A Computer Program to Plot Isotherms in Bodies of Water

D. L. DeAngelis

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1199

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ABSTRACT

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For purposes of graphic display it is convenient to represent temperature versus depth data in bodies of water in the form of isotherms (lines of equal temperature). Because it can be tedious to draw such lines by hand from raw data, a computer code has been devised to plot these lines automatically. The procedure assumes that the temperature can be linearly interpolated between the points at which measurements are taken. Details of the code are explained by means of examples. With minor changes, the program can be used to plot isoclines of other environmental parameters.

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INTRODUCTION

A subject area of much interest in ecology is the response of biota to environmental gradients. This can involve the behavior of individual organisms, the distribution of a species population, and/or the structure of a community along the gradient. Computer graphics methods can make contributions to these studies by displaying data on environmental gradients in the form of diagrams. This report documents a method for transforming raw data on such gradients into graphs.

This report is confined to the graphic display of temperature gradients in aquatic systems. The work was stimulated by current studies on fish movement in Cherokee Lake, a reservoir in east Tennessee. Therefore, the figures and examples used here are oriented to this specific body of water. However, the technique should be useful for a variety of ecological situations where environmental conditions are varying.

Temperature gradients strongly influence the movements of fish in lakes, reservoirs, and other bodies of water (e.g., Coutant 1975a,b). With the increasing thermal loading caused by power plants, it is necessary to investigate the effects of temperature gradients on fish distribution. Graphical displays of temperature data can help in this work.

Spatial temperature data in bodies of water usually consist of measurements at a sequence of depths for a number of horizontal sites in the body of water. For a river, estuary, or elongated lake or reservoir, the temperature distribution is often adequately represented using two coordinate axes, depth and distance along the waterbody (see Fig. 1). Alternatively, a series of cross-sections could be used, so that depth and distance across the reservoir are the coordinates. Finally, overhead views of the body of water, in which horizontal temperature distributions are given for specified depths, might be desirable. None of these two-dimensional displays is as convenient as a three-dimensional display would be. Three-dimensional displays are more difficult computationally, however, and are not included in this report.

Figure 1. Hypothetical reservoir. The vertical dimension is depth in meters (disproportionately scaled), and the horizontal dimension is length along the reservoir in kilometers, with the dam at the left-hand side.

From a visual point of view, it is most useful to transform data on temperature versus depth into plots of isotherms (lines of equal temperature). Since this can be tedious to do by hand, a computer program has been designed to automatically carry out the procedure. The computer program is fairly general and has been applied to other isoclines such as isobars of dissolved oxygen in water. Presumably, it is also applicable to isoclines of environmental parameters in other environments.

This paper presents the mathematical basis of the isotherm plotting procedure and describes the associated computer program and its use.

MATHEMATICAL BASIS OF THE METHOD

Consider a short series of hypothetical measurements of temperature versus depth along the longitudinal axis of a body of water (Fig. 2). We wish to draw a particular isotherm from these data, say 31°C. It is clear that the isotherm will fall between the rows of points and that some form of interpolation procedure is necessary. We assume that a linear interpolation is adequate. For a given horizontal site, i , denote the depth of the j^{th} point by $\text{DEPT}_{i,j}$ and the temperature at that depth by $\text{TEMP}_{i,j}$. Then the depth, DP , at which the isotherm, THERM_k , occurs, is

$$\text{DP} = \text{DEPT}_{i,j} + \{(\text{THERM}_k - \text{TEMP}_{i,j}) * (\text{DEPT}_{i,j+1} - \text{DEPT}_{i,j}) / (\text{TEMP}_{i,j+1} - \text{TEMP}_{i,j})\}, \quad (1)$$

where $*$ signifies multiplication. The values $\text{DEPT}_{i,j}$ and $\text{TEMP}_{i,j}$ are assumed to be given in the data. The 31°C isotherm is plotted in Fig. 2.

The concept described here is quite simple, and it is not hard to design a computer program to locate and plot the points of an isotherm.

Figure 2. A series of hypothetical (and unrealistically high) temperature-versus-depth measurements along a body of water. The 31 C isotherm is sketched in. Distance is measured from a point further downstream.

Difficulties can arise, however, when the thermal structure of the body of water is complicated, and more than one line needs to be drawn to describe points of equal temperature. Programming techniques to handle this situation are described in the next section.

COMPUTER METHODS

The present program is designed to handle complex isotherm problems. Consider the series of hypothetical depth-versus-temperature measurements along a reservoir shown in Fig. 3. Note that this is a rather atypical temperature pattern. In most bodies of water, temperature usually decreases monotonically with increasing depth. In the example in Fig. 3, however, temperature is a fairly complicated function of depth and length. A situation this complicated may not often occur in nature, but it is prudent to construct a program sophisticated enough to handle this situation should it occur, especially since power plant discharge could produce contorted isotherm configurations.

The computer search procedure starts from the upper left of Fig. 3, moving down each column of measurements from left to right, seeking out and storing the depth values at which the desired isotherm temperature occurs. The linear interpolation scheme described in the preceding section is employed to determine the depths of points on the isotherms. Notice that the same horizontal site may have two or more depths with the same temperature. This makes it rather difficult for the program to correctly assign each point to its proper isotherm line. For example, the temperature is 33°C at both points P' and P, which are at the same horizontal site but at different depths. The same holds for points Q and Q', R and R', and a number of other points. The human observer, with an ability to recognize patterns, can easily place all of these points in the proper three isotherms. The computer program as described so far, however, is designed merely to connect points of equal temperature as it finds them, regardless of the reasonableness of the overall pattern produced. Without additional built-in logic, the program would tend to draw the isotherm line from P' to the next point at

Figure 3. A series of hypothetical temperature-versus-depth measurements, deliberately designed to be complicated. The 33 C isotherm lines are sketched in.

33°C it finds, P, then back to R', next to R, and so forth, producing a nonsensical isotherm. A method to discriminate which point belongs to which line must be introduced. We assume that isotherms do not change their depth too rapidly as a function of horizontal distance. Let D_{crit} be the assumed maximum change in the depth of a particular isotherm line from one site along the length (or width) of the reservoir to the next horizontal site. If $D_{p'}$ is the depth at point P', and D_p is the depth at point P (Fig. 3), and

$$\left| D_p - D_{p'} \right| > D_{crit} \quad , \quad (2)$$

points P and P' are not plotted on the same line. D_{crit} is arbitrary and has to be chosen with some care involving a prior survey of data to check on the magnitude of changes the temperature might undergo between points. As long as the assumption of slow change in depth of the isotherm lines is valid, the isotherms will be plotted accurately. If the assumption is not valid, there will be some gaps in the plots.

