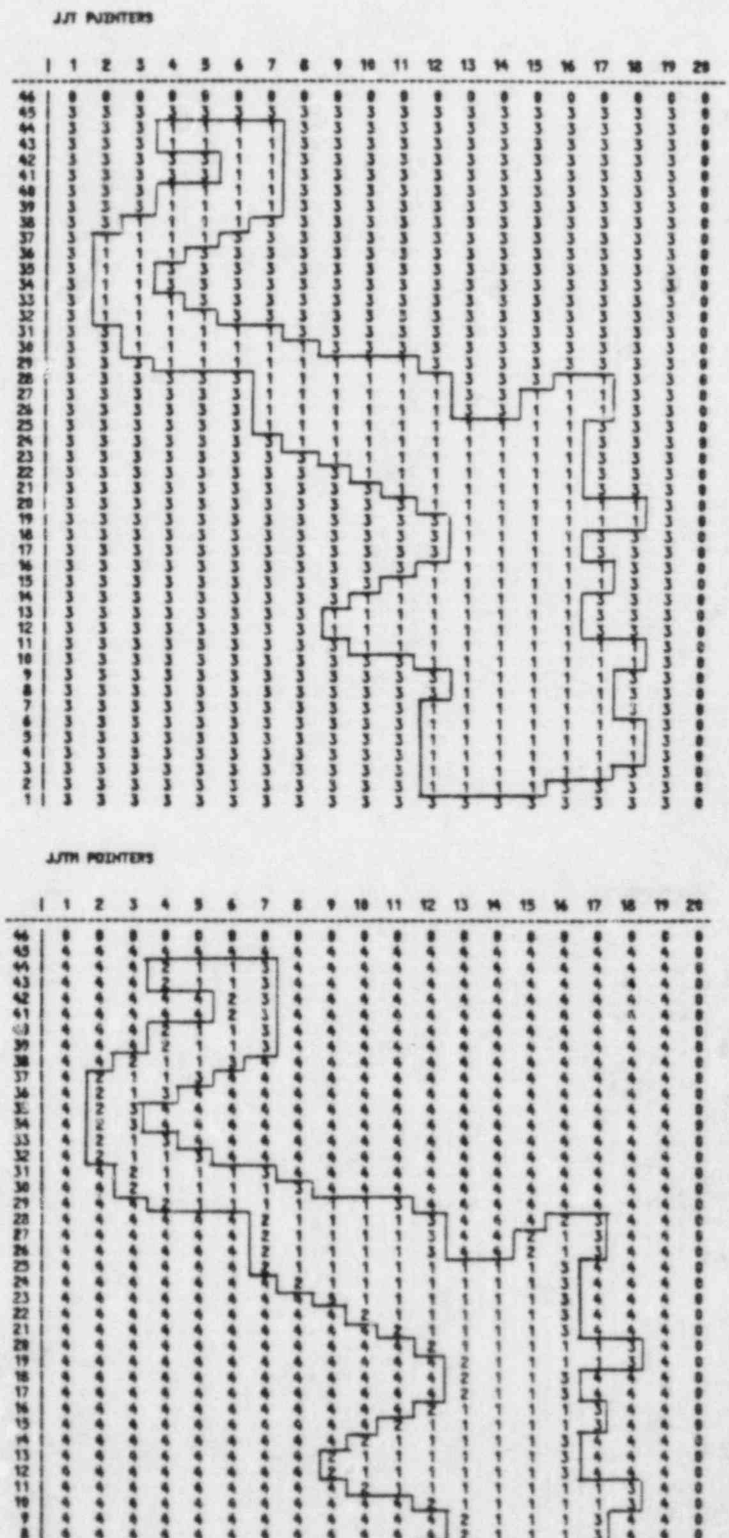
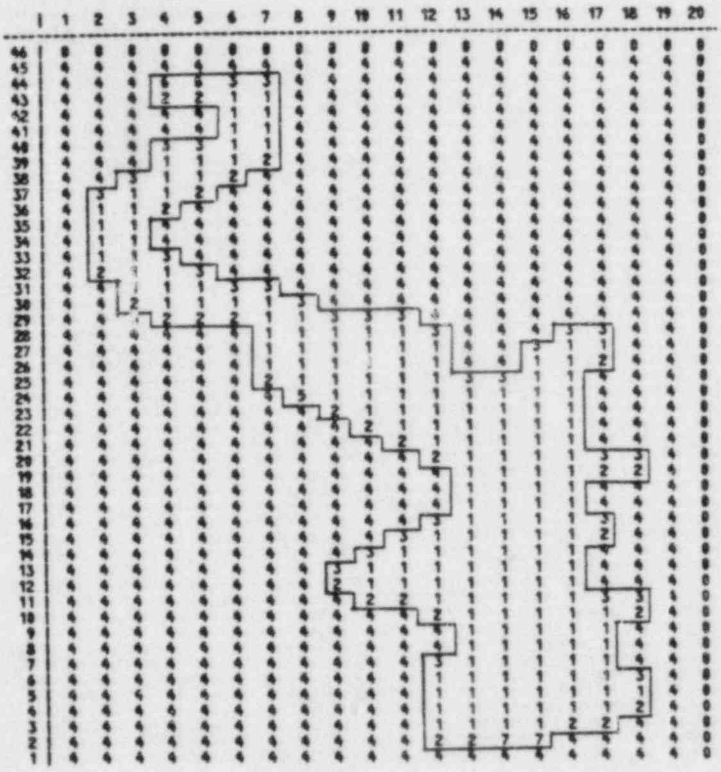
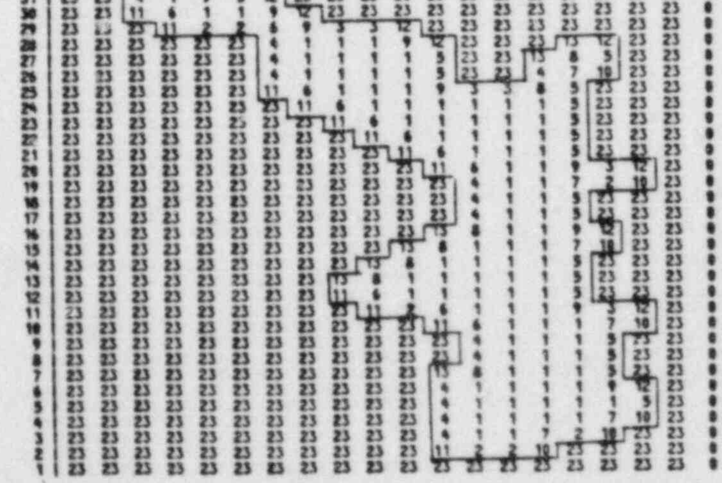


Fig. 6-18. JJTN and JJP Pointers for H.B. Robinson Run of Paul Model.

JJTN POINTERS



JJP POINTERS



7. APPLICATION OF PAUL MODEL TO CATAWBA ULTIMATE HEAT SINK COOLING POND

The Paul Model is applied here to a prototype UHS case. No field data exist for this application. The purpose of the calculation is to predict the character of the flow in the pond, i.e., the relative importance of the physical phenomena acting (wind, buoyant convective motions, discharge/intake flows). In addition to the physical structure of the pond, the pond intake temperature as a function of time is required for prediction. The design consideration is that the maximum temperature at the intake is not to exceed 95°F. Simulations for this problem were made using 50 days of meteorological data identified by R. Codell of NRC as representing the 30-year-worst case conditions. It is preferable to choose the critical period of ambient meteorology from an analysis of 20 years of meteorological data from an offsite (usually distant) location as compared to only one year of onsite data. Following the NRC recommendations, the nominal starting time of the accident was the 325th hour of the meteorological data period. Pond area and volume were taken to be constant at 1.79×10^6 ft^2 and 2.18×10^7 ft^3, respectively.

A map of the geometry of the Catawba UHS pond including local bottom depths is given in Fig. 7-1. Two discharges and one intake are present. The discharges are at the surface and the intake is located near the bottom. The grid used measures 30 × 25 × 10 cells with 25 in the X direction, 30 in the Y direction, and 10 in the Z direction. The cell size is 30.48 m by 30.48 m in the horizontal direction and the cell varies in size in the vertical direction depending on bottom topography to assure 10 equally spaced cells. Fig. 7-2 presents the grid used for model simulation, and the local bottom depths on a node by node basis as simulated and superimposed on the grid structure. Note that many cells are on dry land and are not used in the calculation. The grid representing the Catawba pond was chosen to have approximately the same area when its surface is at 570 ft MSL. The grid chosen has smaller surface area by about 1% and a larger volume by about 9%. The heat load into the pond is represented as a function of time in Fig. 7-3.

Characteristics of the Paul model run for Catawba were:

(a) an initial run of 5 days before the simulated accident in order to estimate natural pond conditions at the beginning of the accident.

At the start of this 5 day run, the pond was assumed to be at a temperature of 27.4°c for the top half and 26.4°C for the bottom half. The value 27.4°C was computed to be the average equilibrium temperature for the 13.5 day period before the start of this run; i.e., 8.5 + 5.0 = 13.5 days before the presumed start of the accident. At the end of this 5 day run of the Paul model, the pond temperature had risen to 28.5°C. This temperature is at the location of the intake; temperatures in the remainder of the pond were only a few tenths of a degree different (generally higher since the intake is located near the bottom). Horizontal velocity predictions at the end of these five days (equivalent to the start of the accident) appear in Figs. 7-4 to 7-15. They reveal a flow pattern dominated by the wind with a bottom flow going in a nearly opposite direction as compared with the surface flow. Surface currents are in the direction of the wind as expected. Surface velocities are in the range 1-2 cm/sec. Horizontal velocities at Level 5 from the surface (Level 1 = surface; Level 10 is just above bottom) are nearly zero. Water travels a short distance on the surface of this pond before it approaches a solid boundary and then travels below the surface.

(b) initiation of accident conditions for a 4-hour period using the results of (a) initial conditions.

These first 4 hours of the accident are run separately because the flow rate is 61,000 gpm into the pond and this flow rate is reduced to 33,200 gpm after 4 hours into the accident. Velocity boundary conditions must be changed after this 4 hour period. Predictions at the end of the 4 hours simulation appear in Figures 7-16 to 7-27. Clearly, the plumes from the two discharges have traveled only part way towards the intake in these 4 hours. The hydraulic residence time for the pond is roughly 2 days. Part of the pond is dominated by the wind induced flow and the other part (near the discharges) is dominated by the momentum and buoyancy of the warm discharges. Note the return flow at Level 10 for these discharges.

(c) continuation of the computer run for 9 more days under reduced flow conditions (33,200 gpm).

Pond flow and temperatures for the time of peak intake temperature (6.38 days after the start of the accident) is presented in Figs. 7-28 to 7-49. Predictions for the time 9 1/6 days after the start of the accident are presented in Figs. 7-50 to 7-61. Fig. 7-62 presents the time history of the intake temperature over this period of time. The maximum intake temperature was 96.3°F (35.7°C) and this temperature occurred 6.38 days after the start of the accident.

Interesting features of these graphical predictions are:

(i) The pond becomes rapidly dominated by the intake/discharge flow circulations and buoyant convective motions due to the warm water discharge. Circulations due to wind influence appear minor during this particular accident scenario. Recall that wind-induced circulations were dominant before the start of the accident. Surface velocities are now in the range of 3-4 cm/s.

(ii) Circulation patterns in vertical cross sections reveal that a significant return flow pattern is set up to provide entrainment water to mixing of both thermal discharges. Three-dimensional eddies are forming which are providing strong vertical and lateral mixing. A typical cross-section of two eddies is given in Fig. 7-39. These circulations tend to bring all parts of the pond into the mixing process.

(iii) The temperature distribution in the pond after 6.38, and 9 1/6 days is nearly fully mixed vertically. Surface to bottom temperatures vary only about 0.1 to 0.5°C at any location. Surface temperatures do decrease from discharge to intake location by about 3°C. The temperature distribution may be represented by a one-dimensional, vertically fully-mixed scenario with all portions of the pond contributing to mixing. Density currents and entrainment demand of the plume apparently cause more remote sections of the pond to contribute to mixing.

(iv) After 6.38 days, the pond appears to be losing more heat than is being input. The velocities in the pond are being reduced due to the lower temperature differences. Eventually the pond will return to being dominated by the wind.

Finally, it should be pointed out that the intake temperature history (in absolute temperatures, not necessarily in terms of excess temperatures over the before-accident values) is very sensitive to the ambient temperature used at the start of the accident. We used 28.4°C based on our computations described above for the 13.5 day period prior to the accident. We believe that our initial pond temperature is in a narrow range of possible correct values since studies using a completely mixed pond model showed a range of 28.1 to 28.7°C for this initial temperature. This range 28.1 to 28.7°C was determined by running a completely mixed model for 13.5 days before the accident starting with 21.1°C (70°F), 26.7°C (80°F), and 32.2°C (90°F) as initial pond temperatures. This wide range of starting temperatures led to a very narrow range of pond initial temperatures at the start of the accident 13.5 days later. Our prediction of 28.5°C is within this narrow range (28.1-28.7°C) of possible correct values.

Application of Zero-Dimensional Models

Alternative computations for the Catawba UHS cooling pond were made using two alternative fully-mixed (zero-dimensional) pond models. The first model, designated "Method 1", uses the equations for calculating surface heat transfer given by Codell and Nuttle (Ref. 1). Method 2 is based on the analysis given by Ryan and Harleman (Ref. 2) as discussed earlier.

Predictions of pond temperature obtained by the two methods are given in Figures 7-63 to 7-66. Figures 7-63 and 7-64 summarize the predictions of Method 1 for the period before and after the nominal start of the hypothetical accident. To provide a better indication of the effect of plant heat rejection, pond temperature without heat rejection is also shown during the accident period. Similar results are presented for Method 2 in Figures 7-65 and 7-66, respectively. In both cases, the point of maximum pond temperature with heat rejection coincides with the point of maximum natural pond temperature indicating that the effect of the accident heat load is superimposed on the natural variation of pond temperature. Moreover, our sensitivity studies showed that the nominal starting point of the accident does indeed yield the highest intake temperature, but that shifts of up to several hours in either direction from the nominal starting time alters the maximum predicted temperature by less than 0.1° F. A maximum intake temperature of 101.8° F is predicted by Method 1 and a maximum intake temperature of 98.0° F is predicted by Method 2, both occurring approximately 150 hours after the start of the accident. These values were obtained using a pond temperature of 85°F at the beginning of the 50-day period.

Our sensitivity analysis showed that a 10°F difference in assumed initial temperature (at -324 hours) produces a 0.3° F difference of the same sign at the time of maximum intake temperature, both with and without the accident. This is as expected since the pond behaves as a first-order system with a time constant of roughly 5.6 days. Thus, initial temperature differences are reduced by a factor of roughly $\exp(-t/\tau)$, where t is elapsed time (474 hours to maximum pond temperature) and τ is the pond time constant. Also, a time constant of several days means that the pond temperature will lag the diurnal variations in solar loading by 1/4 cycle or roughly 6 hours.

Time variation of the surface heat transfer coefficient, K, and the equilibrium temperature, E, predicted by Method 1, both before and after the start of the hypothetical accident, are shown in Figures 7-67 through 7-70. Large diurnal swings are observed with the equilibrium temperature varying between roughly 70° F and 150° F. Fig. 7-71 reveals that the power plant heat load is of the same order of magnitude as the solar input. For ponds used in normal cooling, solar input is much larger than plant input.

Application of One-Dimensional Model

Considering that the flow pattern was found to be one-dimensional from the Paul computer run, it is interesting to apply a one-dimensional model to the pond. We chose the MITEMP model (Ref. 3) using its longitudinally-dispersive submodel option. This submodel involves the schematization of the pond as a channel with the discharge at one end and intake at the other. The heated discharge is transported to the intake by advection and diffusion processes. The difficulty comes in schematizing the irregular pond structure into a idealized open channel configuration. The Catawba pond was split into two separate independent ponds where each pond had a different intake and discharge temperature as a function of time. Dimensions for ponds A and B are:

	A	B
Length	340 m	780 m
Depth	3.58 m	3.76 m
Width	157 m	145 m

A "combined" intake temperature was computed at each time step from each leg of the pond by weighing the predicted intake temperatures by the flow rate through the respective segment. The peak temperature occurred at 6 days, 8 hours after the start of the accident and was 97.0°F (see Fig. 7-72 for intake temperature history). As expected, the one-dimensional model compared quite favorably with the Paul model result, since they both represented a one-dimensional pond.

Criteria have been proposed by Jirka, et al. (Ref. 3), in an attempt to determine the character of flow in a cooling pond based only on easily-computed characteristic numbers. The heat loading parameter, Φ, is defined as the artificial heat loading divided by the pond area. A Φ value above 0.2 identifies the region of validity for use of the "pond number," P. For the pond schematization described above, the Φ value for the entire pond was 1.7. The pond numbers were then calculated for the "two-channel" schematization described above. The values of P are time-dependent because of the time-dependent heat loading, and range from 0.025 to 0.21. According to the classification scheme of Jirka, et al., $P > 0.5$ for vertically-mixed ponds with longitudinal dispersion, while $P < 0.5$ for deep stratified cooling ponds. The pond number criterion indicates a stratified pond in this case and is not represented by the Paul Model prediction. Thus, we cannot decide ahead of time on the basis of such guidelines whether the pond will be stratified or vertically-mixed. The Paul model calculations are a more reliable indicator of actual stratification than empirical relationships that are themselves proposed with the caution ... "As yet, a complete analysis of the shallow pond behavior as a function of governing parameters is lacking." (Ref. 3).

We have discussed this discrepancy between expectations based on P and the predictions of the Paul model with one of the developers of MITEMP, (Dr. Eric Adams, MIT), and agree with his interpretation that the difference probably stems from the use of data from much larger ponds to obtain the pond number criterion, and on the presence at Catawba of significant wind shear effects for a pond of this size during the study period. We conclude that it is not possible as yet to determine a priori whether or not the flow in a ultimate heat sink pond will be one-dimensional. We would place the greatest confidence in model predictions from a three-dimensional model such as the Paul model, which can predict the full range of pond thermal stratification and circulation.

Paul Model Input for Catawba Run

This section presents the details of the input to the Paul Model following the user's guide instructions presented in Chapter 4. Figure 7-73 provides a sketch of the computational grid superimposed over the Catawba pond with key dimensions identified. The pond has two discharges, each is simulated from 9 1/2 of the total 10 cells in the vertical direction. The bottom half cell always has zero velocity due to no-slip boundary conditions. A sketch of the simulation of the discharges is given in Fig. 7-74. The bottom intake is simulated with a specified velocity at the ninth cell from the surface. The intake is located near the middle of the pond at the pond boundary.

The model predictions were made from four continuation runs. They are:

(1) calculations of the ambient pond environment for a period of five days before the accident. The model input is listed in Tables 7-1 and 7-2. Table 7-3 provides the main input to the model and Table 7-4 the meteorological input data. The pointers are not shown here but are very similar to the pointers used for continuation runs 2-4 presented below.

(2) calculations made for the first four hours of the accident in which the flow rates at discharge and intake were large and different than for the remaining two continuation runs. Tables 7-4 and 7-5 provide the main and meterological input, respectively, to the model. Figs. 7-75 to 7-77 present a sketch of the pointers used in continuation runs 2-4.

(3) calculations made for the next five days of the accident. The pointers in Figs. 7-75 to 7-77 apply here as well and are not changed. Tables 7-6 and 7-7 present the main and meteorological input data for this continuation run.

(4) calculations made for the final five days of the run. Tables 7-8 and 7-9 provide the set of input conditions for the last continuation run.

References

1. R. Codell and W. K. Nuttle, "Analysis of Ultimate Heat Cooling Ponds." U.S. Nuclear Regulatory Commission Report NUREG-0693, November, 1980.

2. P.J. Ryan and D.R.F. Harleman, "An Analytical and Experimental Study of Transient Cooling Pond Behavior." Report No. 161, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., January, 1973.

3. G. Jirka, M. Watanabe, K. Octavio, C. Cerco, and D.R.F. Harleman, "Mathematical Predictive Models for Cooling Ponds and Lakes. Part A: Model Development and Design Considerations, Part B: User's Guide." Report No. 238. Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology. December 1978.

Table 7-1. Summary of Key Input Parameters in Paul Model Run for Catawba

b_o = maximum distance in x direction = 793 m
h_o = maximum pond depth (reference) = 9.14 m
u_o = reference velocity = 10 cm/s

DT = 7.749×10^{-5}	RE = 35.4	BH = 3.0
DEL = 1.0	RD = 1.88	BVO = 0.1
EPST = 10^{-5}	FR = 1.16×10^{-2}	BVI = 2.25×10^{-3}
EPS = 10^{-6}	RATIO = 69.7	THV = 1.0
RA(1) = 1000.0	PR = 5.0	THP = 0.55
RA(2) = 283.0	TWX = 10^{-8}	THC = 0.5
RA(3) = -3.98	TWY = 10^{-8}	THT = 1.0
RA(4) = 503.4	PLEV = 1000.	BET = 0.0
RA(5) = 67.3	AH = 15.0	BETI = 1.0
RA(6) = 0.0	AVO = 0.1	
RA(7) = 0.0	AVI = 2.25×10^{-3}	
RA(8) = 0.0		

Table 7-2. Main Input to Paul Model for Continuation Run No. 1: Five Days Before Start of Accident.

```
     20
CATAHBA NUCLEAR POWER PLANT  -- POND ?ID 31 X 26, DS=30.48 METERS
      0       0      09       0
      2       2       2       2       2       2       2       2       2       2
      1      30      25      10
      1       1       2    2400       0       1       1     480    3000       1     100     100       1
    100
      4       2       2       0       2       0       0     480      01       0
0.000155  1.0        .00001     .000001
1000.0    283.0      -3.98      503.37     67.26
152.4     116.1288   0.01056    1.0        83.3374    0.018      0.018      1000.
5000.0    10.0       0.0        5000.0     10.0       0.0        0.000155   15.0
1.0       0.55       0.50       1.0        0.0        1.0
1.0       1.0        900.0      914.36
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.100000  0.100000  0.100000
  0.100000  0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.100000  0.266667  0.333333  0.166667
  0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.100000  0.100000  0.166667  0.366667  0.266667
  0.100000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.100000  0.100000  0.100000  0.300000  0.200000
  0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.166667  0.433333  0.100000
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.100000  0.100000  0.100000  0.166667  0.500000  0.200000  0.100000
  0.166667  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.466667  0.666667  0.533333  0.433333  0.533333  0.600000  0.166667  0.333333
  0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.100000
  0.100000  0.233333  0.333333  0.733333  0.733333  0.500000  0.400000  0.166667
  0.200000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.333333  0.333333  0.766667  0.700000  0.566667  0.300000  0.400000
  0.266667  0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  0.0       0.366667  0.366667  0.866667  0.833333  0.766667  0.833333  1.000000
  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Table 7-2. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.366667	0.366667	0.866667	0.900000	1.000000	1.000000	1.000000
61.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64.	0.0	0.366667	0.366667	0.833333	1.000000	0.833333	0.333333	0.500000
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.100000	0.533333	0.900000	1.000000	1.000000	1.000000	0.0
69.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72.	0.100000	0.833333	0.833333	1.000000	1.000000	0.833333	0.833333	0.0
73.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.100000
76.	0.500000	0.900000	1.000000	1.000000	0.933333	0.833333	0.0	0.0
77.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.	0.0	0.0	0.100000	0.366667	0.200000	0.200000	0.500000	0.800000
80.	0.900000	0.933333	0.900000	0.766667	0.600000	0.0	0.0	0.0
81.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82.	0.0	0.100000	0.100000	0.100000	0.100000	0.133333	0.100000	0.100000
83.	0.100000	0.100000	0.533333	0.733333	0.766667	0.833333	0.800000	0.733333
84.	0.766667	0.733333	0.600000	0.400000	0.0	0.0	0.0	0.0
85.	0.0	0.0	0.100000	0.100000	0.100000	0.166667	0.100000	0.100000
86.	0.166667	0.166667	0.266667	0.600000	0.566667	0.533333	0.533333	0.533333
87.	0.633333	0.800000	0.866667	0.800000	0.633333	0.466667	0.266667	0.333333
88.	0.300000	0.266667	0.233333	0.0	0.0	0.0	0.0	0.0
89.	0.0	0.100000	0.166667	0.300000	0.366667	0.333333	0.400000	0.566667
90.	0.633333	0.700000	0.666667	0.700000	0.766667	0.766667	0.500000	0.566667
91.	0.600000	0.800000	0.700000	0.166667	0.100000	0.100000	0.100000	0.100000
92.	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
93.	0.100000	0.300000	0.366667	0.333333	0.300000	0.333333	0.433333	0.433333
94.	0.233333	0.333333	0.366667	0.433333	0.266667	0.166667	0.100000	0.166667
95.	0.500000	0.500000	0.166667	0.0	0.0	0.0	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.300000
97.	0.266667	0.100000	0.100000	0.100000	0.100000	0.333333	0.133333	0.100000
98.	0.0	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.100000
99.	0.433333	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.0	0.166667	0.400000
103.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.100000	0.166667	0.166667
107.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.0	0.0	0.0		
116.	0.04261	0.02874						
117.	0.04319	0.03035						

Table 7-2. Continued

118.	0.04373	0.03201
119.	0.04425	0.03371
120.	0.04473	0.03545
121.	0.04517	0.03724
122.	0.04558	0.03907
123.	0.04596	0.04095
124.	0.04629	0.04286
125.	0.04658	0.04482
126.	0.04682	0.04682
127.	0.04703	0.04887
128.	0.04718	0.05095
129.	0.04729	0.05307
130.	0.04734	0.05523
131.	0.04734	0.05743
132.	0.04729	0.05967
133.	0.04719	0.06194
134.	0.04703	0.06425
135.	0.04680	0.06659
136.	0.04652	0.06897
137.	0.04967	0.07351
138.	0.05295	0.07821
139.	0.05635	0.08307
140.	0.05987	0.08810
141.	0.06352	0.09330
142.	0.06731	0.09867
143.	0.07122	0.10421
144.	0.07526	0.10992
145.	0.07944	0.11581
146.	0.08376	0.12187
147.	0.08821	0.12811
148.	0.09281	0.13453
149.	0.09754	0.14113
150.	0.10242	0.14792
151.	0.10745	0.15488
152.	0.11262	0.16204
153.	0.11794	0.16938
154.	0.12341	0.17691
155.	0.12904	0.18462
156.	0.13481	0.19253
157.	0.13256	0.18211
158.	0.13011	0.17204
159.	0.12749	0.16231
160.	0.12472	0.15292
161.	0.12180	0.14387
162.	0.11875	0.13516
163.	0.11557	0.12679
164.	0.11230	0.11875
165.	0.10893	0.11104
166.	0.10547	0.10365
167.	0.10195	0.09658
168.	0.09838	0.08983
169.	0.09475	0.08339
170.	0.09109	0.07725
171.	0.08741	0.07141
172.	0.08371	0.06587
173.	0.08001	0.06062
174.	0.07631	0.05565
175.	0.07263	0.05095
176.	0.06897	0.04652
177.	0.07511	0.05066

Table 7-3. Meteorological Data Input to Paul Model for Continuation Run No. 1: Five Days Before Start of Accident.

1.	4.603	88.000	70.000	5741.434	29.190
2.	4.661	88.050	70.050	5734.000	29.189
3.	4.718	88.100	70.100	5726.570	29.188
4.	4.776	88.150	70.150	5719.141	29.187
5.	4.833	88.200	70.200	5711.711	29.186
6.	4.891	88.250	70.250	5704.281	29.185
7.	4.948	88.300	70.300	5696.848	29.184
8.	5.006	88.350	70.350	5689.418	29.183
9.	5.063	88.400	70.400	5681.988	29.182
10.	5.121	88.450	70.450	5674.559	29.181
11.	5.178	88.500	70.500	5667.129	29.180
12.	5.236	88.550	70.550	5659.695	29.179
13.	5.294	88.600	70.600	5652.266	29.178
14.	5.351	88.650	70.650	5644.836	29.177
15.	5.409	88.700	70.700	5637.406	29.176
16.	5.466	88.750	70.750	5629.977	29.175
17.	5.524	88.800	70.800	5622.543	29.174
18.	5.581	88.850	70.850	5615.113	29.173
19.	5.639	88.900	70.900	5607.684	29.172
20.	5.696	88.950	70.950	5600.254	29.171
21.	5.754	89.000	71.000	5592.824	29.170
22.	5.927	89.100	71.000	5523.008	29.169
23.	6.099	89.200	71.000	5453.191	29.168
24.	6.272	89.300	71.000	5383.375	29.167
25.	6.444	89.400	71.000	5313.559	29.166
26.	6.617	89.500	71.000	5243.746	29.165
27.	6.790	89.600	71.000	5173.930	29.164
28.	6.962	89.700	71.000	5104.113	29.163
29.	7.135	89.800	71.000	5034.297	29.162
30.	7.307	89.900	71.000	4964.480	29.161
31.	7.480	90.000	71.000	4894.668	29.160
32.	7.653	90.100	71.000	4824.852	29.159
33.	7.825	90.200	71.000	4755.035	29.158
34.	7.998	90.300	71.000	4685.219	29.157
35.	8.170	90.400	71.000	4615.402	29.156
36.	8.343	90.500	71.000	4545.590	29.155
37.	8.516	90.600	71.000	4475.773	29.154
38.	8.688	90.700	71.000	4405.957	29.153
39.	8.861	90.800	71.000	4336.141	29.152
40.	9.033	90.900	71.000	4266.324	29.151
41.	9.206	91.000	71.000	4196.512	29.150
42.	9.033	90.900	71.050	4168.309	29.149
43.	8.861	90.800	71.100	4140.109	29.148
44.	8.688	90.700	71.150	4111.910	29.147
45.	8.516	90.600	71.200	4083.712	29.146
46.	8.343	90.500	71.250	4055.513	29.145
47.	8.170	90.400	71.300	4027.313	29.144
48.	7.998	90.300	71.350	3999.113	29.143
49.	7.825	90.200	71.400	3970.913	29.142
50.	7.653	90.100	71.450	3942.713	29.141
51.	7.480	90.000	71.500	3914.513	29.140
52.	7.307	89.900	71.550	3886.314	29.139
53.	7.135	89.800	71.600	3858.114	29.138
54.	6.962	89.700	71.650	3829.914	29.137
55.	6.790	89.600	71.700	3801.714	29.136
56.	6.617	89.500	71.750	3773.514	29.135
57.	6.444	89.400	71.800	3745.314	29.134

Table 7-4. Main Input to Paul Model for Continuation Run No. 2: Four Hours After Start of Accident.

1.	20												
2.	CATAWBA NUCLEAR POWER PLANT -- POND GRID 31 X 26, DS=30.48 METERS												
3.	1	8	09	0									
4.	2	2	2	2	2	2	2	2	2	2			
5.	2	30	25	10									
6.	2	1	2	160	0	2	1	040	1201	1	100	100	1
7.	100												
8.	4	2	002	0	2	0	0	040	01	0			
9.	0.0000775	1.0	.00001	.000001									
10.	1000.0	283.0	-3.98	503.37	67.26								
11.	152.4	116.1288	0.01056	1.0	83.3374	0.018	0.018	1000.					
12.	5000.0	10.0	0.0	5000.0	10.0	0.0	0.000155	15.0					
13.	1.0	0.55	0.50	1.0	0.0	1.0							
14.	1.0	1.0	900.0	914.36									
15.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
16.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
17.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
18.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
19.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
20.	0.0	0.0	0.0	0.0	0.0	0.100000	0.100000	0.100000					
21.	0.100000	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.0					
22.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
23.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
24.	0.0	0.0	0.0	0.0	0.100000	0.266667	0.333333	0.166667					
25.	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0					
26.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
27.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
28.	0.0	0.0	0.0	0.100000	0.100000	0.166667	0.3666[illegible]7	0.266667					
29.	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0					
30.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
31.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
32.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.300000	0.200000					
33.	0.100000	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
34.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
35.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
36.	0.0	0.0	0.0	0.0	0.0	0.166667	0.433333	0.100000					
37.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
38.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
39.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
40.	0.0	0.100000	0.100000	0.100000	0.166667	0.500000	0.200000	0.100000					
41.	0.166667	0.100000	0.0	0.0	0.0	0.0	0.0	0.0					
42.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
43.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
44.	0.466667	0.666667	0.533333	0.433333	0.533333	0.600000	0.166667	0.333333					
45.	0.100000	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
46.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
47.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.100000					
48.	0.100000	0.233333	0.333333	0.733333	0.733333	0.500000	0.400000	0.166667					
49.	0.200000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0					
50.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
51.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
52.	0.0	0.333333	0.333333	0.766667	0.700000	0.566667	0.300000	0.400000					
53.	0.266667	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
54.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
55.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
56.	0.0	0.366667	0.366667	0.866667	0.833333	0.766667	0.833333	1.000000					
57.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					

Table 7-4. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.366667	0.366667	0.866667	0.900000	1.000000	1.000000	1.000000
61.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64.	0.0	0.366667	0.366667	0.833333	1.000000	0.833333	0.333333	0.500000
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.100000	0.533333	0.900000	1.000000	1.000000	1.000000	0.0
69.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72.	0.100000	0.833333	0.833333	1.000000	1.000000	0.833333	0.833333	0.0
73.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.100000
76.	0.100000	0.900000	1.000000	1.000000	0.933333	0.833333	0.0	0.0
77.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.	0.0	0.0	0.100000	0.366667	0.200000	0.200000	0.500000	0.800000
80.	0.900000	0.933333	0.900000	0.766667	0.600000	0.0	0.0	0.0
81.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82.	0.0	0.100000	0.100000	0.100000	0.100000	0.133333	0.100000	0.100000
83.	0.100000	0.100000	0.533333	0.733333	0.766667	0.833333	0.800000	0.733333
84.	0.766667	0.733333	0.600000	0.400000	0.0	0.0	0.0	0.0
85.	0.0	0.0	0.100000	0.100000	0.100000	0.166667	0.100000	0.100000
86.	0.166667	0.166667	0.266667	0.600000	0.566667	0.533333	0.533333	0.533333
87.	0.633333	0.800000	0.866667	0.800000	0.633333	0.466667	0.266667	0.333333
88.	0.300000	0.266667	0.233333	0.0	0.0	0.0	0.0	0.0
89.	0.0	0.100000	0.166667	0.300000	0.366667	0.333333	0.400000	0.566667
90.	0.633333	0.700000	0.666667	0.700000	0.766667	0.766667	0.500000	0.566667
91.	0.600000	0.800000	0.700000	0.166667	0.100000	0.100000	0.100000	0.100000
92.	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
93.	0.100000	0.300000	0.366667	0.333333	0.300000	0.333333	0.433333	0.433333
94.	0.233333	0.333333	0.366667	0.433333	0.266667	0.166667	0.100000	0.166667
95.	0.500000	0.500000	0.166667	0.0	0.0	0.0	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.300000
97.	0.266667	0.100000	0.100000	0.100000	0.100000	0.333333	0.133333	0.100000
98.	0.0	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.100000
99.	0.433333	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.0	0.166667	0.400000
103.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.100000	0.166667	0.166667
107.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.0	0.0	0.0		
116.	000003							
117.	006019021003026012							

Table 7-4. Continued

```
118.    0.7266792 0.7266792 0.7266792 0.7266792 0.7266792 0.7266792 0.7266792 0.7266792
119.    0.7266792 0.7266792 0.0
120.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
121.    0.0       0.0       0.0
122.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
123.    0.0       0.0       0.0
124.    -0.7266792-0.7266792-0.7266792-0.7266792-0.7266792-0.7266792-0.7266792-0.7266792
125.    -0.7266792-0.7266792 0.0
126.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
127.    0.0       -0.69034520.0
128.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
129.    0.0       +0.69034520.0
130.    000006
131.    001005
132.      28.32985  28.32985  28.32985  28.32985  28.32985  28.32985  28.32985  28.32985
133.      28.32985  28.32985  28.32985
134.    001006
135.      28.33301  28.33301  28.33301  28.33301  28.33301  28.33301  28.33301  28.33301
136.      28.33301  28.33301  28.33301
137.    004002
138.      28.14973  28.14973  28.14973  28.14973  28.14973  28.14973  28.14973  28.14973
139.      28.14973  28.14973  28.14973
140.    004003
141.      28.17082  28.17082  28.17082  28.17082  28.17082  28.17082  28.17082  28.17082
142.      28.17082  28.17082  28.17082
143.    004011
144.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
145.    0.0       0.0       0.0
146.    001026
147.    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
148.    0.0       0.0       0.0
149.       0.07109   0.10153
150.       0.07306   0.10435
151.       0.07507   0.10721
152.       0.07710   0.11011
153.       0.07917   0.11306
154.       0.08126   0.11605
155.       0.08339   0.11910
156.       0.08555   0.12218
157.       0.08775   0.12531
158.       0.08997   0.12849
159.       0.09223   0.13172
160.       0.09452   0.13499
161.       0.09685   0.13831
162.       0.09920   0.14168
163.       0.10159   0.14509
164.       0.10402   0.14855
165.       0.10647   0.15206
166.       0.10897   0.15562
167.       0.11149   0.15923
168.       0.11405   0.16288
169.       0.11664   0.16659
170.       0.11927   0.17034
171.       0.12194   0.17414
172.       0.12463   0.17800
173.       0.12737   0.18190
174.       0.13013   0.18585
175.       0.13294   0.18985
176.       0.13578   0.19391
177.       0.13865   0.19801
```

Table 7-5. Meteorological Data Input to Paul Model for Continuation Run No. 2: Four Hours After Start of Accident.

1.	6.905	84.000	70.000	2394.307	29.280	3.714
2.	6.991	84.000	70.000	2431.749	29.279	3.714
3.	7.078	84.000	70.000	2469.190	29.279	3.714
4.	7.164	84.000	70.000	2506.632	29.278	3.714
5.	7.250	84.000	70.000	2544.074	29.278	3.714
6.	7.336	84.000	70.000	2581.516	29.277	3.714
7.	7.423	84.000	70.000	2618.958	29.277	3.714
8.	7.509	84.000	70.000	2656.400	29.276	3.714
9.	7.595	84.000	70.000	2693.842	29.276	3.714
10.	7.682	84.000	70.000	2731.283	29.275	3.714
11.	7.768	84.000	70.000	2768.725	29.275	3.714
12.	7.854	84.000	70.000	2806.167	29.274	3.714
13.	7.941	84.000	70.000	2843.609	29.274	3.714
14.	8.027	84.000	70.000	2881.051	29.273	3.714
15.	8.113	84.000	70.000	2918.493	29.273	3.714
16.	8.199	84.000	70.000	2955.935	29.272	3.714
17.	8.286	84.000	70.000	2993.376	29.272	3.714
18.	8.372	84.000	70.000	3030.818	29.271	3.714
19.	8.458	84.000	70.000	3068.260	29.271	3.714
20.	8.545	84.000	70.000	3105.702	29.270	3.714
21.	8.631	84.000	70.000	3143.144	29.270	3.714
22.	8.717	84.000	70.000	3180.586	29.269	3.714
23.	8.804	84.000	70.000	3218.027	29.269	3.714
24.	8.890	84.000	70.000	3255.469	29.268	3.714
25.	8.976	84.000	70.000	3292.911	29.268	3.714
26.	9.063	84.000	70.000	3330.353	29.267	3.714
27.	9.149	84.000	70.000	3367.795	29.267	3.714
28.	9.235	84.000	70.000	3405.237	29.266	3.714
29.	9.321	84.000	70.000	3442.679	29.266	3.714
30.	9.408	84.000	70.000	3480.120	29.265	3.714
31.	9.494	84.000	70.000	3517.562	29.265	3.714
32.	9.580	84.000	70.000	3555.004	29.264	3.714
33.	9.667	84.000	70.000	3592.446	29.264	3.714
34.	9.753	84.000	70.000	3629.888	29.263	3.714
35.	9.839	84.000	70.000	3667.330	29.263	3.714
36.	9.925	84.000	70.000	3704.771	29.262	3.714
37.	10.012	84.000	70.000	3742.213	29.262	3.714
38.	10.098	84.000	70.000	3779.655	29.261	3.714
39.	10.184	84.000	70.000	3817.097	29.261	3.714
40.	10.271	84.000	70.000	3854.539	29.260	3.714
41.	10.357	84.000	70.000	3891.981	29.260	3.748
42.	10.443	84.100	70.025	3923.380	29.259	3.782
43.	10.530	84.200	70.050	3954.779	29.258	3.813
44.	10.616	84.300	70.075	3986.178	29.257	3.844
45.	10.702	84.400	70.100	4017.577	29.256	3.873
46.	10.788	84.500	70.125	4048.976	29.255	3.902
47.	10.875	84.600	70.150	4080.375	29.254	3.929
48.	10.961	84.700	70.175	4111.773	29.253	3.955
49.	11.047	84.800	70.200	4143.172	29.252	3.980
50.	11.134	84.900	70.225	4174.570	29.251	4.004
51.	11.220	85.000	70.250	4205.969	29.250	4.027
52.	11.306	85.100	70.275	4237.367	29.249	4.050
53.	11.393	85.200	70.300	4268.766	29.248	4.071
54.	11.479	85.300	70.325	4300.168	29.247	4.092
55.	11.565	85.400	70.350	4331.566	29.246	4.112
56.	11.651	85.500	70.375	4362.965	29.245	4.131
57.	11.738	85.600	70.400	4394.363	29.244	4.150

Table 7-6. Main Input to Paul Model for Continuation Run No. 3: Period 1/6 to 5 1/6 Days After Start of Accident.

