

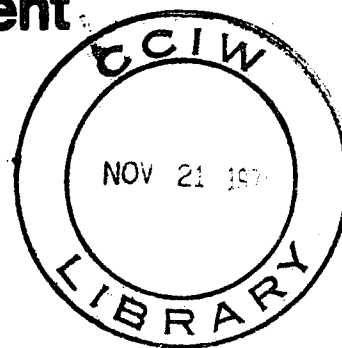


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SURVEY 8

A BUDGET CALCULATION PROGRAM

FOR LAKE ERIE

Hanson, Rosa, Burns

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SURVEY 8

A BUDGET CALCULATION PROGRAM

FOR LAKE ERIE

Hanson, Rosa, Burns

Hanson - Applied Research Division, Data Management Section

Rosa, Burns - Process Research Division, Nutrient Dynamics Section

PROGRAM NAME:

SURVEY 8

CCIW PROJECT:

INACTIVE

MACHINE:

CDC3170

SOURCE LANGUAGE:

ANSI FORTRAN 2.3

COMPILATION MODE:

SINGLE LENGTH INTEGER (24 bits)

PROGRAMMERS:

B. HANSON, F. ROSA

USERS:

N.M. BURNS, F. ROSA

DATE:

MARCH 1978

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1. SURVEY 8

A characteristic of the different water masses in Lake Erie is that, even while horizontal variability exists, they are usually vertically well mixed and almost isothermal. For this reason Survey 8 is designed to compute the mean concentrations of variables for each thermal layer at each sampling station. These depth-weighted epilimnion, mesolimnion and hypolimnion average temperatures and concentrations for each station then become the basic data units used in the computation scheme.

The program develops horizontal distribution maps for each variable and thermal layer and calculates the volume of the thermal layers in each basin. The quantity of heat or a substance in each of these water masses is obtained and the resultant quantity for the whole lake is estimated by summing the amounts in each of the water masses.

A particularly strong point of Survey 8 is its capacity to perform the above calculations on survey data collected according to any station plan designed for the lake. The program is refined and few if any distortions result from the computation scheme. This being the case, it must be remembered that the accuracy of any results calculated rests on the sampling grid used for the survey.

2. PURPOSE

Given a sub-file of parameter/value pairs, (such as those retrieved from the Monitor Cruise data files) program SURVEY 8 computes lake-wide volume-weighted means and associated quantities, and plots line-printer distribution maps of stratified layers for Lake Erie, and for any user defined basins thereof. Several subjective methods have been incorporated into this program, according to the research being done by particular scientists at the Canada Centre for Inland Waters, as described in Method.

3. METHOD

3.1 Initialization

Subroutine PREINIT performs the job initialization of various arrays and conditions described in 4.2.

3.2 User Specifications

Subroutine SPECS is used to read all Program Control Cards, described in detail in section 7.2, allowing the user to control the values of certain key program parameters.

3.3 Grid Depth File

Fundamental to SURVEY8 is the rectangular Grid Depth file of Lake Erie consisting of 57 rows (S-N) and 209 columns (W-E) providing the average depths of each cell in metres, where each cell is 2 km square. (see 7.3 and 10.3 below).

3.4 Datum Correction

From the YEAR and MONTH information supplied on User Program Control Cards, a table look-up is performed in order to apply the appropriate datum correction to the above Grid Depth file, prior to the interpolation of lake-wide layer depths.

3.5 Layer Depth Cards

The Station Layer Depth Control Cards, described in section 7.2.15, provide the depths in metres of the Epilimnion and Hypolimnion, together with the sounding depth for each station, which are read by subroutine SPECS. Lake-wide layer depths and thicknesses are computed by this program from these important user determined values, obtained from depth temperature profiles.

3.6 Station Layer Depths and Concentrations

Subroutine EROSFIL is used to read the sub-file of Monitor Cruise Data retrieved by EROS, the record format of this file is described in section 7.4. Subroutine SEED converts the station latitude and longitude into coordinates (II, JJ) which are compatible with the co-ordinate system used by the Grid Depth file. The User Specified Value NVAR (see 7.2.8) is used to extract all depth/value pairs at a station corresponding to that parameter required. Using these depth/value pairs in conjunction with the Station Layer Depth information allows the layer concentration values to be calculated by subroutines LAYER and SUM, where the following rules are applied in the order given below:

3.6.1 Rule 1

A station Layer Depth card must exist for each set of station depth/value pairs retrieved from the cruise data file.