The procedure consists of two basic steps. Each continuous line associated with a particular temperature, $THERM_k$, is first stored in a separate array in the computer program. Then, after the program has moved across the length of the body of water, storing the isotherm data, these arrays are all plotted out using the DISSPLA computer plotting routine (Integrated Software Systems Corporation 1970). A sample display is exhibited in Fig. 4; the outline of the body of water is also plotted by computer.

Often, one wishes to plot the isotherms for a given body of water on a given date, but there are too few data points from which to construct isotherms that show detailed temperature variations. One way to alleviate this problem is to interpolate a new, finely meshed grid of points within the area bounded by the original data points. Suppose, as in the hypothetical example in Fig. 5, that only 20 original data points (boldly marked) are given. In order to obtain a sufficient number of points from which smooth isotherms can be drawn, in this case a 21 x 13 grid of new (lightly marked) points is substituted between

HYPOTHETICAL RESERVOIR

AUGUST 19, 1977

Figure 4. A computer plot of the 33 C isotherms from the temperature-versus-depth data given in Fig. 3.

the known points. The temperature at each of the new points is obtained by interpolation based on the four surrounding original data points. For example, the temperature, TEMP(P), at point P is given by

$$\text{TEMP}(P) = (d_{P,A}\text{TEMP}(A) + d_{P,B}\text{TEMP}(B) + d_{P,C}\text{TEMP}(C) + d_{P,D}\text{TEMP}(D)) / (d_{P,A} + d_{P,B} + d_{P,C} + d_{P,D}), \quad (3)$$

where $d_{P,A}$ is the distance between points P and A, etc. Equation (3) merely says that the temperature at point P is a linear average of temperatures at four surrounding points, weighted according to proximity.

In the computer program, the use of the interpolated grid of points is optional. If the option is chosen, then a 100 x 40 grid of points is substituted between the known data points. The temperature at each of these new grid points is calculated using Eq. (3). Figure 6 shows the isotherms of Fig. 4 recalculated using the new grid of points.

One additional option is available. The user can have the actual temperature data points printed out at the appropriate depths on the computer plots. Instructions for use of this and the other option are described in the following section, along with some plots in which temperatures are printed.

COMPUTER PROGRAM

The computer program consists of a MAIN PROGRAM and a SUBROUTINE PLOTT.

The MAIN PROGRAM first reads in the input data, which is described in Part A, below, and prints this out (see Part B, below). The input data include the outline of the body of water, the specification of the desired isotherms, the temperature-versus-depth data, and D_{crit} . The program iterates over the desired isotherms. For each isotherm, the procedure described in the preceding section is executed. The points of each of the distinct lines associated with a particular value of THERM are stored in a separate array. The lines are then plotted from these values.

Figure 5. A simple hypothetical example showing the replacement of original data points by a grid of new points. The boldly marked points are the original data while the lightly marked points are interpolated.

Figure 6. A computer plot of isotherms from the temperature-versus-depth data given in Fig. 3 after the original data points have been replaced by a 100 x 40 grid of interpolated points.

SUBROUTINE PLOTT causes the outline of the body of water to be plotted (see the descriptions of Cards H and I below).

It is possible to produce any number of plots in the same job, as long as the same basic data on input cards A through M (below) are appropriate to each of the plots. Cards N through R provide data specific to a particular plot. To produce more than one plot, all that is necessary is to stack additional sets of cards N through R, one set for each additional plot.

Part A. Input Cards

Figure 7 is a listing of the input cards relevant to the temperature-versus-depth measurements in the preceding section. These input cards are described below:

Card A

Input parameters: (LCAP(I), I=1,10)

Format: 10A4

LCAP(I) = caption appropriate to all plots for a particular job
(e.g., Cherokee Lake)

Card B

Input parameters: (LHOR(I), I=1,10)

Format: 10A4

LHOR(I) = legend for horizontal axis of all plots included in a particular job.

Card C

Input parameters: (LVER(I), I=1,10)

Format: 10A4

LVER(I) = legend for vertical axis of all plots included in a particular job

HYPOTHETICAL RESERVOIR
KILOMETERS
ELEVATION (METERS)

2												
50.	105.	270.	330.									
6.0												
0												
11												
51.	51.	53.	71.	76.	82.	89.						
94.	103.	103.	51.									
312.	283.	278.	291.	296.	299.	308.						
309.	310.	312.	312.									
1												
33.51												
AUGUST 19, 1977												
22	323.											
12	52.											
0.0	4.0	7.0	11.0	14.0	17.0	20.0	24.0	28.0	32.0	36.0	42.0	
40.0	39.5	38.5	37.0	36.0	34.5	33.0	32.0	31.0	29.5	28.0	27.0	
12	54.											
0.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	
39.0	38.5	37.5	36.0	35.5	34.0	32.5	31.0	30.5	29.5	29.0	28.5	
12	56.											
0.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	
39.0	38.0	37.0	35.5	35.0	33.0	32.0	31.0	30.5	29.9	29.0	29.5	
13	58.											
0.0	3.0	6.0	9.0	12.0	15.0	18.0	22.0	26.0	30.0	34.0	38.0	41.0
38.0	37.5	36.5	35.5	35.0	34.0	33.0	31.5	31.0	30.5	30.0	29.5	29.4
12	60.											
0.0	3.0	6.0	9.0	12.0	15.0	18.0	22.0	26.0	30.0	34.0	38.0	
37.5	36.5	36.0	35.1	34.6	33.8	32.6	32.0	31.6	31.2	30.6	31.0	
14	62.											
0.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0
37.0	36.0	35.5	34.9	34.0	32.8	32.3	32.0	31.8	31.7	32.0	32.5	32.9
13	64.											
0.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0
36.0	35.5	34.8	33.9	33.1	32.2	31.7	31.0	31.5	31.7	32.3	33.0	34.0
12	66.											
0.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	35.0	
34.5	34.1	33.6	33.3	32.7	32.3	31.7	31.2	30.7	31.0	33.0	34.5	
13	68.											
0.0	3.0	5.0	7.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0
33.5	33.1	32.8	32.6	32.2	31.7	31.5	31.1	30.9	31.5	32.8	34.0	36.5
12	70.											
0.0	3.0	5.0	7.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	
32.5	32.3	32.0	31.5	31.0	30.5	30.4	29.9	29.5	32.0	34.5	36.5	
13	72.											
0.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	18.0	21.0	24.0	27.0	30.0
32.9	32.6	32.3	31.9	31.5	31.0	30.5	30.0	32.0	32.5	34.0	36.0	38.