```
 1.       20
 2.     CATAWBA NUCLEAR POWER PLANT  -- POND GRID 31 X 26, DS=30.48 METERS
 3.        2     8    09     0
 4.        2     2     2     2     2     2     2     2     2     2
 5.        3    30    25    10
 6.        2     1     2  2880     0     2     1   120  3000     1   100   100     1
 7.      100
 8.        4     2   002     0     2     0     0   120    01     0
 9.     0.000155  1.0       .00001    .000001
10.     1000.0    283.0     -3.93     503.37    67.26
11.     152.4     116.1288  0.01056   1.0       83.3374   0.018     0.018     1000.
12.     5000.0    10.0      0.0       5000.0    10.0      0.0       0.000155  15.0
13.     1.0       0.55      0.50      1.0       0.0       1.0
14.     1.0       1.0       900.0     914.36
15.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
16.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
19.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20.       0.0       0.0       0.0       0.0       0.0       0.100000  0.100000  0.100000
21.       0.100000  0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0
22.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
23.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
24.       0.0       0.0       0.0       0.0       0.100000  0.266667  0.333333  0.166667
25.       0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0       0.0
26.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28.       0.0       0.0       0.0       0.100000  0.100000  0.166667  0.366667  0.266667
29.       0.100000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
30.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
31.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
32.       0.0       0.0       0.0       0.100000  0.100000  0.100000  0.300000  0.200000
33.       0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
34.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
35.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
36.       0.0       0.0       0.0       0.0       0.0       0.166667  0.433333  0.100000
37.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
38.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
39.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
40.       0.0       0.100000  0.100000  0.100000  0.166667  0.500000  0.200000  0.100000
41.       0.166667  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
42.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
43.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
44.       0.466667  0.666667  0.533333  0.433333  0.533333  0.600000  0.166667  0.333333
45.       0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
46.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
47.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.100000
48.       0.100000  0.233333  0.333333  0.733333  0.733333  0.500000  0.400000  0.166667
49.       0.200000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
50.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
51.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
52.       0.0       0.333333  0.333333  0.766667  0.700000  0.566667  0.300000  0.400000
53.       0.266667  0.0       0.0       0.0       0.0       0.0       0.0       0.0
54.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
55.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
56.       0.0       0.366667  0.366667  0.866667  0.833333  0.766667  0.833333  1.000000
57.       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Table 7-6. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.366667	0.366667	0.866667	0.900000	1.000000	1.000000	1.000000
61.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64.	0.0	0.366667	0.366667	0.833333	1.000000	0.833333	0.333333	0.500000
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.100000	0.533333	0.900000	1.000000	1.000000	1.000000	0.0
69.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72.	0.100000	0.833333	0.833333	1.000000	1.000000	0.833333	0.833333	0.0
73.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.100000
76.	0.500000	0.900000	1.000000	1.000000	0.933333	0.833333	0.0	0.0
77.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.	0.0	0.0	0.100000	0.366667	0.200000	0.200000	0.500000	0.800000
80.	0.900000	0.933333	0.900000	0.766667	0.600000	0.0	0.0	0.0
81.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82.	0.0	0.100000	0.100000	0.100000	0.100000	0.133333	0.100000	0.100000
83.	0.100000	0.100000	0.533333	0.733333	0.766667	0.833333	0.800000	0.733333
84.	0.766667	0.733333	0.600000	0.400000	0.0	0.0	0.0	0.0
85.	0.0	0.0	0.100000	0.100000	0.100000	0.166667	0.100000	0.100000
86.	0.166667	0.166667	0.266667	0.600000	0.566667	0.533333	0.533333	0.533333
87.	0.633333	0.800000	0.866667	0.800000	0.633333	0.466667	0.266667	0.333333
88.	0.300000	0.266667	0.233333	0.0	0.0	0.0	0.0	0.0
89.	0.0	0.100000	0.166667	0.300000	0.366667	0.333333	0.400000	0.566667
90.	0.633333	0.700000	0.666667	0.700000	0.766667	0.766667	0.500000	0.566667
91.	0.600000	0.800000	0.700000	0.166667	0.100000	0.100000	0.100000	0.100000
92.	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
93.	0.100000	0.300000	0.366667	0.333333	0.300000	0.333333	0.433333	0.433333
94.	0.233333	0.333333	0.366667	0.433333	0.266667	0.166667	0.100000	0.166667
95.	0.500000	0.500000	0.166667	0.0	0.0	0.0	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.300000
97.	0.266667	0.100000	0.100000	0.100000	0.100000	0.333333	0.133333	0.100000
98.	0.0	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.100000
99.	0.433333	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.0	0.166667	0.400000
103.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.100000	0.166667	0.166667
107.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.0	0.0	0.0		
116.	000003							
117.	006019021003026012							

Table 7-6. Continued

```
0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041
0.3955041 0.3955041 0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0
-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041
-0.3955041-0.39550410.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       -0.37572890.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       +0.37572890.0
000006
001005
  32.93129  32.93129  32.93129  32.93129  32.93129  32.93129  32.93129  32.93129
  32.93129  32.93129  32.93129
001006
  32.72372  32.72372  32.72372  32.72372  32.72372  32.72372  32.72372  32.72372
  32.72372  32.72372  32.72372
004002
  33.01357  33.01357  33.01357  33.01357  33.01357  33.01357  33.01357  33.01357
  33.01357  33.01357  33.01357
004003
  32.94116  32.94116  32.94116  32.94116  32.94116  32.94116  32.94116  32.94116
  32.94116  32.94116  32.94116
004011
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0
001026
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0
   0.05041   0.11323
   0.05079   0.09841
   0.05008   0.08468
   0.04845   0.07209
   0.04604   0.06065
   0.04301   0.05036
   0.03951   0.04120
   0.03567   0.03315
   0.03162   0.02616
   0.02749   0.02019
   0.02338   0.01518
   0.01940   0.01106
   0.01563   0.00776
   0.01215   0.00518
   0.00902   0.00325
   0.00631   0.00187
   0.00405   0.00095
   0.00228   0.00040
   0.00101   0.00012
   0.00025   0.00001
   0.0       0.0
   0.00006   0.00000
   0.00025   0.00003
   0.00056   0.00012
   0.00098   0.00027
   0.00150   0.00053
   0.00212   0.00092
   0.00281   0.00145
   0.00356   0.00216
```

Table 7-7. Meteorological Data Input to Paul Model for Continuation Run No. 3: Period 1/6 to 5 1/6 Days After Start of Accident.

1.	6.905	87.000	71.000	2012.627	29.220	8.156
2.	6.560	87.100	71.050	1983.045	29.219	8.145
3.	6.214	87.200	71.100	1953.464	29.219	8.132
4.	5.869	87.300	71.150	1923.882	29.218	8.120
5.	5.524	87.400	71.200	1894.301	29.218	8.107
6.	5.179	87.500	71.250	1864.719	29.217	8.094
7.	4.834	87.600	71.300	1835.138	29.217	8.081
8.	4.488	87.700	71.350	1805.556	29.216	8.068
9.	4.143	87.800	71.400	1775.975	29.216	8.054
10.	3.798	87.900	71.450	1746.393	29.215	8.041
11.	3.453	88.000	71.500	1716.812	29.215	8.027
12.	3.107	88.100	71.550	1687.230	29.214	8.013
13.	2.762	88.200	71.600	1657.649	29.214	7.998
14.	2.417	88.300	71.650	1628.067	29.214	7.984
15.	2.072	88.400	71.700	1598.486	29.213	7.970
16.	1.726	88.500	71.750	1568.904	29.212	7.955
17.	1.381	88.600	71.800	1539.323	29.212	7.940
18.	1.036	88.700	71.850	1509.741	29.212	7.926
19.	0.691	88.800	71.900	1480.159	29.211	7.911
20.	0.345	88.900	71.950	1450.578	29.210	7.895
21.	0.0	89.000	72.000	1420.996	29.210	11.044
22.	0.173	88.800	72.050	1379.000	29.210	11.018
23.	0.345	88.600	72.100	1337.003	29.210	10.993
24.	0.518	88.400	72.150	1295.007	29.210	10.968
25.	0.690	88.200	72.200	1253.010	29.210	10.943
26.	0.863	88.000	72.250	1211.013	29.210	10.918
27.	1.036	87.800	72.300	1169.017	29.210	10.894
28.	1.208	87.600	72.350	1127.021	29.210	10.870
29.	1.381	87.400	72.400	1085.024	29.210	10.846
30.	1.553	87.200	72.450	1043.028	29.210	10.823
31.	1.726	87.000	72.500	1001.031	29.210	10.800
32.	1.899	86.800	72.550	959.035	29.210	10.777
33.	2.071	86.600	72.600	917.038	29.210	10.754
34.	2.244	86.400	72.650	875.042	29.210	10.731
35.	2.416	86.200	72.700	833.045	29.210	10.709
36.	2.589	86.000	72.750	791.049	29.210	10.687
37.	2.762	85.800	72.800	749.052	29.210	10.666
38.	2.934	85.600	72.850	707.056	29.210	10.644
39.	3.107	85.400	72.900	665.059	29.210	10.623
40.	3.279	85.200	72.950	623.062	29.210	10.602
41.	3.452	85.000	73.000	581.066	29.210	10.581
42.	3.855	84.700	72.800	559.573	29.211	10.560
43.	4.258	84.400	72.600	538.079	29.212	10.540
44.	4.660	84.100	72.400	516.586	29.213	10.520
45.	5.063	83.800	72.200	495.093	29.214	10.500
46.	5.466	83.500	72.000	473.600	29.215	10.480
47.	5.869	83.200	71.800	452.107	29.216	10.460
48.	6.272	82.900	71.600	430.614	29.217	10.441
49.	6.674	82.600	71.400	409.120	29.218	10.422
50.	7.077	82.300	71.200	387.627	29.219	10.403
51.	7.480	82.000	71.000	366.134	29.220	10.384
52.	7.883	81.700	70.800	344.641	29.221	10.365
53.	8.286	81.400	70.600	323.148	29.222	10.347
54.	8.688	81.100	70.400	301.655	29.223	10.328
55.	9.091	80.800	70.200	280.161	29.224	10.310
56.	9.494	80.500	70.000	258.668	29.225	10.292
57.	9.897	80.200	69.800	237.175	29.226	10.274

Table 7-8. Main Input to Paul Model for Continuation Run No. 4: Period 5 1/6 to 10 1/6 Days After Start of Accident.

```
      20
  CATAWBA NUCLEAR POWER PLANT  -- POND GRID 31 X 26, DS=30.48 METERS
       3     8    09     0
       2     2     2     2     2     2     2     2     2     2
       4    30    25    10
       2     1     2  1440     0     2     1   120  3000     1   100   100     1
     100
       4     2   002     0     2     0     0   120    01     0
  0.000155  1.0       .00001    .000001
  1000.0    283.0     -3.98     503.37    67.26
  152.4     116.1288  0.01056   1.0       83.3374   0.018     0.018     1000.
  5000.0    10.0      0.0       5000.0    10.0      0.0       0.000155  15.0
  1.0       0.55      0.50      1.0       0.0       1.0
  1.0       1.0       500.0     914.36
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.100000  0.100000  0.100000
    0.100000  0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.100000  0.266667  0.333333  0.166667
    0.100000  0.100000  0.100000  0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.100000  0.100000  0.166667  0.366667  0.266667
    0.100000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.100000  0.100000  0.100000  0.300000  0.200000
    0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.166667  0.433333  0.100000
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.100000  0.100000  0.100000  0.166667  0.500000  0.200000  0.100000
    0.166667  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.466667  0.666667  0.533333  0.433333  0.533333  0.600000  0.166667  0.333333
    0.100000  0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.100000
    0.100000  0.233333  0.333333  0.733333  0.733333  0.500000  0.400000  0.166667
    0.200000  0.100000  0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.333333  0.333333  0.766667  0.700000  0.566667  0.300000  0.400000
    0.266667  0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    0.0       0.366667  0.366667  0.866667  0.833333  0.766667  0.833333  1.000000
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Table 7-8. Continued

58.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.	0.0	0.366667	0.366667	0.866667	0.900000	1.000000	1.000000	1.000000
61.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64.	0.0	0.366667	0.366667	0.833333	1.000000	0.833333	0.333333	0.500000
65.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68.	0.0	0.100000	0.533333	0.900000	1.000000	1.000000	1.000000	0.0
69.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72.	0.100000	0.833333	0.833333	1.000000	1.000000	0.833333	0.833333	0.0
73.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.100000
76.	0.500000	0.900000	1.000000	1.000000	0.933333	0.833333	0.0	0.0
77.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79.	0.0	0.0	0.100000	0.366667	0.200000	0.200000	0.500000	0.800000
80.	0.900000	0.933333	0.900000	0.766667	0.600000	0.0	0.0	0.0
81.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82.	0.0	0.100000	0.100000	0.100000	0.100000	0.133333	0.100000	0.100000
83.	0.100000	0.100000	0.533333	0.733333	0.766667	0.833333	0.800000	0.733333
84.	0.766667	0.733333	0.600000	0.400000	0.0	0.0	0.0	0.0
85.	0.0	0.0	0.100000	0.100000	0.100000	0.166667	0.100000	0.100000
86.	0.166667	0.166667	0.266667	0.600000	0.566667	0.533333	0.533333	0.533333
87.	0.633333	0.800000	0.866667	0.800000	0.633333	0.466667	0.266667	0.333333
88.	0.300000	0.266667	0.233333	0.0	0.0	0.0	0.0	0.0
89.	0.0	0.100000	0.166667	0.300000	0.366667	0.333333	0.400000	0.566667
90.	0.633333	0.700000	0.666667	0.700000	0.766667	0.766667	0.500000	0.566667
91.	0.600000	0.800000	0.700000	0.166667	0.100000	0.100000	0.100000	0.100000
92.	0.100000	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
93.	0.100000	0.300000	0.366667	0.333333	0.300000	0.333333	0.433333	0.433333
94.	0.233333	0.333333	0.366667	0.433333	0.266667	0.166667	0.100000	0.166667
95.	0.500000	0.500000	0.166667	0.0	0.0	0.0	0.0	0.0
96.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.300000
97.	0.266667	0.100000	0.100000	0.100000	0.100000	0.333333	0.133333	0.100000
98.	0.0	0.100000	0.100000	0.100000	0.0	0.0	0.0	0.100000
99.	0.433333	0.100000	0.0	0.0	0.0	0.0	0.0	0.0
100.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101.	0.0	0.0	0.0	0.100000	0.100000	0.100000	0.100000	0.0
102.	0.0	0.0	0.0	0.0	0.0	0.0	0.166667	0.400000
103.	0.166667	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106.	0.0	0.0	0.0	0.0	0.0	0.100000	0.166667	0.166667
107.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
109.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
112.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
113.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.	0.0	0.0	0.0	0.0	0.0	0.0		
116.	000003							
117.	006019021003026012							

Table 7-8. Continued