3.6.2 Rule 2

No attempt is made to calculate the layer concentrations at a particular station unless a set of two or more depth/value pairs exist.

3.6.3 Rule 3

If the cell depth of the station, as obtained from the Grid Depth file, is less than sounding depth obtained from the EROS retrieval, then the station may be automatically "moved", so to speak, to one

of the possible eight surrounding cells which has the best relationship between cell grid depth and cruise sounding depth, by subroutine TILE. There are four possible flags related to this procedure, see 4.7.

3.6.4 Rule 4

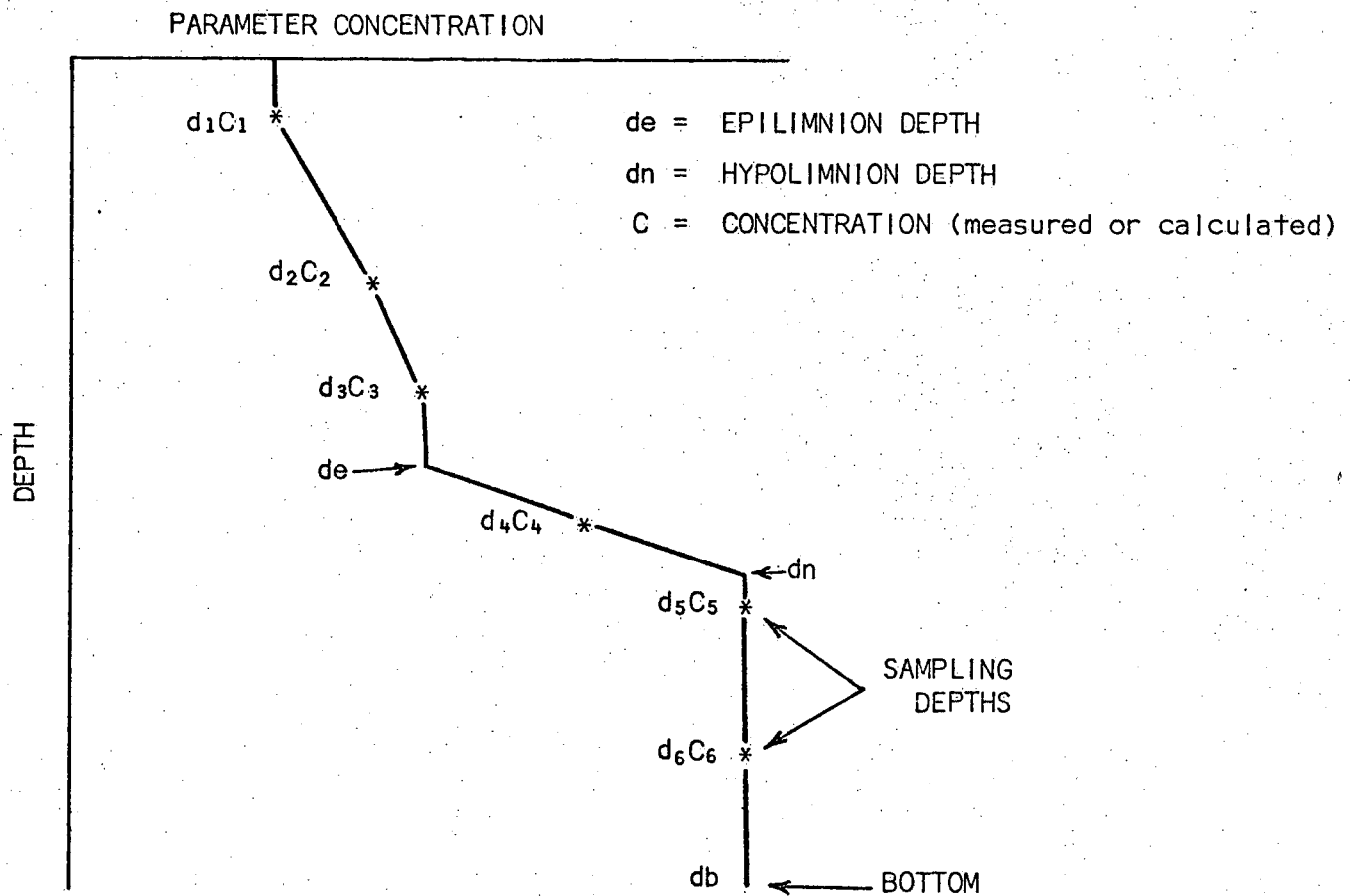
Layer concentrations are then computed according to the scheme shown in 3.7. If there is no sample within the mesolimnion but samples exist that allow both Epi and Hypo concentrations to be calculated then the Meso concentration is taken to be the mean of the deepest Epi concentration and shallowest Hypo concentration.