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z

38.5	37.0	36.5	34.5	33.5	32.5	31.0	30.0	29.0	28.0	28.5	29.0	33.1	Q	
13		82.											O	
0.0	2.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.0	21.0	23.0	P	
39.0	37.5	37.0	35.5	34.5	33.0	32.0	31.0	30.0	29.0	28.0	27.0	26.5	Q	
12		84.											O	
0.0	2.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.0	21.0		P	
39.5	38.0	37.5	36.5	35.5	34.3	33.0	32.0	30.5	29.5	28.0	27.5		Q	
12		86.											O	
0.0	2.0	3.0	4.0	5.0	6.0	7.0	9.0	11.0	13.0	15.0	18.0		P	
40.0	38.5	38.0	37.0	36.0	34.7	33.5	32.5	31.0	30.0	28.5	28.0		Q	
12		88.											O	
0.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	10.0	12.0	14.0	16.0		P	
40.2	39.0	38.4	37.4	36.4	35.2	33.9	32.9	31.4	30.4	28.9	28.4		Q	
12		90.											O	
0.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	11.0	13.0	15.0		P	
40.7	39.3	38.8	37.8	36.8	35.7	34.4	33.4	31.8	30.8	29.3	28.8		Q	
12		92.											O	
0.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	11.0	13.0	15.0		P	
41.0	39.7	39.2	38.2	37.2	36.2	35.0	33.9	32.4	31.3	29.8	29.2		Q	
12		94.											O	
0.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	11.0	13.0	15.0		P	
41.3	40.0	39.5	38.6	37.6	36.6	35.5	34.5	32.8	31.9	30.4	29.9		Q	
40.0	39.5	38.5	37.0	36.0	34.5	33.0	32.0	31.0	29.5	28.0	27.0		R	
39.0	38.5	37.5	36.0	35.5	34.0	32.5	31.0	30.5	29.5	29.0	28.5		R	
39.0	38.0	37.0	35.5	35.0	33.0	32.0	31.0	30.5	29.9	29.0	29.5		R	
38.0	37.5	36.5	35.5	35.0	34.0	33.0	31.5	31.0	30.5	30.0	29.5	29.4	R	
37.5	36.5	36.0	35.1	34.6	33.8	32.6	32.0	31.6	31.2	30.6	31.0		Q	
37.0	36.0	35.5	34.9	34.0	32.8	32.3	32.0	31.8	31.7	32.0	32.5	32.9	33.1	R
36.0	35.5	34.8	33.9	33.1	32.2	31.7	31.0	31.5	31.7	32.3	33.0	34.0		R
34.5	34.1	33.6	33.3	32.7	32.3	31.7	31.2	30.7	31.0	33.0	34.5			R
33.5	33.1	32.8	32.6	32.2	31.7	31.5	31.1	30.9	31.5	32.8	34.0	36.5		R
32.5	32.3	32.0	31.5	31.0	30.5	30.4	29.9	29.5	32.0	34.5	36.5			R
32.9	32.6	32.3	31.9	31.5	31.0	30.5	30.0	32.0	32.5	34.0	36.0	38.5		R
34.5	33.8	33.1	32.8	32.5	31.0	30.0	29.5	31.5	33.5	35.0	37.0			R
37.0	35.5	34.5	34.0	33.5	32.5	31.0	31.5	32.5	33.5	34.5	36.0			R
38.0	36.5	35.5	34.0	33.0	32.0	30.5	29.5	29.0	31.5	33.0	34.5	33.6		R
38.5	37.0	36.5	34.5	33.5	32.5	31.0	30.0	29.0	28.0	28.5	29.0	33.1		R
39.0	37.5	37.0	35.5	34.5	33.0	32.0	31.0	30.0	29.0	28.0	27.0	26.5		R
39.5	38.0	37.5	36.5	35.5	34.3	33.0	32.0	30.5	29.5	28.0	27.5			R
40.0	38.5	38.0	37.0	36.0	34.7	33.5	32.5	31.0	30.0	28.5	28.0			R
40.2	39.0	38.4	37.4	36.4	35.2	33.9	32.9	31.4	30.4	28.9	28.4			R
40.7	39.3	38.8	37.8	36.8	35.7	34.4	33.4	31.8	30.8	29.3	28.8			R
41.0	39.7	39.2	38.2	37.2	36.2	35.0	33.9	32.4	31.3	29.8	29.2			R
41.3	40.0	39.5	38.6	37.6	36.6	35.5	34.5	32.8	31.9	30.4	29.9			R

Figure 7. Listing of input cards relevant to the temperature-versus-depth measurements given in Fig. 3.

Card D

Input parameter: KPLOT

Format: I5

KPLOT = 2 if temperature-versus-depth data is to be printed out on
all plots in a particular job
≠ 2 otherwise

Card E

Input parameters: HORL, HORU, VERL, VERU

Format: 4E10.0

HORL = lower limit on the horizontal axis

HORU = upper limit on the horizontal axis

VERL = lower limit on the vertical axis

VERU = upper limit on the vertical axis

Card F

Input parameter: DCRIT

Format: E10.0

DCRIT = maximum assumed change in the depth of isotherm lines from one
site to the next along the longitudinal axis

Card G

Input parameter: NEWGRD

Format: I5

NEWGRD = 1 if a new grid of interpolated points is to be substituted
for the original data points
= 0 if the original data points are used to calculate the
isotherms

Card H

Input parameter: NREGP

Format: I5

NREGP = the number of points on the line to be drawn to define the
boundary of the body of water

Card Set I

Input parameters: (ALNG(J), J=1,NREGP)

Format: 7E10.0

ALNG(J) = the horizontal coordinates of points on the line defining the boundary of the body of water

Card Set J

Input parameters: (ELEVA(J), J=1,NREGP)

Format: 7E10.0

ELEVA(J) = the vertical coordinates of points on the line defining the body of water (elevation above sea level). The elevation of the surface, which may be variable from day to day, is specified separately by ELEV (see Card G).

Card K

Input parameter: NTHERM

Format: I5

NTHERM = number of isotherms to be plotted

Card L

Input parameters: (THERM(I), I=1,NTHERM)

Format: 7E10.0

THERM(I) = temperature of the I^{th} isotherm

Card M

Input parameters: (LMESS(I), I=1,5)

Format: 5A4

LMESS(I) = date of measurements (e.g., June 1, 1977)

Card N

Input parameters: NSITES, ELEV

Format: I5, 5X, E10.0

NSITES = number of sites along the length of the reservoir at which measurements are taken

ELEV = current elevation of the surface of water above sea level

Card 0 (one for each site I)

Input parameters: NPT(I), HOR(I)

Format: I5, 5X, E10.0

NPT(I) = number of depth positions at site I

HOR(I) = longitudinal position of site I

Card Set P (one for each site I)

Input parameters: DEPT(J), J=1,NPT(I))

Format: 7E10.0

DEPT(J) = depth of point J

Card Set Q (one for each site I)

Input parameters: (TEMP(J), J=1,NPT(I))

Format: 7E10.0

TEMP(J) = temperature at point J

Card Set R (one for each longitudinal site; included only if KPL0T=2)

Input parameters: (ATEMP(J), J=1,NPT(I))

Format: 7E10.0

ATEMP(J) = same as TEMP(J); now read in A-format for printing out on computer plots

Part B: Output

The output consists of two parts. First, the input data are printed out (Fig. 8). Second, an outline of the body of water is plotted, along with the isotherms, if desired (Fig. 4). The plotting is done using the DISSPLA graphics package (Integrated Software Systems Corporation 1970), which is available at many computer installations. Programming changes would be necessary to adapt the program to other graphics packages. Several typical plots are shown in Fig. 9.