```
118.   0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041 0.3955041
119.   0.3955041 0.3955041 0.0
120.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
121.   0.0       0.0       0.0
122.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
123.   0.0       0.0       0.0
124.   -0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041-0.3955041
125.   -0.3955041-0.39550410.0
126.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
127.   0.0       -0.37572890.0
128.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
129.   0.0       +0.37572890.0
130.   000006
131.   001005
132.     39.65804  39.65804  39.65804  39.65804  39.65804  39.65804  39.65804  39.65804
133.     39.65804  39.65804  39.65804
134.   001006
135.     39.52046  39.52046  39.52046  39.52046  39.52046  39.52046  39.52046  39.52046
136.     39.52046  39.52046  39.52046
137.   004002
138.     39.68771  39.68771  39.68771  39.68771  39.68771  39.68771  39.68771  39.68771
139.     39.68771  39.68771  39.68771
140.   004003
141.     39.58385  39.58385  39.58385  39.58385  39.58385  39.58385  39.58385  39.58385
142.     39.58385  39.58385  39.58385
143.   004011
144.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
145.   0.0       0.0       0.0
146.   001026
147.   0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
148.   0.0       0.0       0.0
149.        0.01730   0.08133
150.        0.02039   0.07159
151.        0.02243   0.06231
152.        0.02353   0.05361
153.        0.02381   0.04555
154.        0.02339   0.03818
155.        0.02239   0.03151
156.        0.02092   0.02555
157.        0.01903   0.02032
158.        0.01700   0.01580
159.        0.01477   0.01195
160.        0.01247   0.00877
161.        0.01020   0.00618
162.        0.00804   0.00415
163.        0.00604   0.00261
164.        0.00427   0.00151
165.        0.00276   0.00077
166.        0.00156   0.00032
167.        0.00070   0.00010
168.        0.00017   0.00001
169.        0.0       0.0
170.        0.0       0.0
171.        0.0       0.0
172.        0.0       0.0
173.        0.0       0.0
174.        0.0       0.0
175.        0.0       0.0
176.        0.0       0.0
177.        0.0       0.0
```

Table 7-9. MeteorologicalData Input to Paul Model for Continuation Run No. 4: Period 5 1/6 to 10 1/6 Days After Start of Accident.

1.	5.754	102.000	71.000	3991.111	29.170	4.416
2.	5.466	102.000	70.900	3931.895	29.169	4.416
3.	5.179	102.000	70.800	3872.679	29.169	4.415
4.	4.891	102.000	70.700	3813.463	29.168	4.415
5.	4.603	102.000	70.600	3754.247	29.168	4.415
6.	4.316	102.000	70.500	3695.031	29.167	4.414
7.	4.028	102.000	70.400	3635.815	29.167	4.414
8.	3.740	102.000	70.300	3576.599	29.166	4.413
9.	3.452	102.000	70.200	3517.382	29.166	4.413
10.	3.165	102.000	70.100	3458.166	29.165	4.413
11.	2.877	102.000	70.000	3398.950	29.165	4.412
12.	2.589	102.000	69.900	3339.734	29.164	4.412
13.	2.302	102.000	69.800	3280.518	29.164	4.412
14.	2.014	102.000	69.700	3221.302	29.163	4.411
15.	1.726	102.000	69.600	3162.086	29.163	4.411
16.	1.439	102.000	69.500	3102.870	29.162	4.410
17.	1.151	102.000	69.400	3043.654	29.162	4.410
18.	0.863	102.000	69.300	2984.437	29.161	4.410
19.	0.575	102.000	69.200	2925.221	29.161	4.409
20.	0.288	102.000	69.100	2866.005	29.160	4.409
21.	0.0	102.000	69.000	2806.789	29.160	4.409
22.	0.0	101.900	68.950	2745.893	29.161	4.408
23.	0.0	101.800	68.900	2684.997	29.162	4.408
24.	0.0	101.700	68.850	2624.101	29.163	4.408
25.	0.0	101.600	68.800	2563.206	29.164	4.407
26.	0.0	101.500	68.750	2502.310	29.165	4.407
27.	0.0	101.400	68.700	2441.414	29.166	4.406
28.	0.0	101.300	68.650	2380.518	29.167	4.406
29.	0.0	101.200	68.600	2319.622	29.168	4.406
30.	0.0	101.100	68.550	2258.727	29.169	4.405
31.	0.0	101.000	68.500	2197.831	29.170	4.405
32.	0.0	100.900	68.450	2136.935	29.171	4.405
33.	0.0	100.800	68.400	2076.039	29.172	4.404
34.	0.0	100.700	68.350	2015.143	29.173	4.404
35.	0.0	100.600	68.300	1954.247	29.174	4.404
36.	0.0	100.500	68.250	1893.351	29.175	4.403
37.	0.0	100.400	68.200	1832.456	29.176	4.403
38.	0.0	100.300	68.150	1771.560	29.177	4.402