THE PLOTTING OF ISOTHERMS FOR A BODY OF WATER

HYPOTHETICAL RESERVOIR

ELEVATION (METERS) VERSUS
DISTANCE (KILOMETERS)

HORL= 50.0000 HORU= 100.0000 VERL= 270.0000 VERU= 330.0000

DCRIT= 6.0000

DESIRED ISOTHERMS, THERM(K) = 33.5100
DECEMBER 19, 1977

NUMBER OF SITES = 22 ELEVATION OF SURFACE ABOVE SEA LEVEL = 323.0000

LONG=	0.51000000E 02	ELEV=	0.32300000E 03
LONG=	0.51000000E 02	ELEV=	0.28300000E 03
LONG=	0.53000000E 02	ELEV=	0.27800000E 03
LONG=	0.71000000E 02	ELEV=	0.29100000E 03
LONG=	0.76000000E 02	ELEV=	0.29600000E 03
LONG=	0.82000000E 02	ELEV=	0.29900000E 03
LONG=	0.89000000E 02	ELEV=	0.30800000E 03
LONG=	0.94000000E 02	ELEV=	0.30900000E 03
LONG=	0.95000000E 02	ELEV=	0.31000000E 03
LONG=	0.95000000E 02	ELEV=	0.32300000E 03
LONG=	0.51000000E 02	ELEV=	0.32300000E 03

SITE= 1 LONGITUDINAL DISTANCE = 52.0000

DEPTH TEMPERATURE

0.0	40.000
4.000	39.500
7.000	38.500
11.000	37.000
14.000	36.000
17.000	34.500
20.000	33.000
24.000	32.000
28.000	31.000
32.000	29.500
36.000	28.000
42.000	27.000

Figure 8. Input data of Fig. 7 as it is printed out by the computer program.

Figure 9(a). A plot of isotherms for Cherokee Lake, Tennessee for June 10-11, 1977. The numbers designating the temperature of each isotherm were typed in by hand.

CHEROKEE LAKE

JUNE 23, 1977

Figure 9(b). A plot of isotherms for Cherokee Lake, Tennessee, for June 23, 1977. The numbers designating the temperature of each isotherm were typed in by hand.

Figure 9(c). A plot of isotherms for Cherokee Lake, Tennessee, for June 4-5, 1977. An option was used to print out the actual temperature-versus-depth data as well.

Figure 9(d). A plot of isotherms for Cherokee Lake, Tennessee, June 15-16, 1977. An option was used to print out the actual temperature-versus-depth data as well.

Part C: Miscellaneous Information

1. The computer program (as currently written) can only be used in the batch mode. A small amount of reprogramming would be necessary to convert it to an interactive (time-sharing) mode program.
2. The DISSPLA graphics routine often chooses its own scaling, overriding the graphing instructions given by the user. For this reason, it is often necessary for the user to make more than one computer run before the desired plot dimensions are obtained. The user must have some familiarity with the DISSPLA plotting package to make the necessary adjustments.
3. The program uses 268K of core. An idea of the amount of CPU time necessary for typical plots can be obtained by considering the four plots shown in Fig. 9, which required about 15 seconds of CPU time.

APPLICATIONS

The computer program described in this report allows the efficient plotting of isotherms in a body of water from raw data on temperature versus depth along one of the horizontal axes. Despite the restriction (in this report) to plots of isotherms in water, the program can easily be adapted to plot isoclines of other environmental parameters in a variety of ecological isoclines. The plots in Fig. 9 illustrate the type of situation that is best handled, though the program can also be applied to somewhat more complex isoclines such as that of Figs. 3 and 4.

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- Coutant, C. C. 1975b. Temperature selection by fish - a factor in power plant impact assessments. pp. 575-597. IN: Environmental Effects of Cooling Systems at Nuclear Power Plants. International Atomic Energy Agency, Vienna.
- Integrated Software Systems Corporation, 1970. DISSPLA: Display Integrated Software System and Plotting Language. Beginners and Intermediate Manual - Vol. I, and Advanced Manual - Vol. II. San Diego, California.

APPENDIX: Computer Program Listing

```

ISN 0002      IMPLICIT REAL*4 (A-H,O-Z)
C
C.....PROGRAM FOR COMPUTING AND PLOTTING ISOTHERMS USING TEMPERATURE VERSUS
C      DEPTH DATA
C
ISN 0003      DIMENSION HOR(30),DEPT(25,30),TEMP(25,30),NPT(30),THERM(30)
ISN 0004      DIMENSION XX(100),YY(100)
ISN 0005      DIMENSION ISTR(50),IDF(50)
ISN 0006      DIMENSION IDF1(50),IDF2(50),IDF3(50)
ISN 0007      DIMENSION DTEMP(100,40),HORA(100)
ISN 0008      DIMENSION ATEMP(25,30)
ISN 0009      COMMON/FINBLK/NFIN,NRE3P
ISN 0010      COMMON/DRAW/ARRAYX(5,100),ARRAYY(5,100)
C      COMMON/DRAW/ARRAYX(7,80),ARRAYY(7,80)
ISN 0011      COMMON/MESSBK/LMESS(5)
ISN 0012      COMMON/RESBLK/ALNG(50),ELRVA(50)
ISN 0013      COMMON/PLTLEG/LCAP(10),LHOR(10),LVER(10)
ISN 0014      COMMON/PLTBND/VERL,VERU,HORL,HORU
ISN 0015      CALL CALCMP
ISN 0016      WRITE(6,2000)
ISN 0017      2000 FORMAT(1H1,/,5X,'THE PLOTTING OF ISOTHERMS FOR A BODY OF WATER',
1//)
C
C.....READ IN TITLE OF PLOTS, AS WELL AS LEGENDS FOR HORIZONTAL AND
C      VERTICAL AXES
ISN 0018      READ(5,1005) (LCAP(I),I=1,10)
ISN 0019      READ(5,1005) (LHOR(I),I=1,10)
ISN 0020      READ(5,1005) (LVER(I),I=1,10)
ISN 0021      WRITE(6,2001) (LCAP(I),I=1,10)
ISN 0022      2001 FORMAT(1H,5X,10A4,/)
ISN 0023      WRITE(6,2002) (LVER(I),I=1,10)
ISN 0024      2002 FORMAT(1H,5X,10A4,'VERSUS',5X,10A4,/)
ISN 0025      WRITE(6,2022) (LHOR(I),I=1,10)
ISN 0026      2022 FORMAT(1H,20X,10A4,/)
C
C.....IF KPLOT=2, THE MEASURED TEMPERATURE VALUES AT VARIOUS DEPTHS ARE
C      PRINTED OUT
C
ISN 0027      READ(5,1000) KPLOT
ISN 0028      IF(KPLOT.NE.2) GO TO 1
ISN 0030      WRITE(6,2003)
ISN 0031      2003 FORMAT(1H,5X,'TEMPERATURES ARE PRINTED OUT ON PLOTS',/)
ISN 0032      1 CONTINUE
C
C.....READ IN THE LOWER AND UPPER LIMITS ON THE HORIZONTAL AND VERTICAL AXES
C
ISN 0033      READ(5,1004) HORL,HORU,VERL,VERU
ISN 0034      2004 FORMAT(1H,5X,'HORL= ',F10.4,2X,'HORU= ',F10.4,2X,'VERL= ',F10.4,
12X,'VERU= ',F10.4,/)
ISN 0035      WRITE(6,2004) HORL,HORU,VERL,VERU
C
C.....READ IN DCRIT, CRITERION ON CONTINUITY OF ISOTHERM LINES
C
ISN 0036      READ(5,1004) DCRIT
ISN 0037      WRITE(6,2005) DCRIT
ISN 0038      2005 FORMAT(1H,5X,'DCRIT= ',F10.4,/)

```

```

C
C.....READ IN THE VARIABLE NEWGRD. IF NEWGRD=1, A NEW GRID OF POINTS (100 X 40)
C IS SUBSTITUTED FOR THE ORIGINAL DATA SET.
C
ISN 0039      READ(5,1000) NEWGRD
ISN 0040      IF(NEWGRD.NE. 1) GO TO 2
ISN 0042      WRITE(6,2006)
ISN 0043      2006 FORMAT(1H,5X,'A NEW 100 X 40 GRID OF POINTS IS SUBSTITUTED FOR TH
                1E ORIGINAL DATA',//)
ISN 0044      2 CONTINUE

C
C.....READ IN DATA ON THE OUTLINE OF THE BODY OF WATER
C
ISN 0045      READ(5,1000) NREGP
ISN 0046      NREGPT = NREGP
ISN 0047      NREGPM = NREGP - 1
ISN 0048      READ(5,1004) (ALNG(J),J=1,NREGP)
ISN 0049      READ(5,1004) (ELEV(J),J=1,NREGP)
ISN 0050      1004 FORMAT(7E10.0)

C
C
C.....READ IN TEMPERATURES OF DESIRED ISOTHERMS
C
ISN 0051      READ(5,1000) NTHERM
ISN 0052      READ(5,1004) (THERM(I),I=1,NTHERM)
ISN 0053      WRITE(6,2007) (THERM(I),I=1,NTHERM)
ISN 0054      2007 FORMAT(1H,5X,'DESIRED ISOTHERMS, THERM(K) = ',3X,6(F10.4,2X),/,
                139X,6(F10.4,2X),/,39X,6(F10.4,2X),/,39X,6(F10.4,2X),//)

C
ISN 0055      4 CONTINUE
ISN 0056      NREGP = NREGPT

C
C.....READ IN NSITES, THE NUMBER OF SITES ALONG THE LENGTH OF THE RESERVOIR
C AT WHICH DATA ARE GIVEN, AND ELEV, THE ELEVATION OF THE SURFACE OF
C THE RESERVOIR ABOVE SEA LEVEL
C
ISN 0057      READ(5,1005) (LMESS(I),I=1,5)
ISN 0058      1005 FORMAT(15A4)
ISN 0059      WRITE(6,2008) (LMESS(I),I=1,5)
ISN 0060      2008 FORMAT(1H,5X,5A4,//)
ISN 0061      READ(5,1000) NSITES, ELEV
ISN 0062      1000 FORMAT(I5,5X,5E10.0)
ISN 0063      WRITE(6,2009) NSITES,ELEV
ISN 0064      2009 FORMAT(1H,5X,'NUMBER OF SITES = ',I5,5X,'ELEVATION OF SURFACE ABO
                1VE SEA LEVEL = ',F10.4,//)
ISN 0065      ELEV(1) = ELEV
ISN 0066      ELEV(NREGP) = ELEV
ISN 0067      ELEV(NREGPM) = ELEV
ISN 0068      DO 5 I=1,NREGP
ISN 0069      WRITE(6,2010) ALNG(I),ELEV(I)
ISN 0070      2010 FORMAT(1H,5X,'LONG= ',E15.8,5X,'ELEV= ',E15.8)
ISN 0071      5 CONTINUE

C
C.....PLOT THE OUTLINE OF THE RESERVOIR
C
ISN 0072      CALL PLOTT

C
C.....READ IN THE TEMPERATURES AND DEPTHS AT EACH SITE

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C
ISN 0073      DO 20 I=1,NSITES
ISN 0074      READ(5,1001) NPT(I), HOR(I)
ISN 0075      1001 FORMAT(I5,5X,5(E10.0))
ISN 0076      NP = NPT(I)
ISN 0077      READ(5,1003) (DEPT(I,J),J=1,NP)
ISN 0078      READ(5,1003) (TEMP(I,J),J=1,NP)
ISN 0079      1003 FORMAT(1X,15F5.1)
ISN 0080      20 CONTINUE
ISN 0081      IF(KPLOT .NE. 2) GO TO 22
ISN 0083      DO 21 I=1,NSITES
ISN 0084      NP = NPT(I)
ISN 0085      READ(5,1006) (ATEMP(I,J),J=1,NP)
ISN 0086      1006 FORMAT(1X,15(1X,A4))
ISN 0087      21 CONTINUE
ISN 0088      22 CONTINUE
ISN 0089      DO 30 I=1,NSITES
ISN 0090      WRITE(6,2011)
ISN 0091      2011 FORMAT(//)
ISN 0092      NP = NPT(I)
ISN 0093      WRITE(6,2012) I, HOR(I)
ISN 0094      2012 FORMAT(1H,5X,'SITE= ',I5,5X,'LONGITUDINAL DISTANCE = ',F10.4,
      1//,8X,'DEPTH',9X,'TEMPERATURE',//)
ISN 0095      DO 25 J=1,NP
ISN 0096      IF(KPLOT .EQ. 2) GO TO 23
ISN 0098      WRITE(6,2013) DEPT(I,J), TEMP(I,J)
ISN 0099      2013 FORMAT(1H,5X,5(F10.3,7X))
ISN 0100      GO TO 24
ISN 0101      23 CONTINUE
ISN 0102      WRITE(6,2014) DEPT(I,J), ATEMP(I,J)
ISN 0103      2014 FORMAT(1H,5X,F10.3,9X,A4)
ISN 0104      24 CONTINUE
ISN 0105      25 CONTINUE
ISN 0106      30 CONTINUE

C
C.....SUBSTITUTE A NEW GRID OF POINTS (100 X 40) FOR THE ORIGINAL DATA SET
C
ISN 0107      IF(NEWGRD .NE. 1) GO TO 91
ISN 0109      BEGX = HOR(1)
ISN 0110      FINX = HOR(NSITES)
ISN 0111      DELX = (FINX - BEGX - 0.2)/100.
ISN 0112      X = BEGX + 0.1001
ISN 0113      DO 80 I=1,100
ISN 0114      HORA(I) = X
ISN 0115      DO 45 J=1,50
ISN 0116      JP = J + 1
ISN 0117      IF(X .LT. HOR(JP)) GO TO 46
ISN 0119      45 CONTINUE
ISN 0120      46 CONTINUE
ISN 0121      ISITE = J
ISN 0122      NP = NPT(J)
ISN 0123      BEGYJ = DEPT(J,1)
ISN 0124      FINYJ = DEPT(J,NP)
ISN 0125      NPP = NPT(JP)
ISN 0126      BEGYJP = DEPT(JP,1)
ISN 0127      FINYJP = DEPT(JP,NPP)
ISN 0128      YBEG = BEGYJ + (X-HOR(J)) * (BEGYJP-BEGYJ) / (HOR(JP)-HOR(J))