39.	0.0	100.200	68.100	1710.664	29.178	4.402
40.	0.0	100.100	68.050	1649.768	29.179	4.402
41.	0.0	100.000	68.000	1588.872	29.180	4.401
42.	0.0	99.750	68.100	1522.675	29.179	4.401
43.	0.0	99.500	68.200	1456.477	29.179	4.401
44.	0.0	99.250	68.300	1390.280	29.178	4.400
45.	0.0	99.000	68.400	1324.083	29.178	4.400
46.	0.0	98.750	68.500	1257.885	29.177	4.400
47.	0.0	98.500	68.600	1191.687	29.177	4.399
48.	0.0	98.250	68.700	1125.490	29.176	4.399
49.	0.0	98.000	68.800	1059.293	29.176	4.398
50.	0.0	97.750	68.900	993.095	29.175	4.398
51.	0.0	97.500	69.000	926.898	29.175	4.398
52.	0.0	97.250	69.100	860.700	29.174	4.397
53.	0.0	97.000	69.200	794.503	29.174	4.397
54.	0.0	96.750	69.300	728.305	29.173	4.397
55.	0.0	96.500	69.400	662.108	29.173	4.396
56.	0.0	96.250	69.500	595.910	29.172	4.396
57.	0.0	96.000	69.600	529.713	29.172	4.396

Fig. 7-1. Sketch of Catawba Ultimate Heat Sink Cooling Pond.

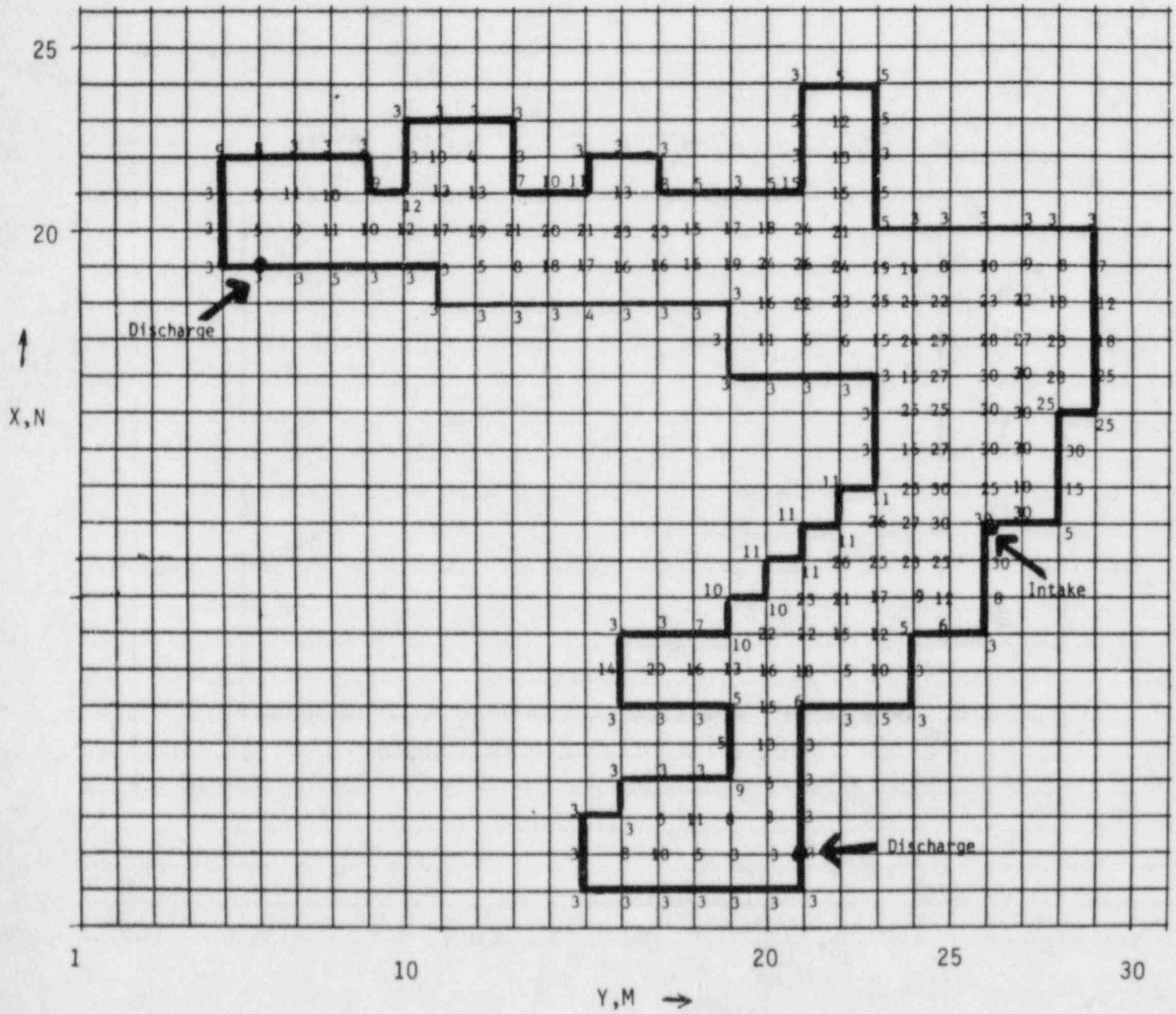


Fig. 7-2. Bottom Depths (In Feet) at Nodal Points of Grid Representing Catawba Pond.

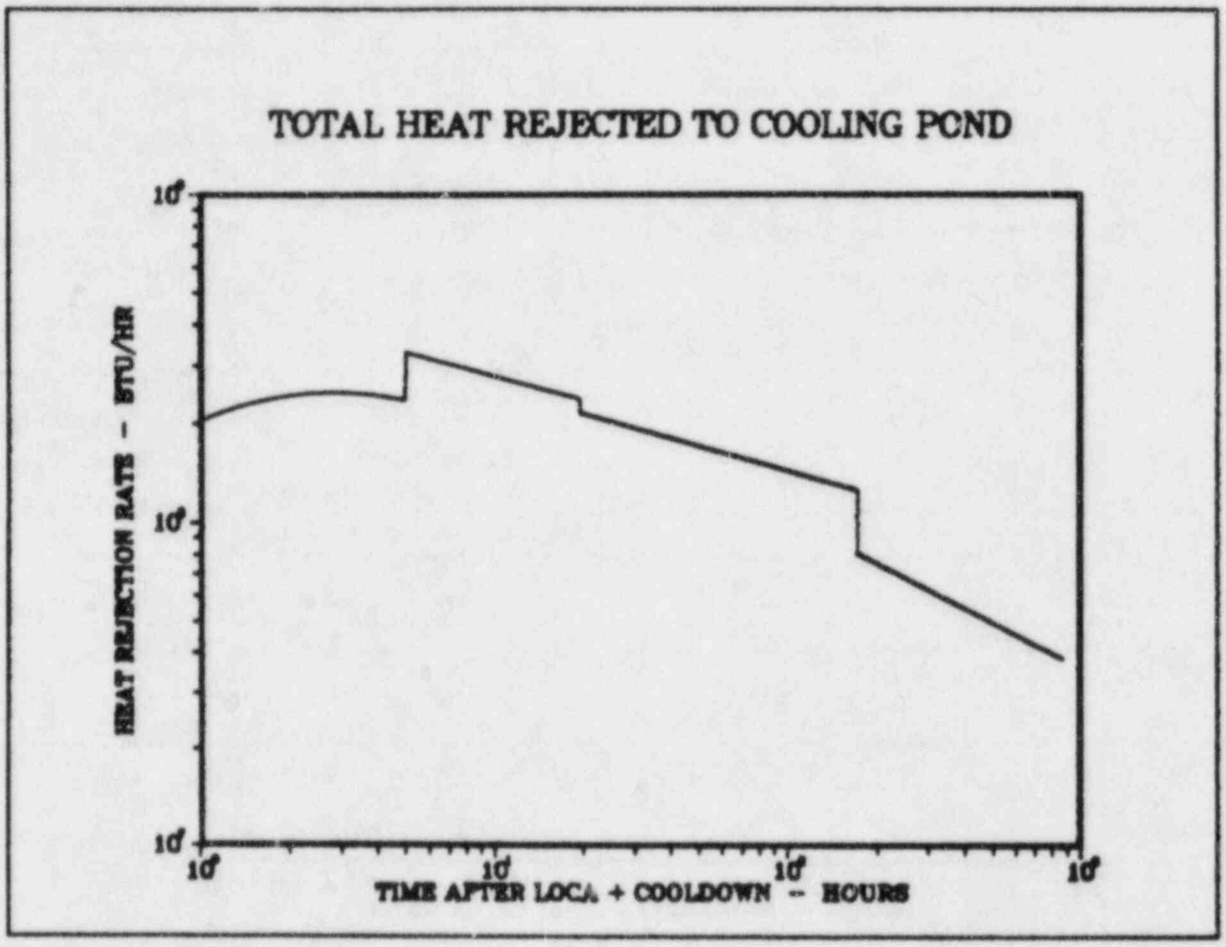


Fig. 7 3. Heat Flux Rejected to Cooling Pond as a Function of Time for Loss of Coolant Accident.

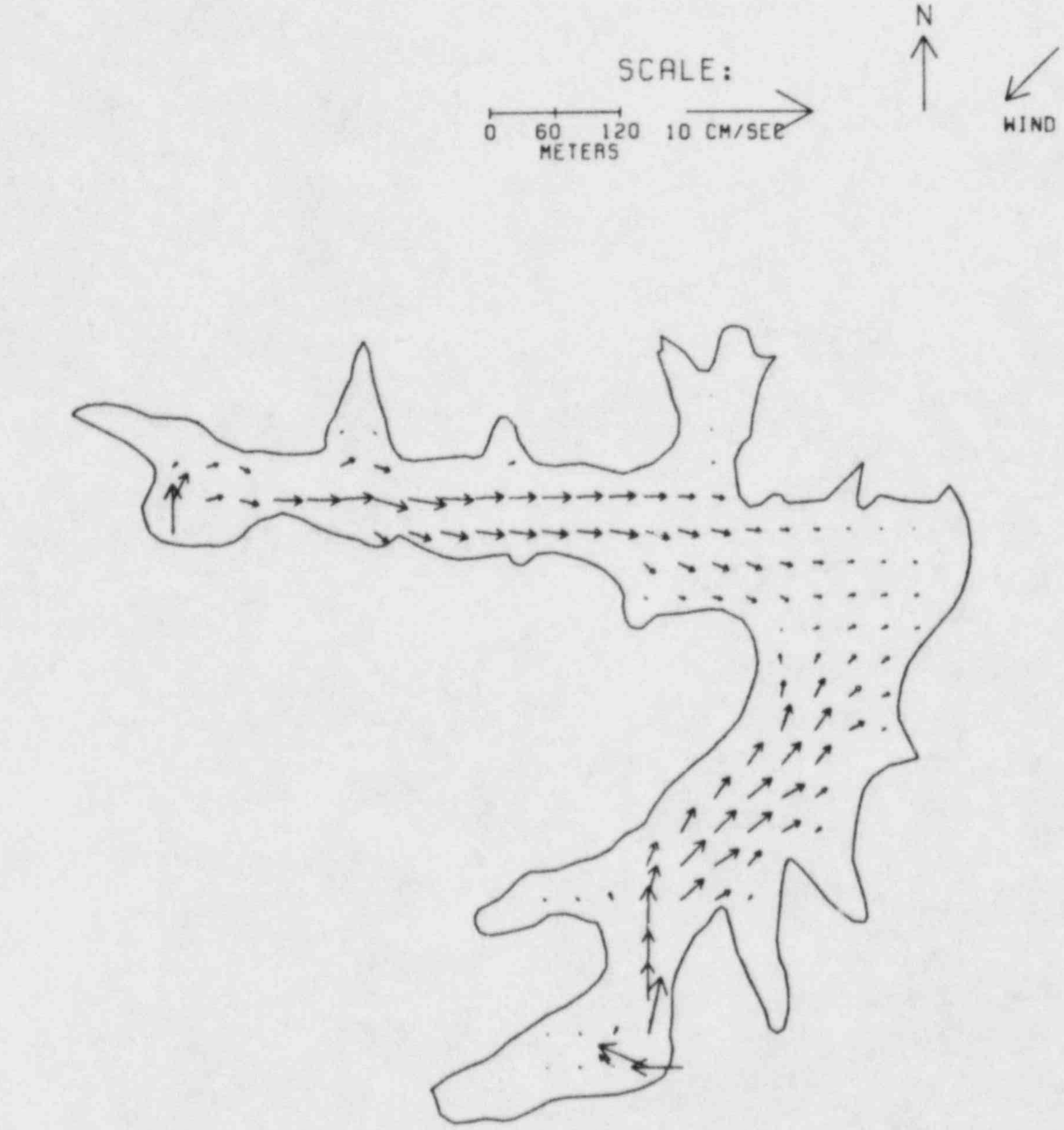


Fig. 7-4. Horizontal Velocities at Grid Points Located at Top Level (Surface) ...End of 5 Days Before Start of Accident.

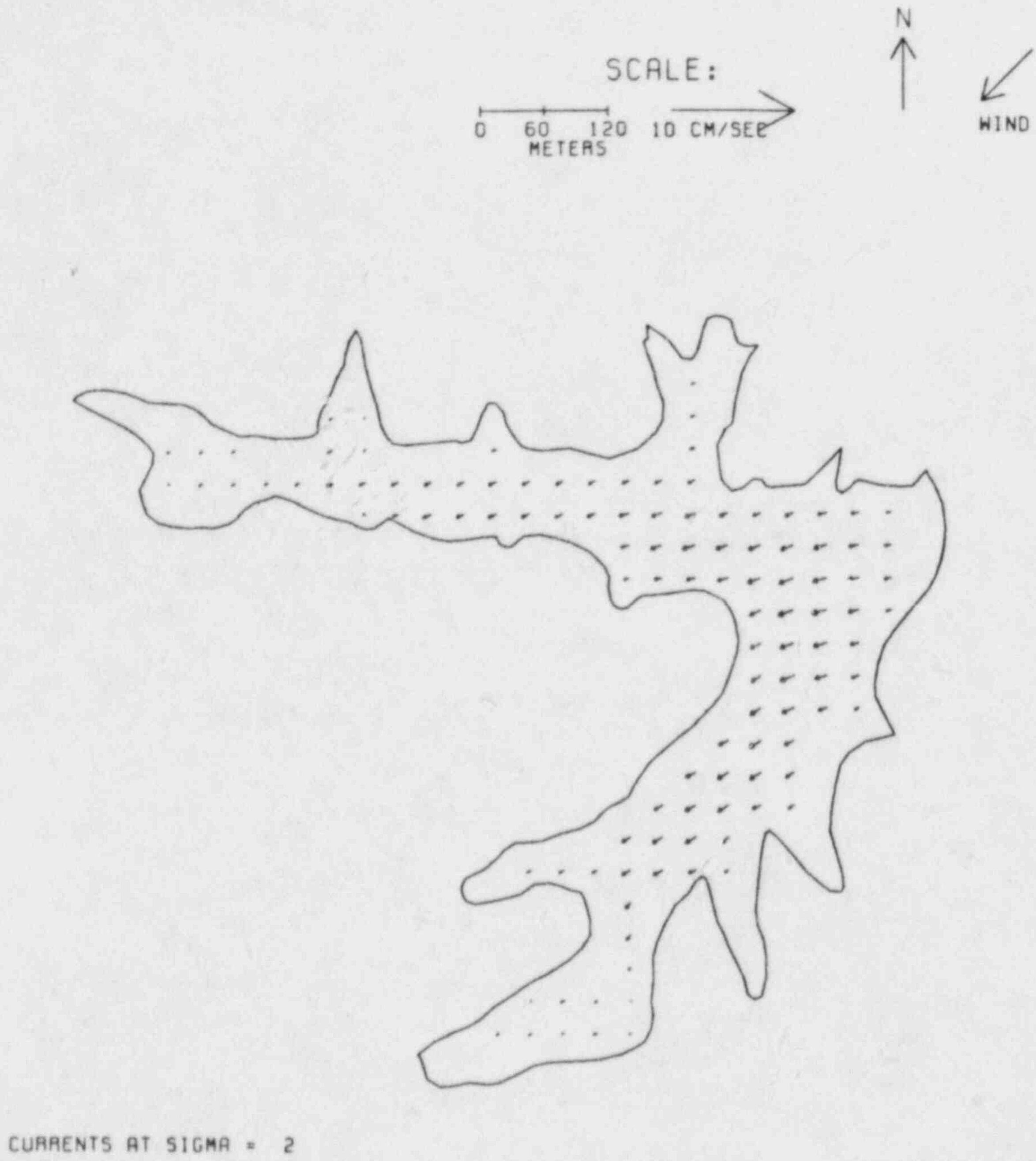


Fig. 7-5. Horizontal Velocities at Grid Points at Level 2 ...End of 5 Days Before Start of Accident.

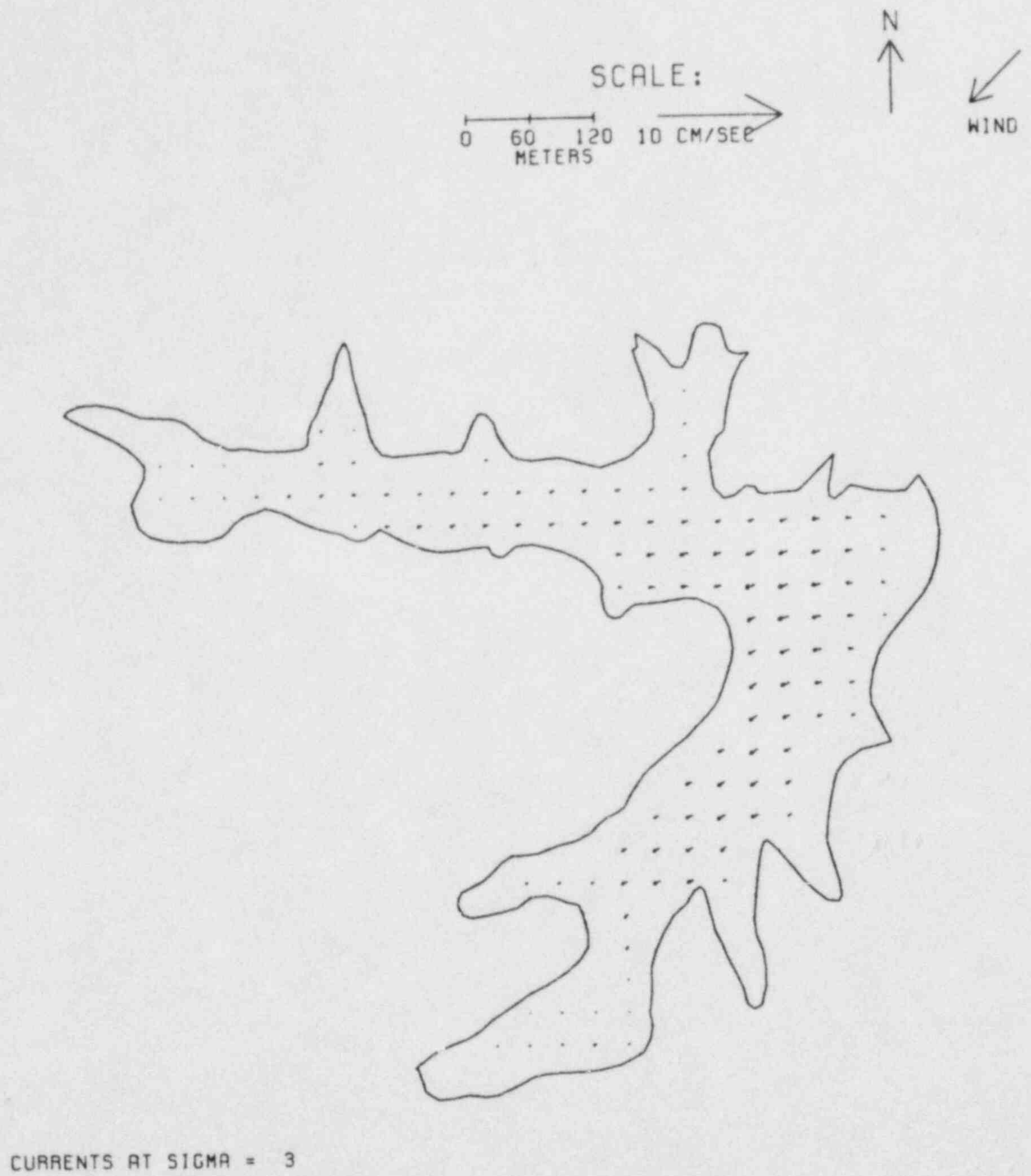


Fig. 7-6. Horizontal Velocities at Grid Points at Level 3
...End of 5 Days Before Start of Accident.

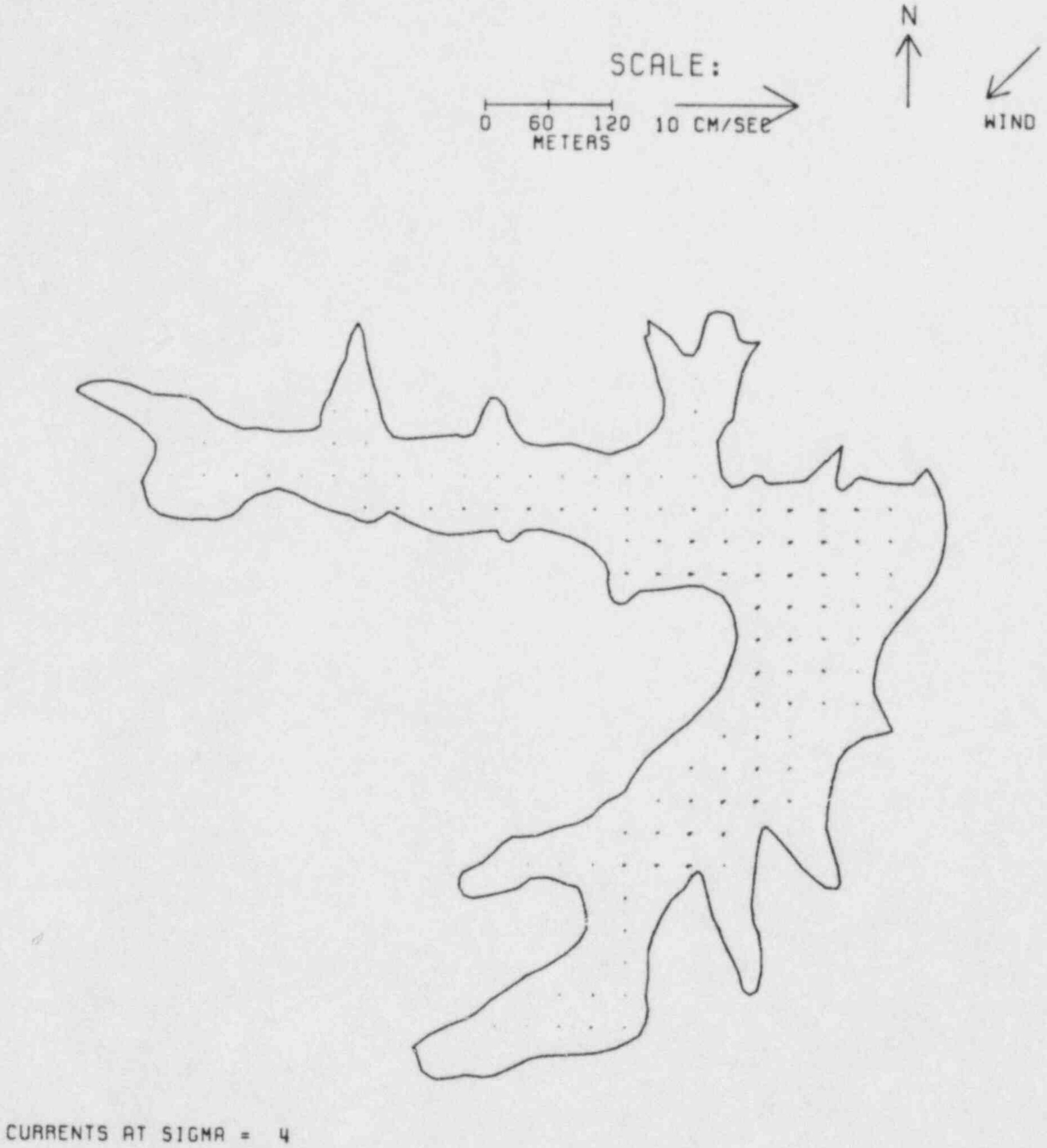


Fig. 7-7. Horizontal Velocities at Grid Points at Level 4
...End of 5 Days Before Start of Accident.

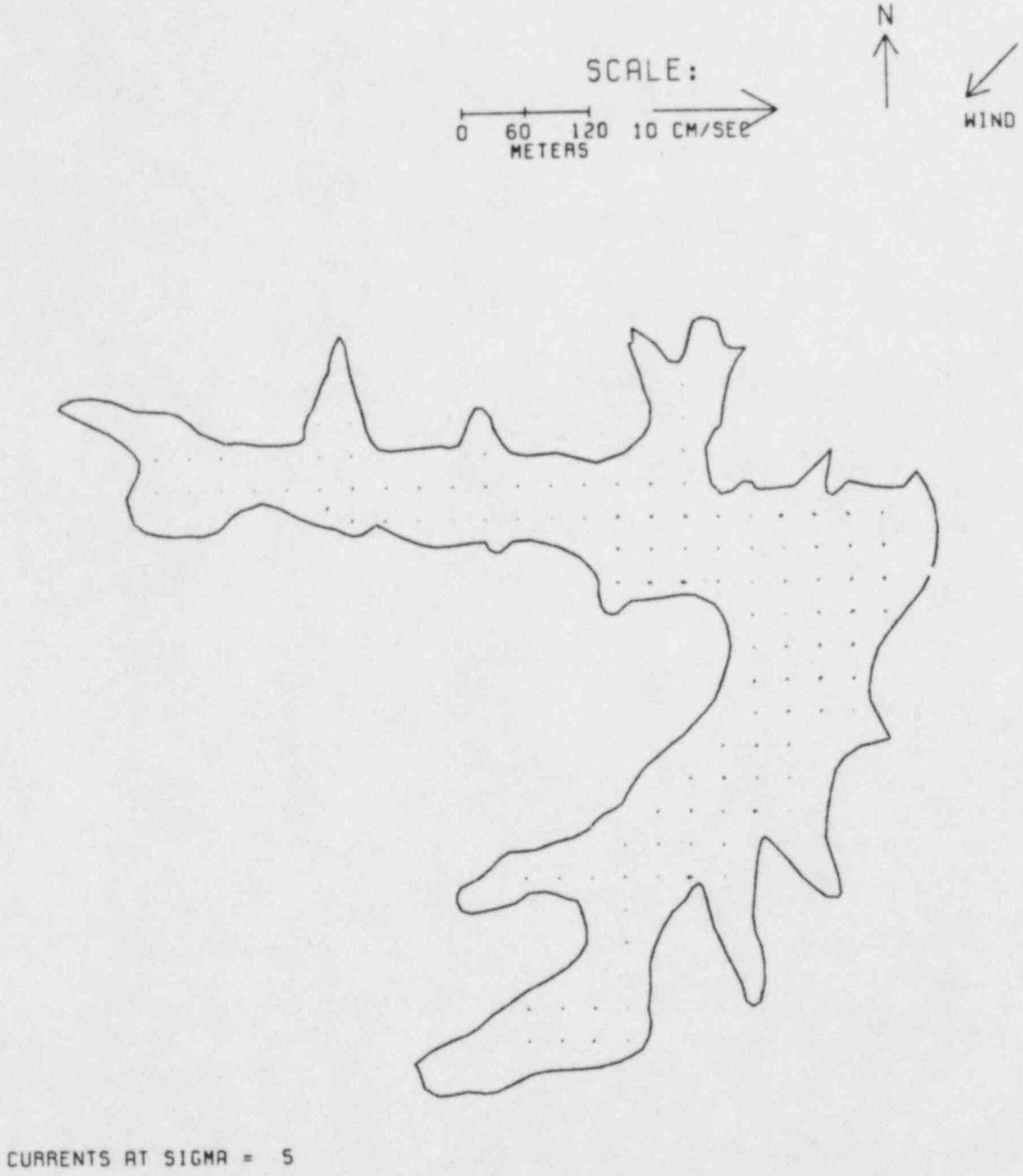


Fig. 7-8. Horizontal Velocities at Grid Points at Level 5 ...End of 5 Days Before Start of Accident.

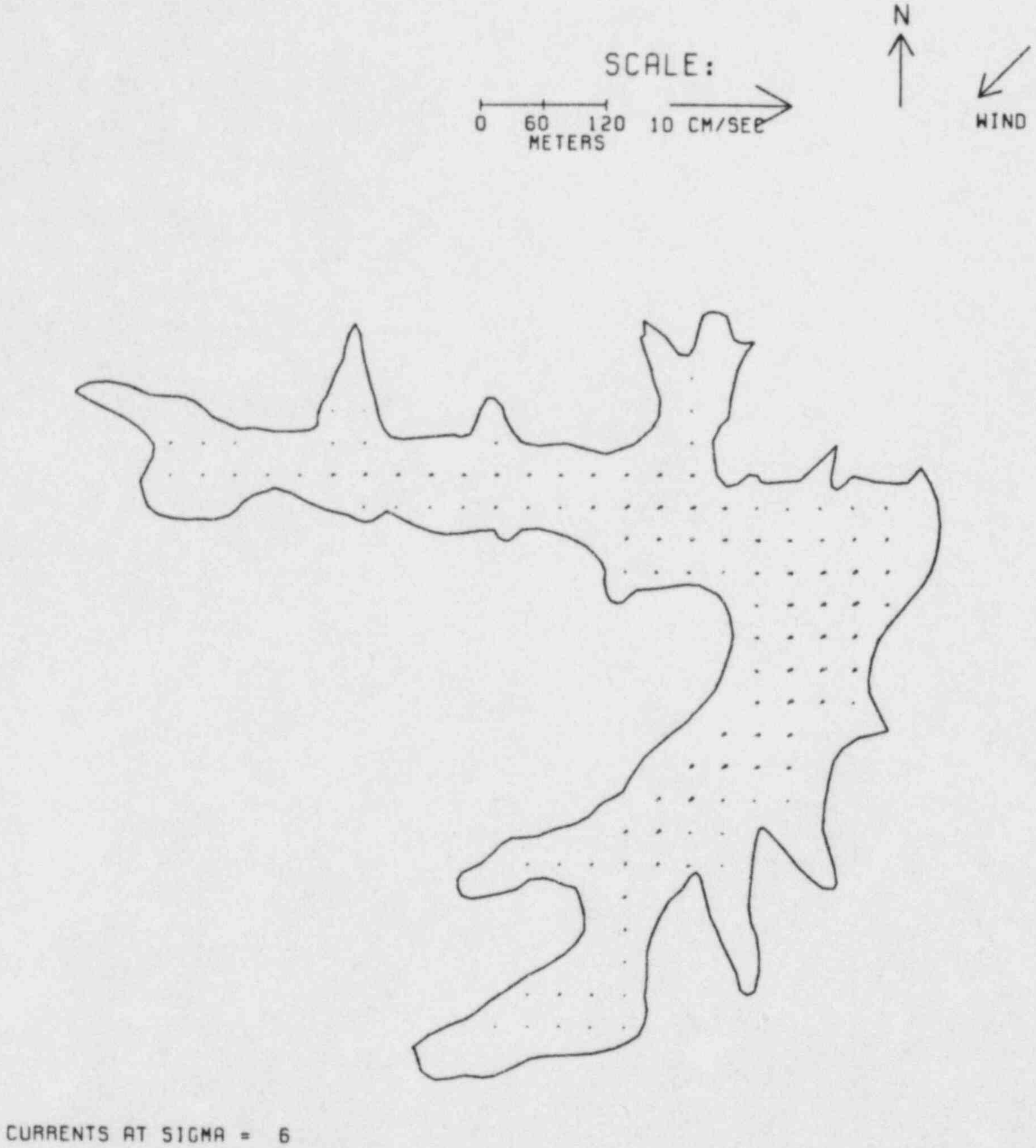


Fig. 7-9. Horizontal Velocities at Grid Points at Level 6
...End of 5 Days Before Start of Accident.

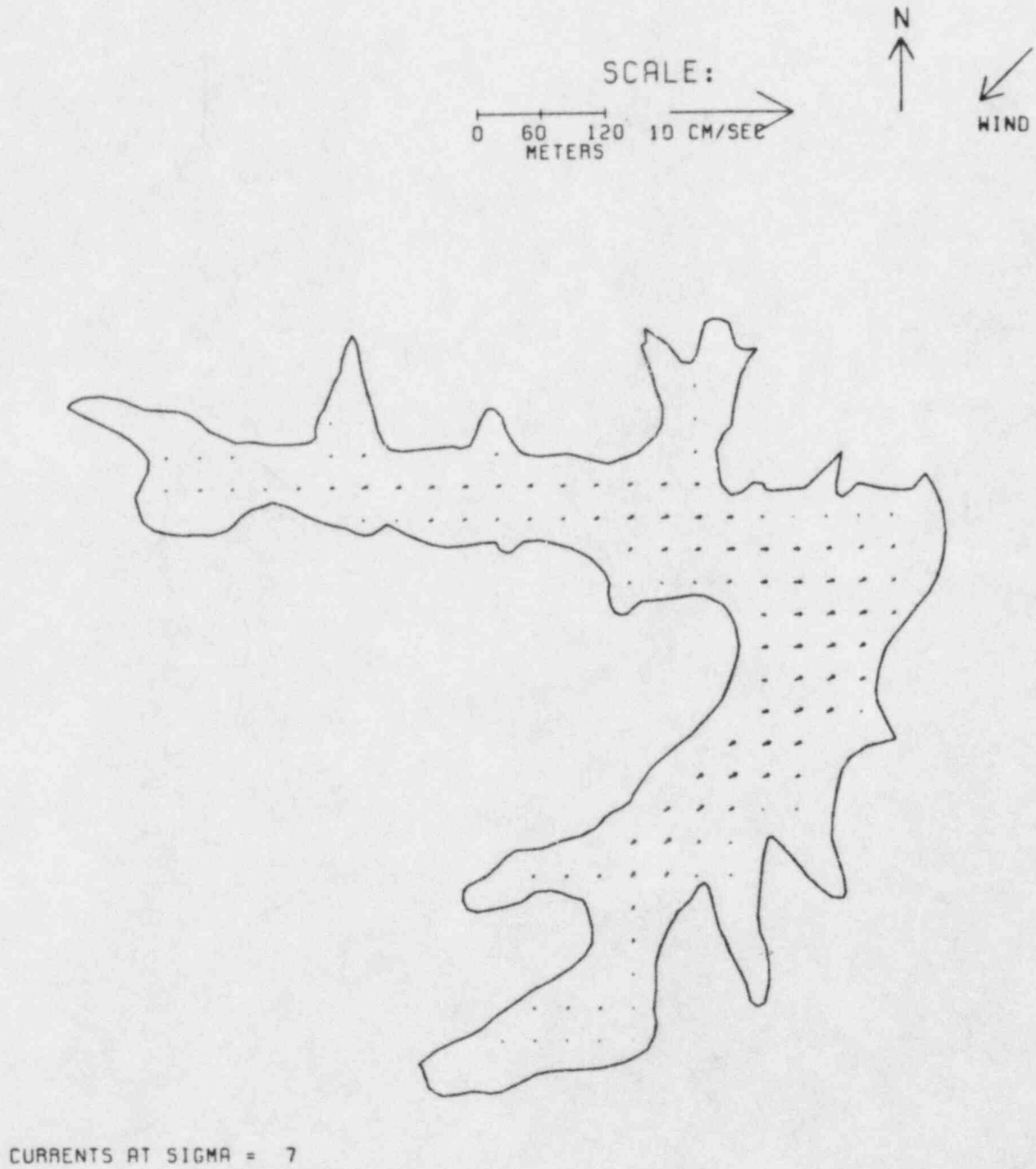


Fig. 7-10. Horizontal Velocities at Grid Points at Level 7 ...End of 5 Days Before Start of Accident.

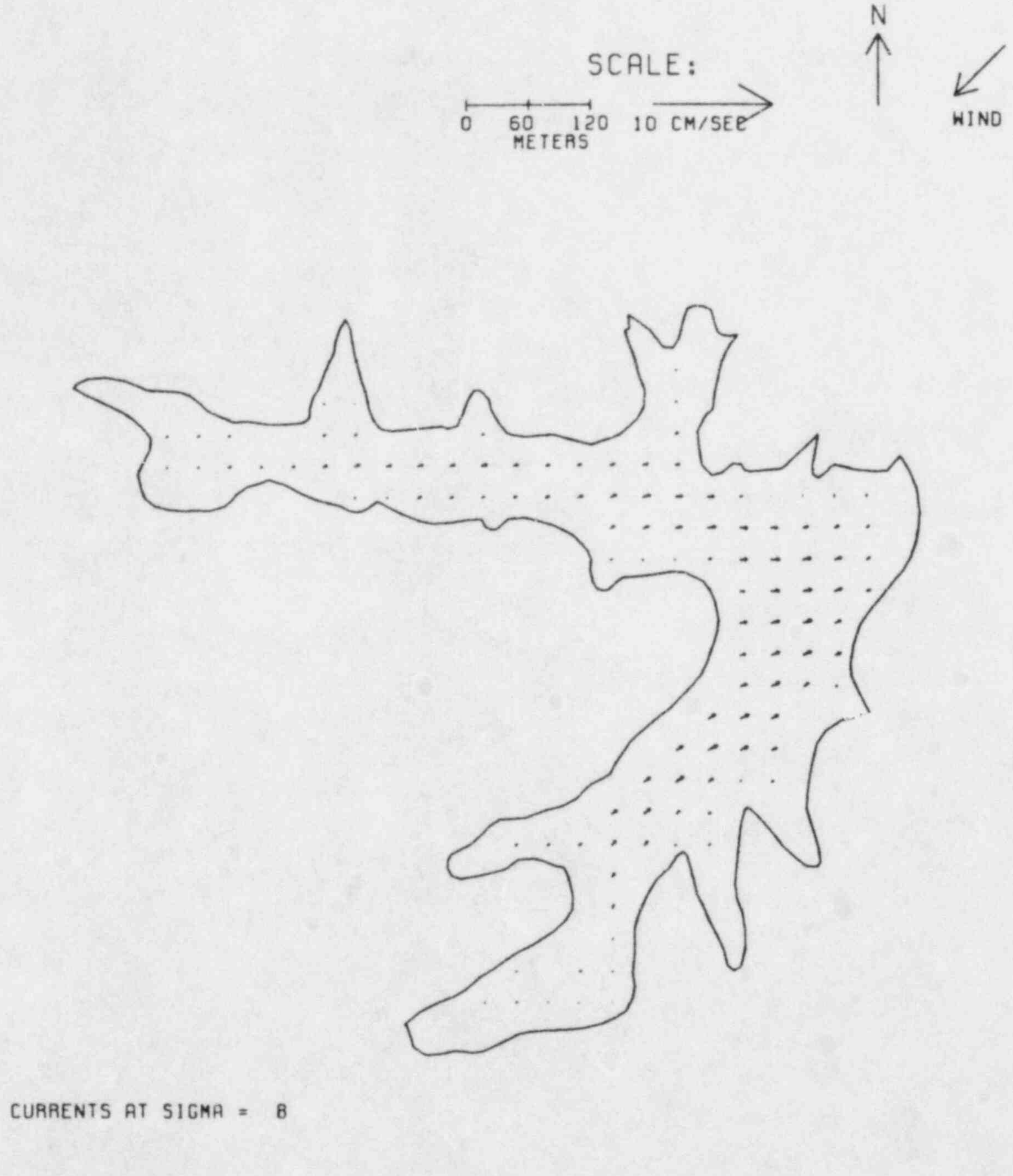


Fig. 7-11. Horizontal Velocities at Grid Points at Level 8 ...End of 5 Days Before Start of Accident.

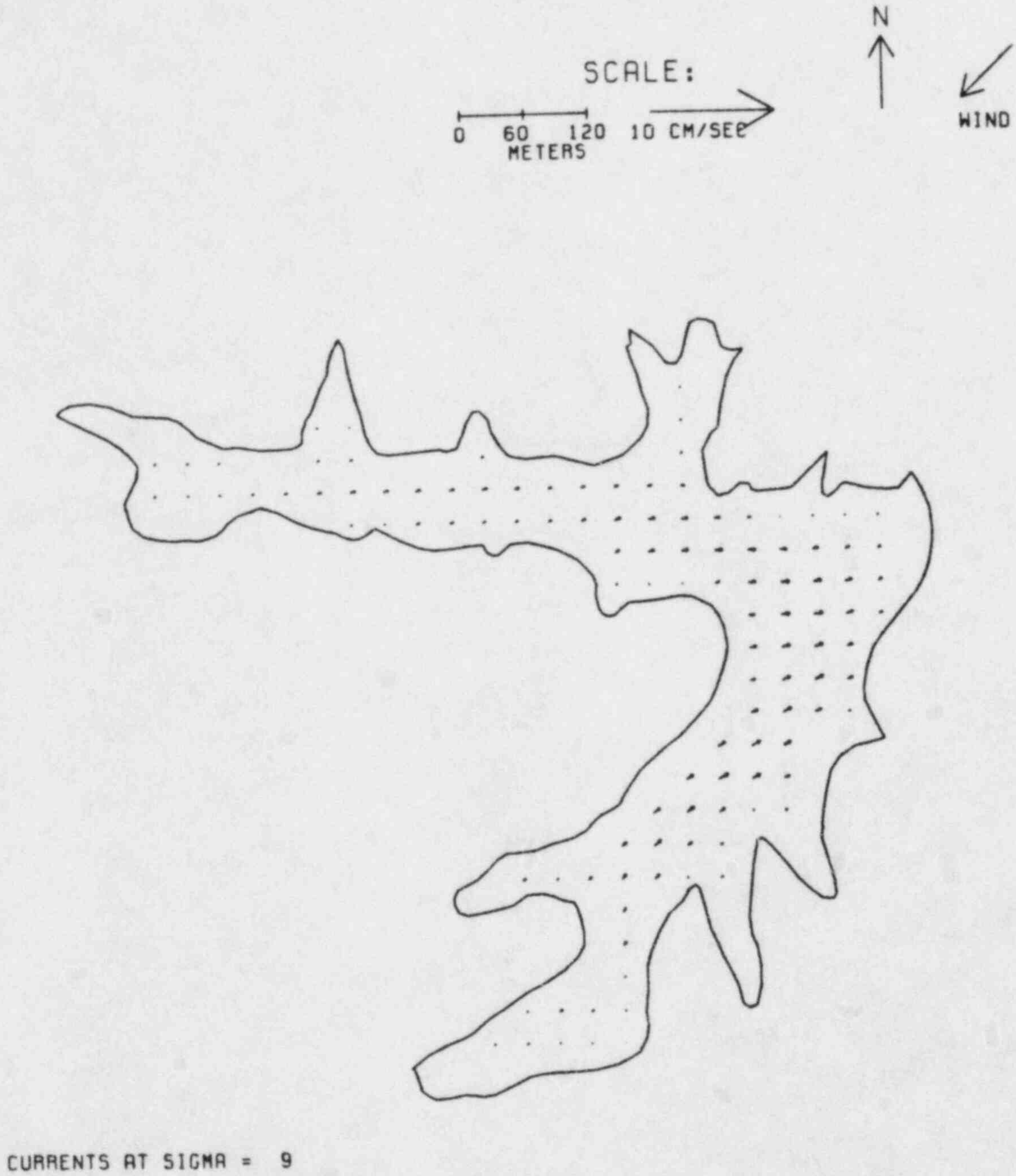


Fig. 7-12. Horizontal Velocities at Grid Points at Level 9 ...End of 5 Days Before Start of Accident.

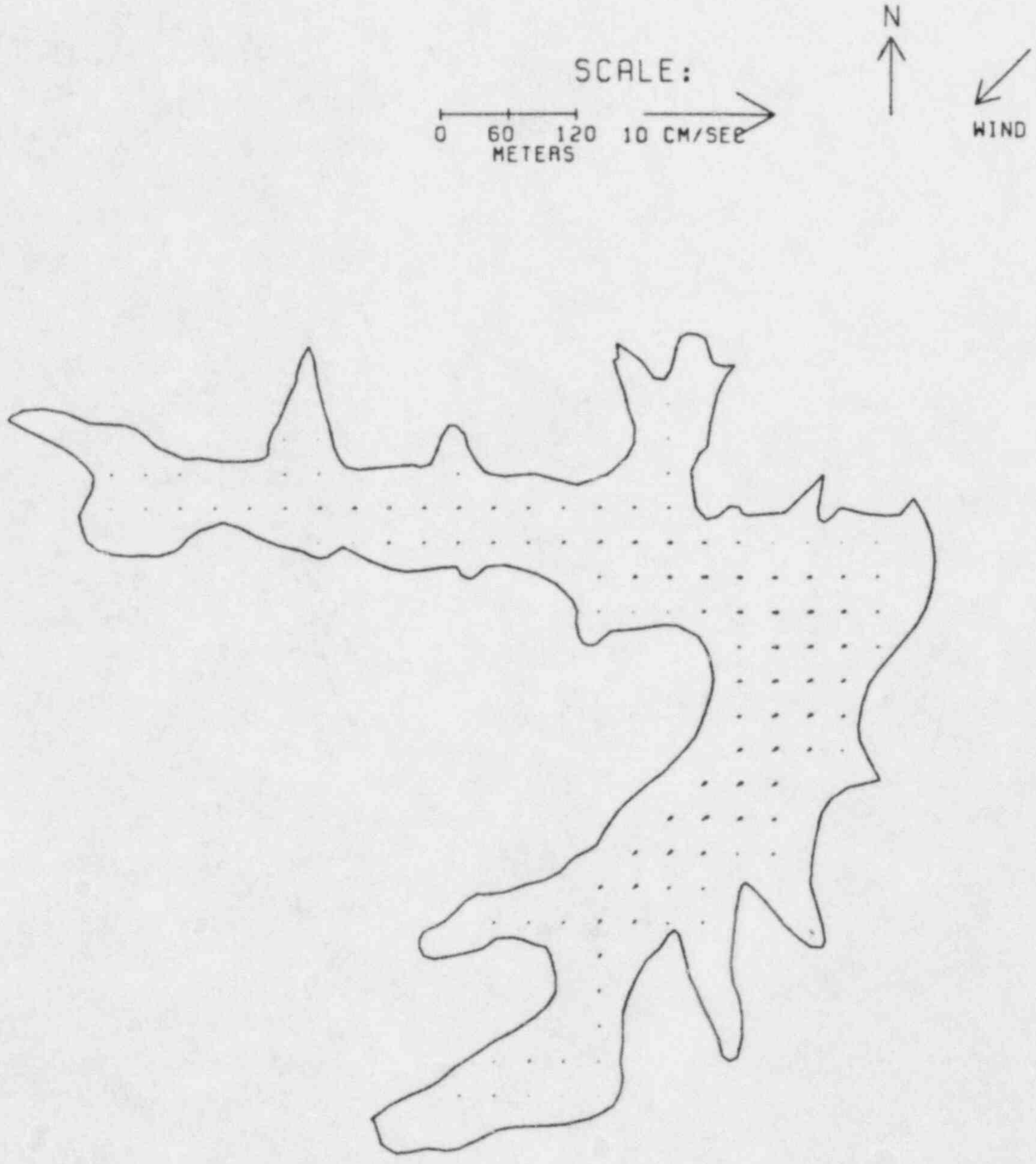


Fig. 7-13. Horizontal Velocities at Grid Points at Level 10 (Level Just Above Bottom) ...End of 5 Days Before Start of Accident.

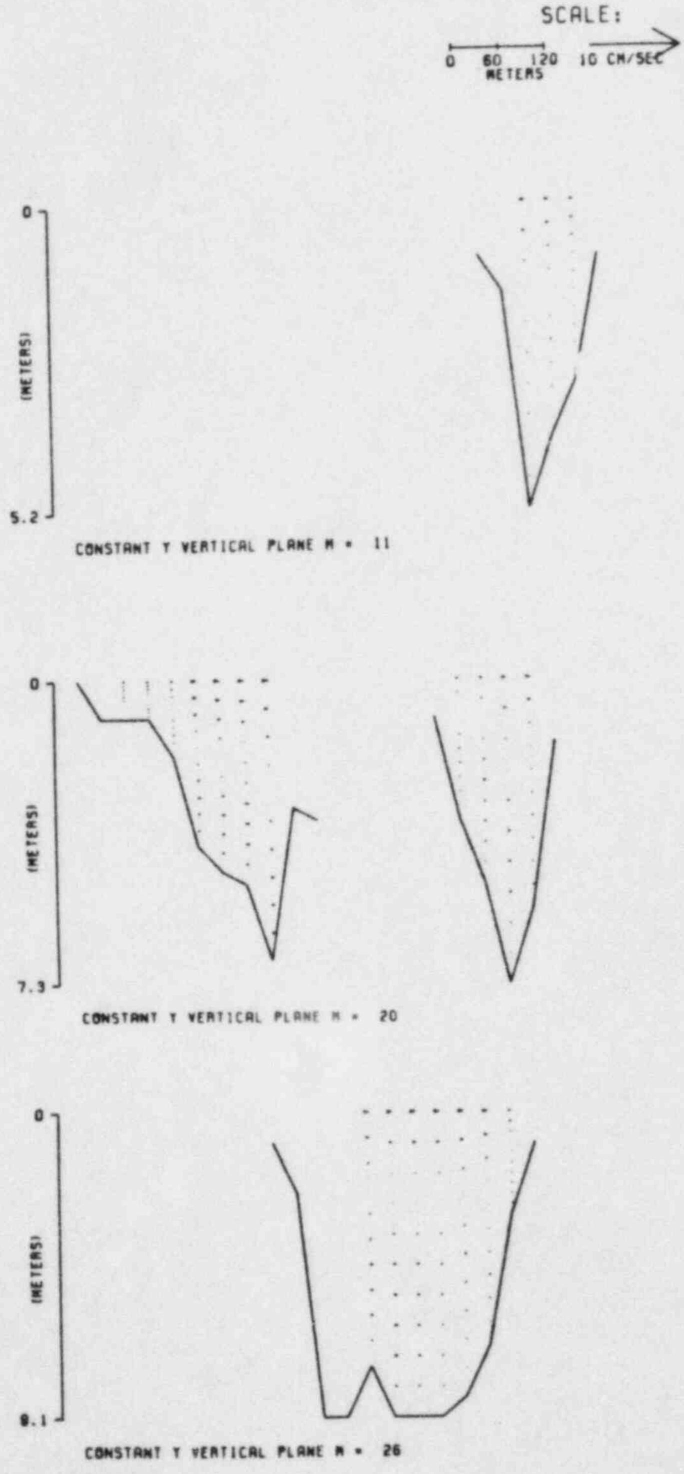


Fig. 7-14. Cross-Sectional Velocities in Plane at (a) M=11 ...Y Constant, (b) M=20 ...Y Constant, and (c) M=26 ...Y Constant ...End of 5 Days Before Start of Accident.

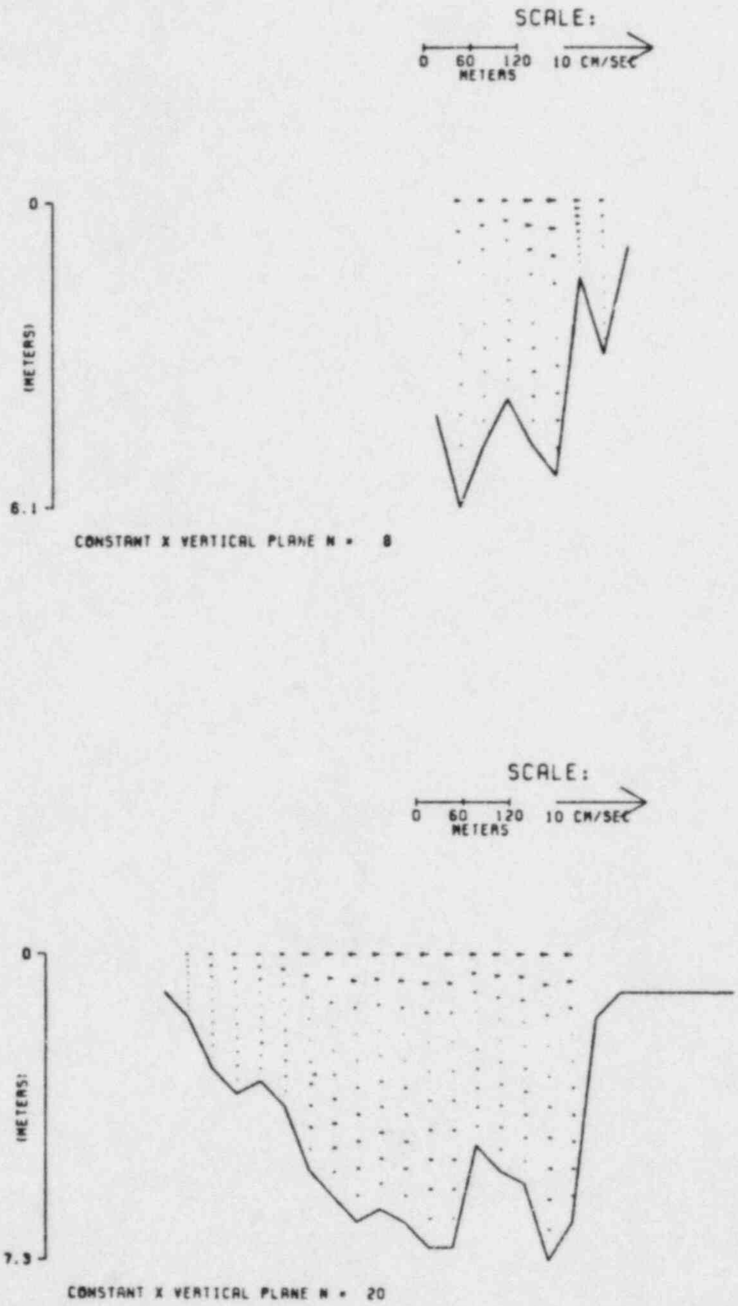


Fig. 7-15. Cross-Sectional Velocities in Plane at (a) N=8 ...X Constant, and (b) N=20 ...X Constant, ...End of 5 Days Before Start of Accident.

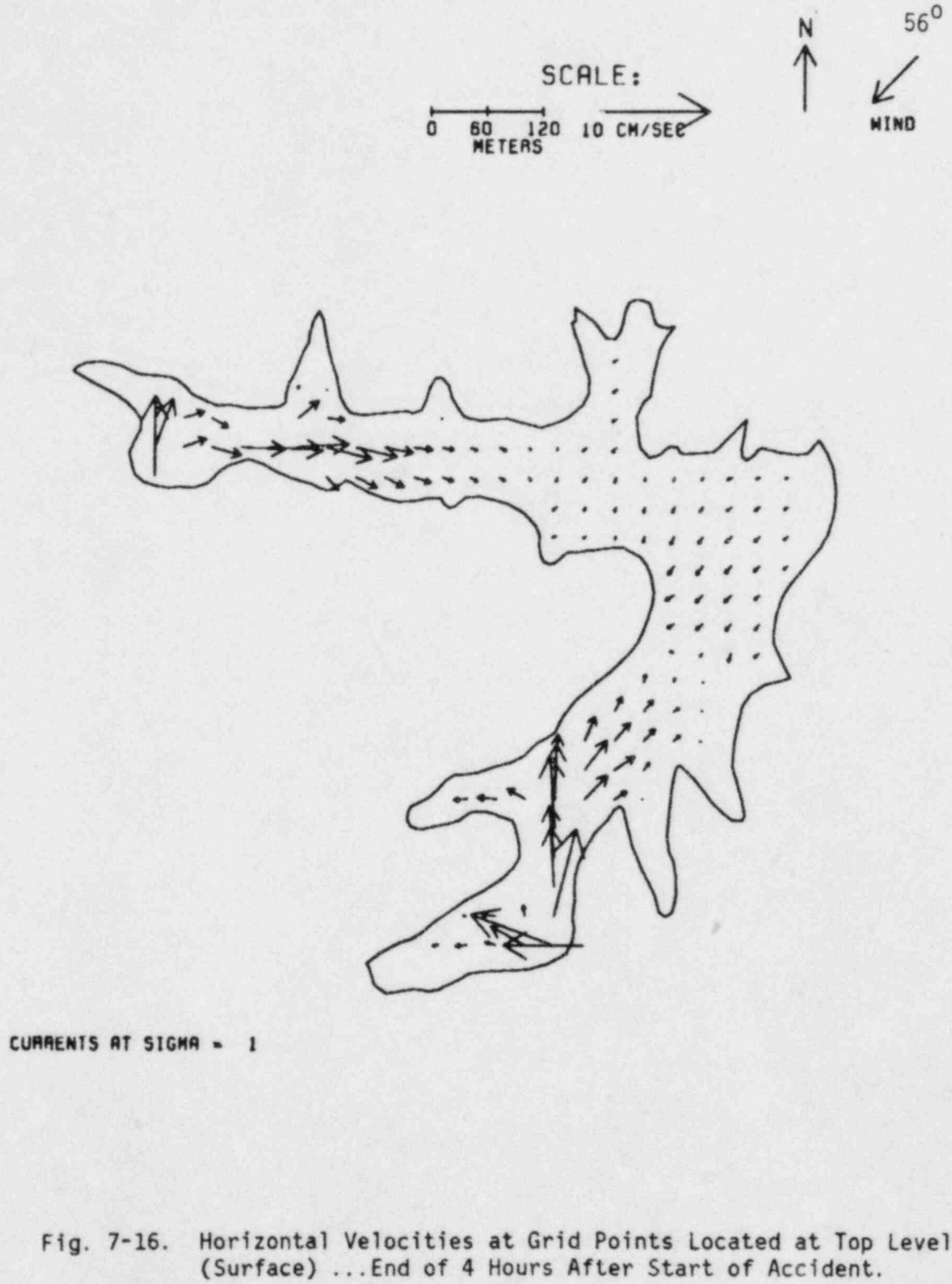


Fig. 7-16. Horizontal Velocities at Grid Points Located at Top Level (Surface) ...End of 4 Hours After Start of Accident.

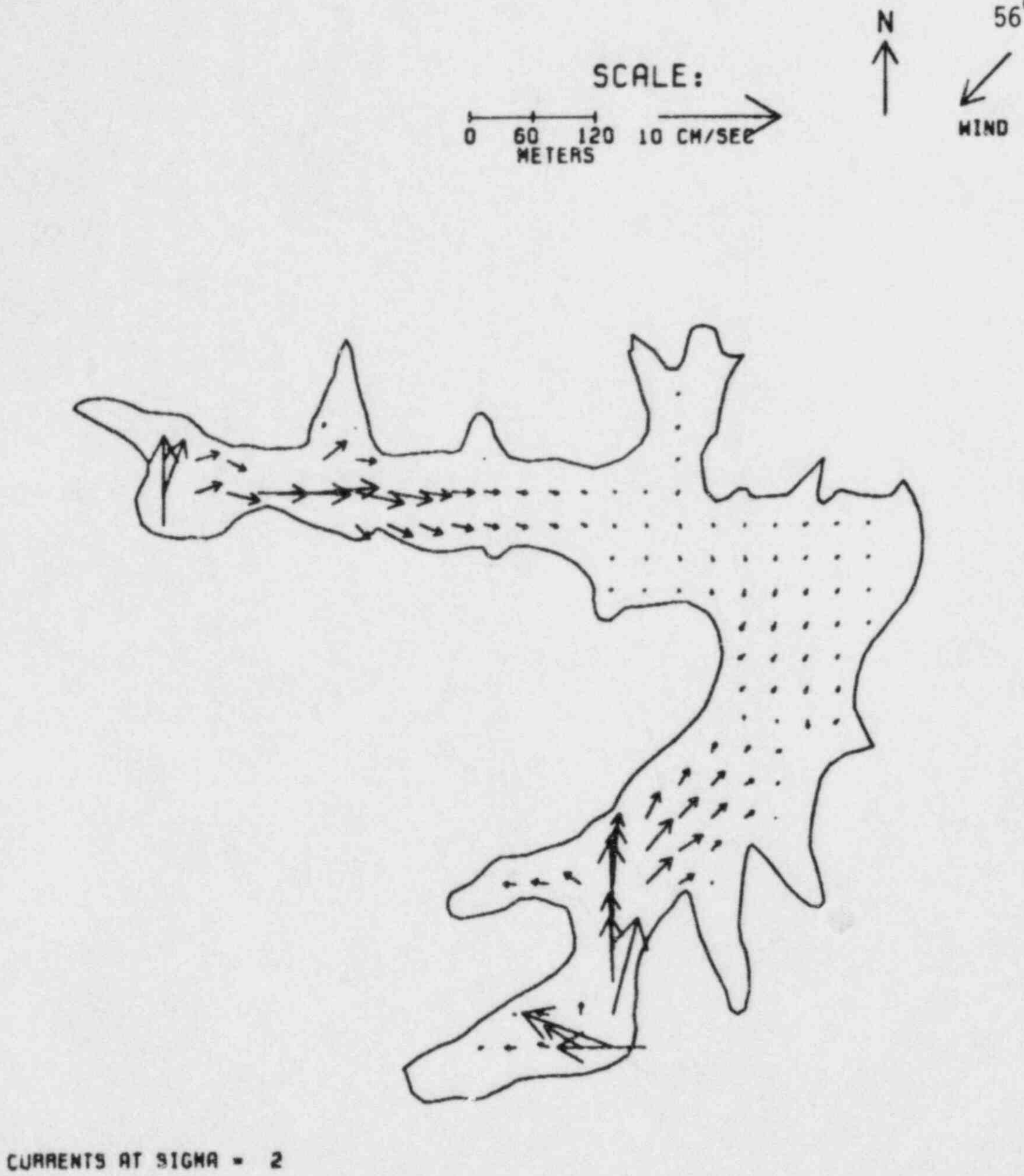


Fig. 7-17. Horizontal Velocities at Grid Points at Level 2 ...End of 4 Hours After Start of Accident.

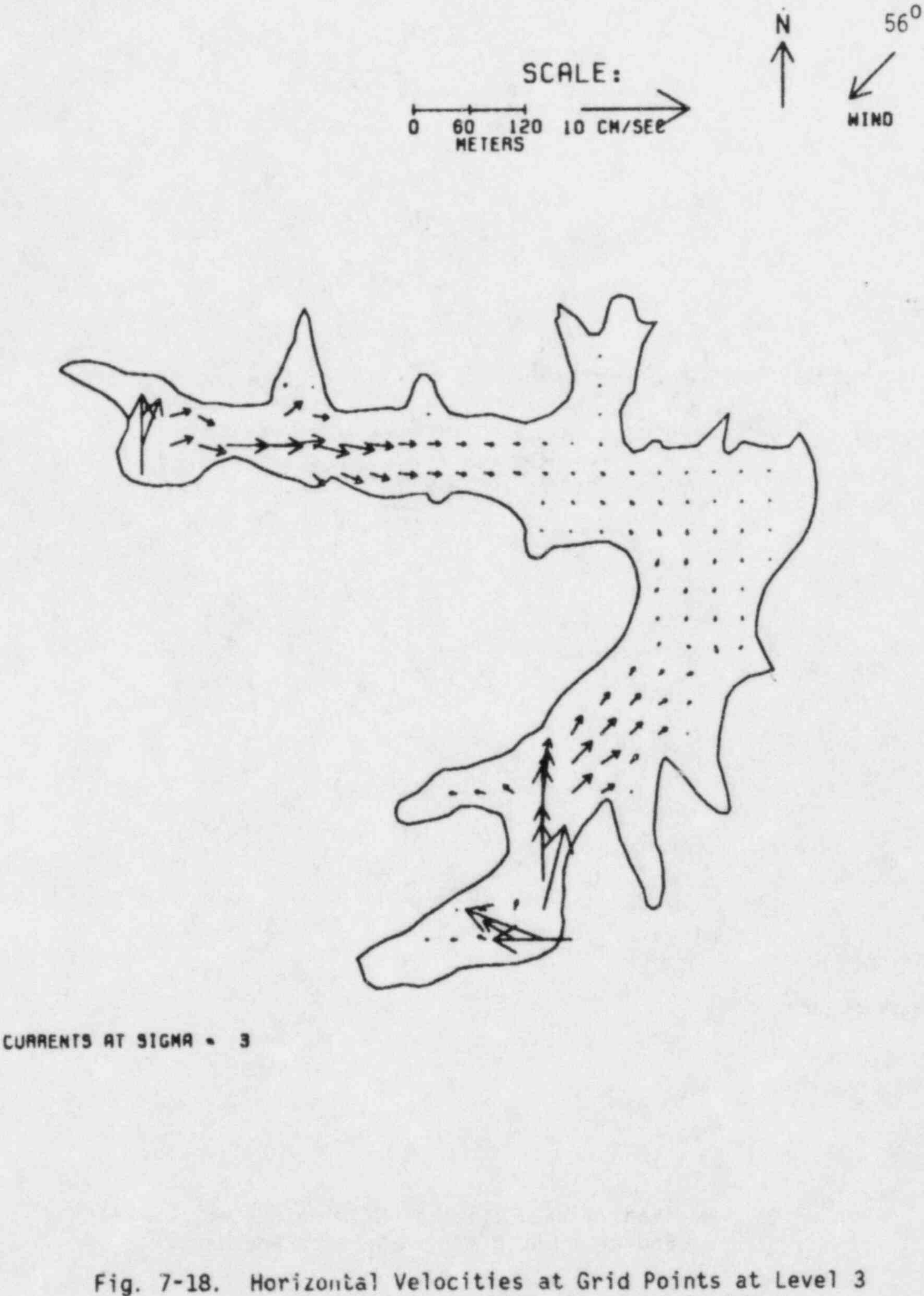


Fig. 7-18. Horizontal Velocities at Grid Points at Level 3
...End of 4 Hours After Start of Accident.

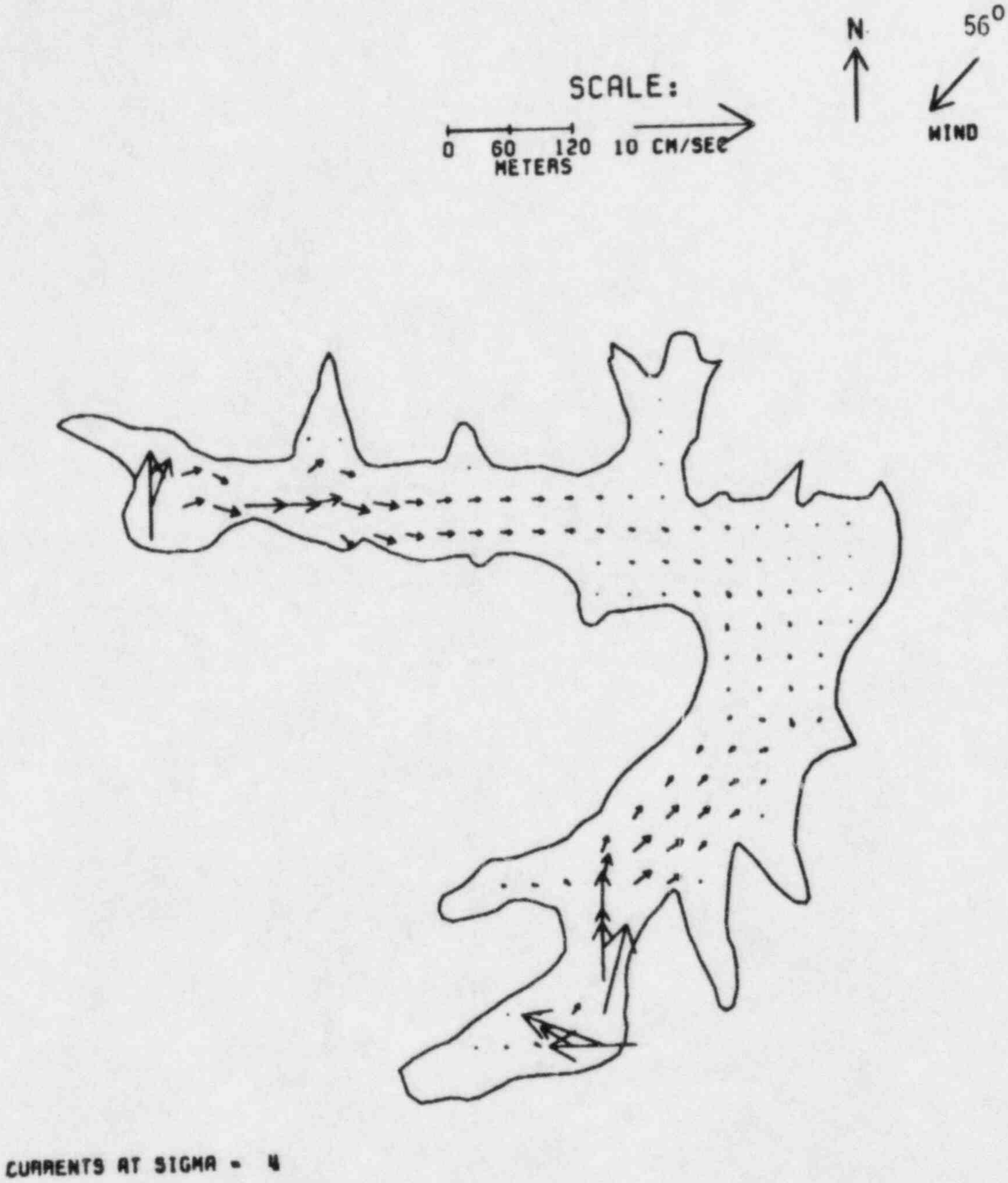


Fig. 7-19. Horizontal Velocities at Grid Points at Level 4 ...End of 4 Hours After Start of Accident.

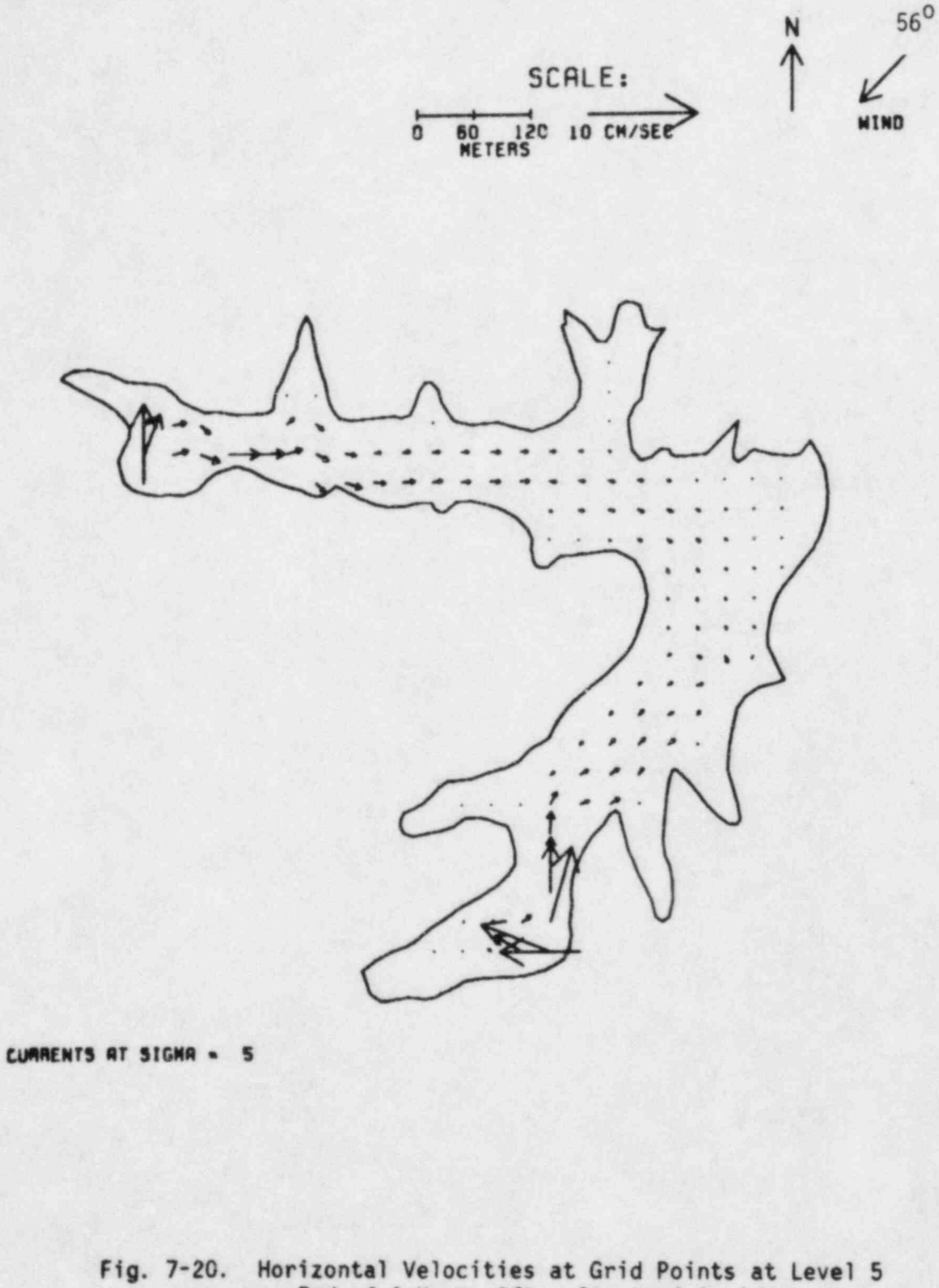


Fig. 7-20. Horizontal Velocities at Grid Points at Level 5 ...End of 4 Hours After Start of Accident.

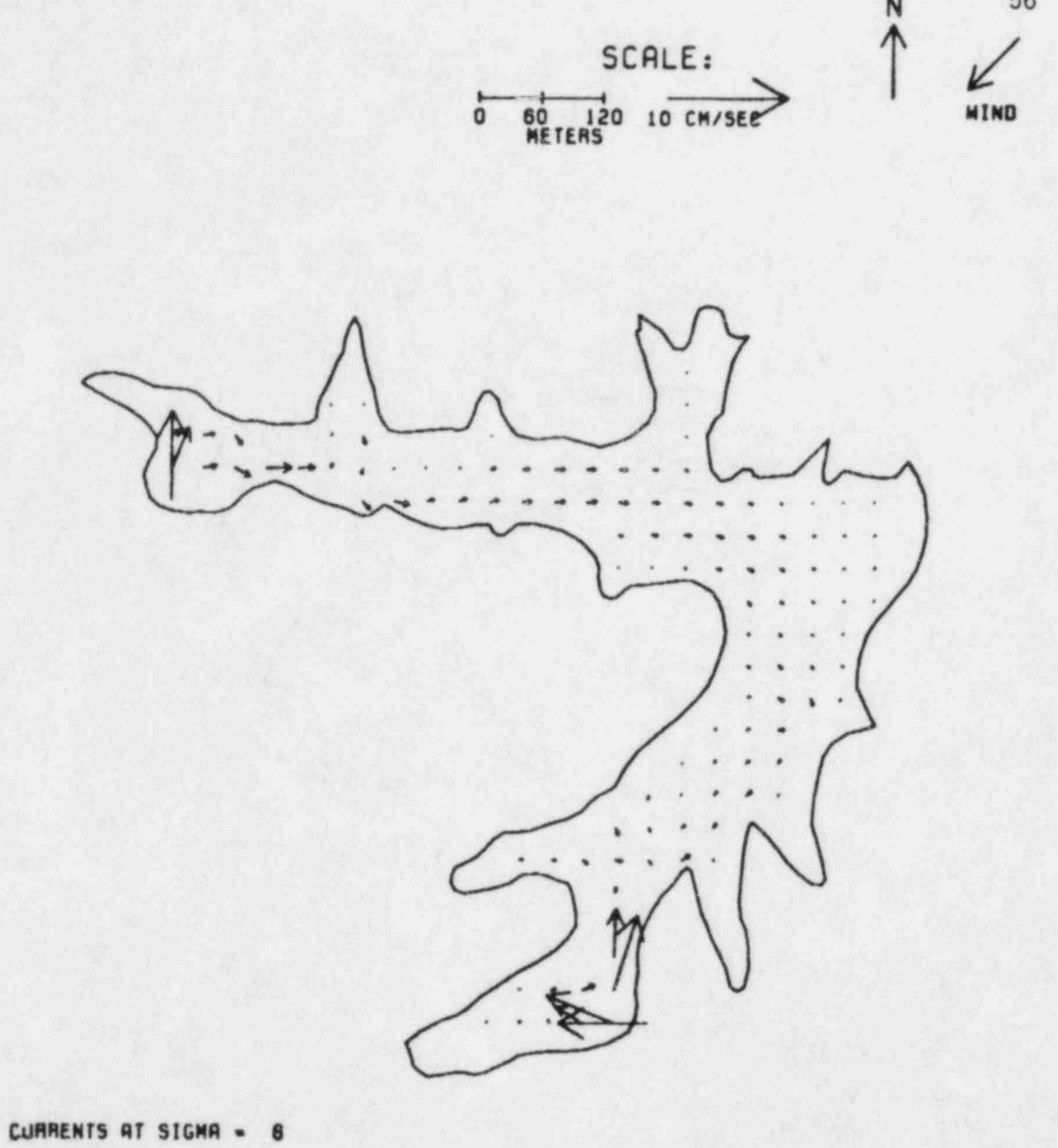


Fig. 7-21. Horizontal Velocities at Grid Points at Level 6 ...End of 4 Hours After Start of Accident.

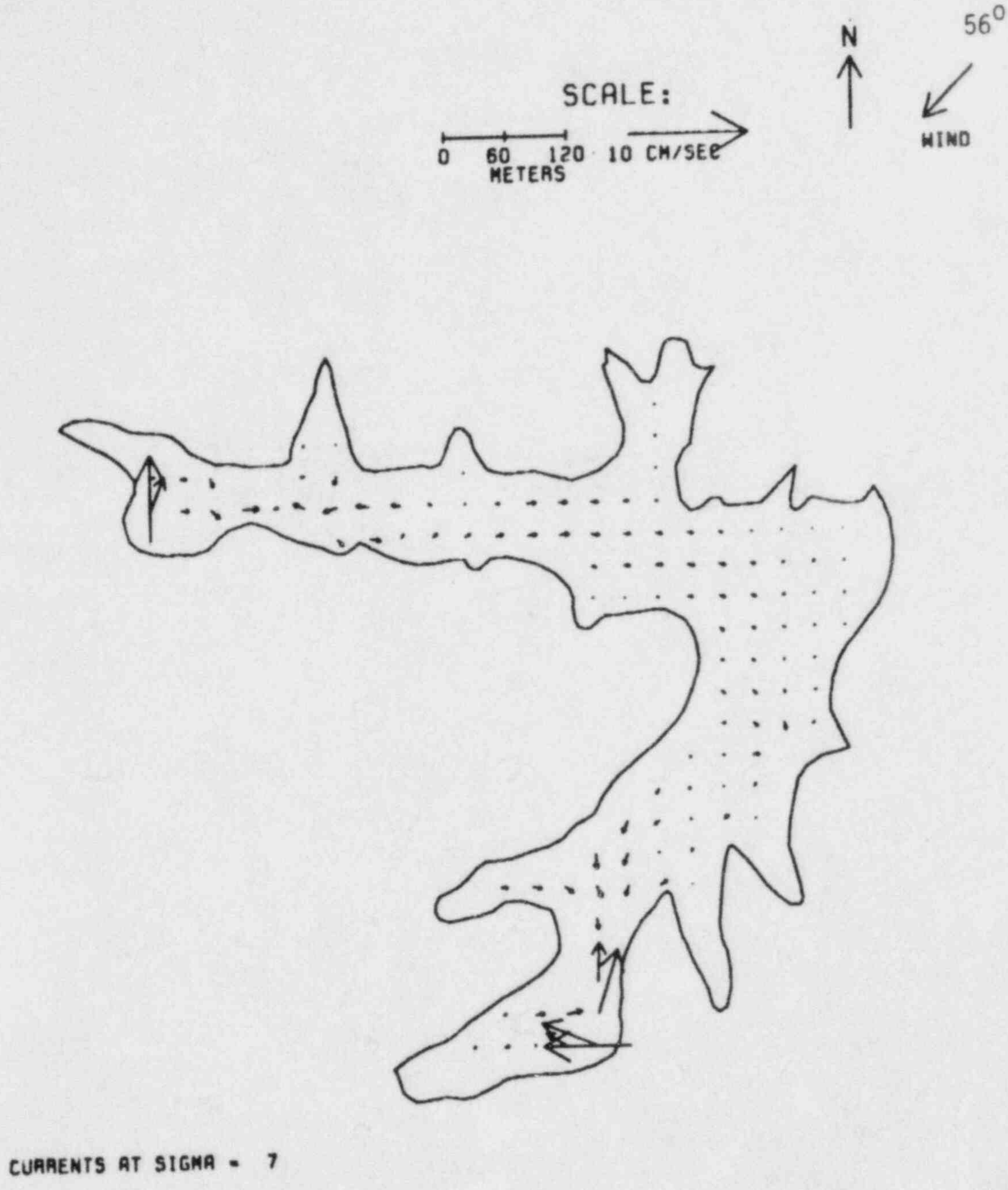