ISN 0129      YFIN = FINYJ + (X-HOR(J)) * (FINYJP-FINYJ) / (HOR(JP)-HOR(J))

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ISN 0130      DELY = (YFIN - YBEG - 0.2)/40.
ISN 0131      Y = YBEG + 0.1001
ISN 0132      DO 70 K=1,40
ISN 0133      Y = 10.*Y
ISN 0134      IY = Y
ISN 0135      SY = IY
ISN 0136      DTEMP(I,K) = SY
ISN 0137      Y = 0.1*Y
ISN 0138      DO 50 KA=1,30
ISN 0139      IF(Y .LT. DEPT(J,KA)) GO TO 51
ISN 0141      IF(KA .EQ. NP) GO TO 51
ISN 0143      50 CONTINUE
ISN 0144      51 CONTINUE
ISN 0145      IJST = KA - 1
ISN 0146      IJPST = KA
ISN 0147      DO 55 KB=1,30
ISN 0148      IF(Y .LT. DEPT(JP,KB)) GO TO 56
ISN 0150      IF(KB .EQ. NPP) GO TO 55
ISN 0152      55 CONTINUE
ISN 0153      56 CONTINUE
ISN 0154      IPJST = KB - 1
ISN 0155      IPJPST = KB
ISN 0156      DAA = DEPT(J,IJST)
ISN 0157      DAB = DEPT(JP,IPJST)
ISN 0158      DBA = DEPT(J,IJPST)
ISN 0159      DBB = DEPT(JP,IPJPST)
ISN 0160      TAA = TEMP(J,IJST)
ISN 0161      TAB = TEMP(JP,IPJST)
ISN 0162      TBA = TEMP(J,IJPST)
ISN 0163      TBB = TEMP(JP,IPJPST)
ISN 0164      HA = HOR(J)
ISN 0165      HB = HOR(JP)
ISN 0166      DAA = SQRT((X-HA)**2 + (Y-DAA)**2)
ISN 0167      DAB = SQRT((X-HB)**2 + (Y-DAB)**2)
ISN 0168      DBA = SQRT((X-HA)**2 + (Y-DBA)**2)
ISN 0169      DBB = SQRT((X-HB)**2 + (Y-DBB)**2)
ISN 0170      DAAI = 1./DAA
ISN 0171      DABI = 1./DAB
ISN 0172      DBAI = 1./DBA
ISN 0173      DBBI = 1./DBB
ISN 0174      DTI = DAAI + DABI + DBAI + DBBI
ISN 0175      TMP = (TAA*DAAI + TAB*DABI + TBA*DBAI + TBB*DBBI)/DTI
ISN 0176      STMP = 0.01*TMP
ISN 0177      DTEMP(I,K) = DTEMP(I,K) + STMP
C 2900 WRITE(6,2900) X,Y,TMP
ISN 0178      2900 FORMAT(1H,5X,'X= ',F10.4,'Y= ',F10.4,'TEMP= ',F10.4)
ISN 0179      Y = Y + DELY
ISN 0180      70 CONTINUE
ISN 0181      X = X + DELX
ISN 0182      80 CONTINUE
ISN 0183      IFIN = 99
ISN 0184      JFIN = 39
ISN 0185      GO TO 92
ISN 0186      91 CONTINUE
ISN 0187      DO 95 I=1,NSITES
ISN 0188      NP = NPT(I)
ISN 0189      HORA(I) = HOR(I)
ISN 0190      DO 95 K=1,NP

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ISN 0191      IY = 10.*DEPT(I,K)
ISN 0192      DTEMP(I,K) = IY
ISN 0193      TMP = TEMP(I,K)
ISN 0194      STMP = 0.01*TMP
ISN 0195      DTEMP(I,K) = DTEMP(I,K) + STMP
ISN 0196      95 CONTINUE
ISN 0197      IFIN = NSITES
ISN 0198      92 CONTINUE

C
C.....LOCATE DEPTHS OF DESIRED ISOTHERMS
C
C
C.....ITERATE OVER DESIRED ISOTHERMS, K=1, NTERM
C
ISN 0199      DO 800 K=1,NTERM
ISN 0200      DO 100 I=1,20
ISN 0201      Istor(I) = 0
ISN 0202      IDP1(I) = 0
ISN 0203      IDP2(I) = 0
ISN 0204      IDP3(I) = 0
ISN 0205      100 CONTINUE
ISN 0206      DO 600 I=1,IFIN
ISN 0207      DP1 = -1.0
ISN 0208      DP2 = -1.0
ISN 0209      DP3 = -1.0
ISN 0210      NP = NPT(I)
ISN 0211      NPM = NP - 1
ISN 0212      IF(NEWGRD .EQ. 1) 30 TO 110
ISN 0214      JFIN = NPM
ISN 0215      110 CONTINUE
ISN 0216      DO 250 J=1,JFIN
ISN 0217      DPA = DTEMP(I,J)
ISN 0218      IDPA = DPA
ISN 0219      TDPA = IDPA
ISN 0220      DPB = DTEMP(I,J+1)
ISN 0221      ABSD = ABS(DPB)
ISN 0222      IF(ABSD .GT. 1.0E10 .OR. ABSD .LT. 1.0E-10) 30 TO 255
ISN 0224      TMA = 100.*(DPA-TDPA)
ISN 0225      IDPB = DPB
ISN 0226      TDPB = IDPB
ISN 0227      TMB = 100.*(DPB-TDPB)
ISN 0228      TED1 = TMA - THERM(K)
ISN 0229      TED2 = TMB - THERM(K)
ISN 0230      IF(TED2 .GT. 1.0E10) GO TO 255
ISN 0232      RT = TED2/TED1
ISN 0233      IF(RT .GT. 0.0) GO TO 210
ISN 0235      IF(TMB .EQ. TMA) GO TO 210
ISN 0237      HR1 = HORA(I)
ISN 0238      DPA = 0.1*DPA
ISN 0239      DPB = 0.1*DPB
ISN 0240      DP1 = DPA + ((THERM(K) - TMA)*(DPB-DPA)/(TMB-TMA))
ISN 0241      THR = THERM(K)
ISN 0242      IF(THR .GT. 13.) GO TO 209
ISN 0244      WRITE(6,2901) I,HR1, DPA, DPB, TMA, TMB, DP1
ISN 0245      2901 FORMAT(1H ,5X,I5,6(E15.8,1X))
ISN 0246      209 CONTINUE
ISN 0247      GO TO 255
ISN 0248      210 CONTINUE

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ISN 0249      250 CONTINUE
ISN 0250      255 CONTINUE
ISN 0251      IF(J .GE. JFIN) GO TO 500