Fig. 7-22. Horizontal Velocities at Grid Points at Level 7 ...End of 4 Hours After Start of Accident.

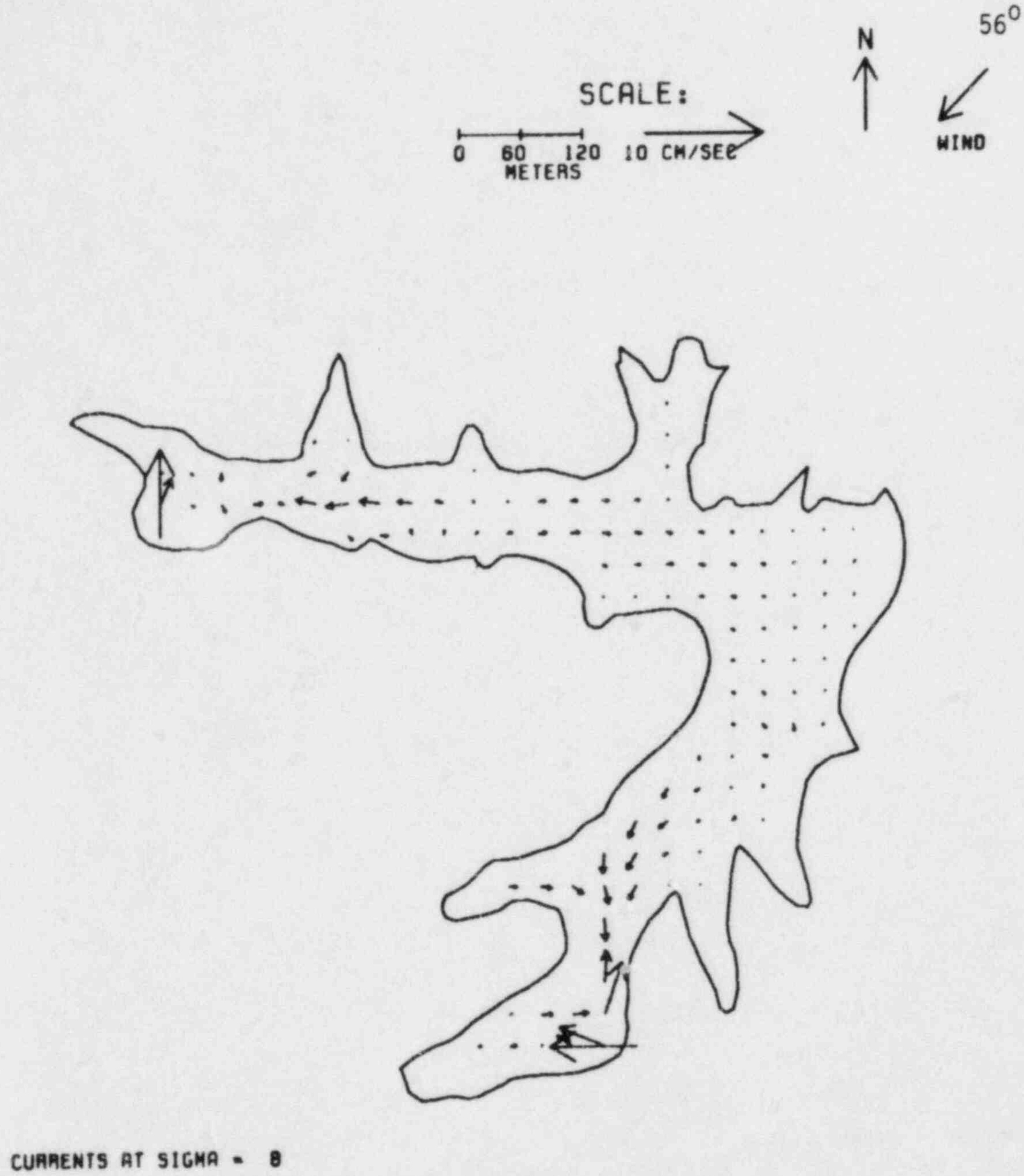


Fig. 7-23. Horizontal Velocities at Grid Points at Level 8
...End of 4 Hours After Start of Accident.

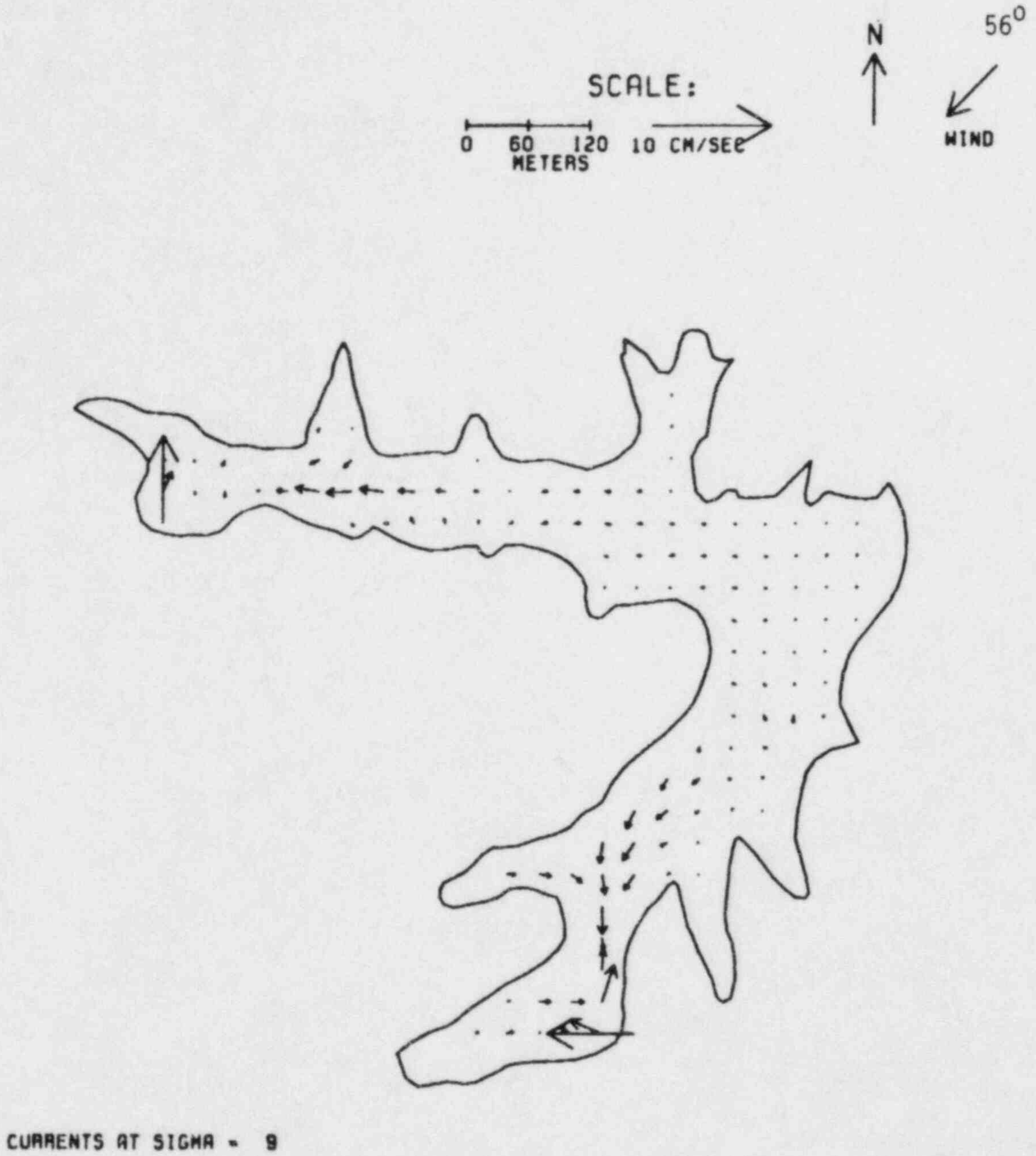


Fig. 7-24. Horizontal Velocities at Grid Points at Level 9 ...End of 4 Hours After Start of Accident.

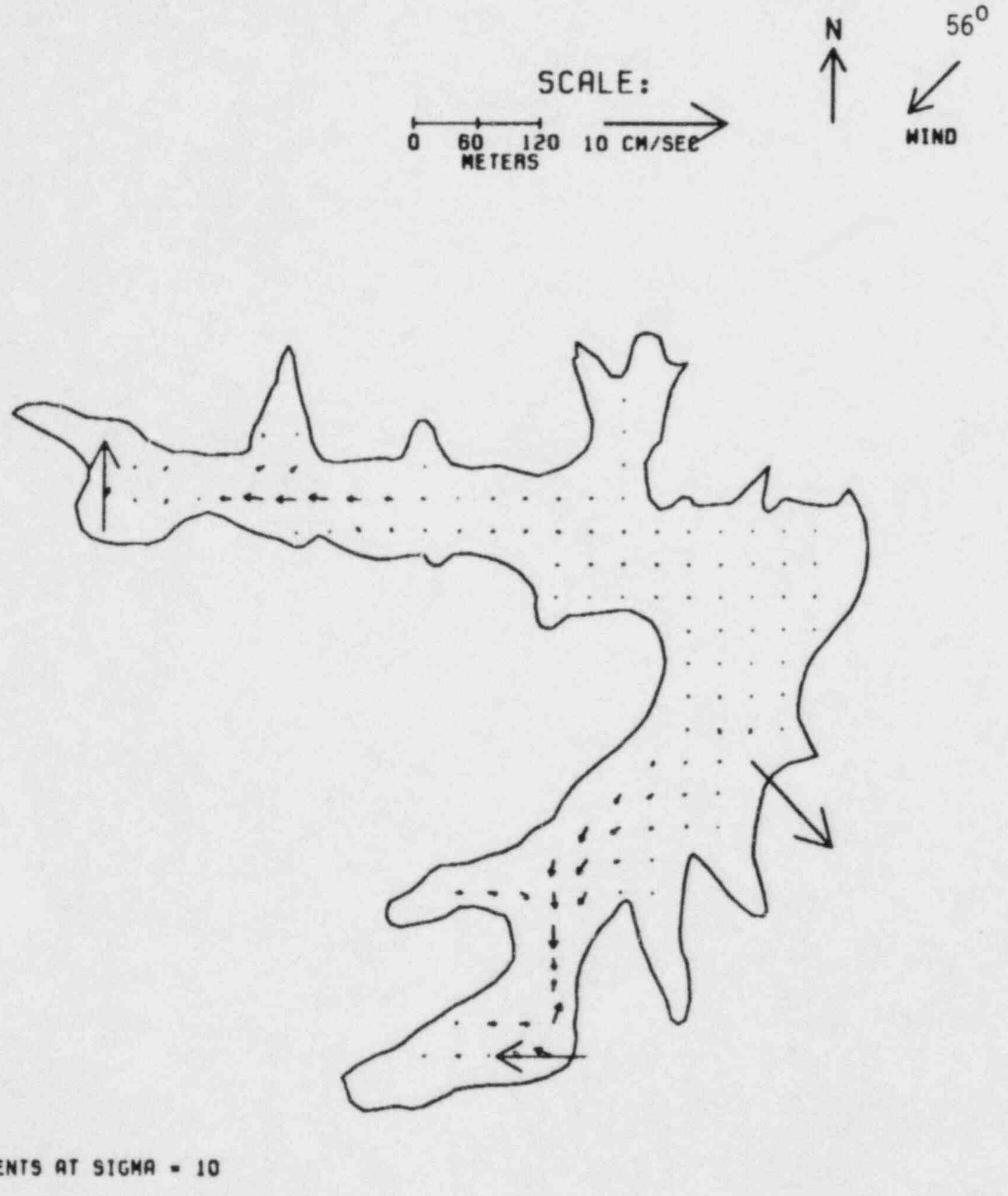


Fig. 7-25. Horizontal Velocities at Grid Points at Level 10 (Level Just Above Bottom) ...End of 4 Hours After Start of Accident.

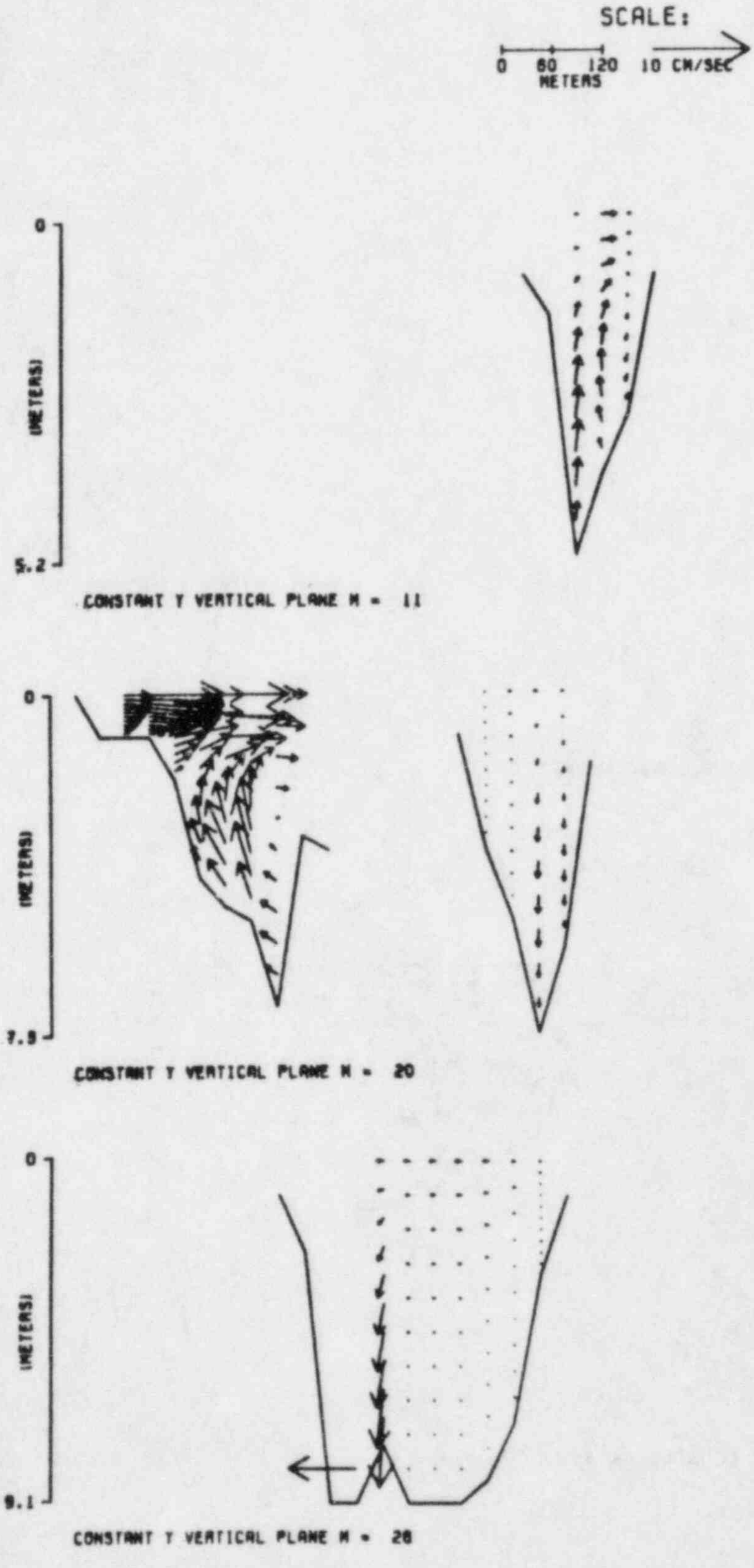


Fig. 7-26. Cross-Sectional Velocities in Plane at (a) M=11 ...Y Constant, (b) M=20 ...Y Constant, and (c) M=26 ...Y Constant ...End of 4 Hours After Start of Accident.

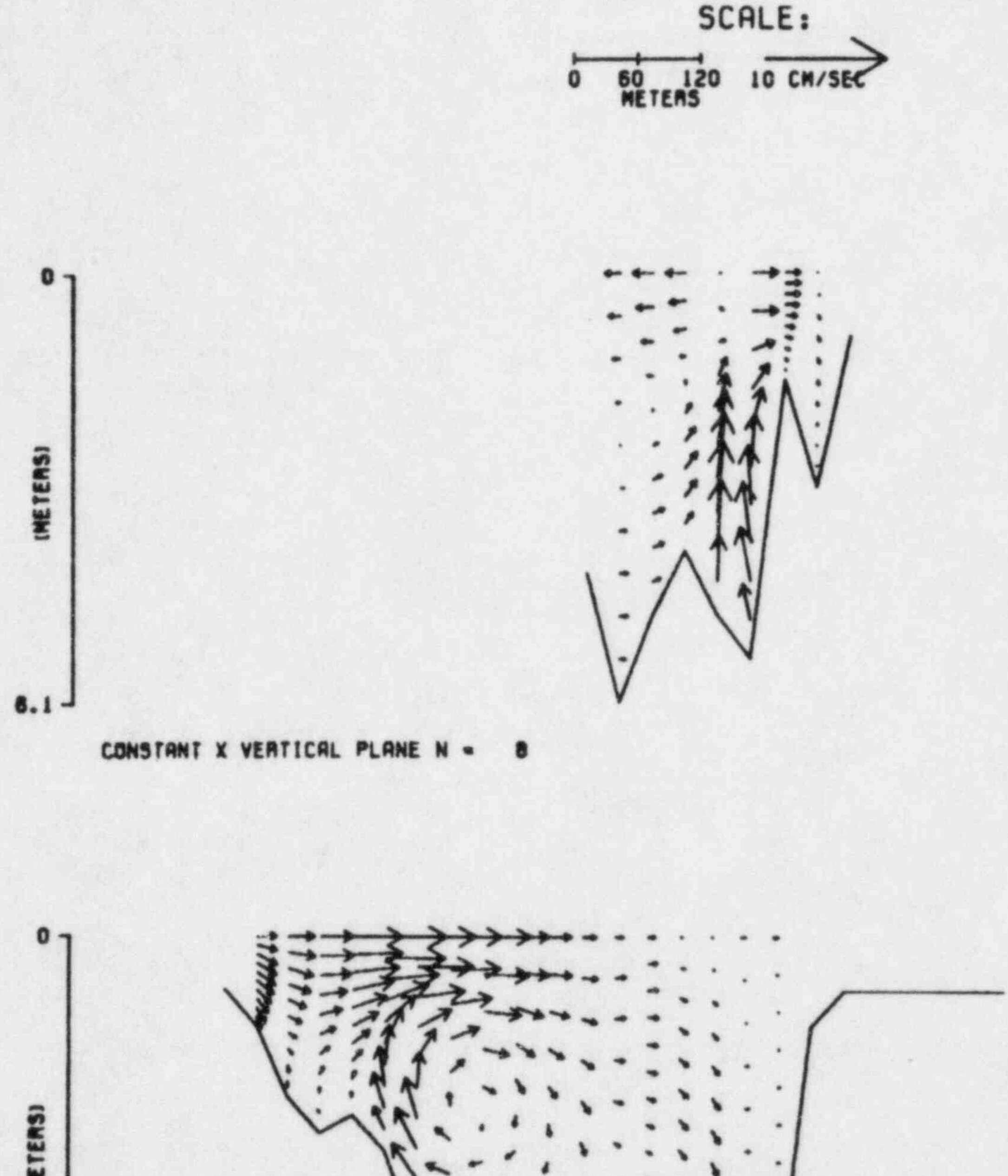


Fig. 7-27. Cross-Sectional Velocities in Plane at (a) N=18 ...X Constant, and (b) N=20 ...X Constant ...End of 4 Hours After Start of Accident.

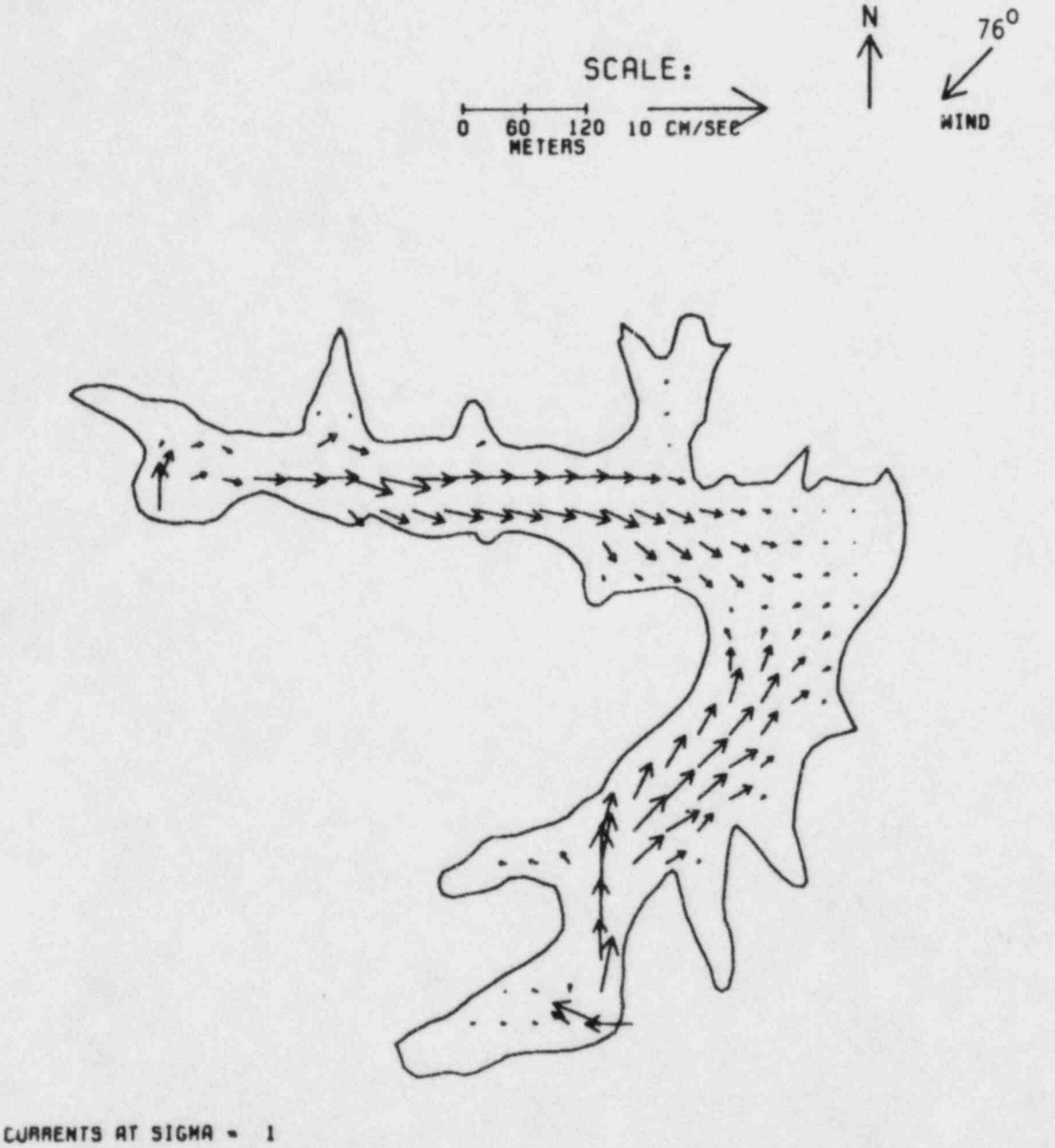


Fig. 7-28. Horizontal Velocities at Grid Points Located at Top Level (Surface) ...End of 6.38 Days (Time Peak Intake Temperature) After Start of Accident.

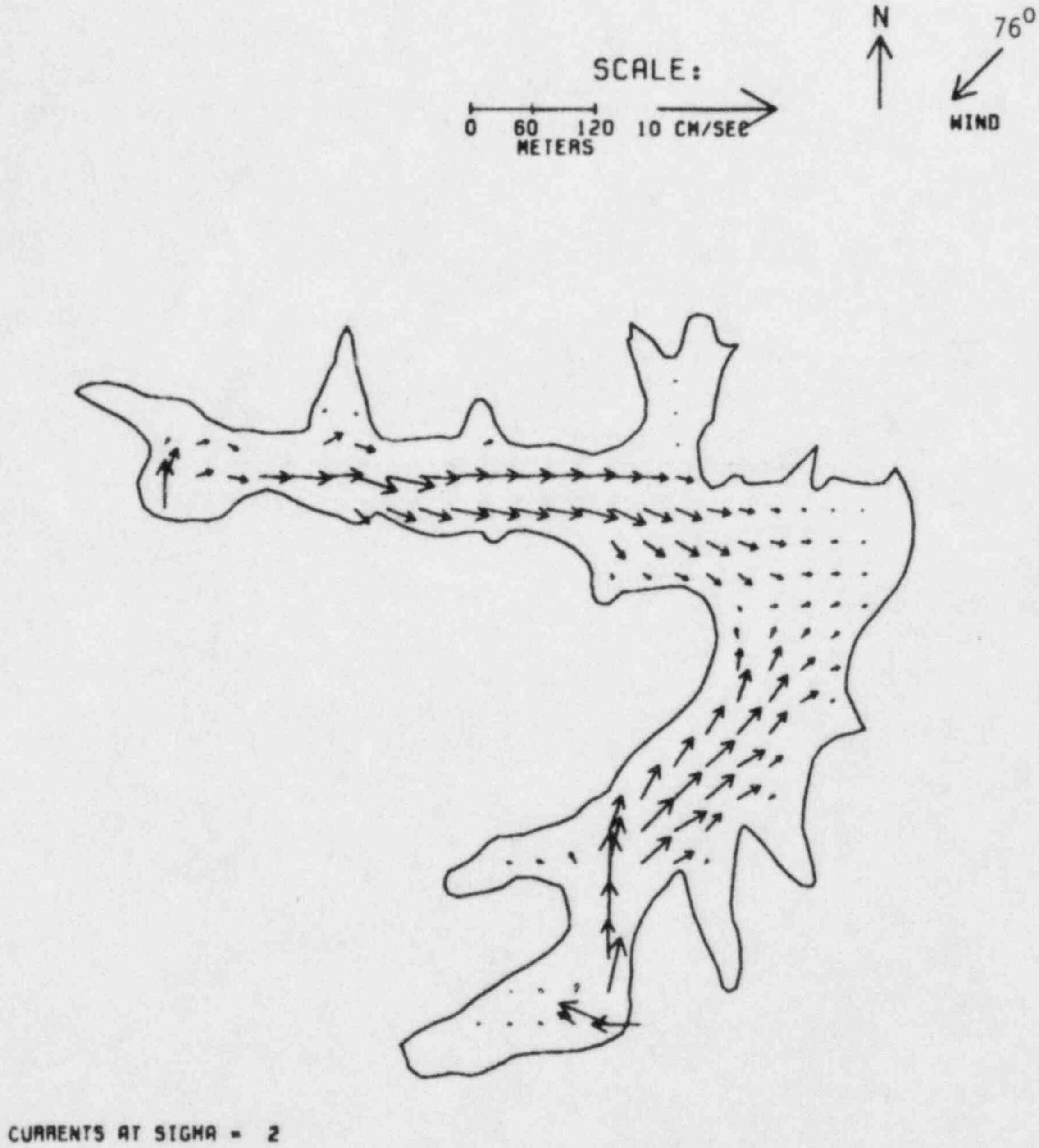


Fig. 7-29. Horizontal Velocities at Grid Points at Level 2 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

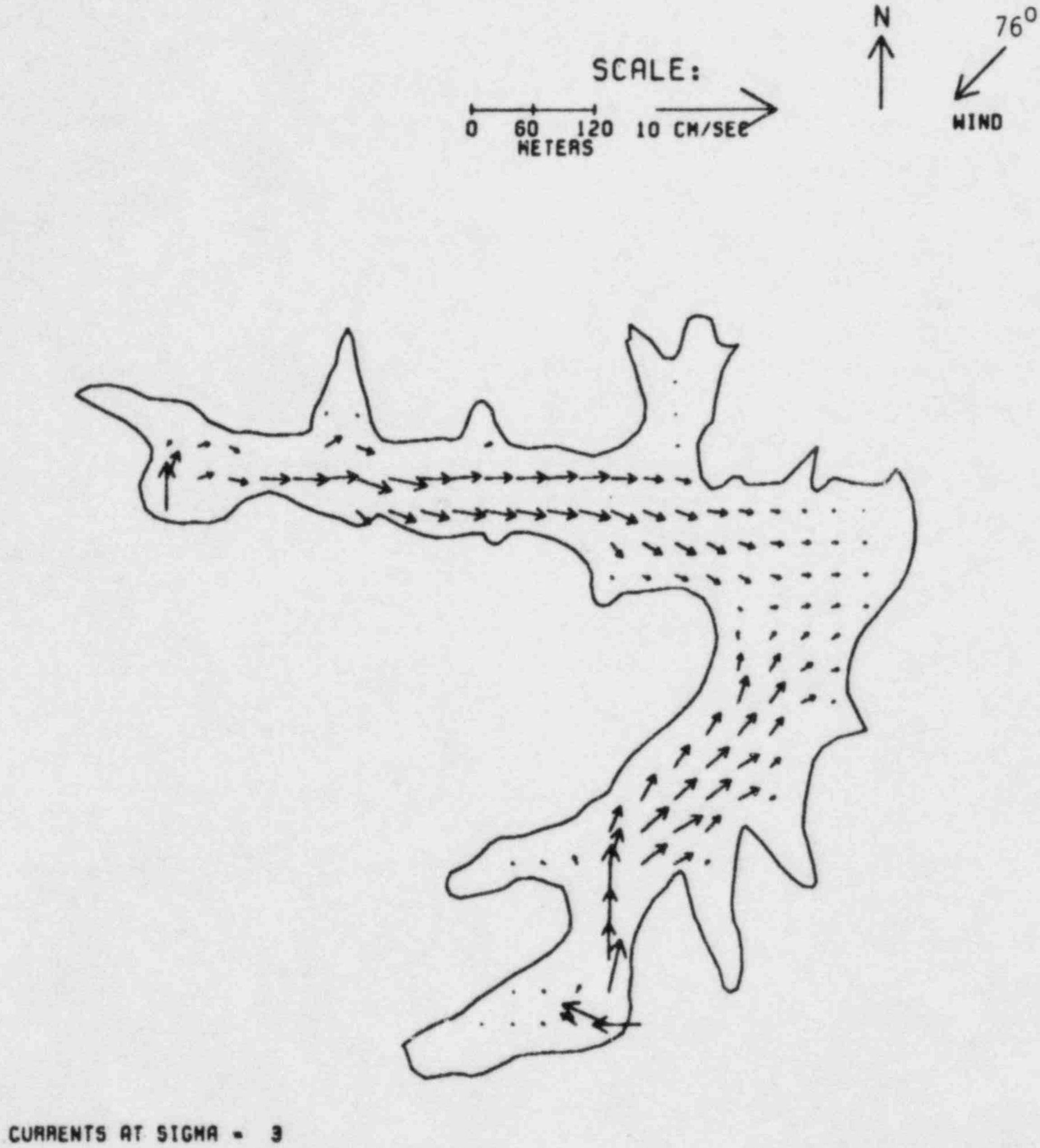


Fig. 7-30. Horizontal Velocities at Grid Points at Level 3 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

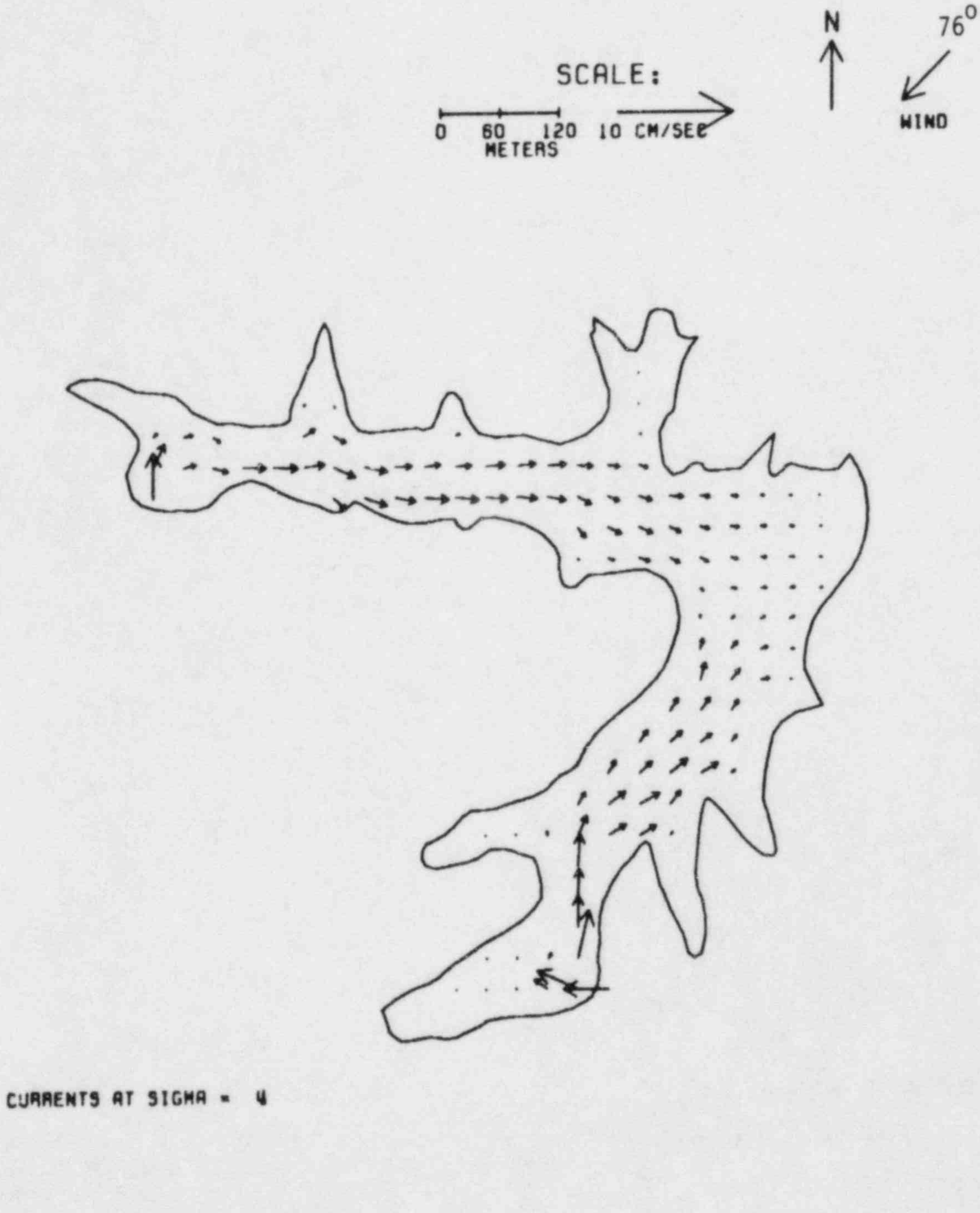


Fig. 7-31. Horizontal Velocities at Grid Points at Level 4 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

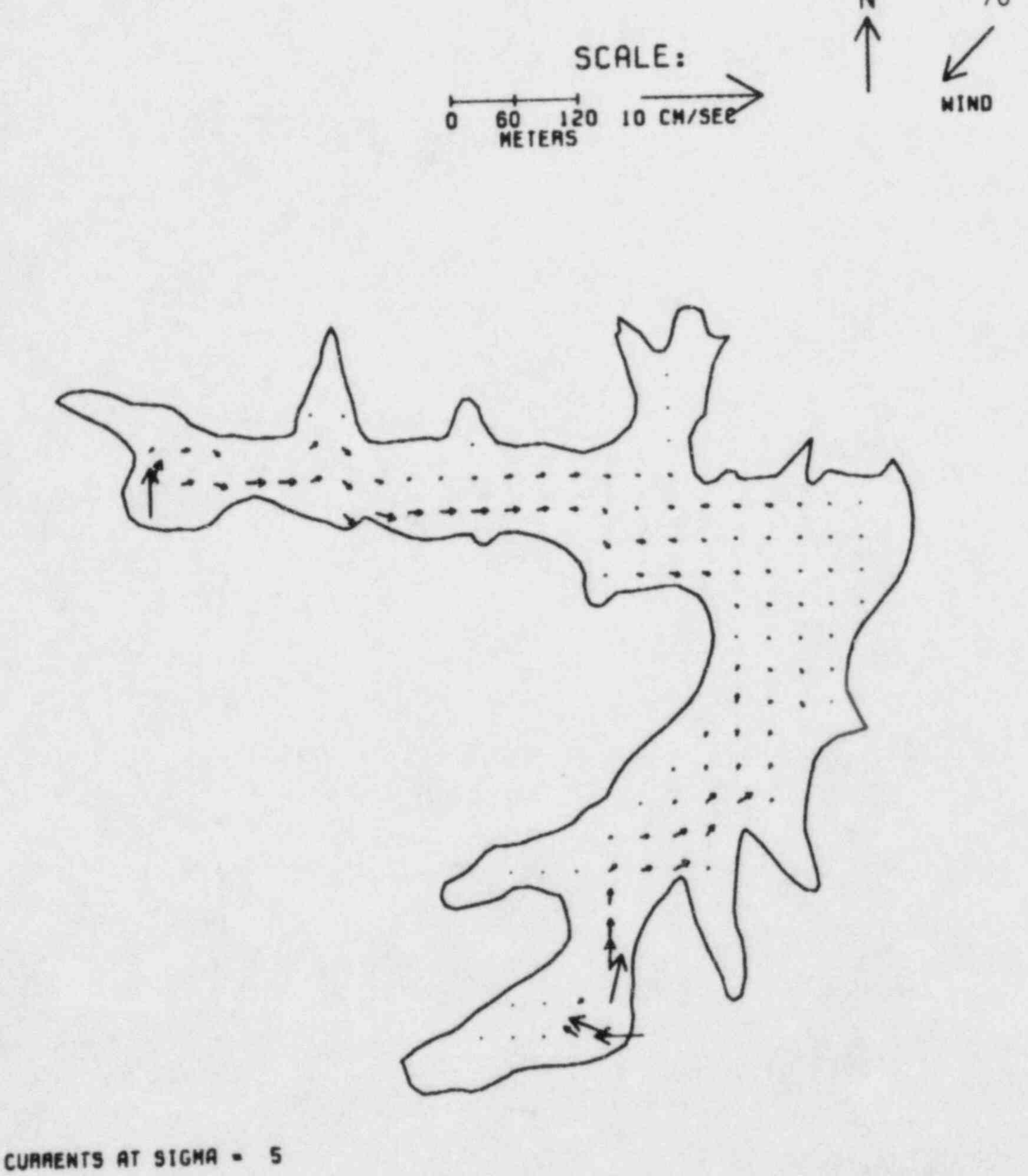


Fig. 7-32. Horizontal Velocities at Grid Points at Level 5 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

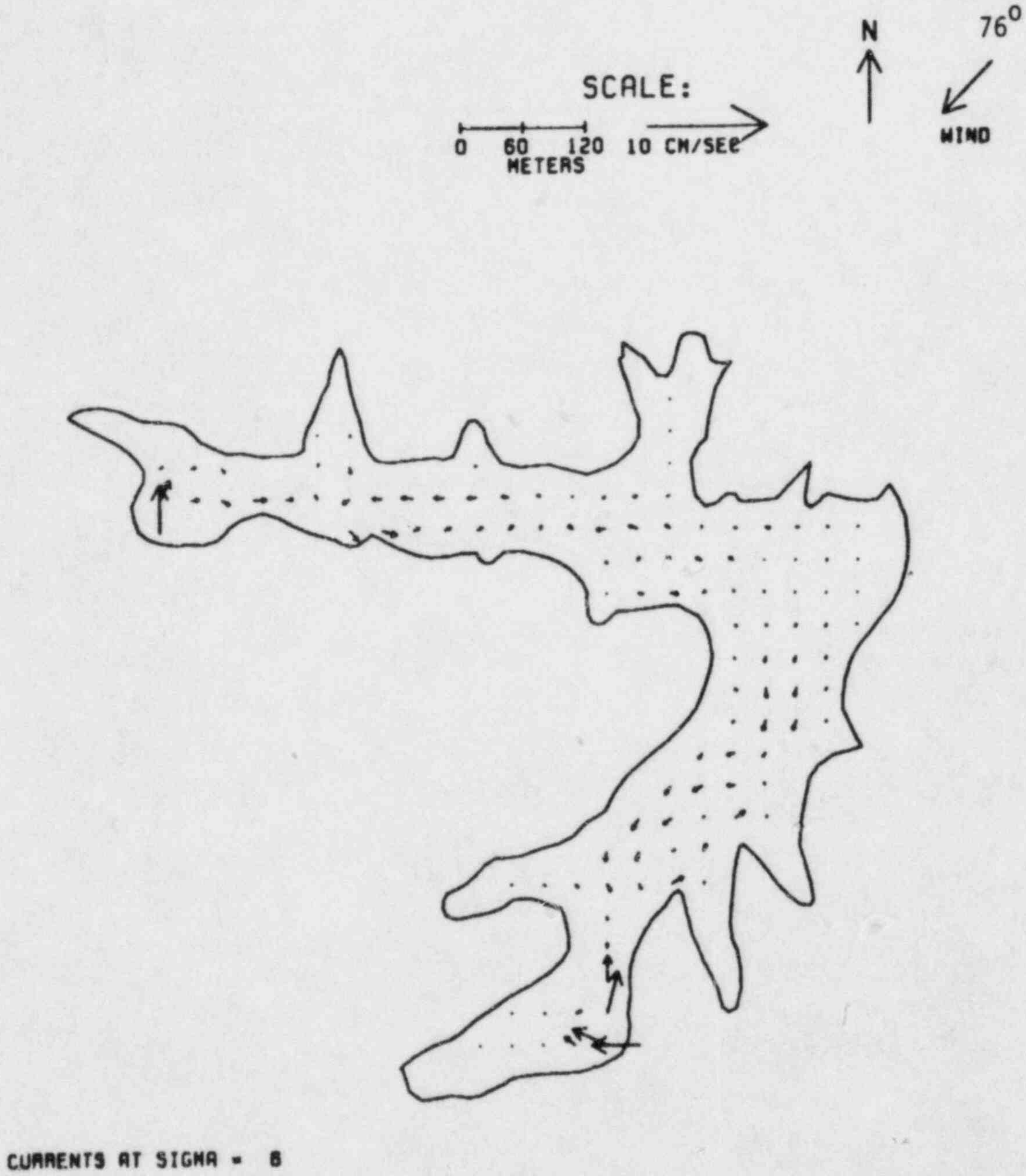


Fig. 7-33. Horizontal Velocities at Grid Points at Level 6 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

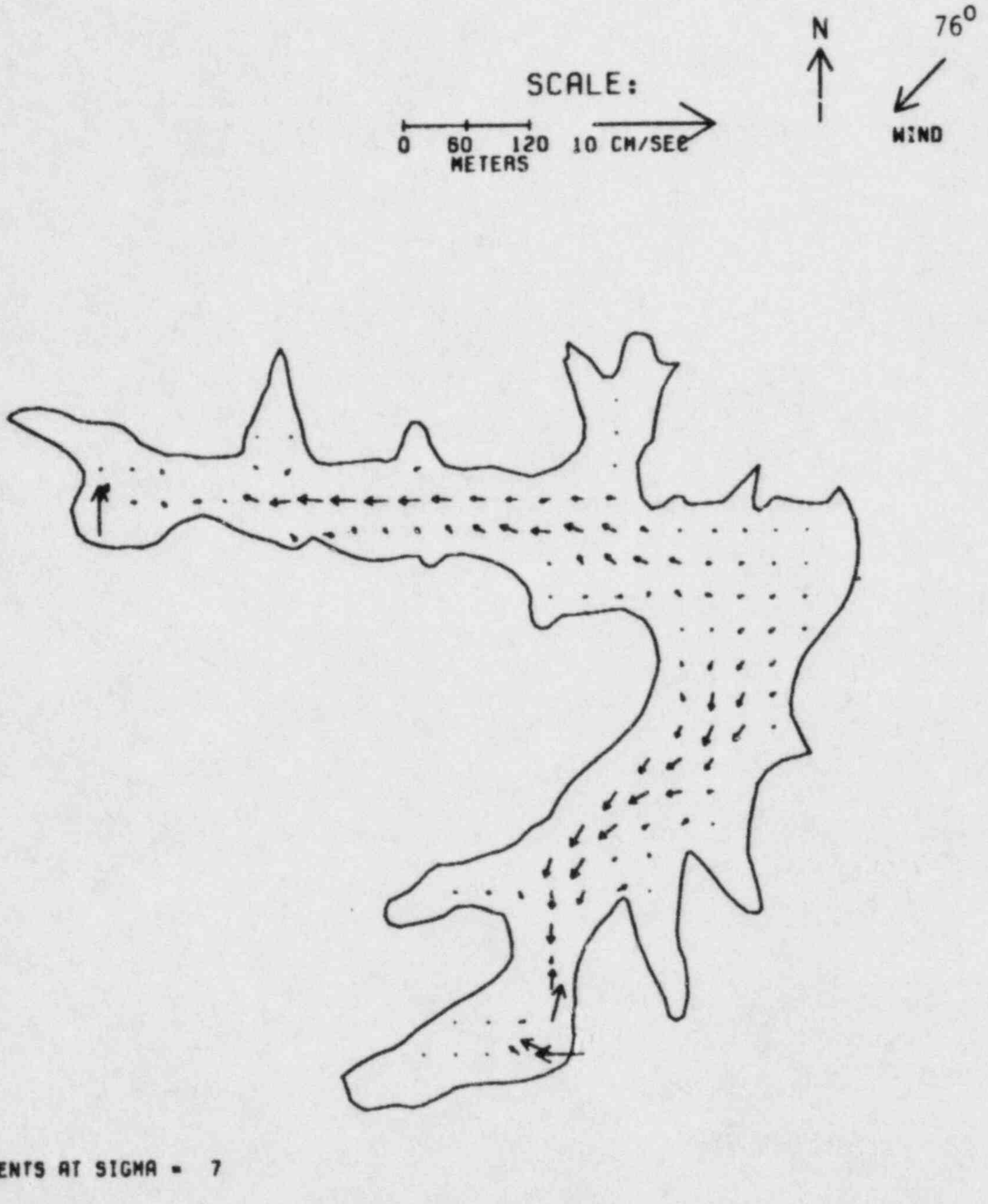


Fig. 7-34. Horizontal Velocities at Grid Points at Level 7 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

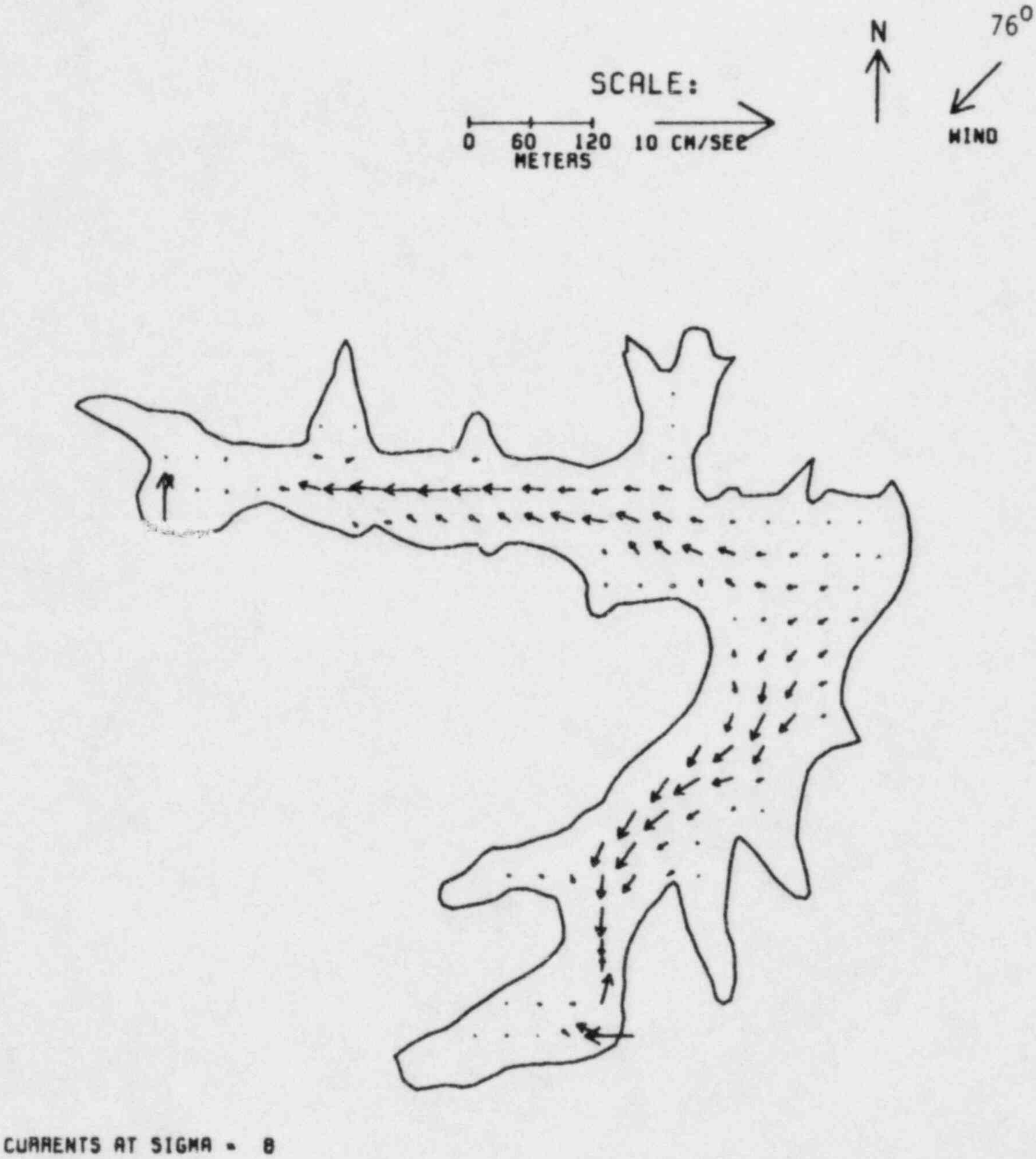


Fig. 7-35. Horizontal Velocities at Grid Points at Level 8 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

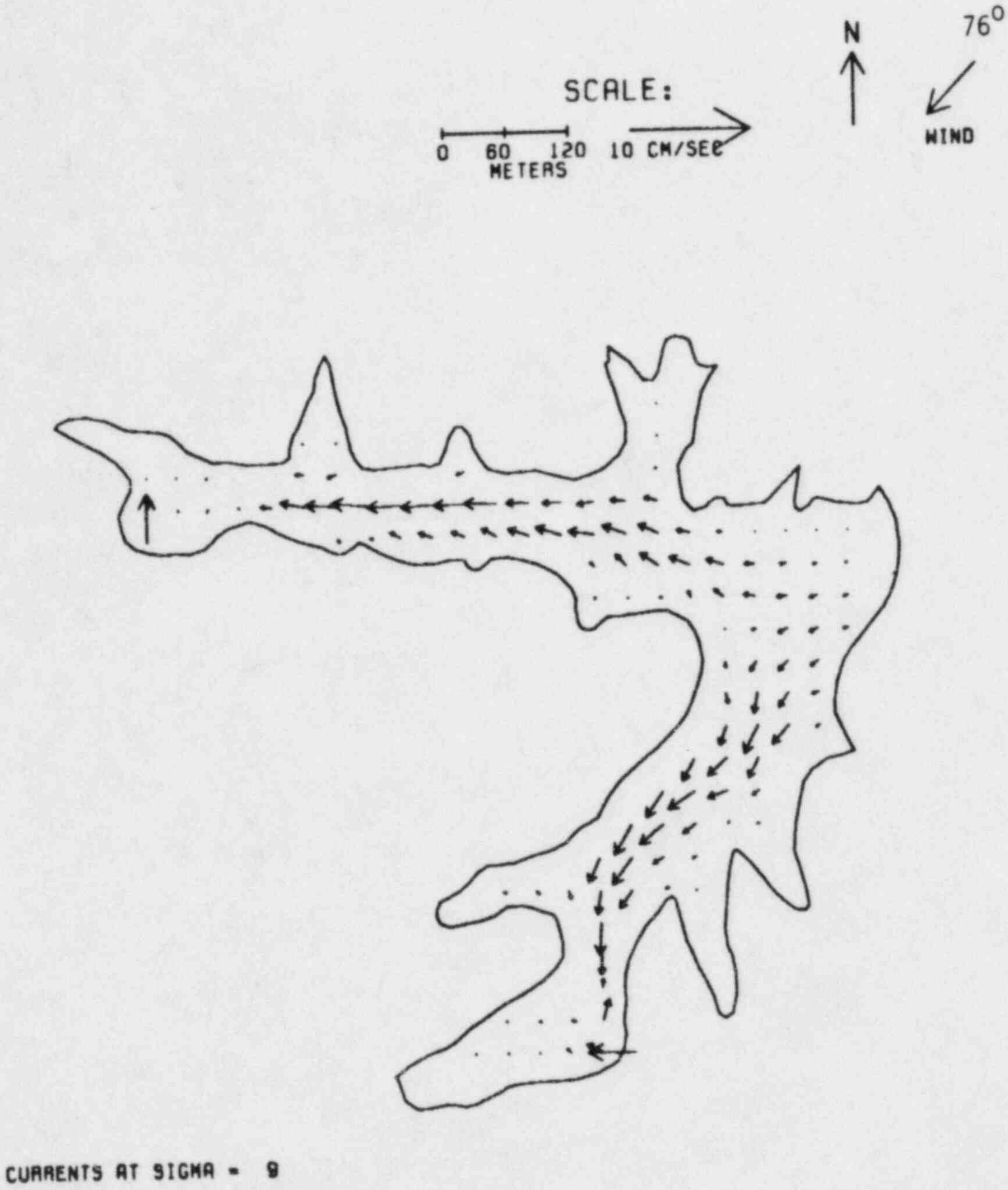


Fig. 7-36. Horizontal Velocities at Grid Points at Level 9 ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

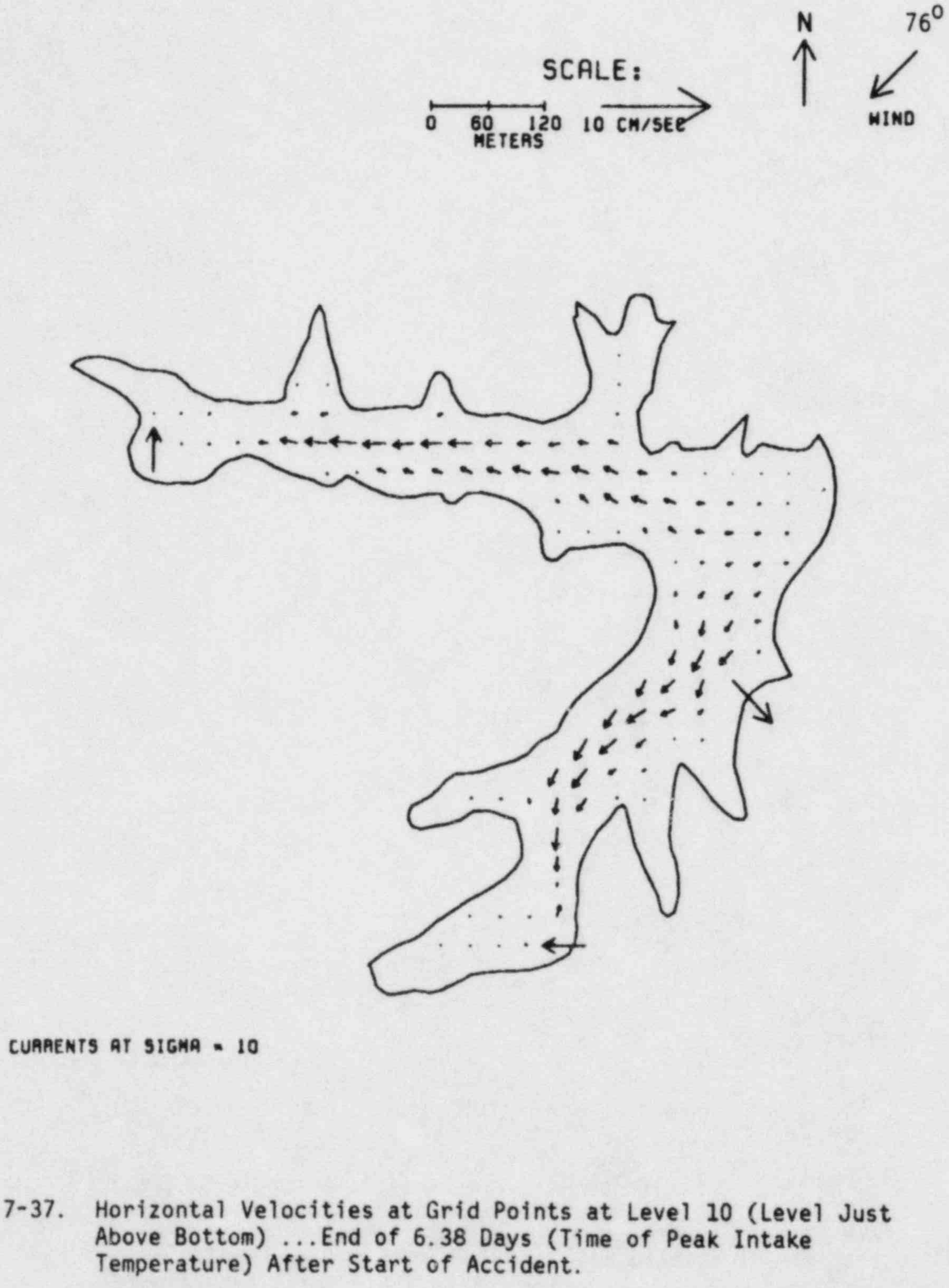


Fig. 7-37. Horizontal Velocities at Grid Points at Level 10 (Level Just Above Bottom) ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

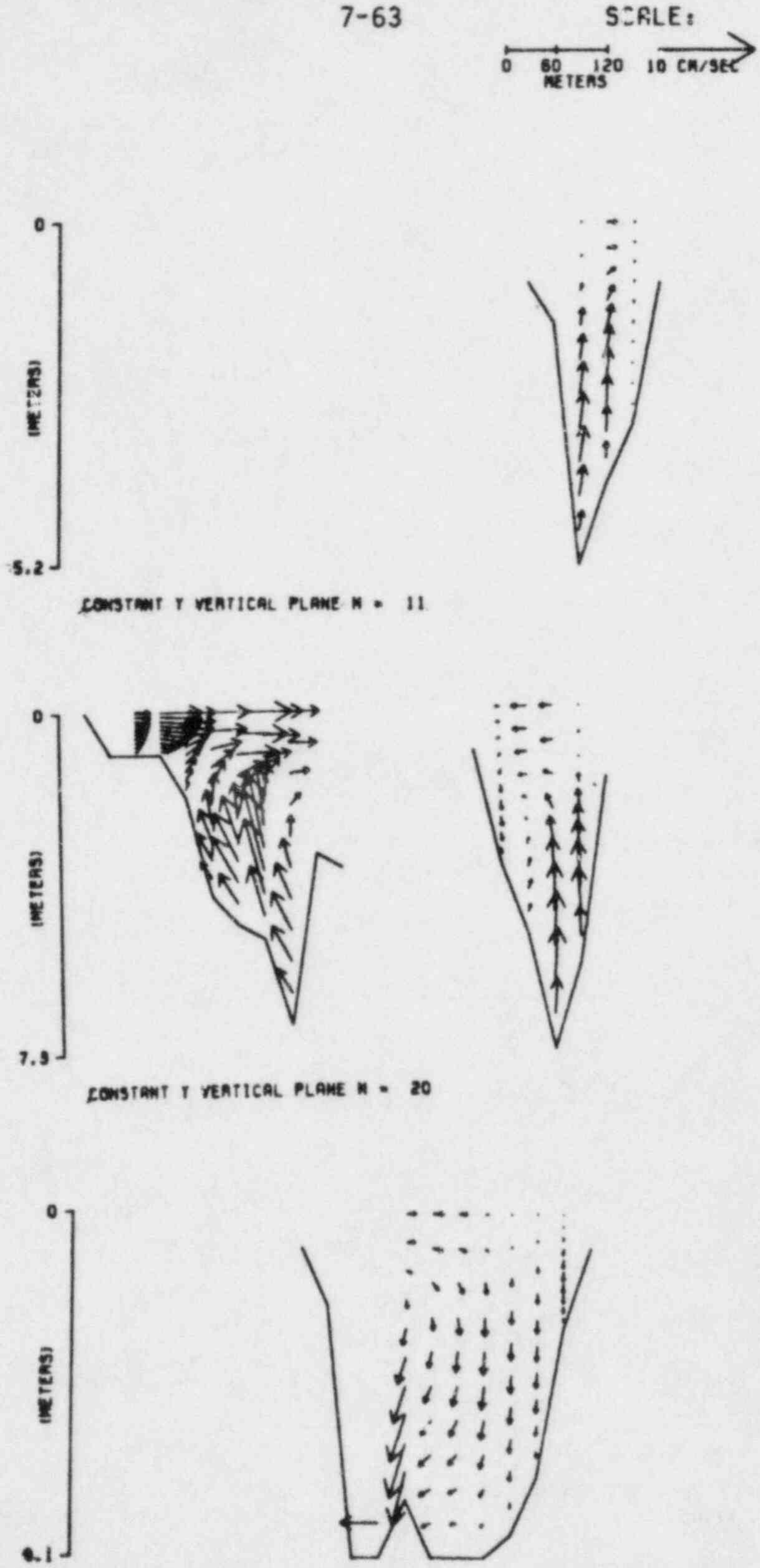


Fig. 7-38. Cross-Sectional Velocities in Plane at (a) M=11 ...Y Constant, (b) M=20 ...Y Constant, and (c) M=26 ...Y Constant ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

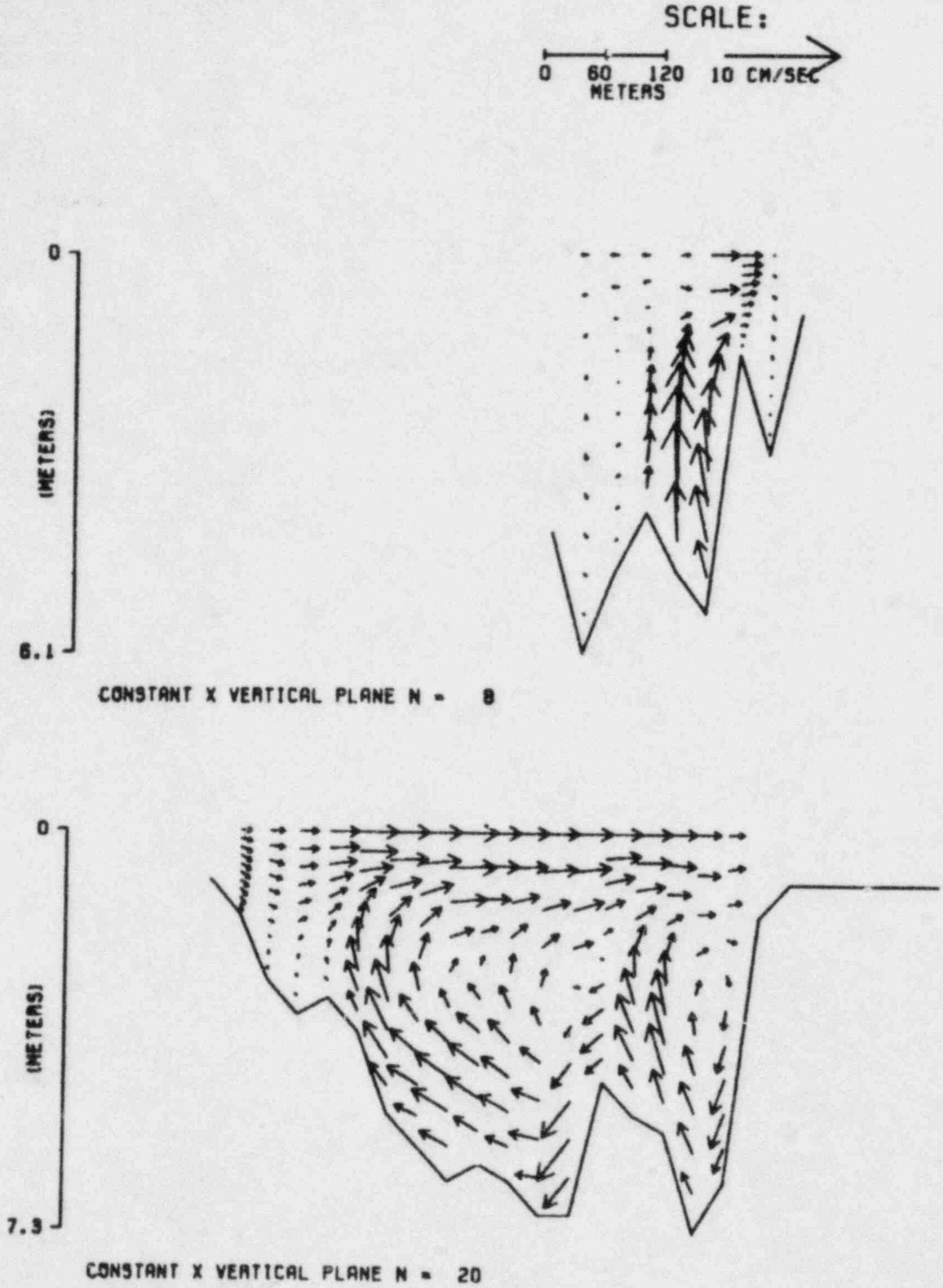


Fig. 7-39. Cross-Sectional Velocities in Plane at (a) N=8 ...X Constant, and (b) N=20 ...X Constant, ...End of 6.38 Days (Time of Peak Intake Temperature) After Start of Accident.

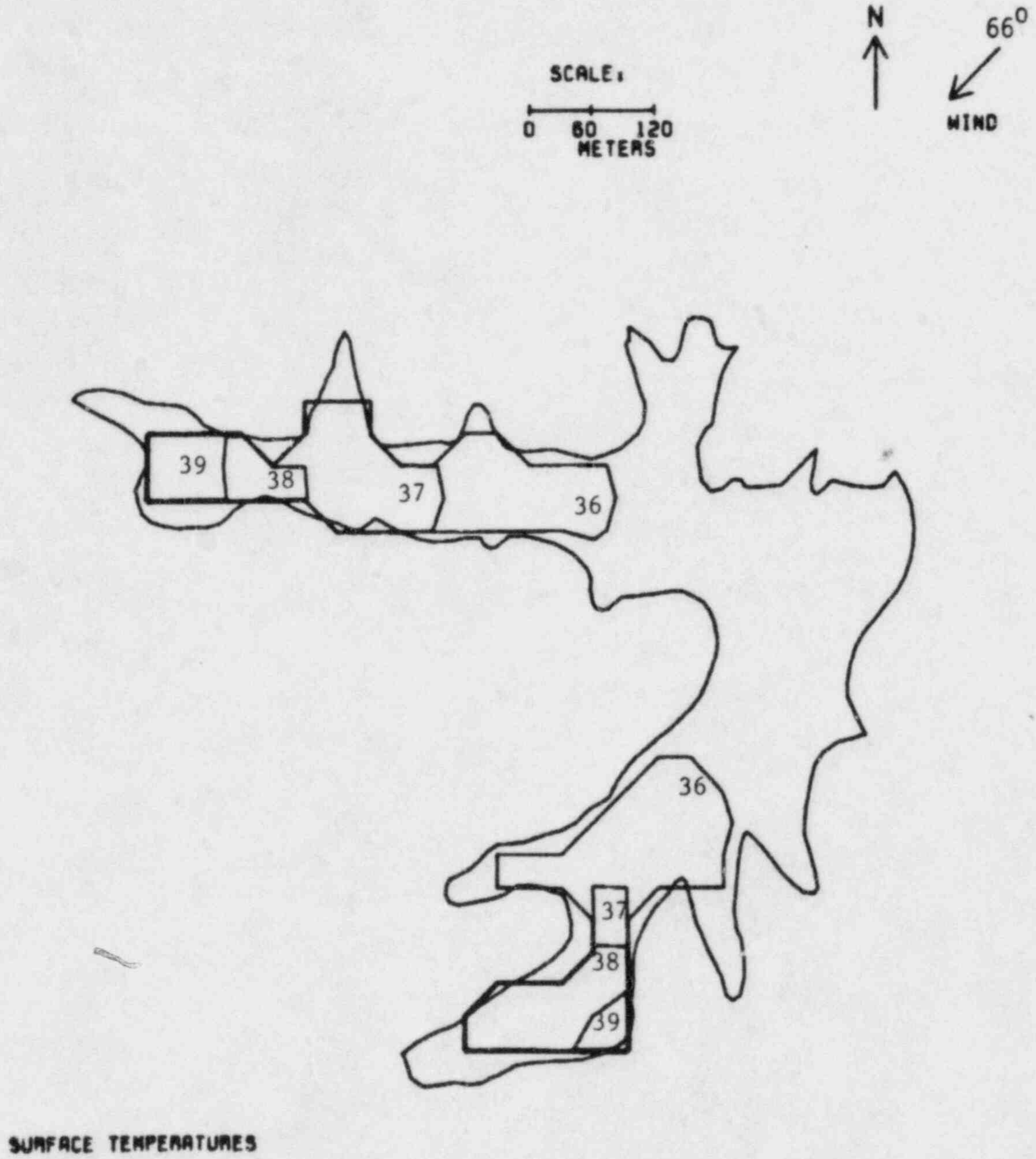


Fig. 7-40. Surface Temperature Isotherms at the Peak Intake Temperature ...6.38 Days After Start of Accident.

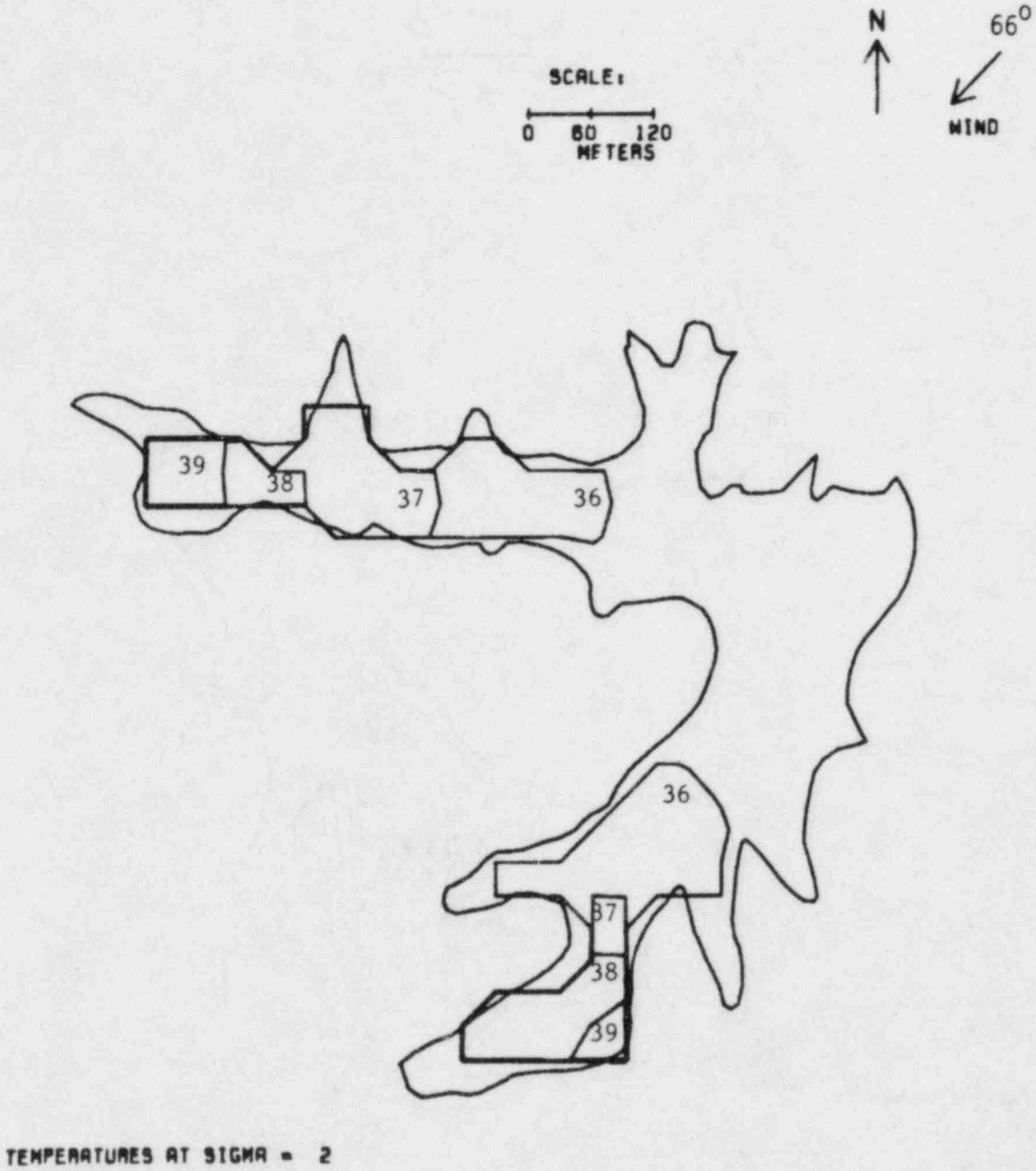


Fig. 7-41. Horizontal Isotherms at Level 2 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

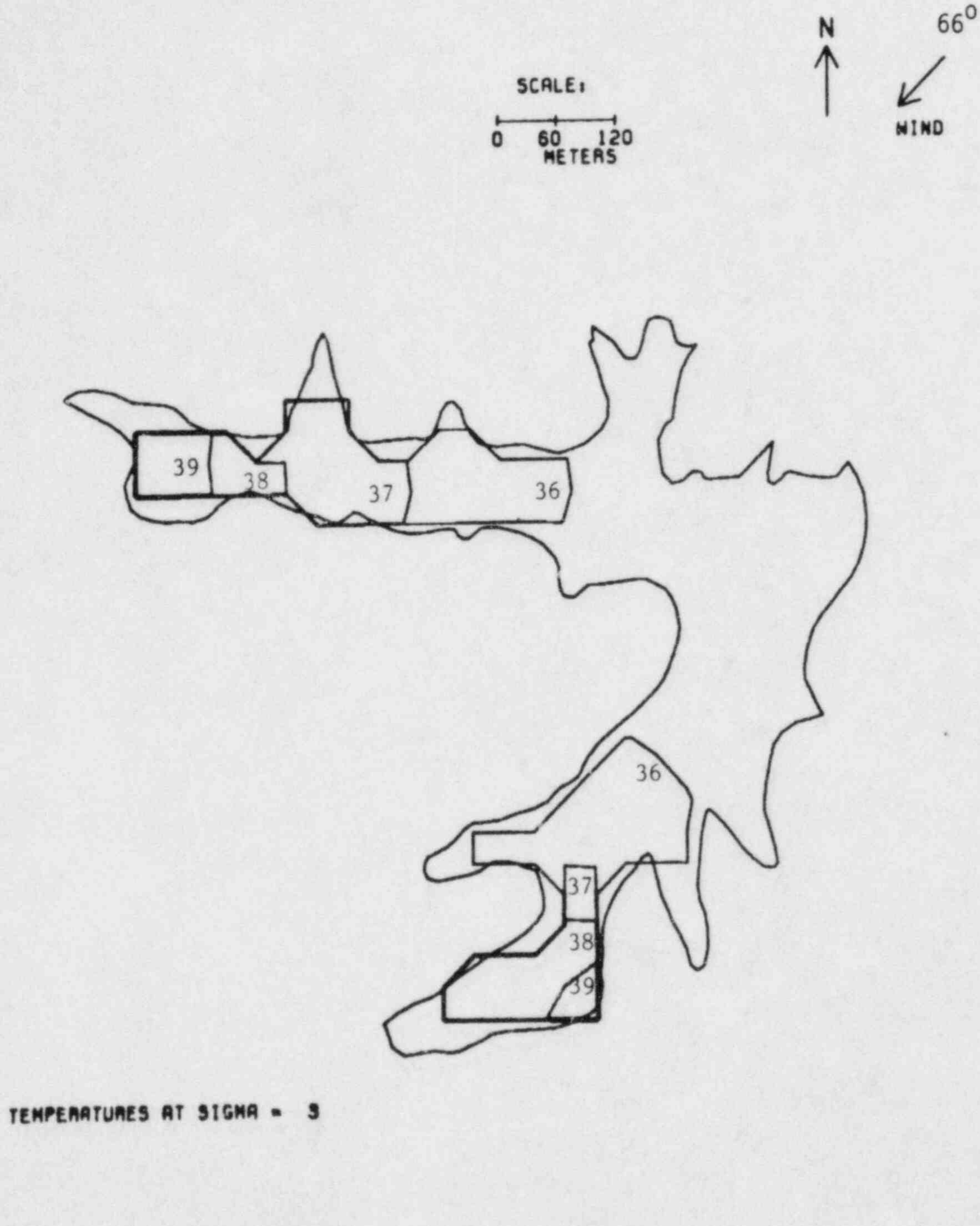


Fig. 7-42. Horizontal Isotherms at Level 3 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

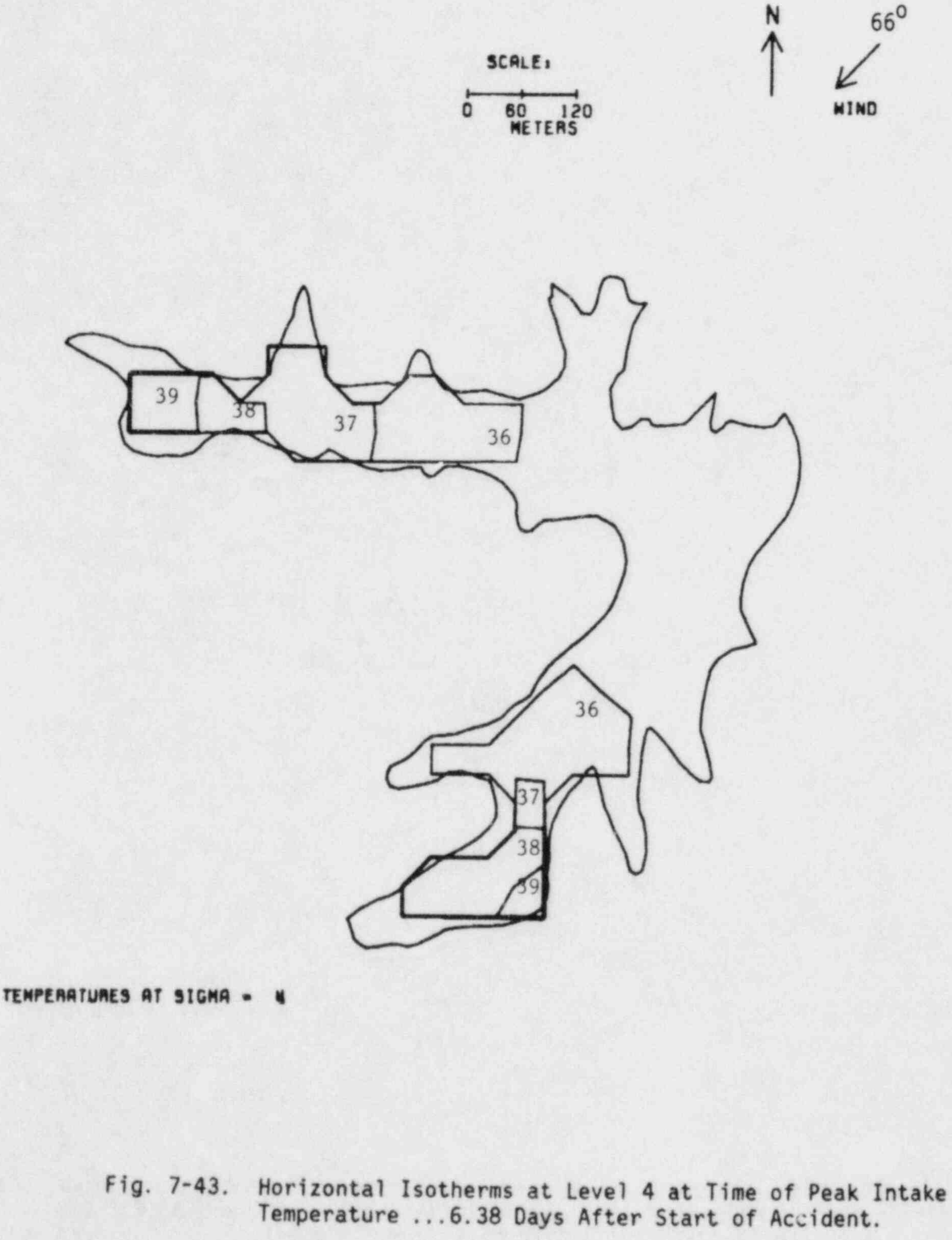


Fig. 7-43. Horizontal Isotherms at Level 4 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

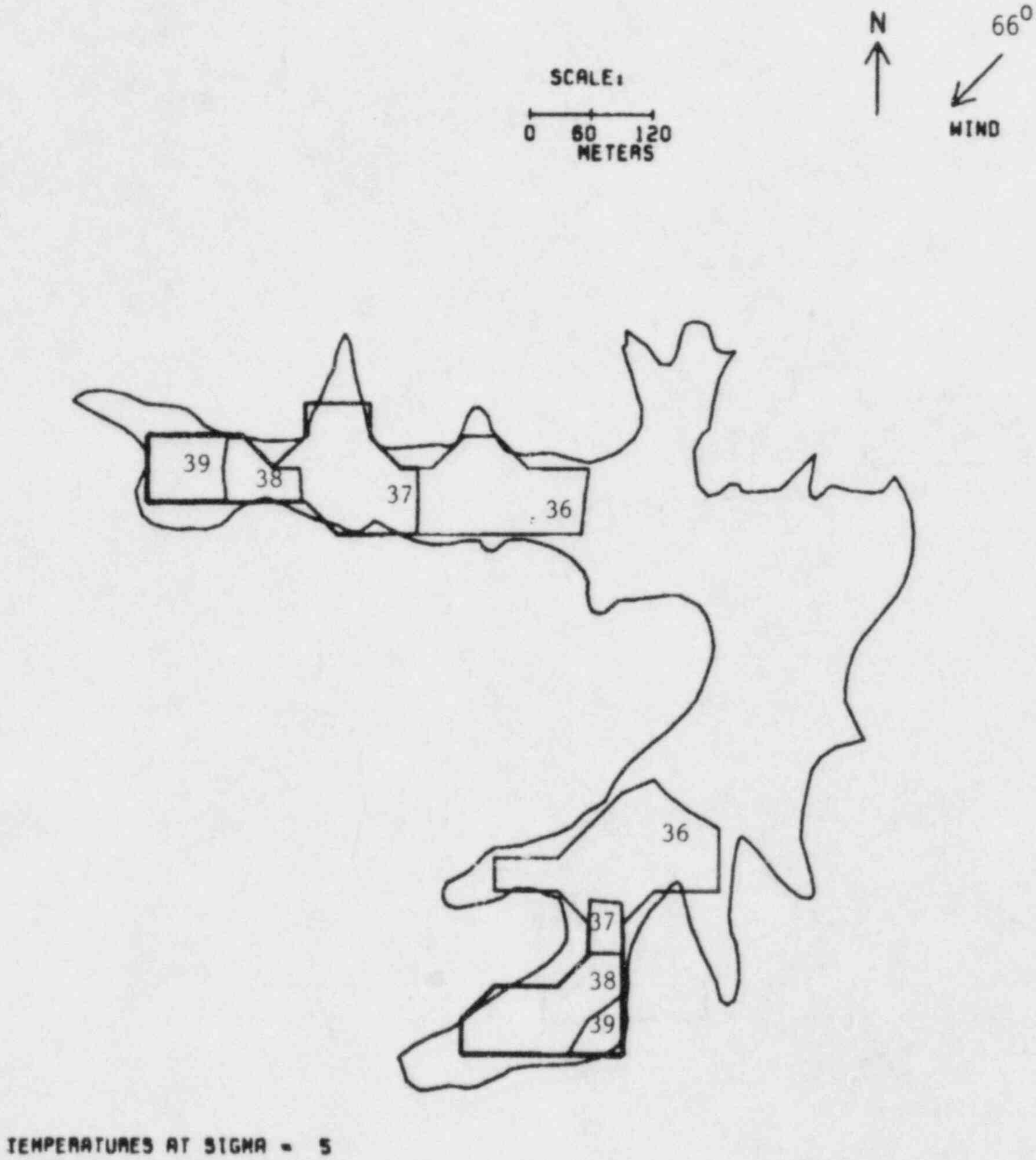


Fig. 7-44. Horizontal Isotherms at Level 5 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

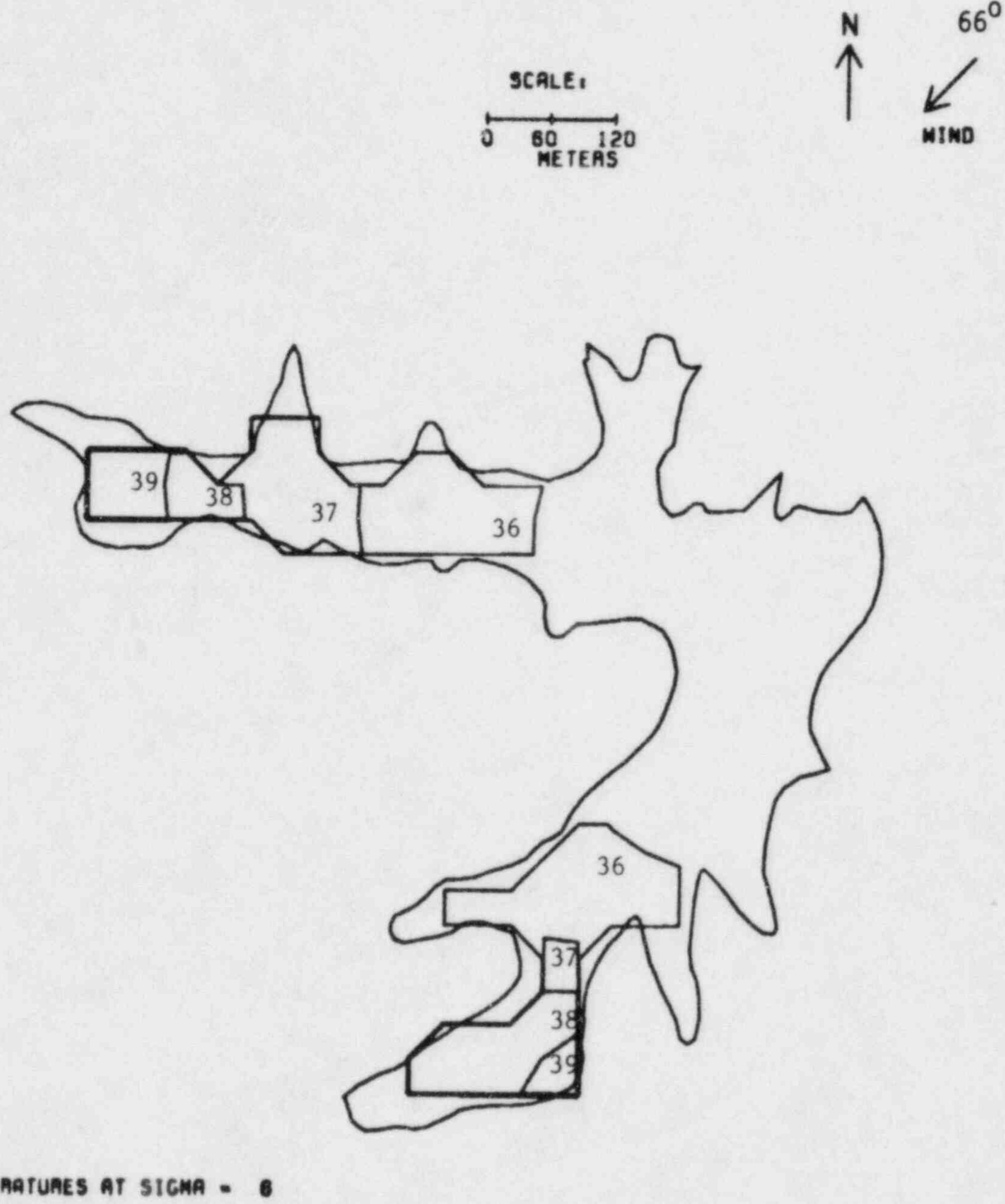


Fig. 7-45. Horizontal Isotherms at Level 6 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

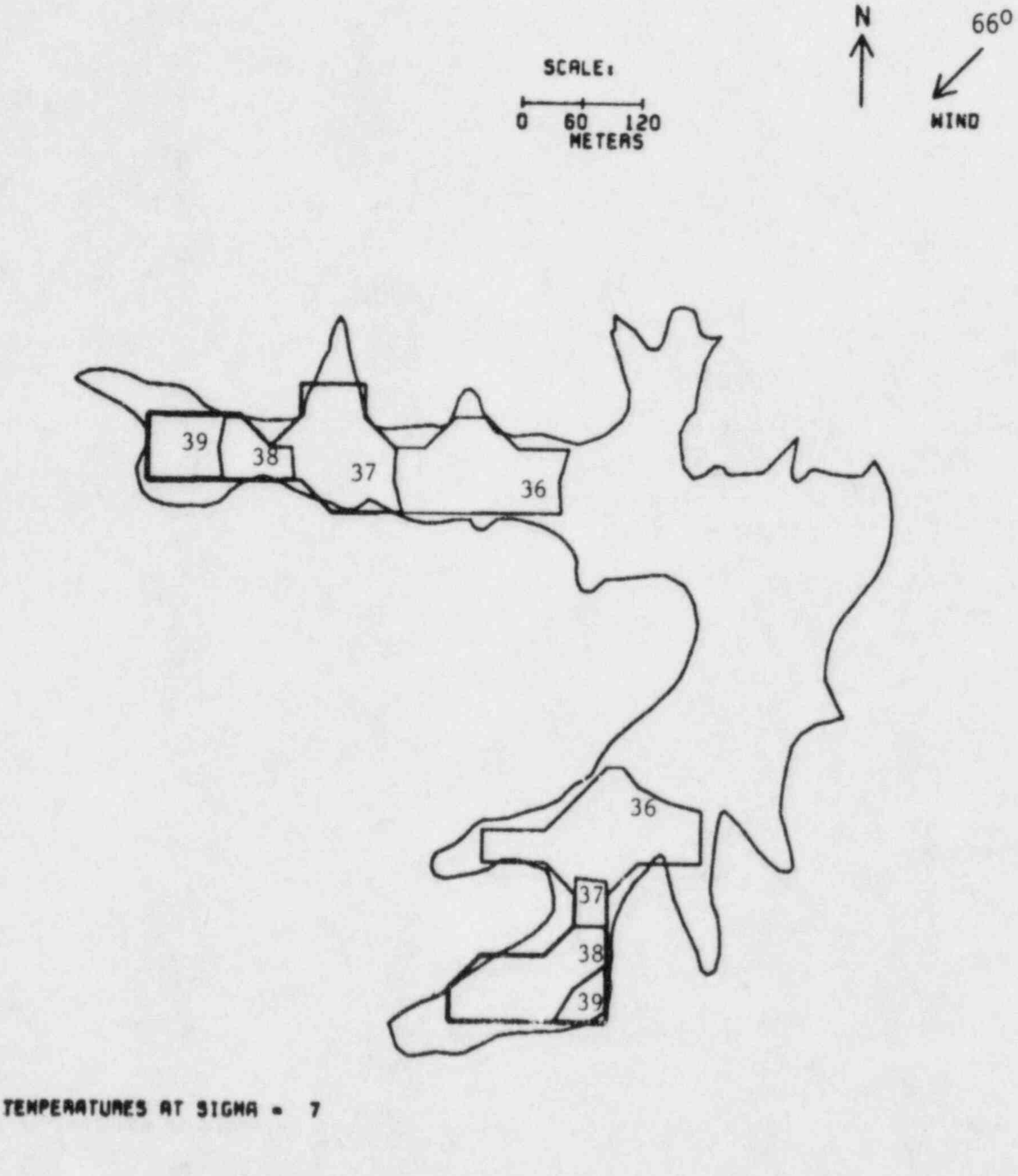


Fig. 7-46. Horizontal Isotherms at Level 7 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

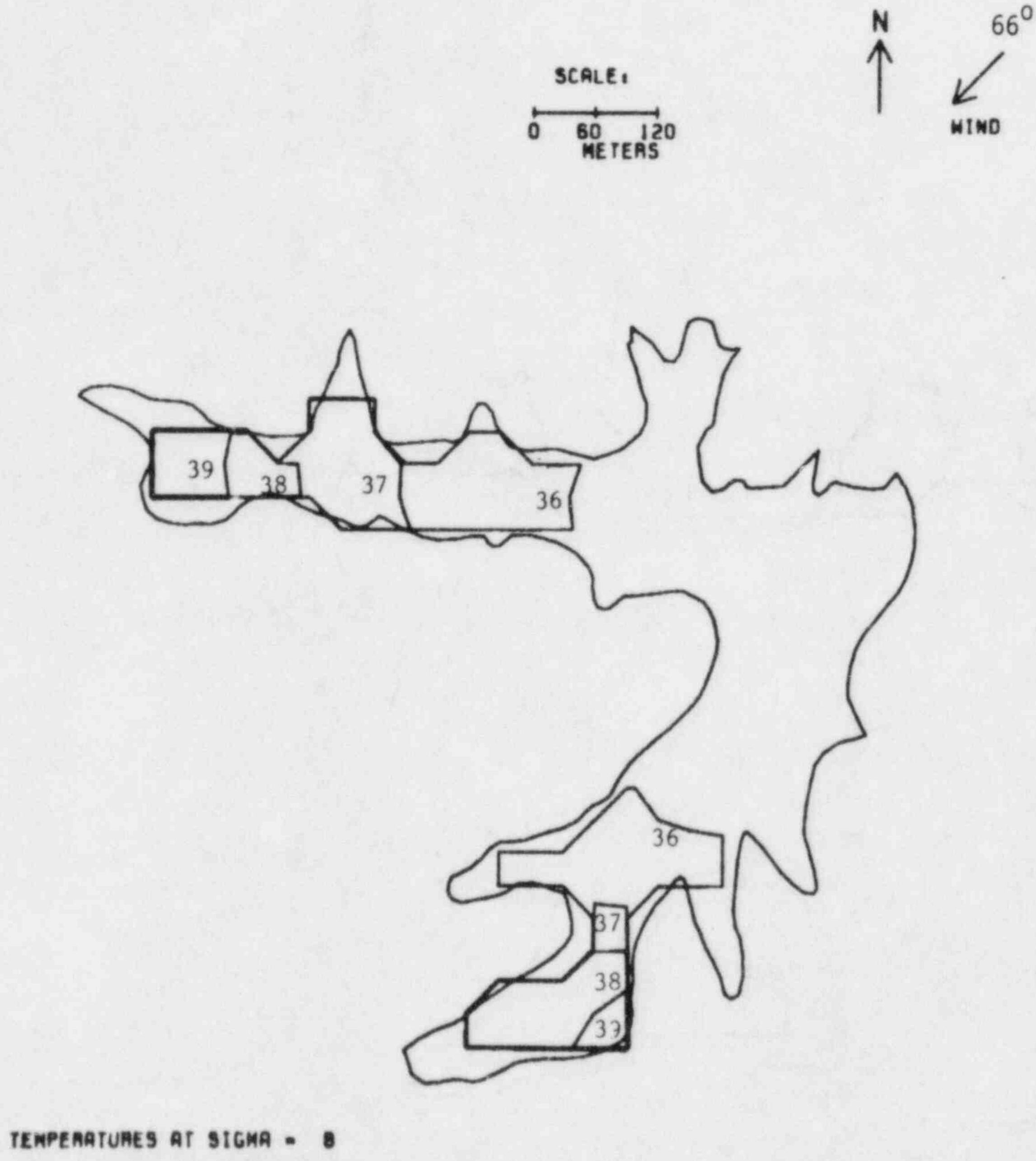