ISN 0253      JP1 = J + 1
ISN 0254      DO 350 J=JP1,JFIN
ISN 0255      DPA = DTEMP(I,J)
ISN 0256      IDPA = DPA
ISN 0257      TDPA = IDPA
ISN 0258      TMA = 100.*(DPA-TDPA)
ISN 0259      DPB = DTEMP(I,J+1)
ISN 0260      ABSD = ABS(DPB)
ISN 0261      IF(ABSD .GT. 1.0E10 .OR. ABSD .LT. 1.0E-10) GO TO 355
ISN 0263      IDPB = DPB
ISN 0264      TDPB = IDPB
ISN 0265      TMB = 100.*(DPB-TDPB)
ISN 0266      TED1 = TMA - THERM(K)
ISN 0267      TED2 = TMB - THERM(K)
ISN 0268      ATED1 = ABS(TED1)
ISN 0269      ATED2 = ABS(TED2)
ISN 0270      IF(ATED1 .GT. 1.0E10 .OR. ATED2 .GT. 1.0E10) GO TO 355
ISN 0272      IF(ATED1 .LT. 1.0E-10 .OR. ATED2 .LT. 1.0E-10) GO TO 355
ISN 0274      RT = TED2/TED1
ISN 0275      IF(RT .GT. 0.0) GO TO 310
ISN 0277      IF(TMB .EQ. TMA) GO TO 310
ISN 0279      DPA = 0.1*DPA
ISN 0280      DPB = 0.1*DPB
ISN 0281      HR2 = HORA(I)
ISN 0282      DP2 = DPA + ((THERM(K) - TMA)*(DPB-DPA)/(TMB-TMA))
ISN 0283      GO TO 355
ISN 0284      310 CONTINUE
ISN 0285      350 CONTINUE
ISN 0286      355 CONTINUE
ISN 0287      IF(J .GE. JFIN) GO TO 500
ISN 0289      JP1 = J + 1
ISN 0290      DO 450 J=JP1,JFIN
ISN 0291      DPA = DTEMP(I,J)
ISN 0292      IDPA = DPA
ISN 0293      TDPA = IDPA
ISN 0294      TMA = 100.*(DPA-TDPA)
ISN 0295      DPB = DTEMP(I,J+1)
ISN 0296      ABSD = ABS(DPB)
ISN 0297      IF(ABSD .GT. 1.0E10 .OR. ABSD .LT. 1.0E-10) GO TO 455
ISN 0299      IDPB = DPB
ISN 0300      TDPB = IDPB
ISN 0301      TMB = 100.*(DPB-TDPB)
ISN 0302      TED1 = TMA - THERM(K)
ISN 0303      TED2 = TMB - THERM(K)
ISN 0304      ATED1 = ABS(TED1)
ISN 0305      ATED2 = ABS(TED2)
ISN 0306      IF(ATED1 .GT. 1.0E10 .OR. ATED2 .GT. 1.0E10) GO TO 455
ISN 0308      IF(ATED1 .LT. 1.0E-10 .OR. ATED2 .LT. 1.0E-10) GO TO 455
ISN 0310      RT = TED2/TED1
ISN 0311      IF(RT .GT. 0.0) GO TO 410
ISN 0313      IF(TMB .EQ. TMA) GO TO 410
ISN 0315      HR3 = HORA(I)
ISN 0316      DPA = 0.1*DPA
ISN 0317      DPB = 0.1*DPB
ISN 0318      DP3 = DPA + ((THERM(K) - TMA)*(DPB-DPA)/(TMB-TMA))

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ISN 0319      GO TO 455
ISN 0320      410 CONTINUE
ISN 0321      450 CONTINUE
ISN 0322      455 CONTINUE
ISN 0323      500 CONTINUE

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C
C.....SORT ISOTHERM POINTS INTO PROPER ARRAYS FOR LATER PLOTTING
C

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ISN 0324      IF(DP1 .LE. 0.0) GO TO 525
ISN 0326      DO 520 J=1,20
ISN 0327      IF(IDP1(J) .EQ. 1) GO TO 520
ISN 0329      IS = ISTORE(J)
ISN 0330      IF(IS .GT. 0) GO TO 510
ISN 0332      ISTORE(J) = 1
ISN 0333      IS = 1
ISN 0334      ARRAYX(J,IS) = HR1
ISN 0335      ARRAYY(J,IS) = DP1
ISN 0336      GO TO 525
ISN 0337      510 CONTINUE
ISN 0338      ISTORE(J) = ISTORE(J) + 1
ISN 0339      IS = ISTORE(J)
ISN 0340      DPP1 = ARRAYY(J,IS-1)
ISN 0341      DF1 = ABS(DPP1 - DP1)
ISN 0342      IF(DP2 .LE. 0.0) GO TO 511
ISN 0344      DF2 = ABS(DPP1-DP2)
ISN 0345      IF(DF2 .LT. DF1) GO TO 515
ISN 0347      511 CONTINUE
ISN 0348      IF(DP3 .LE. 0.0) GO TO 512
ISN 0350      DF3 = ABS(DPP1-DP3)
ISN 0351      IF(DF3 .LT. DF1) GO TO 515
ISN 0353      512 CONTINUE
ISN 0354      IF(DP1 .GT. DCRIT) GO TO 515
ISN 0356      ARRAYX(J,IS) = HR1
ISN 0357      ARRAYY(J,IS) = DP1
ISN 0358      GO TO 525
ISN 0359      515 CONTINUE
ISN 0360      IDP1(J) = 1
ISN 0361      ISTORE(J) = ISTORE(J) - 1
ISN 0362      520 CONTINUE
ISN 0363      525 CONTINUE
ISN 0364      IF(DP2 .LE. 0.0) GO TO 550
ISN 0366      DO 545 J=1,20
ISN 0367      IF(IDP2(J) .EQ. 1) GO TO 545
ISN 0369      IS = ISTORE(J)
ISN 0370      IF(IS .GT. 0) GO TO 535
ISN 0372      ISTORE(J) = 1
ISN 0373      IS = 1
ISN 0374      ARRAYX(J,IS) = HR2
ISN 0375      ARRAYY(J,IS) = DP2
ISN 0376      GO TO 550
ISN 0377      535 CONTINUE
ISN 0378      ISTORE(J) = ISTORE(J) + 1
ISN 0379      IS = ISTORE(J)
ISN 0380      DPP2 = ARRAYY(J,IS-1)
ISN 0381      DF2 = ABS(DPP2 - DP2)
ISN 0382      IF(DP3 .LT. 0.0) GO TO 536
ISN 0384      DF3 = ABS(DPP2-DP3)
ISN 0385      IF(DF3 .LT. DF2) GO TO 540