Fig. 7-47. Horizontal Isotherms at Level 8 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

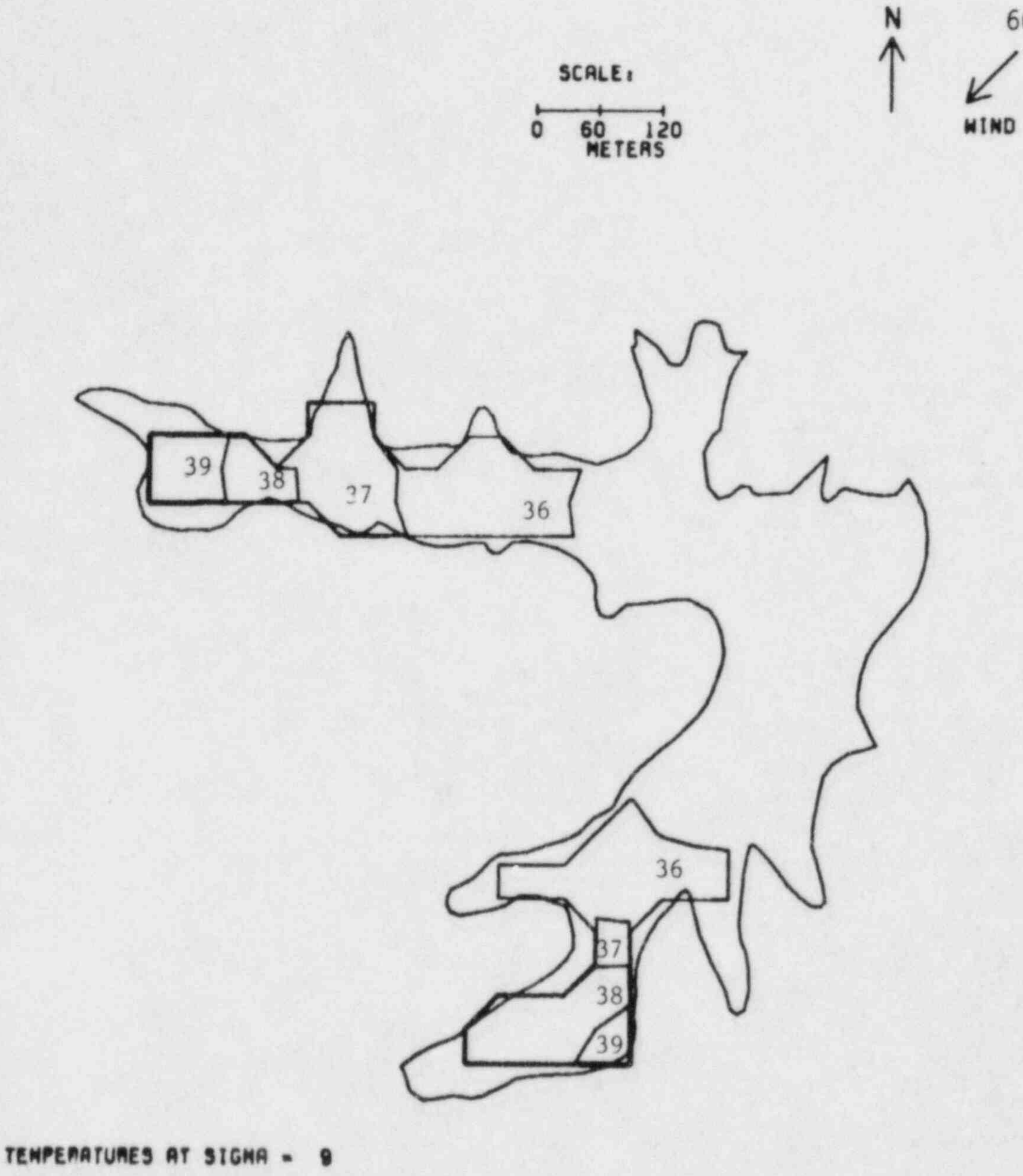


Fig. 7-48. Horizontal Isotherms at Level 9 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

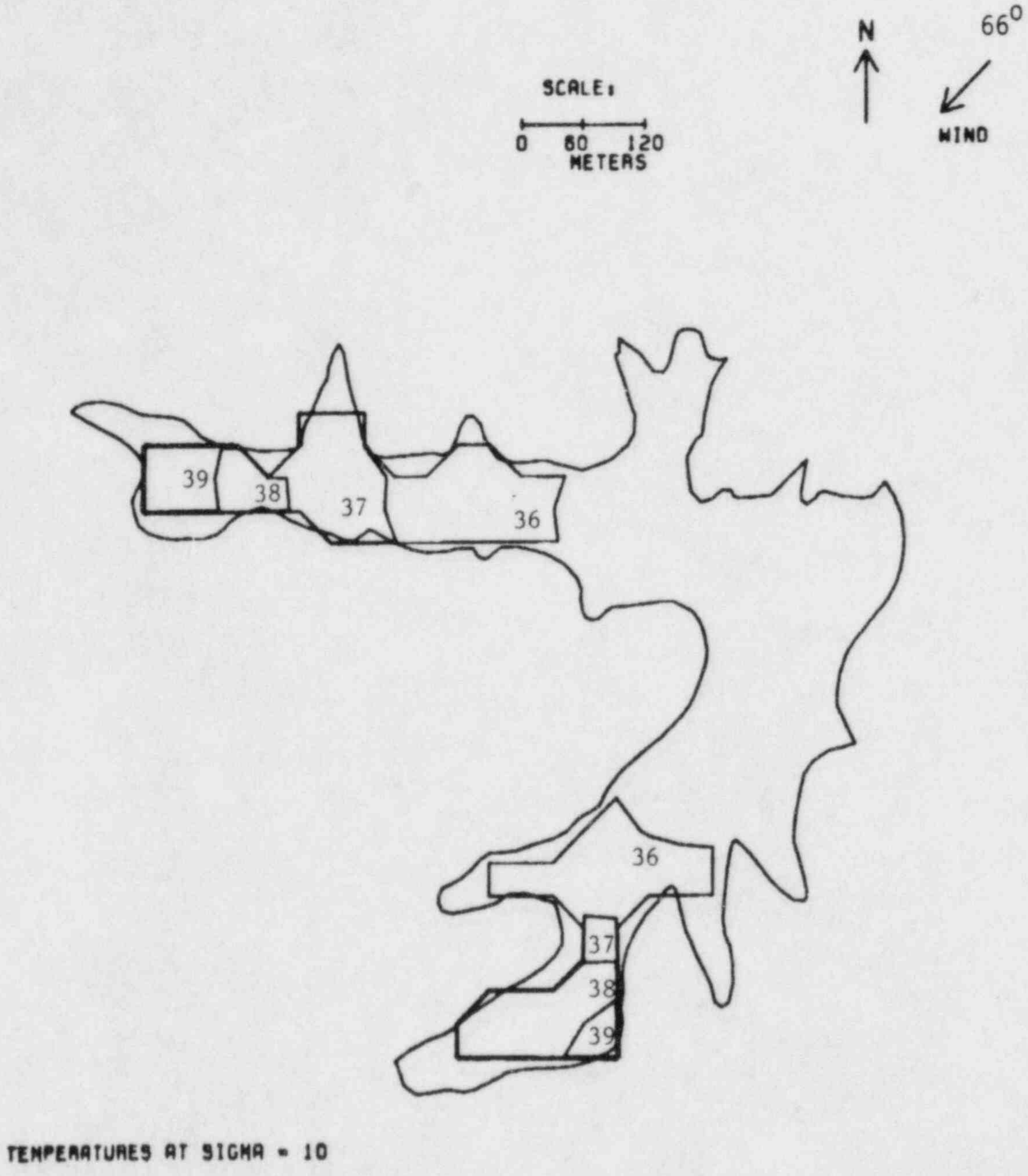


Fig. 7-49. Horizontal Isotherms at Level 10 at Time of Peak Intake Temperature ...6.38 Days After Start of Accident.

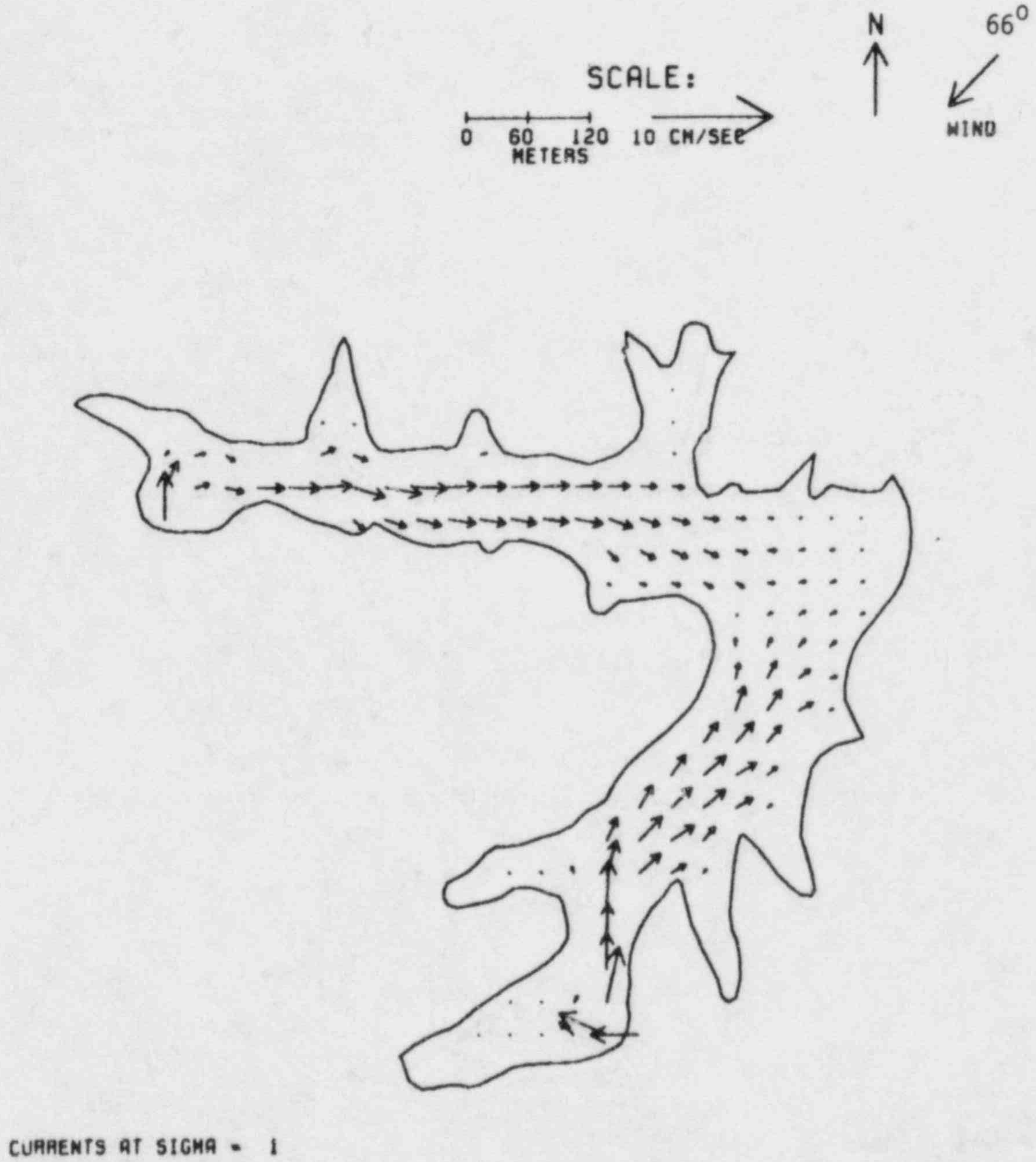


Fig. 7-50. Horizontal Velocities at Grid Points Located at Top Level (Surface) ...End of 4 Hours Plus 9 Before Start of Accident.

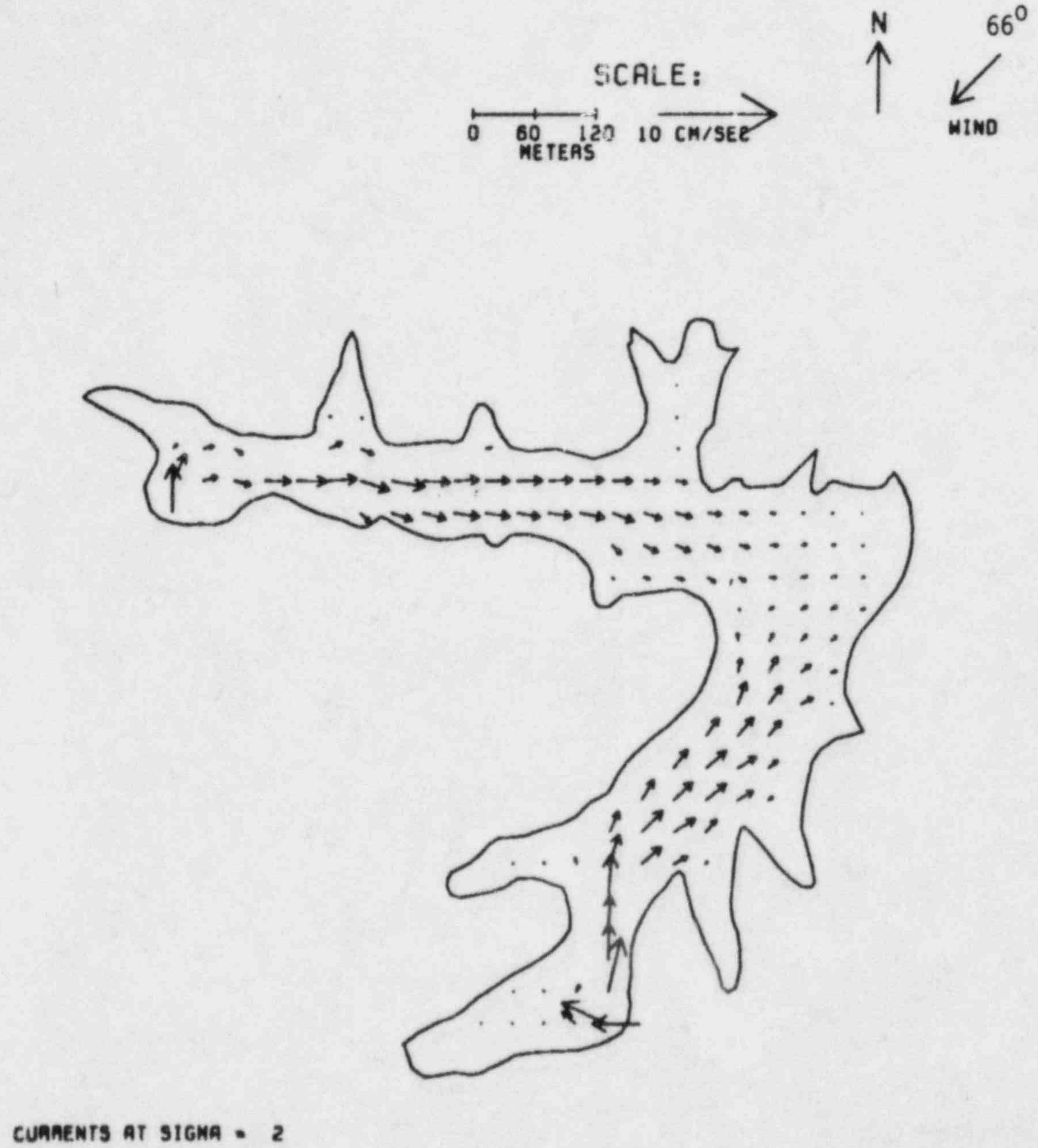


Fig. 7-51. Horizontal Velocities at Grid Points at Level 2 ...End of 4 Hours Plus 9 Days After Start of Accident.

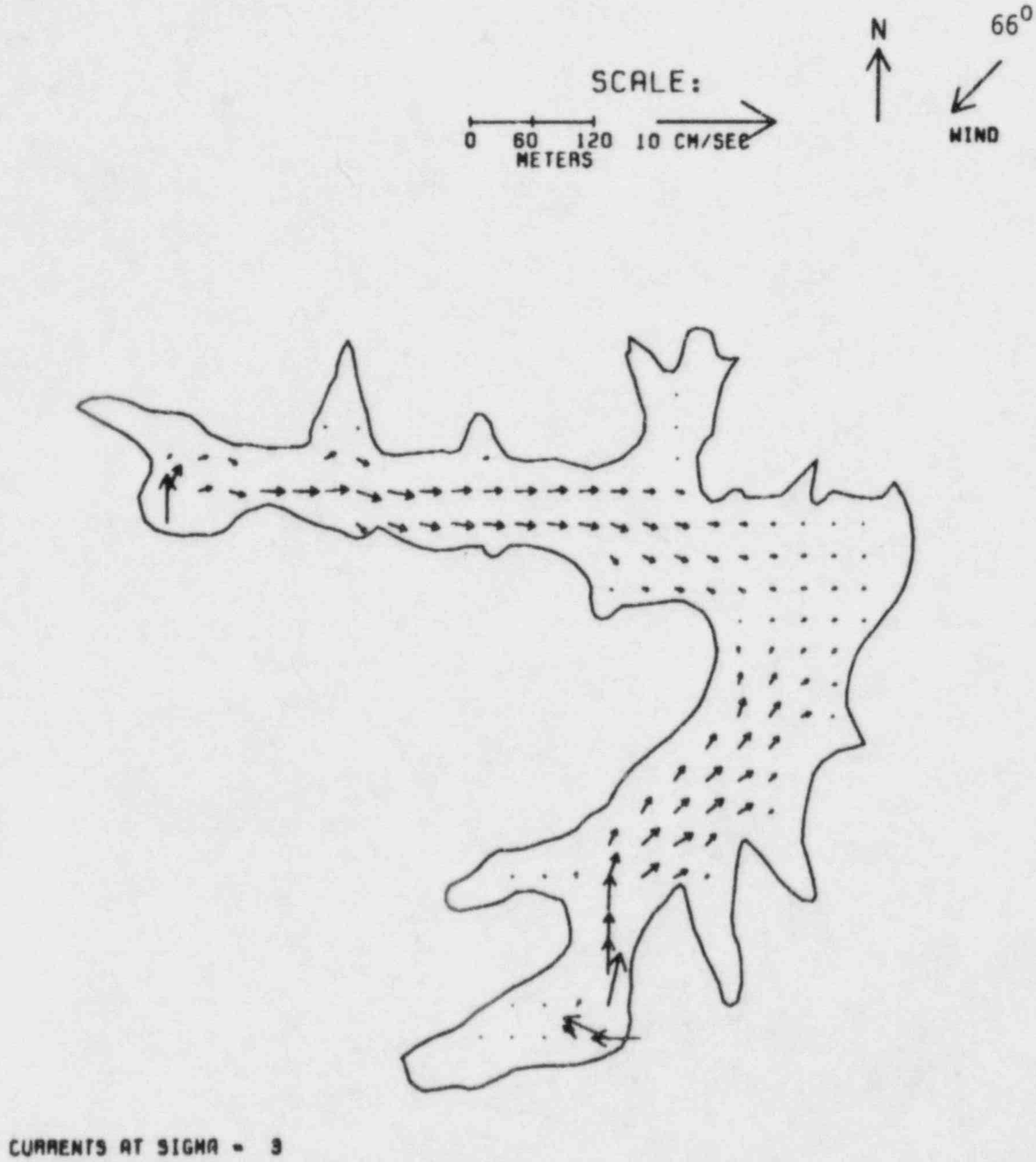


Fig. 7-52. Horizontal Velocities at Grid Points at Level 3 ...End of 4 Hours Plus 9 Days After Start of Accident.

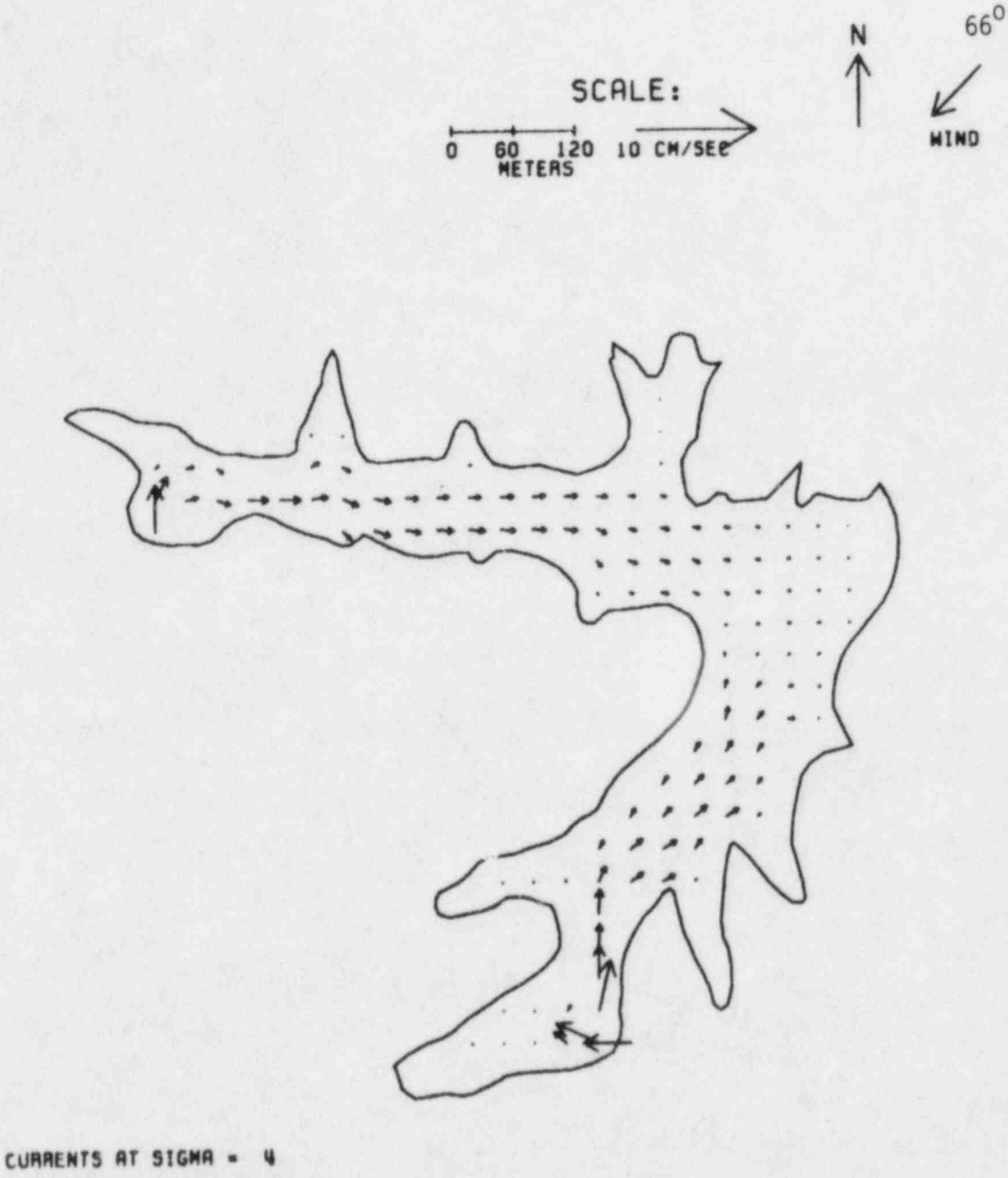


Fig. 7-53. Horizontal Velocities at Grid Points at Level 4 ...End of 4 Hours Plus 9 Days After Start of Accident.

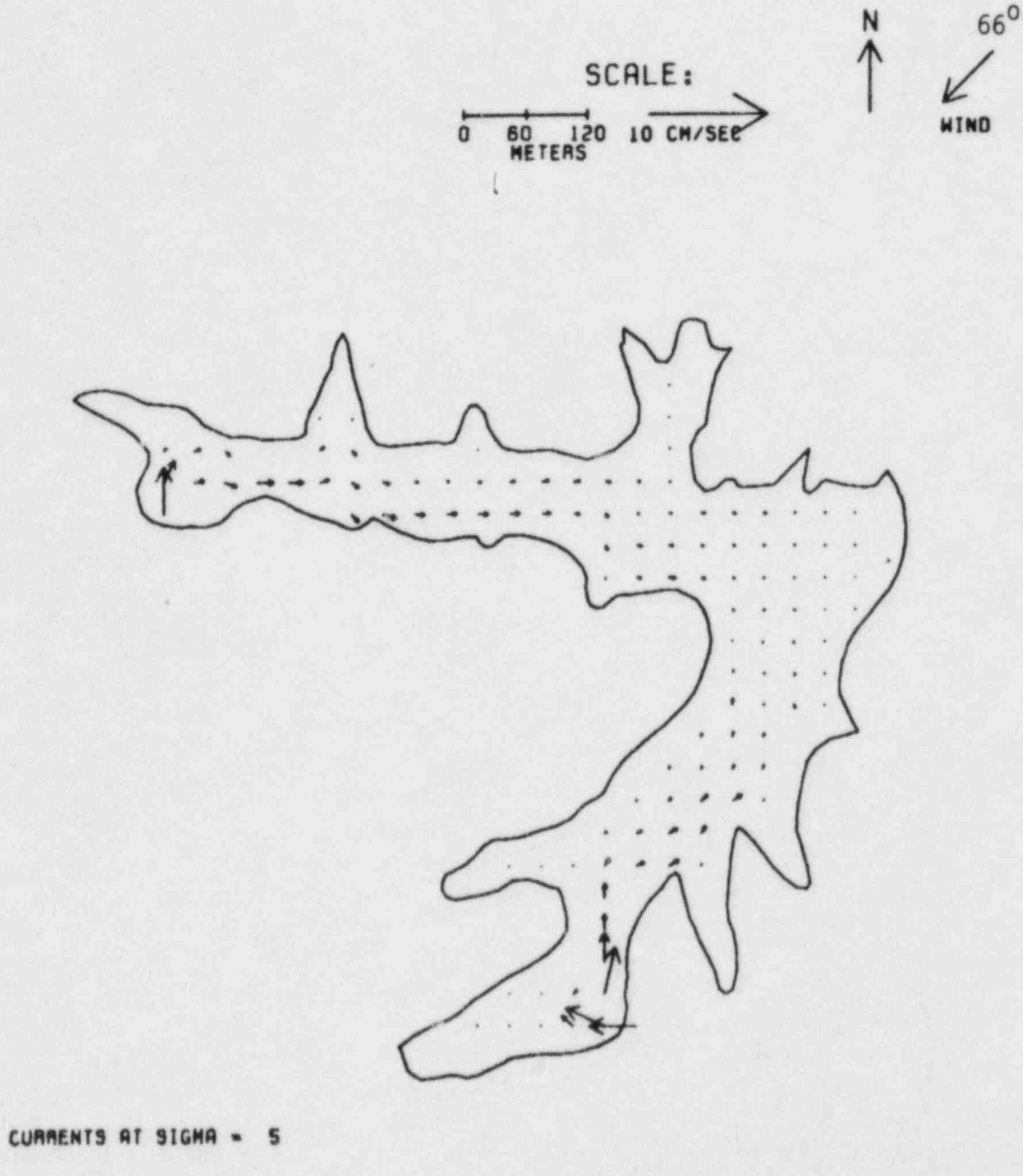


Fig. 7-54. Horizontal Velocities at Grid Points at Level 5 ...End of 4 Hours Plus 9 Days After Start of Accident.

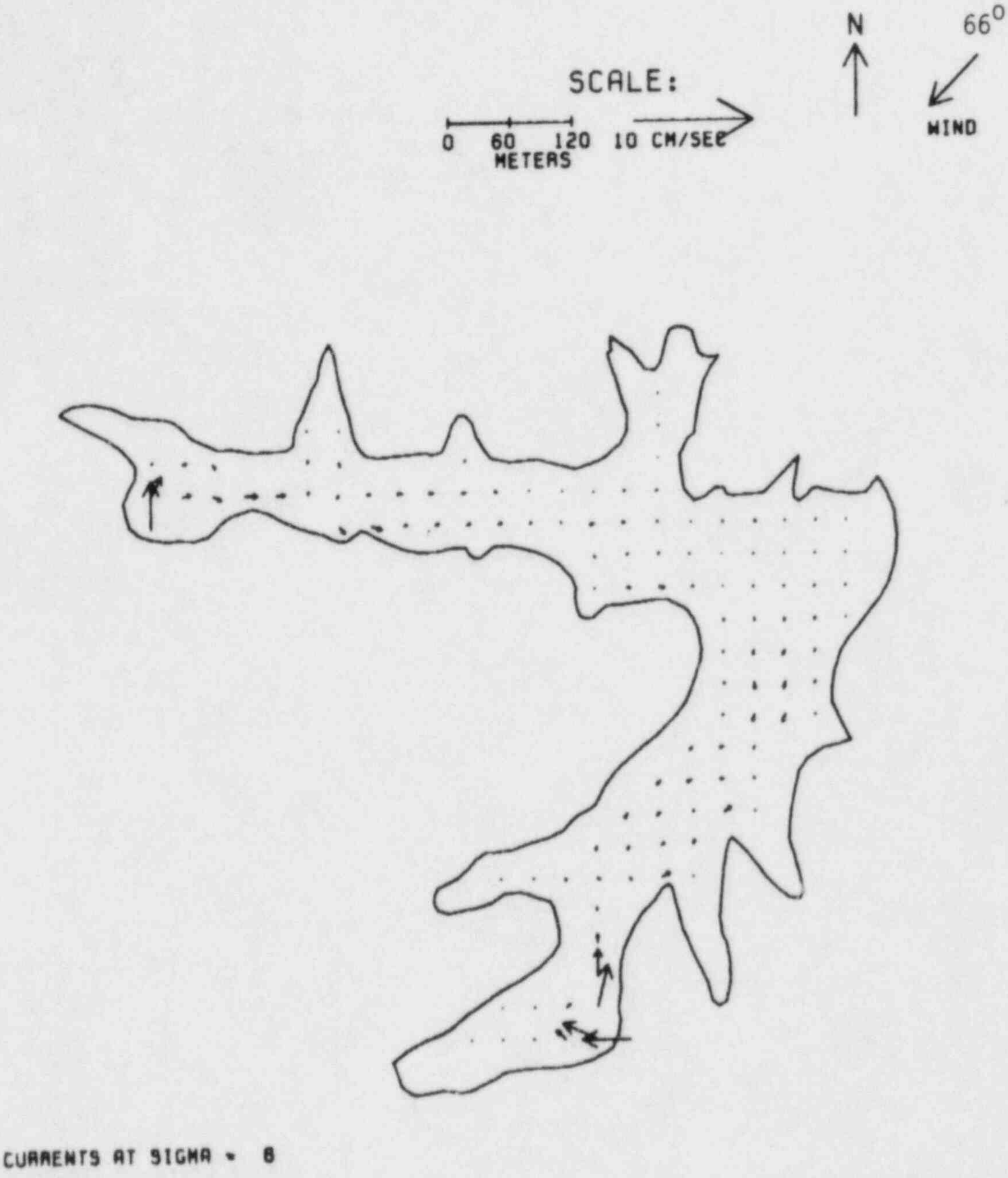


Fig. 7-55. Horizontal Velocities at Grid Points at Level 6 ...End of 4 Hours Plus 9 Days After Start of Accident.

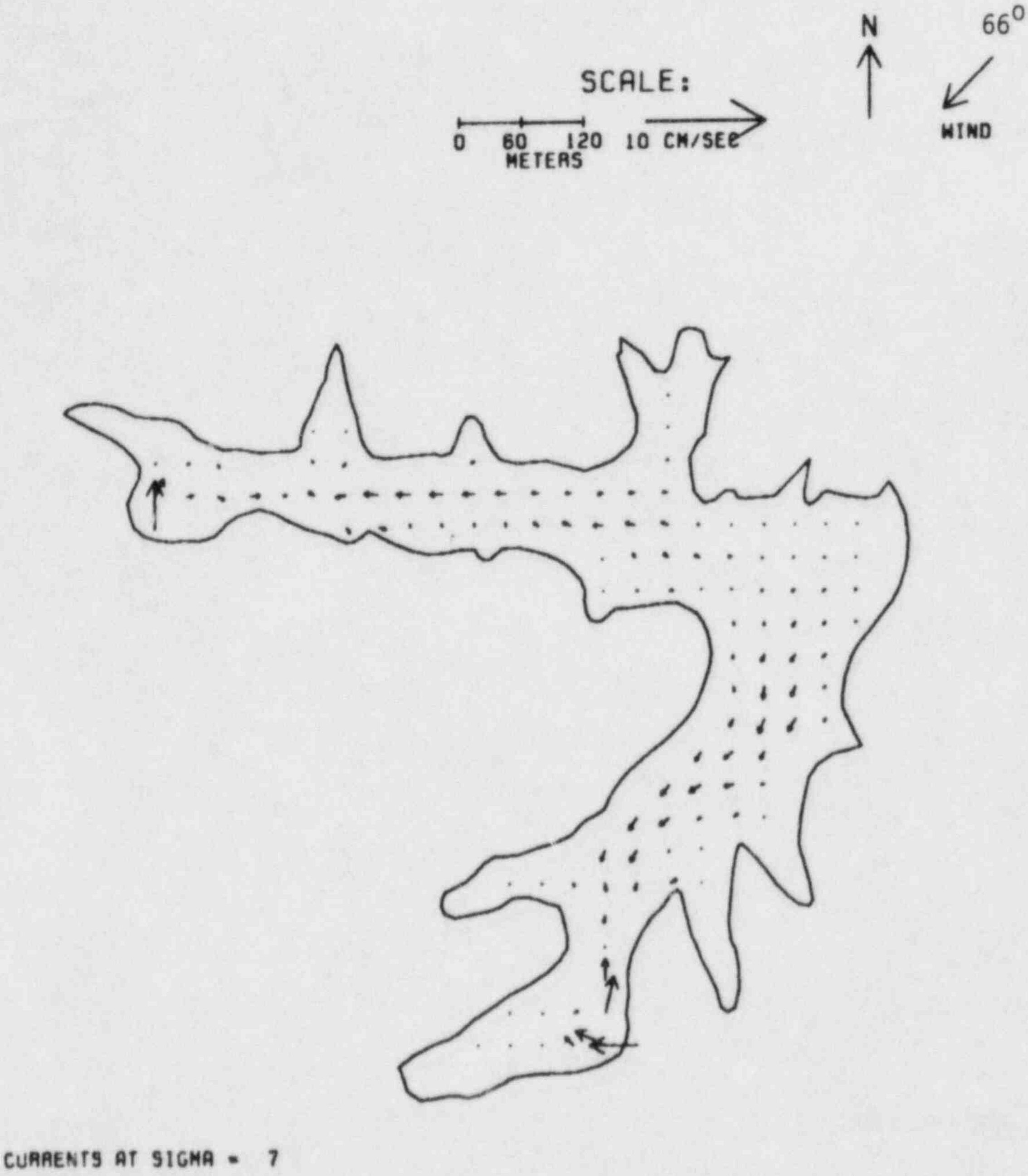


Fig. 7-56. Horizontal Velocities at Grid Points at Level 7 ...End of 4 Hours Plus 9 Days After Start of Accident.

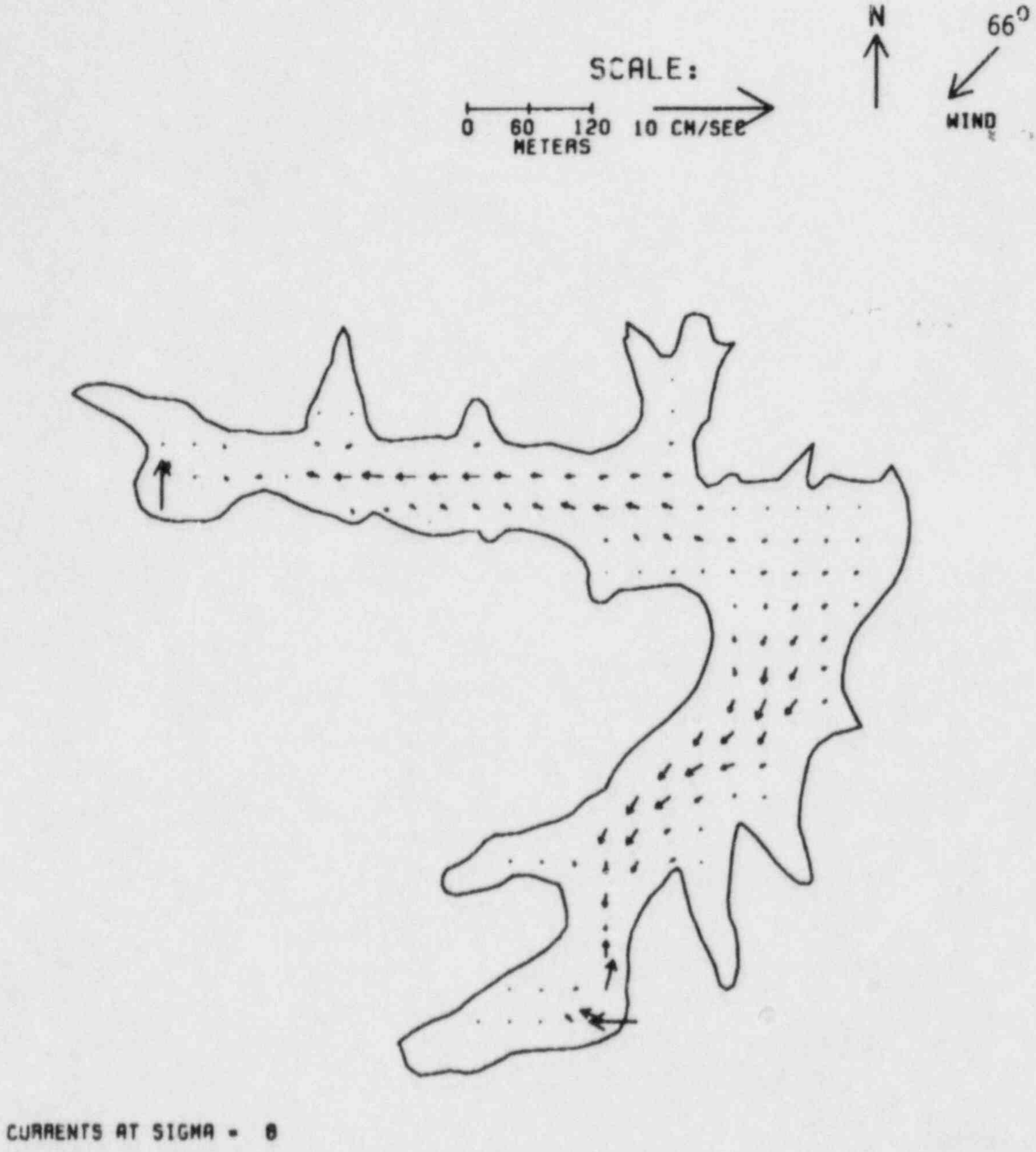


Fig. 7-57. Horizontal Velocities at Grid Points at Level 8 ...End of 4 Hours Plus 9 Days After Start of Accident.

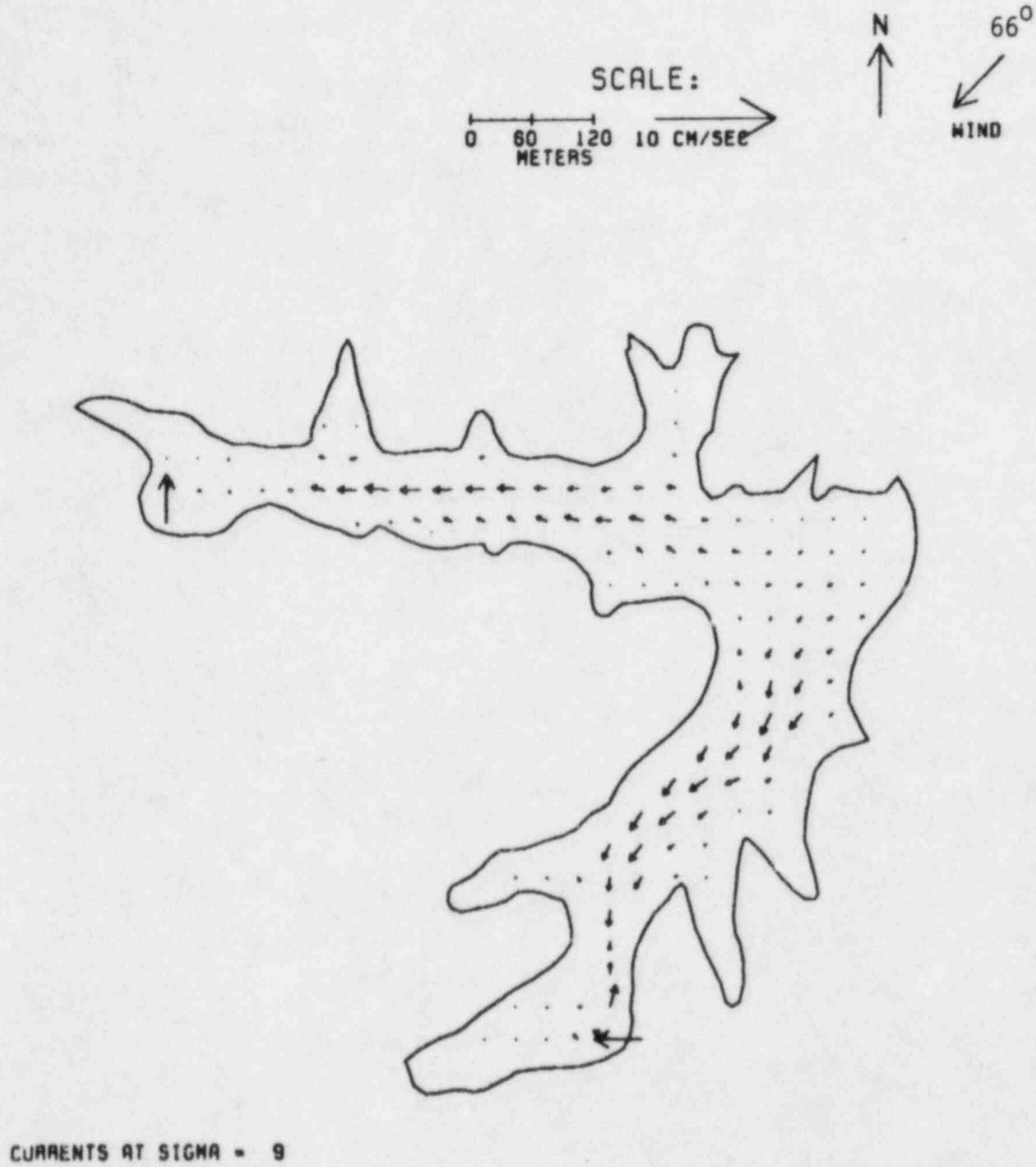


Fig. 7-58. Horizontal Velocities at Grid Points at Level 9 ...End of 4 Hours Plus 9 Days After Start of Accident.

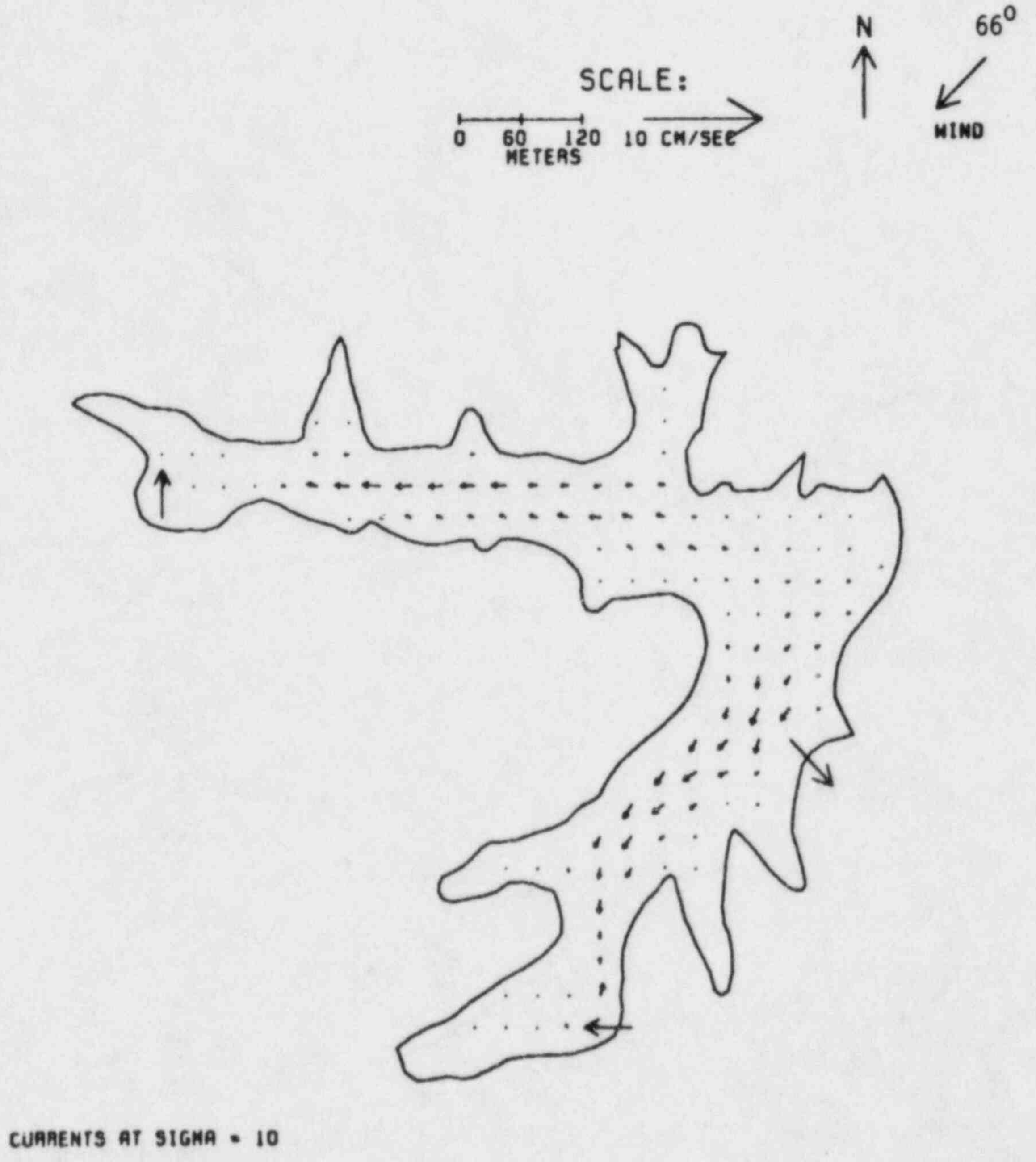


Fig. 7-59. Horizontal Velocities at Grid Points at Level 10 (Level Just Above Bottom) ...End of 4 Hours Plus 9 Days After Start of Accident.

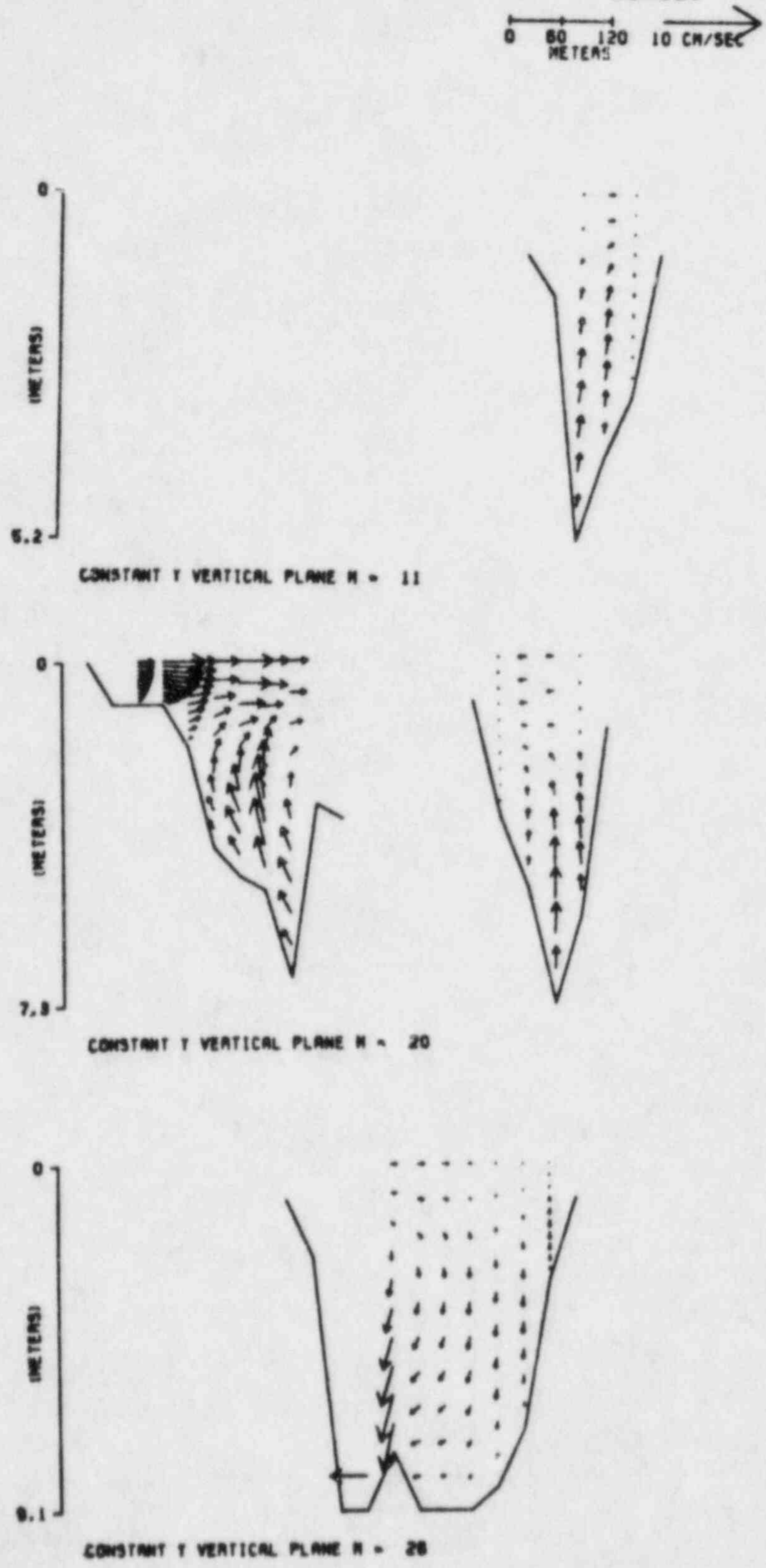


Fig. 7-60. Cross-Sectional Velocities in Plane at (a) M=11 ...Y Constant, (b) M=20 ...Y Constant, and (c) M=26 ...Y Constant ...End of 4 Hours Plus 9 Days After Start of Accident.

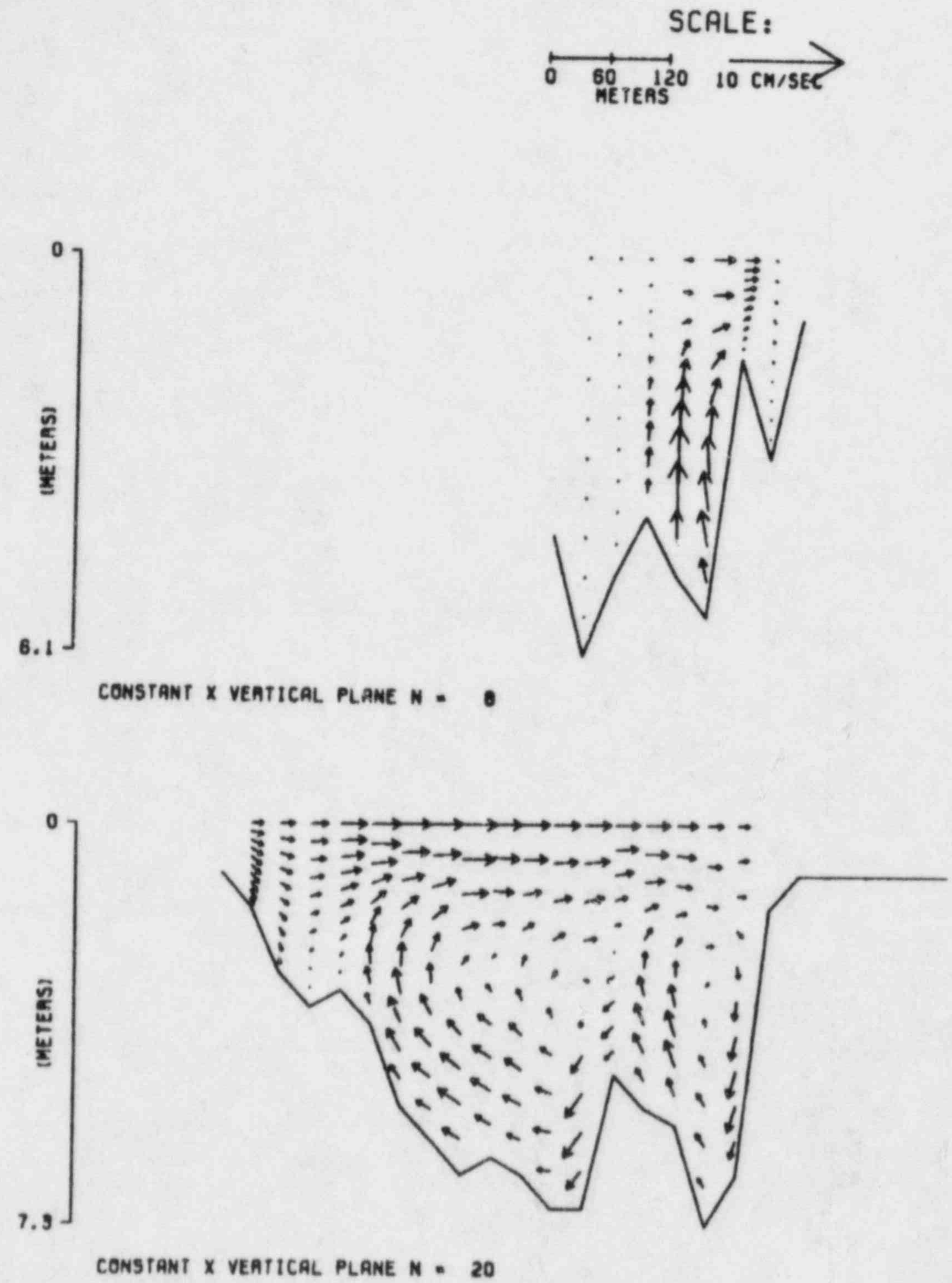


Fig. 7-61. Cross-Sectional Velocities in Plane at (a) N=8 ...X Constant, and (b) N=20 ...X Constant ...End of 4 Hours Plus 9 Days After Start of Accident.

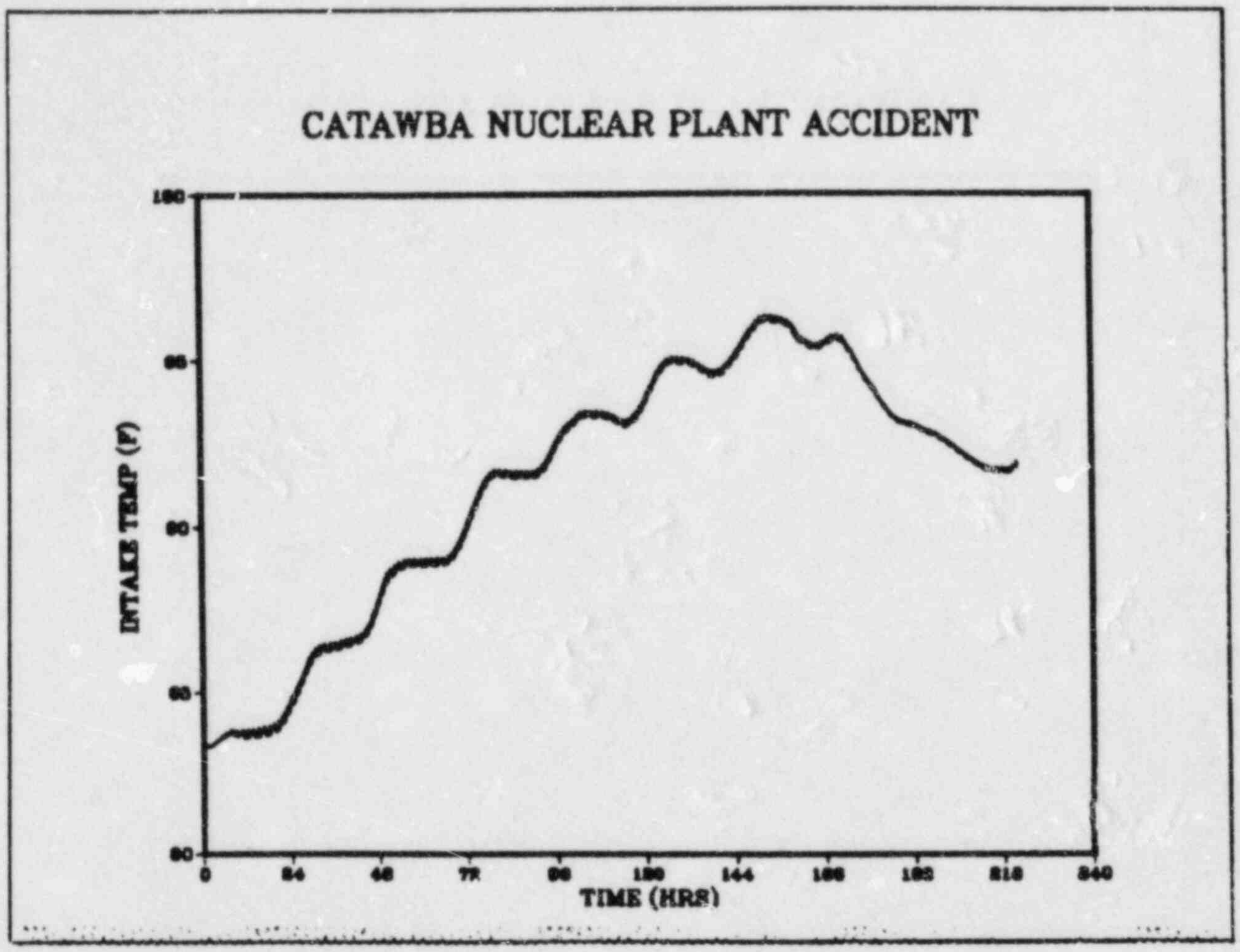


Fig. 7-62. Intake Temperature as a Function of Time from Start of Loss of Coolant Accident.

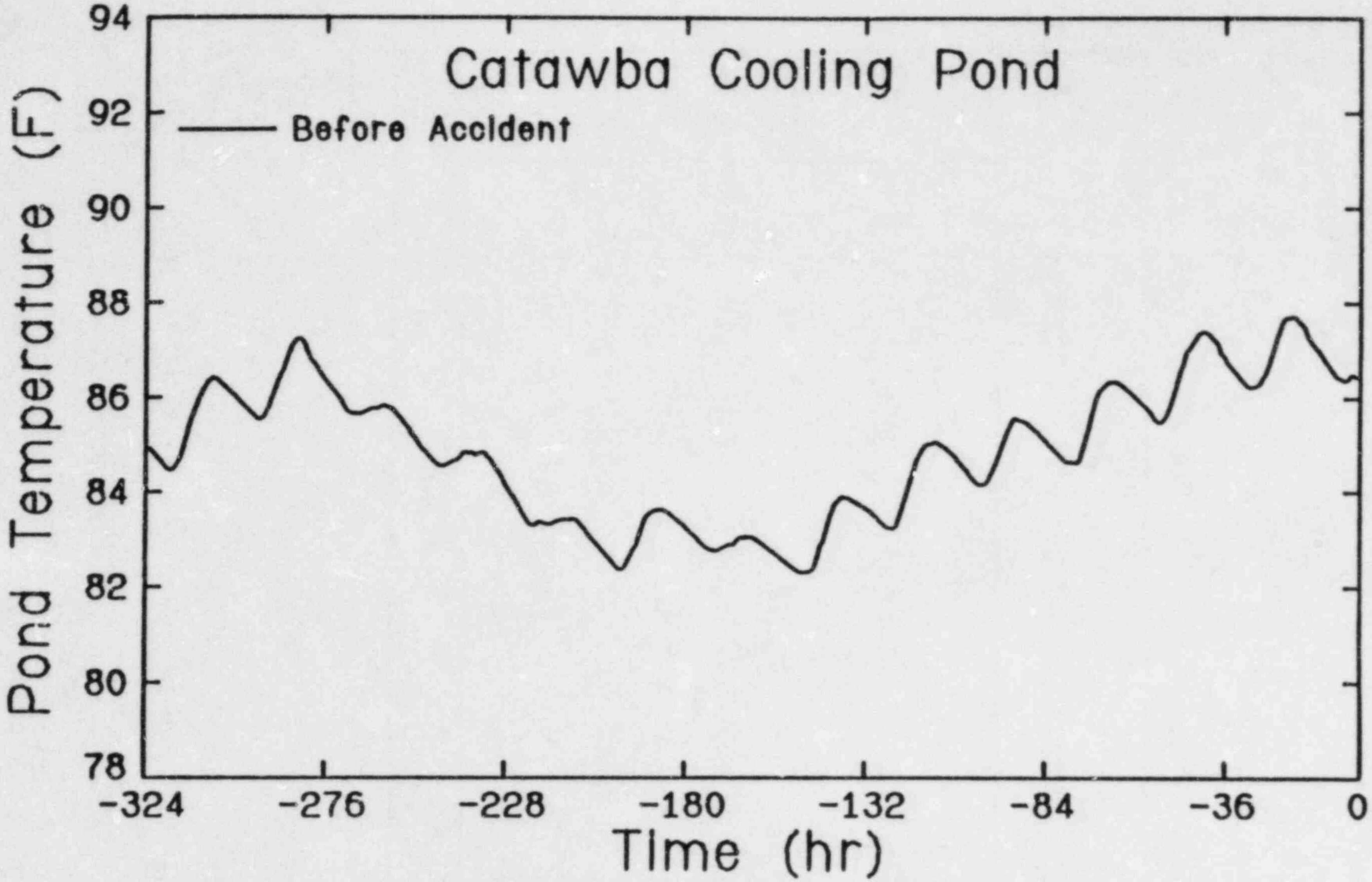


Fig. 7-63. Predicted Pond Temperature Before Accident (Method 1).

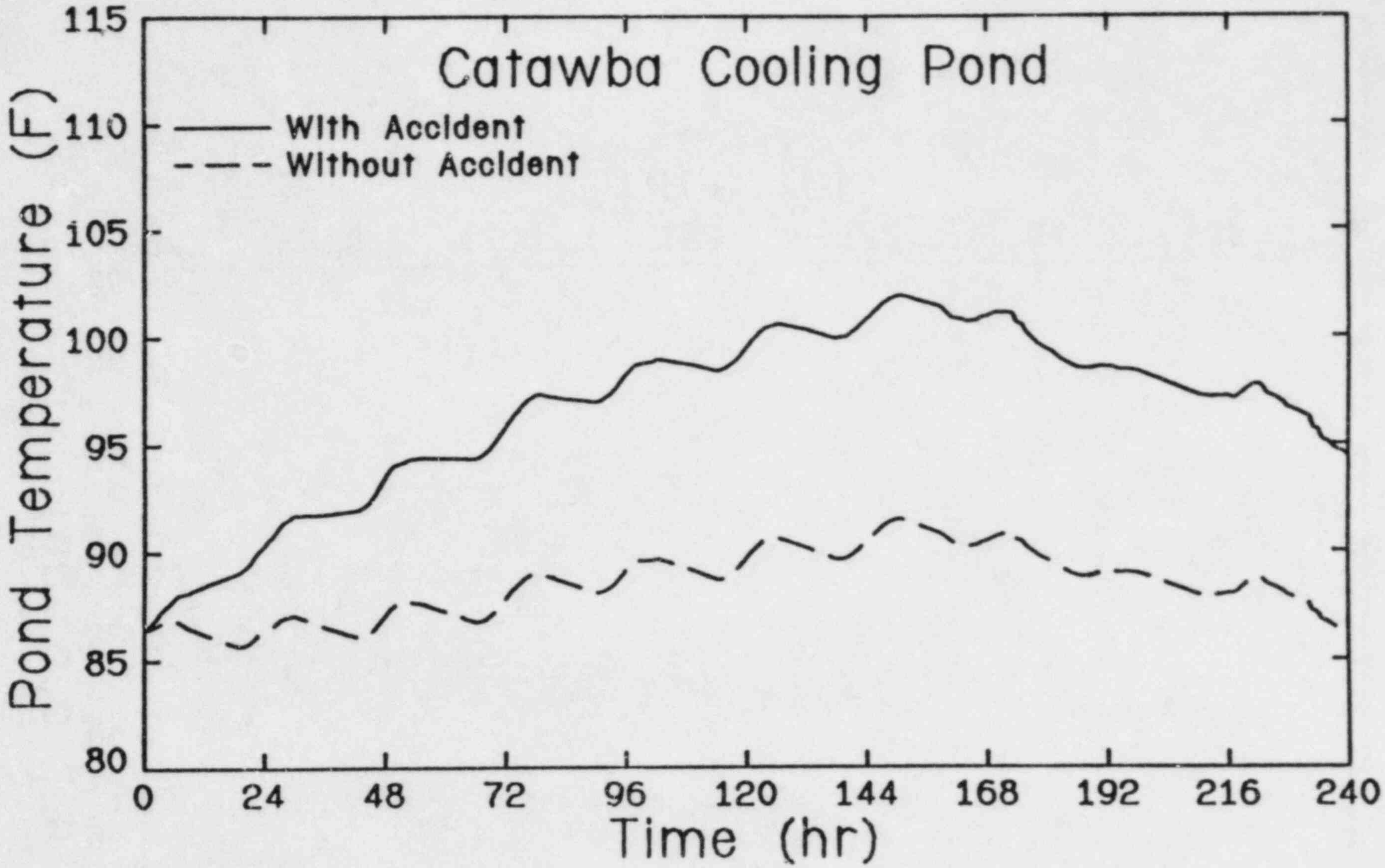


Fig. 7-64. Predicted Pond Temperature During Period of Simulated Accident With and Without Power Plant Heat Rejection (Method 1).

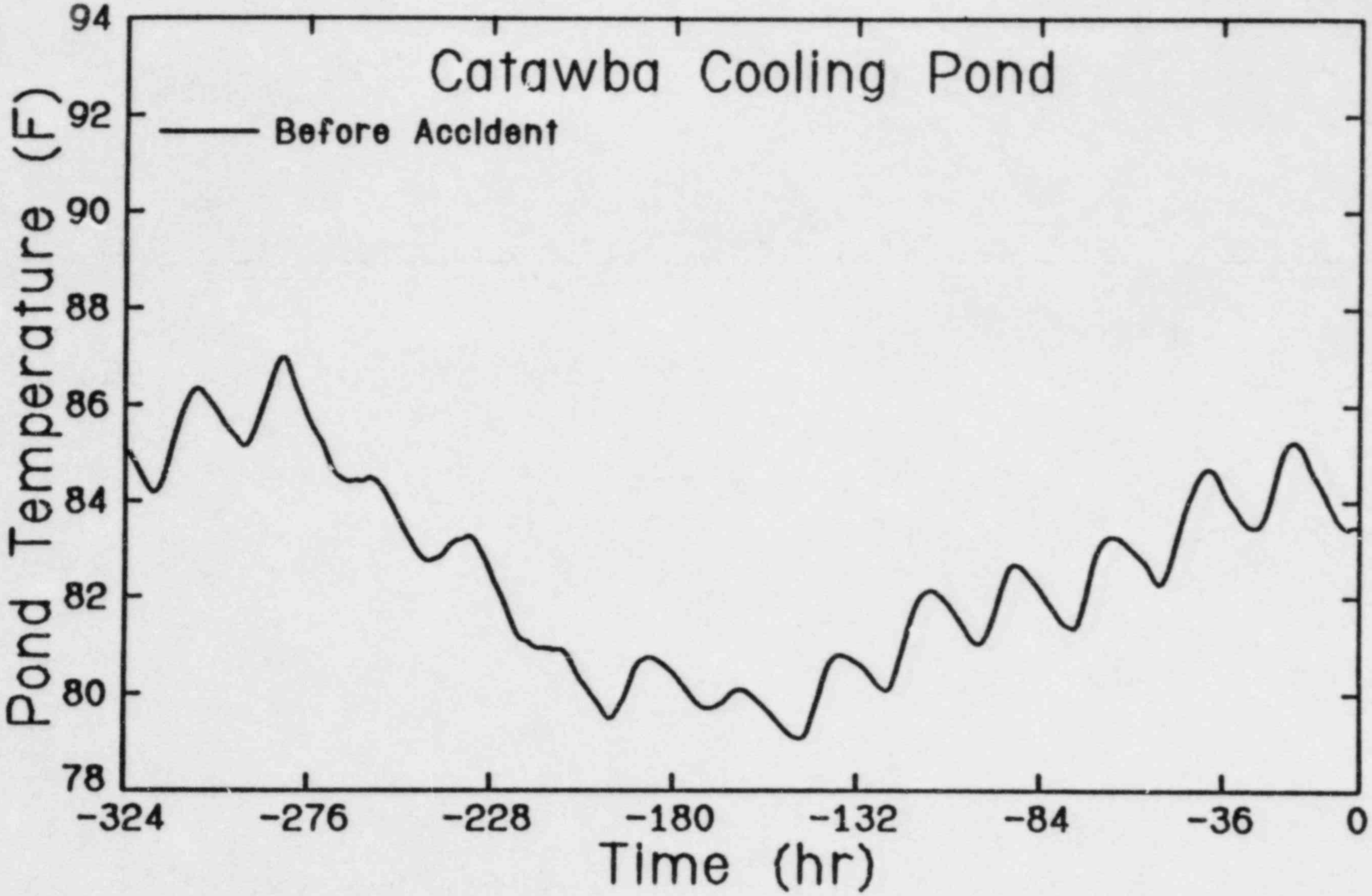


Fig. 7-65. Predicted Pond Temperature Before Accident (Method 2).

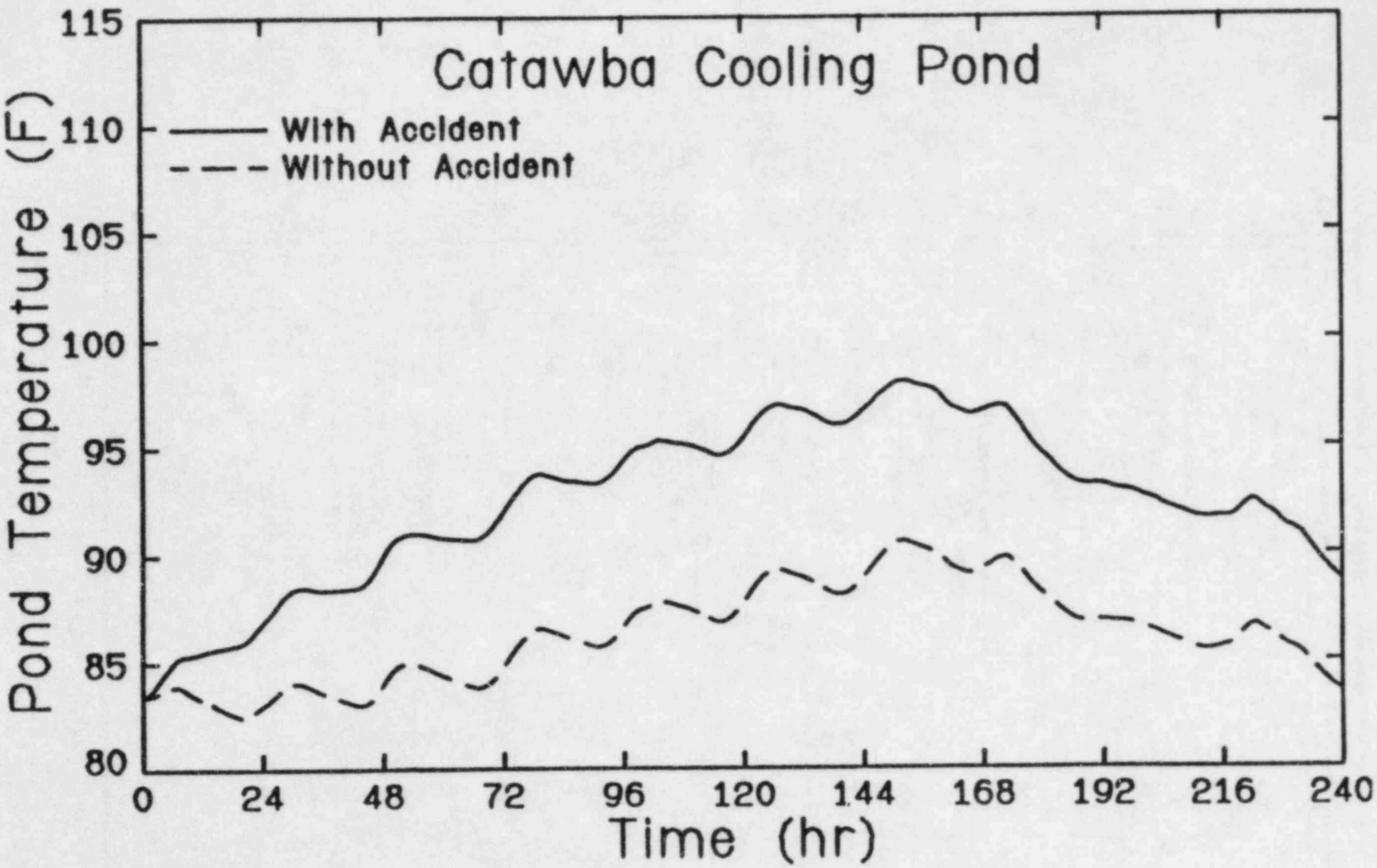


Fig. 7-66. Predicted Pond Temperature During Period of Simulated Accident With and Without Power Plant Heat Rejection (Method 2).

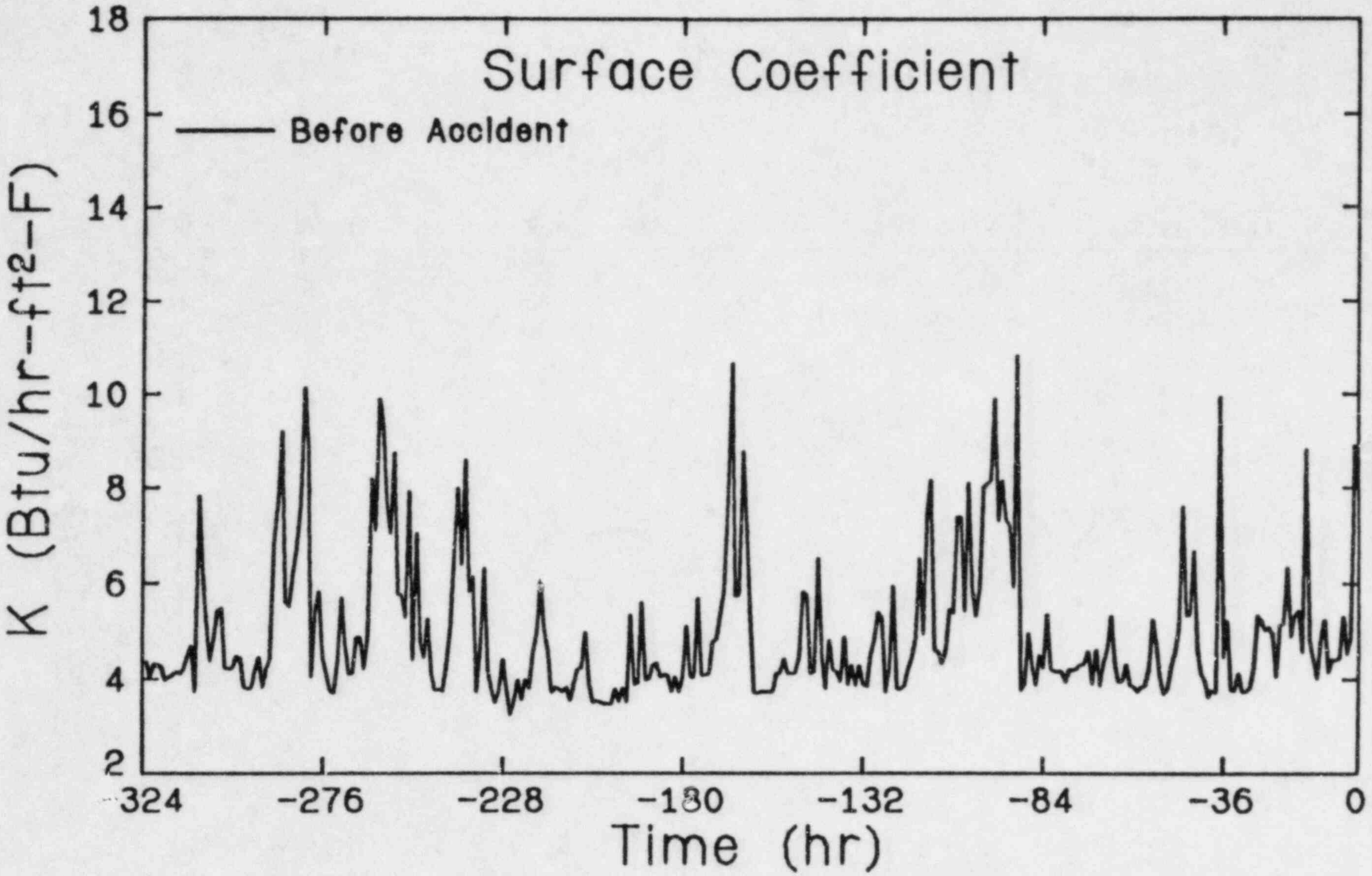


Fig. 7-67. Variation of Surface Heat Transfer Coefficient Before Accident (Method 1).

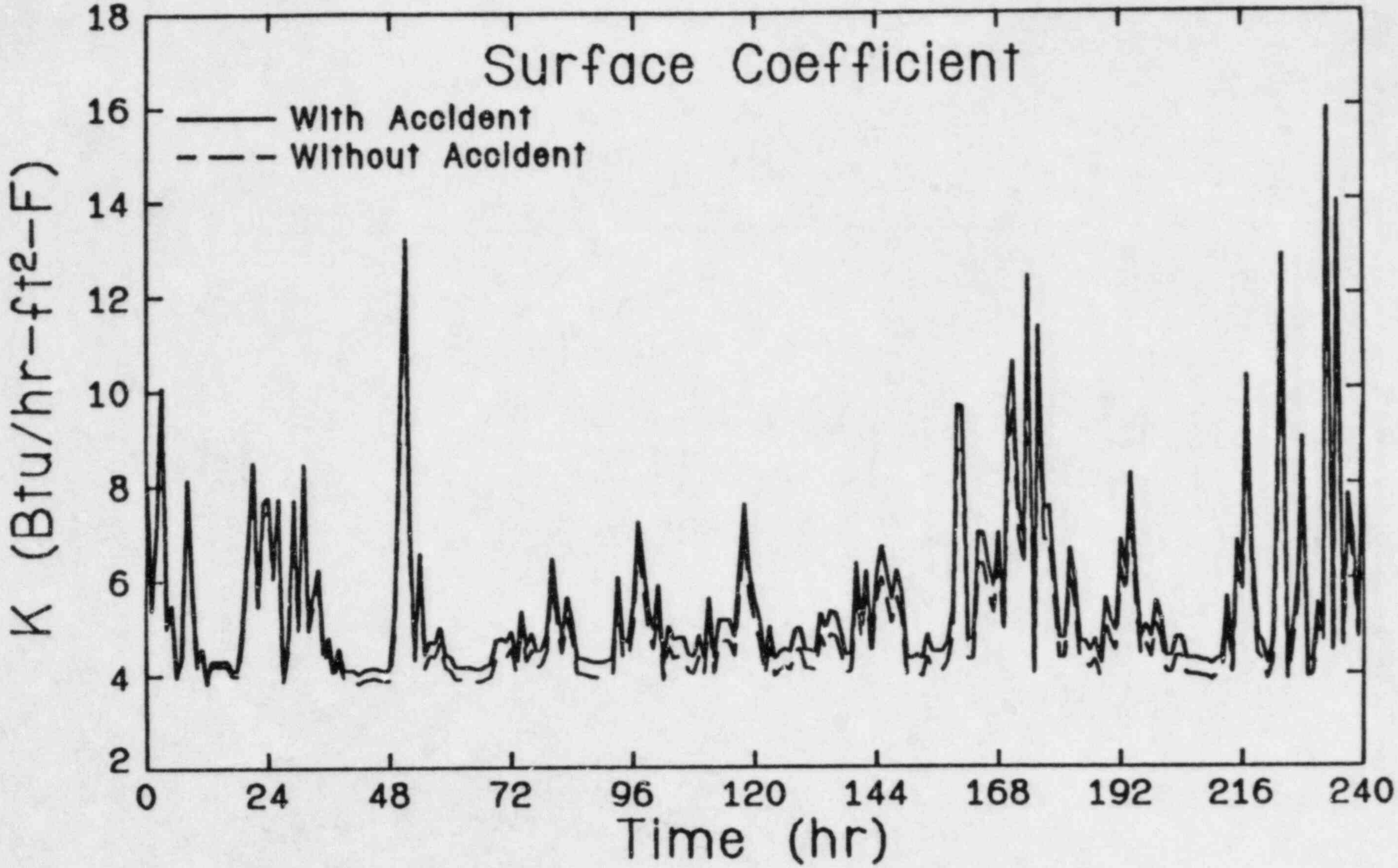


Fig. 7-68. Variation of Surface Heat Transfer Coefficient During Period of Simulated Accident With and Without Power Plant Heat Rejection (Method 1).

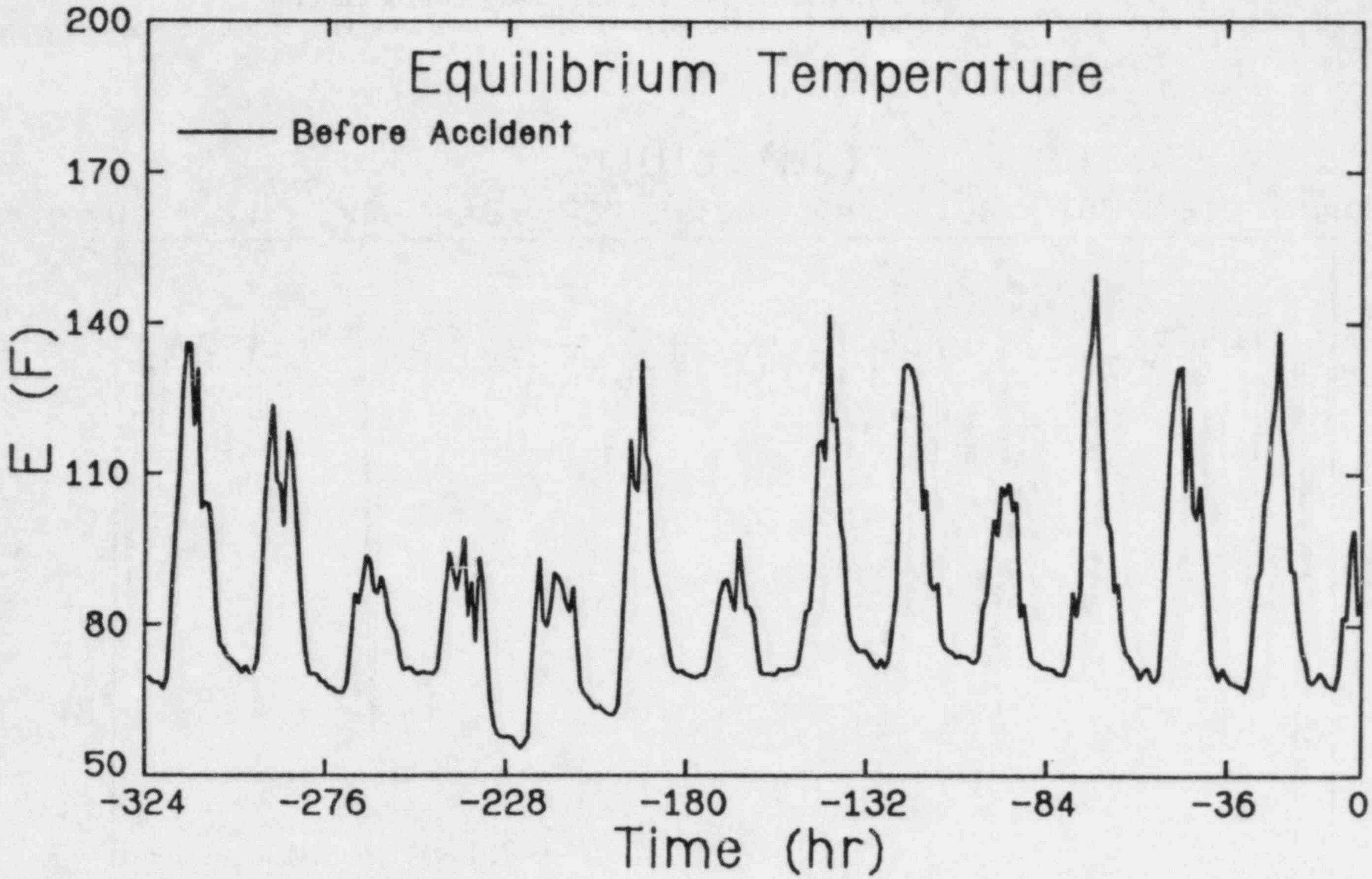


Fig. 7-69. Variation of Pond Equilibrium Temperature Before Accident (Method 1).

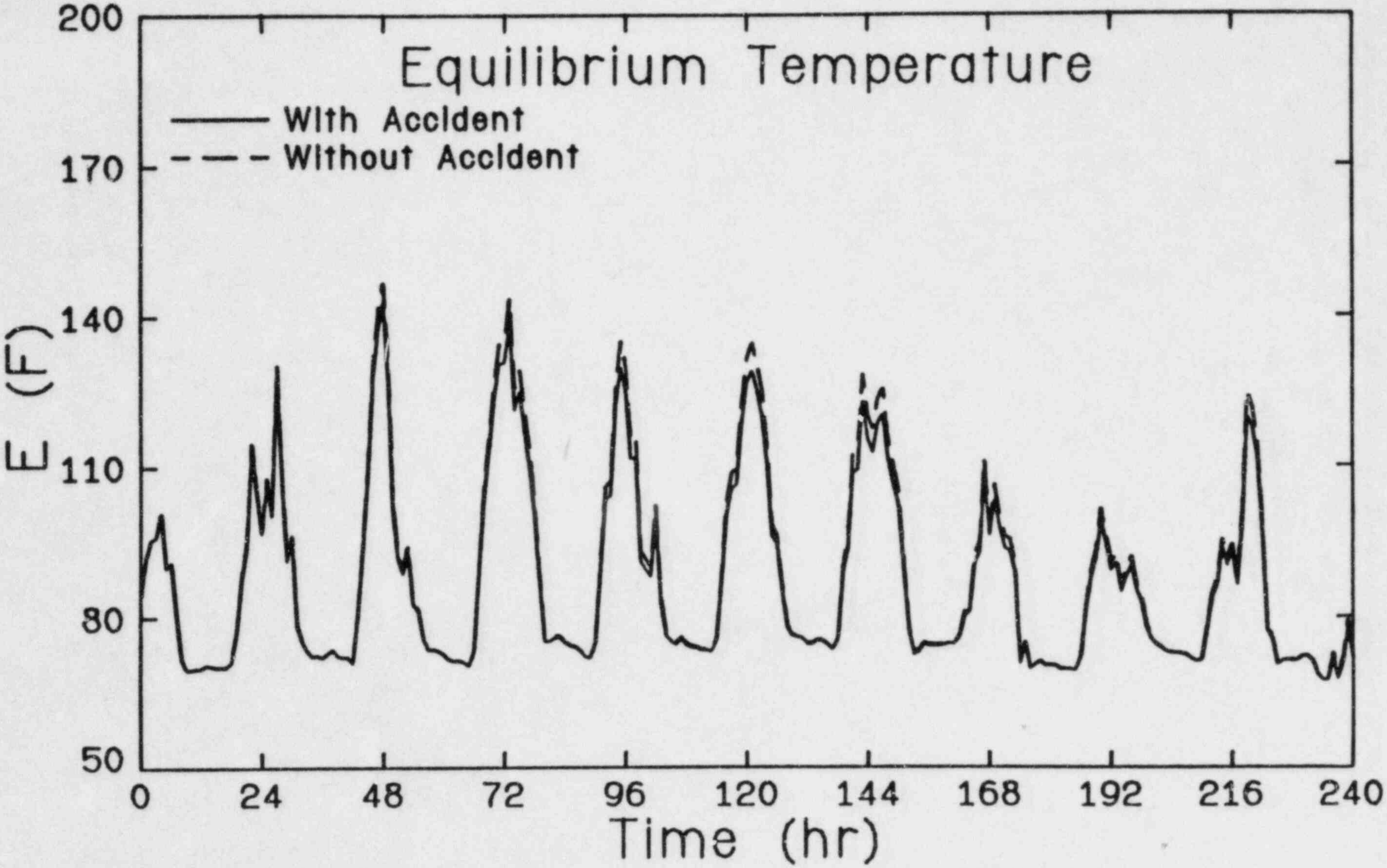


Fig. 7-70. Variation of Pond Equilibrium Temperature During Period of Simulated Accident With and Without Power Plant Heat Rejection (Method 1).

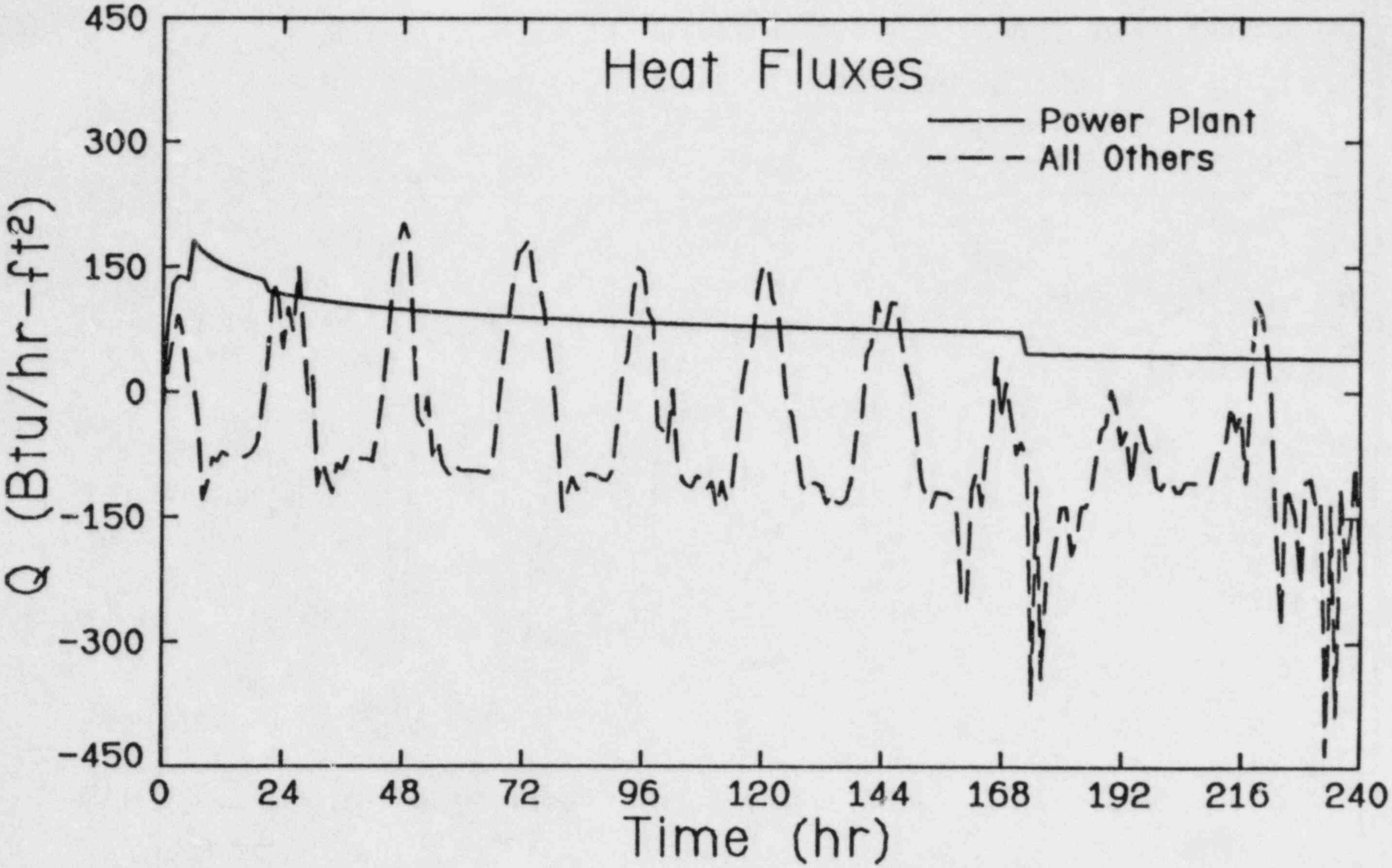


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Fig. 7-71. Comparison of Power Plant Heat Rejection With Net Heat Transfer Through Surface (Method 1).

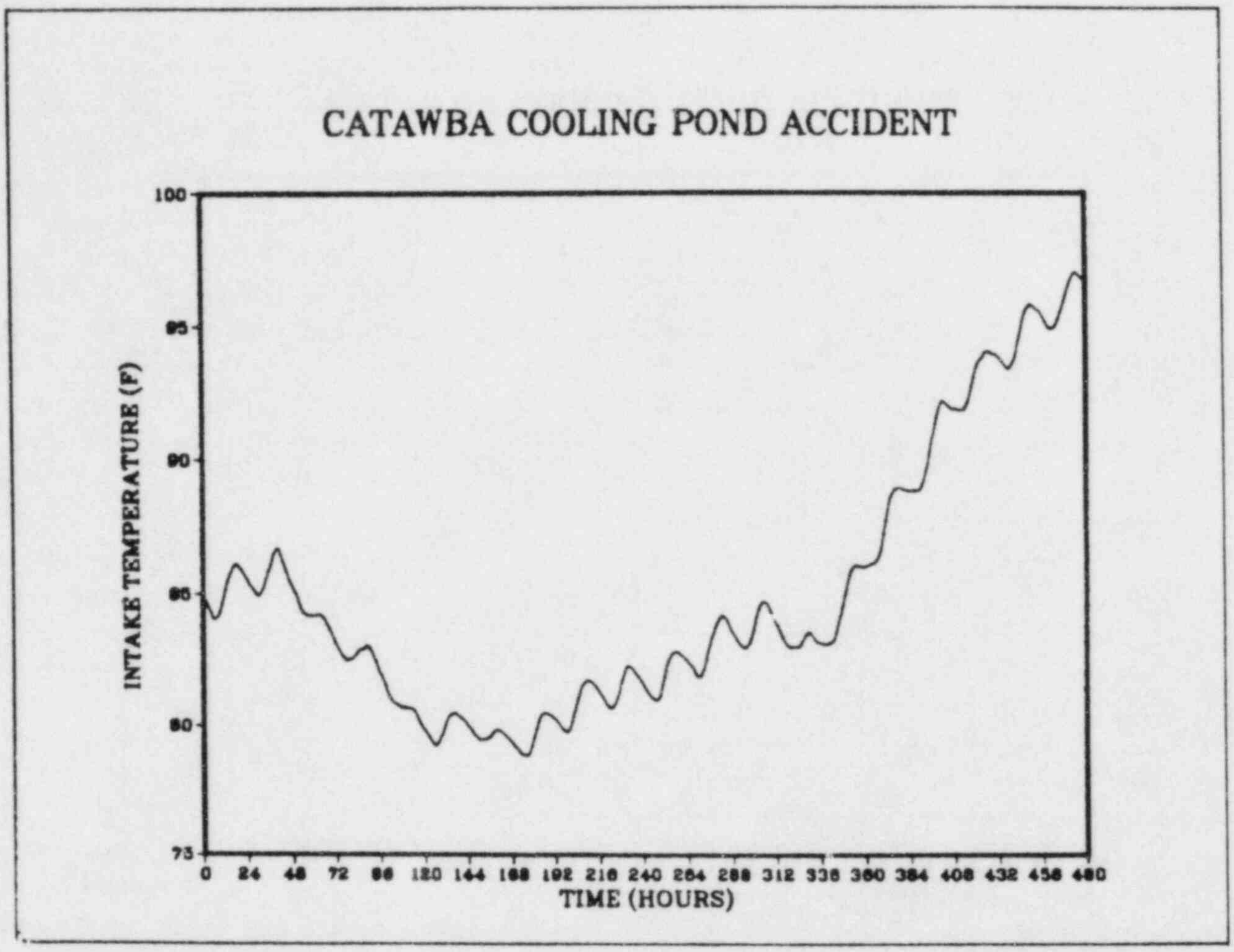