```

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ISN 0387      536 CONTINUE
ISN 0388      IF (DP2 .GT. DCRIT) GO TO 540
ISN 0390      ARRAYX(J,IS) = HR2
ISN 0391      ARRAYY(J,IS) = DP2
ISN 0392      GO TO 550
ISN 0393      540 CONTINUE
ISN 0394      Istor(J) = Istor(J) - 1
ISN 0395      IDP2(J) = 1
ISN 0396      545 CONTINUE
ISN 0397      550 CONTINUE
ISN 0398      IF (DP3 .LE. 0.0) GO TO 575
ISN 0400      DO 570 J=1,20
ISN 0401      IF (IDP3(J) .EQ. 1) GO TO 570
ISN 0403      IS = Istor(J)
ISN 0404      IF (IS .GT. 0) GO TO 560
ISN 0406      Istor(J) = 1
ISN 0407      IS = 1
ISN 0408      ARRAYX(J,IS) = HR3
ISN 0409      ARRAYY(J,IS) = DP3
ISN 0410      GO TO 575
ISN 0411      560 CONTINUE
ISN 0412      Istor(J) = Istor(J) + 1
ISN 0413      IS = Istor(J)
ISN 0414      DPP3 = ARRAYY(J,IS-1)
ISN 0415      DP3 = ABS(DPP3 - DP3)
ISN 0416      IF (DP3 .GT. DCRIT) GO TO 565
ISN 0418      ARRAYX(J,IS) = HR3
ISN 0419      ARRAYY(J,IS) = DP3
ISN 0420      GO TO 575
ISN 0421      565 CONTINUE
ISN 0422      IDP3(J) = 1
ISN 0423      Istor(J) = Istor(J) - 1
ISN 0424      570 CONTINUE
ISN 0425      575 CONTINUE
ISN 0426      600 CONTINUE

C
C.....PLOT OUT ISOTHERMS
C
ISN 0427      WRITE(6,2019)
ISN 0428      2019 FORMAT(1H1)
ISN 0429      DO 700 I=1,20
ISN 0430      NREGP = Istor(I)
ISN 0431      IF (NREGP .EQ. 0) GO TO 680
ISN 0433      DO 650 J=1,NREGP
ISN 0434      XX(J) = ARRAYX(I,J)
ISN 0435      YY(J) = ELEV - ARRAYY(I,J)
ISN 0436      WRITE(6,2020) I,J,XX(J),YY(J),THERM(K)
ISN 0437      2020 FORMAT(1H,5X,'I= ',I3,5X,'J= ',I3,5X,'XX = ',E15.8,5X,'YY = ',
1E15.8,5X,'THERM = ',F10.4)
ISN 0438      650 CONTINUE
ISN 0439      CALL CURVE(XX,YY,NREGP,0)
ISN 0440      680 CONTINUE
ISN 0441      700 CONTINUE
ISN 0442      800 CONTINUE
ISN 0443      801 CONTINUE
ISN 0444      DO 820 I=1,NSITES
ISN 0445      NP = NPT(I)
ISN 0446      DO 820 J=1,NP

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ISN 0447      DL = (HOR(I) - HORL) * (7.375 / (HORU - HORL))
ISN 0448      DD = (4.5 / (VERU - VERL)) * (ELEV - VERL - DEPT(I,J))
ISN 0449      DT = ATEMP(I,J)
ISN 0450      CALL HEIGHT(0.06)
ISN 0451      CALL MESSAG(DT, 5, DL, DD)
ISN 0452      820 CONTINUE
ISN 0453      821 CONTINUE
ISN 0454      CALL ENDPL(1)
ISN 0455      GO TO 4
ISN 0456      CALL DONEPL
ISN 0457      STOP
ISN 0458      END

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ISN 0002      SUBROUTINE PLOTT
ISN 0003      COMMON/FINBLK/NFIN,NREGP
ISN 0004      COMMON/MESSBK/LMESS(5)
ISN 0005      COMMON/RESBLK/ALNG(50),ELEVA(50)
ISN 0006      COMMON/PLTLEG/LCAP(10),LHOR(10),LVER(10)
ISN 0007      COMMON/PLTBND/VERL,VERU,HORL,HORU
ISN 0008      DIMENSION XX(500),YY(500)
ISN 0009      CALL BGNPL(-1)
ISN 0010      CALL PAGE(14.,11.)
ISN 0011      CALL TITLE(LCAP,40,LHOR,40,LVER,40,7.375,4.5)
ISN 0012      CALL MESSAG(LMESS,20,2.5,4.4)
ISN 0013      CALL GRAF(HORL,'SCALE',HORU,VERL,'SCALE',VERU)
ISN 0014      DO 50 J=1,NREGP
ISN 0015      XX(J) = ALNG(J)
ISN 0016      YY(J) = ELEVA(J)
ISN 0017      50 CONTINUE
ISN 0018      CALL CURVE(XX,YY,NREGP,0)
ISN 0019      RETURN
ISN 0020      END

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