Fig. 7-72. MITEMP Model Prediction of Catawba Intake Temperature as a Function of Time Starting 13.5 Days Before Accident.

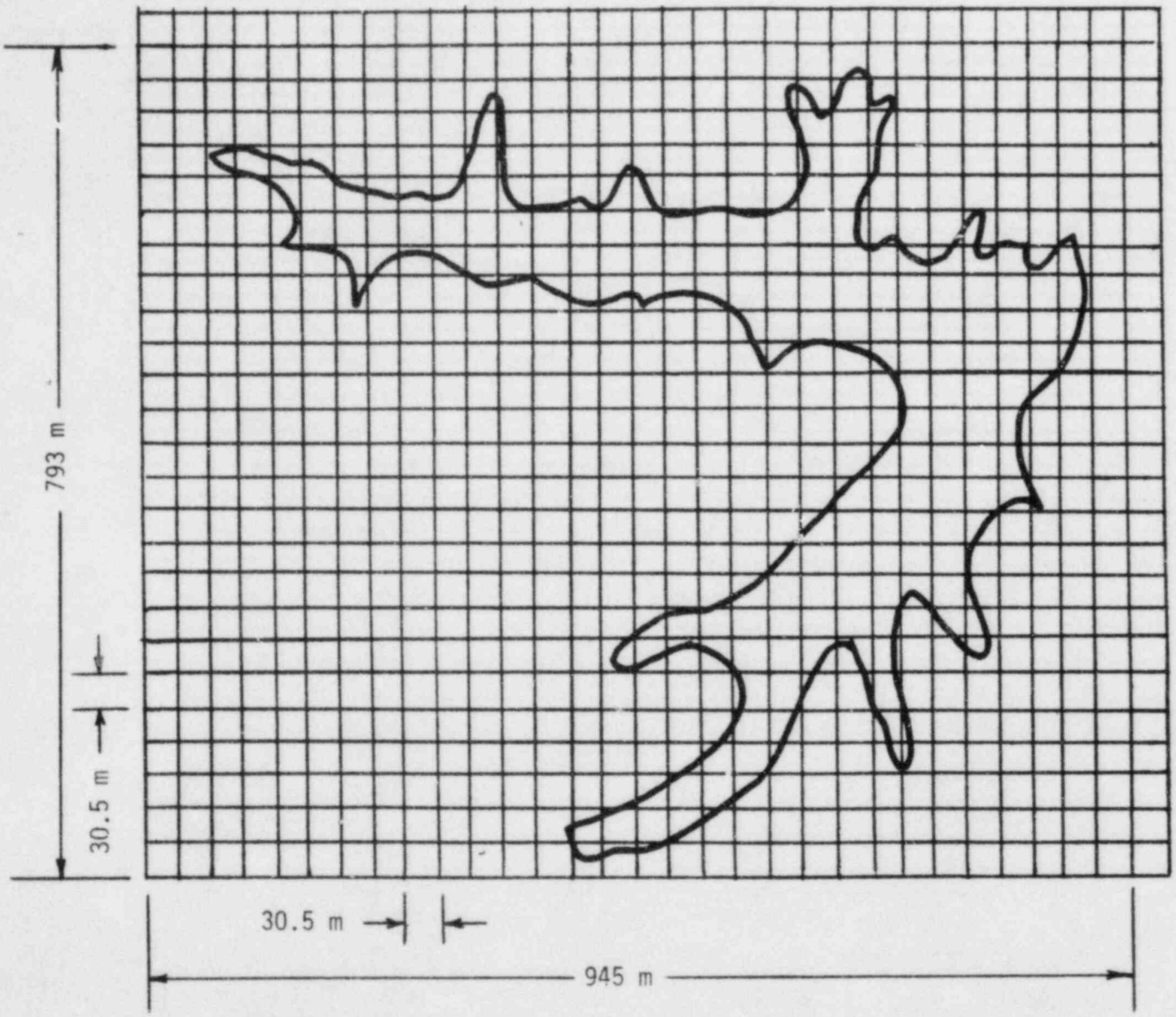
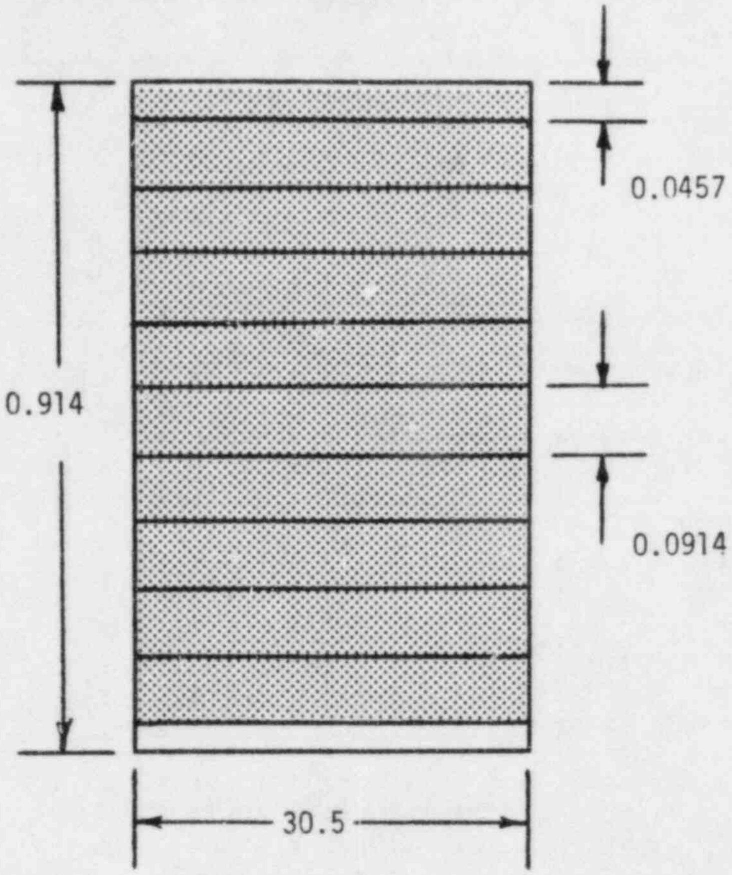
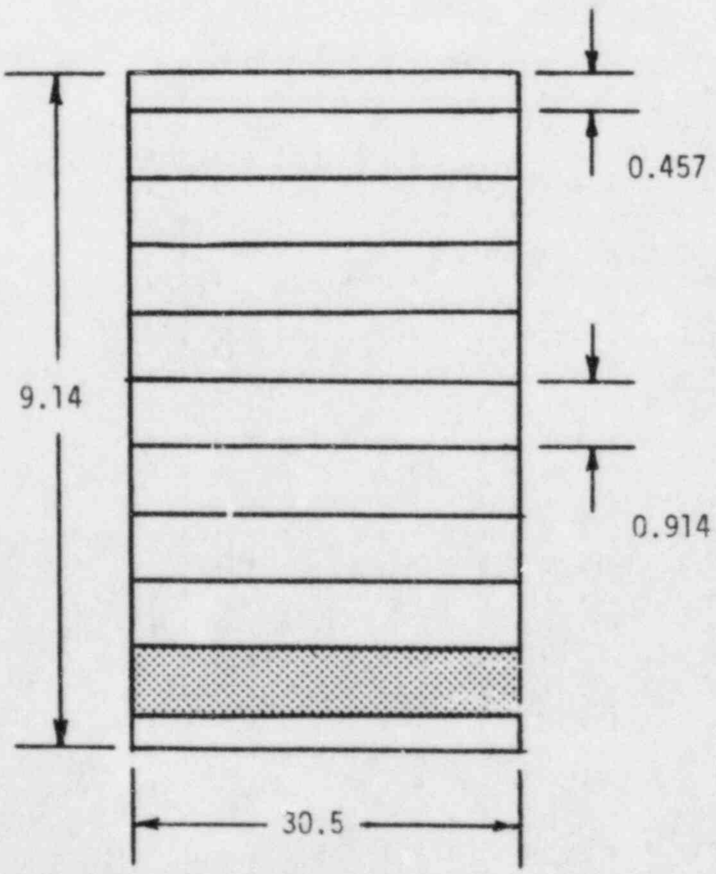


Fig. 7-73. Sketch of Computational Grid and Important Characteristic Lengths.



Plant discharge configuration for Catawba study. Top ten cells used with an initial exit velocity of 7.27 cm/s.



Plant intake configuration for Catawba study. Cell 10 was used with an intial intake velocity of 13.8 cm/s.

Fig. 7-74. Simulation of Discharges and Intake as Grid Cells.

Fig. 7-75. Pointer Arrays JJV and JJW for Continuation Runs 2-4.

JJV POINTERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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JJW POINTERS

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16	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	2	2	2	1	1	1	1	1	4	6	6	8
15	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	1	1	1	1	8	6	6	8
14	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	1	1	1	4	6	6	6	8
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3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	9	1	1	1	1	14	6	6	6	6	6	6	6	6	6	6	8
2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	2	2	2	2	14	6	6	6	6	6	6	6	6	6	6	8
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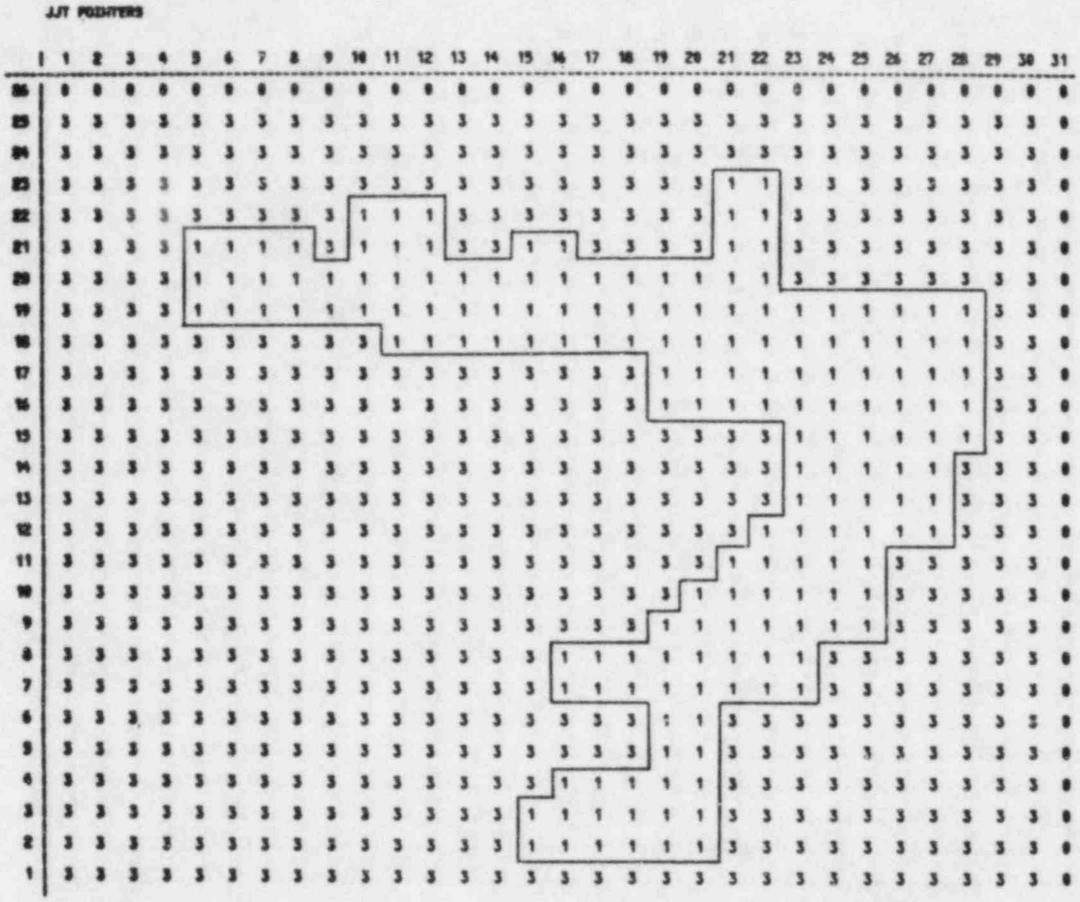
Fig. 7-76. Pointer Arrays JJT and JJTM for Continuation Runs 2-4.



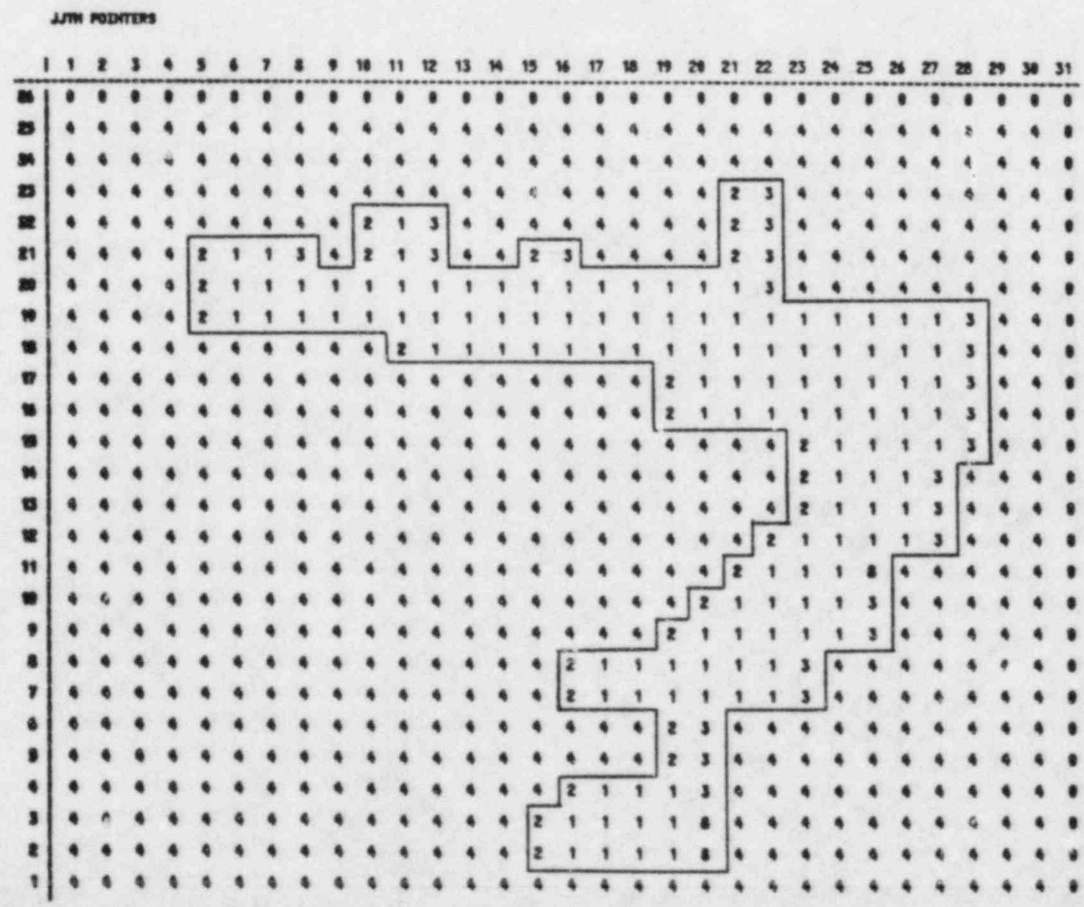


Fig. 7-77. Pointer Arrays JJTN and JJP for Continuation Runs 2-4.

JJTN POINTERS

I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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19	4	4	4	4	7	7	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	4	4	0
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17	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	1	1	1	4	4	0
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10	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	1	1	1	1	1	4	4	4	4	4	0
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JJP POINTERS

I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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8. SUMMARY AND CONCLUSIONS

The lack of field data on an operating ultimate heat sink cooling pond requires the use of data in related pond flow problems to provide a validated model for UHS applications. Such a model can then be applied to UHS cooling ponds to determine thermal performance. Direct scale modeling of a UHS pond in the laboratory is not possible due to conflicting similarity requirements. Our project plan had three phases which are described below,

1. Determination of accurate surface heat transfer relations.

Two surface heat transfer formulations were tested with field data from the artificial hot pond at Raft River, Idaho. The pond was found to be completely mixed at all times as it cooled from an initially hot state. The Ryan-Harleman model performed very well with these data and predicted pond temperatures within the accuracy of the data.

2. Identification of a three-dimensional numerical model for flow simulations.

The next step was the identification of the Paul Model as a tool which could simulate three-dimensional thermal hydraulics in pond applications. The Paul Model was modified to employ the Ryan-Harleman surface heat transfer formulation. Application to the Cerco Laboratory and H.B. Robinson field data revealed good accuracy in modeling stratified and unstratified conditions in heated ponds.

3. Application of Paul Model to prototype UHS pond.

At this step, the Paul Model has been shown to be capable of treating a variety of flow configurations in cooling ponds. Application to the Catawba UHS pond should reveal the balance of physical mechanisms in such a UHS pond. Model results indicated a very different flow pattern than in ponds used for normal cooling. Our computer modeling results indicated that a vertically mixed pond occured as a result of the following contributing factors:

(a) the strong buoyant convective motions present in the pond due to the high heat loading applied to the pond;

(b) the large effect that discharge/intake flow circulations have on the flow field of such small ponds;

(c) the short distances a water parcel must travel to reach a solid boundary before it displaces below the surface, mixing with the subsurface layers in the pond; and

(d) the large effect of surface heat transfer which is to cool the surface layers causing them to be heavier than the water below leading to vertical convective motions.

The effect of wind stress appears to be a secondary factor in dispersing the heated effluent. From the Catawba run of the Paul model, large three-dimensional eddy circulations are created which aid in mixing all portions of the pond. Only a one-dimensional decay of temperature (longitudinal) with distance was present leading to the decay of temperature from discharge to intake. The assumption of vertical stratification often made in models of normal cooling ponds and presumed to apply to UHS ponds appears to be inapplicable for UHS cooling pond application.

4. Methodology for Modeling Future UHS Cooling Ponds.

It is very likely that the same mechanisms found for the Catawba UHS will be present for most of the other UHS designs considering the necessarily small size and heavy loading of these ponds. As a general recommendation, it would be wise to first apply the zero- and one-dimensional models to a prototype case. The maximum intake temperature should be lower for the one-dimensional run than for the zero-dimensional simulation considering that the discharge and intake are always widely separated in these designs and that the zero-dimensional prediction represents only the time dependency of the <u>average</u> pond temperature. If these temperatures are close to (± a few degrees of) the maximum not to be exceeded intake temperature, then a run of the three-dimensional model may be in order to provide a more refined prediction. If the zero- and one-dimensional predictions are significantly below the maximum intake temperature required and the pond is of reasonably similar design to the Catawba case, it should not be required to apply the three-dimensional model. The present state-of-the-art is such that three-dimensional model calculations may be the only way to determine the true character of the pond flow field when needed.

Future work could involve the development and validation of a two-dimensional model (horizontal spatial variations only) that is consistent in formulation to the three-dimensional Paul model. Such a two-dimensional model should be inexpensive to run and should provide a valuable and cost-effective complement to the zero, one, and three-dimensional models described in this report.

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16. ABSTRACT (200 words or less)

A general treatment of ultimate heat sink (UHS) cooling pond thermal performance is proposed through the application of a three-dimensional grid model. Validation of the model has been shown through comparisons of predictions with data from a field and laboratory pond. The advantage of the model lies in its ability to determine the detailed character of the flow field whether it be one, two, or three dimensional. Existing models require a priori knowledge of the character and dimensionality of the flow field in such ponds.

Application of the model to a prototype UHS pond revealed that the balance of physical mechanisms involved in the thermal hydraulics of these ponds is quite different than for ponds used in normal cooling. The small, heavily-loaded, irregularly-shaped nature of the UHS pond should, in many cases, lead to a vertically mixed pond with only a one-dimensional (longitudinal) variation in pond temperature.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Ultimate heat sink
Cooling pond modeling
Pond thermal hydraulics
Pond surface heat transfer

17b. IDENTIFIERS/OPEN-ENDED TERMS

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