3.6.5 Rule 5

Where a station cell is non-stratified, the user specified epilimnion depth is replaced by the grid depth of the station cell.

Where a station cell does not contain a hypolimnion, the user specified hypolimnion depth (if any) is replaced by the grid depth of the station cell.

3.7 Schematic representation of the method for the calculation of depth-weighted averages.



$$C_{\text{EPI LIMNION}} = \frac{1}{d_e} [d_1 C_1 + (d_2 - d_1) \times \frac{1}{2} (C_1 + C_2) + (d_3 - d_2) \times \frac{1}{2} (C_2 + C_3) + (d_e - d_3) C_3]$$

$$C_{\text{MESOLIMNION}} = \frac{1}{2} (C_3 + C_5) \quad * \quad \text{If no } C_4 \text{ observed}$$

$$C_{\text{MESOLIMNION}} = \frac{1}{(d_n - d_e)} (d_4 - d_e) \times \frac{1}{2} (C_3 + C_4) + (d_n - d_4) \times \frac{1}{2} (C_4 + C_5)$$

$$C_{\text{HYPOLIMNION}} = \frac{1}{(d_b - d_n)} [(d_5 - d_n) C_5 + (d_6 - d_5) \times \frac{1}{2} (C_5 + C_6) + (d_b - d_6) C_6]$$

3.8 Subroutine SORT begins by printing-out all the basic values at each station, including the station layer concentration calculations computed by subroutines LAYER and SUM described in section 3.6 and 3.7.

Then the routine sorts the stations, and associated values which may be used in the interpolation of lake-wide layer concentrations, into ascending order of abscissa and then ordinate values, (II, JJ). Where more than one station occupies a cell, the station layer depths and computed concentrations are averaged. For details regarding the station value tables printed-out, see 8.2.6.

3.9 Subroutine CALCOL is used to determine those cells to be considered at the "edge" of the lake on the north and south ends of each "column" in terms of the number of 2 km "wet" cells at these shorelines as given on the User Specification card, KEDGE (see 7.2.3). For each of the 209 columns written in the Grid Depth file these "edges" are found in terms of row numbers and stored in arrays MINJ (209) and MAXJ (209). In addition the array KOEF (209) is formed, see 4.9 for details.

These values are printed-out for reference, see section 8, and Partial Job Example,

3.10 Interpolation

Interpolation of lake-wide layer concentrations of a given parameter, and of layer depths is performed by subroutine INTER, for each lake basin defined by the user on BASIN program control cards, see 7.2.14.

The routine interpolates the concentration (or layer depth) C_i for each cell within a given basin as follows:

$$C_i = \frac{C_1/X_1^2 + C_2/X_2^2 + C_3/X_3^2}{\frac{1}{X_1^2} + \frac{1}{X_2^2} + \frac{1}{X_3^2}}$$

Where X_1 , X_2 and X_3 are the distances to the nearest three sampling stations within the given basin and C_1 , C_2 and C_3 are the concentrations (or layer depths) at these stations, using the following rules:

3.10.1 Rule 1

For interpolating layer concentrations the nearest sampling station is used unconditionally.

3.10.2 Rule 2

If the cell i in question is determined to be a "shoreline" cell (see 3.9) then a Depth Rule is applied, to the 2nd and 3rd nearest stations: If the cell depth differs from the station cell depth by more than a given amount (see BASIN control card 7.2.14) and the difference is greater than $KOEF_i$ (see 4.9) then that station is not used. For example if both the second and third nearest stations failed the Depth Rule test then $C_i = C_1$ (Subject to rules 3 to 6 for layer depths).

Interpolated concentrations which are more than a given distance from the nearest station (see DISLIM Spec Card 7.2.13) are not printed on the distribution maps (i.e. are represented as blanks)

but such values are included in the Total Quantities print-out (see 8.2.10).

3.10.3 Rule 3

Where an epilimnion depth C_i for a particular cell would be interpolated from stations C_1 , C_2 and C_3 which are all non-stratified, then C_i is instead made equal to the cell grid depth.

3.10.4 Rule 4

Where interpolating a hypolimnion depth C_i for a particular cell, only the stations among C_1 , C_2 and C_3 which have a hypolimnion are used on the calculation of C_i . In the case that none of the latter stations have a hypolimnion, then C_i is again made equal to the cell grid depth (see 3.10.7).

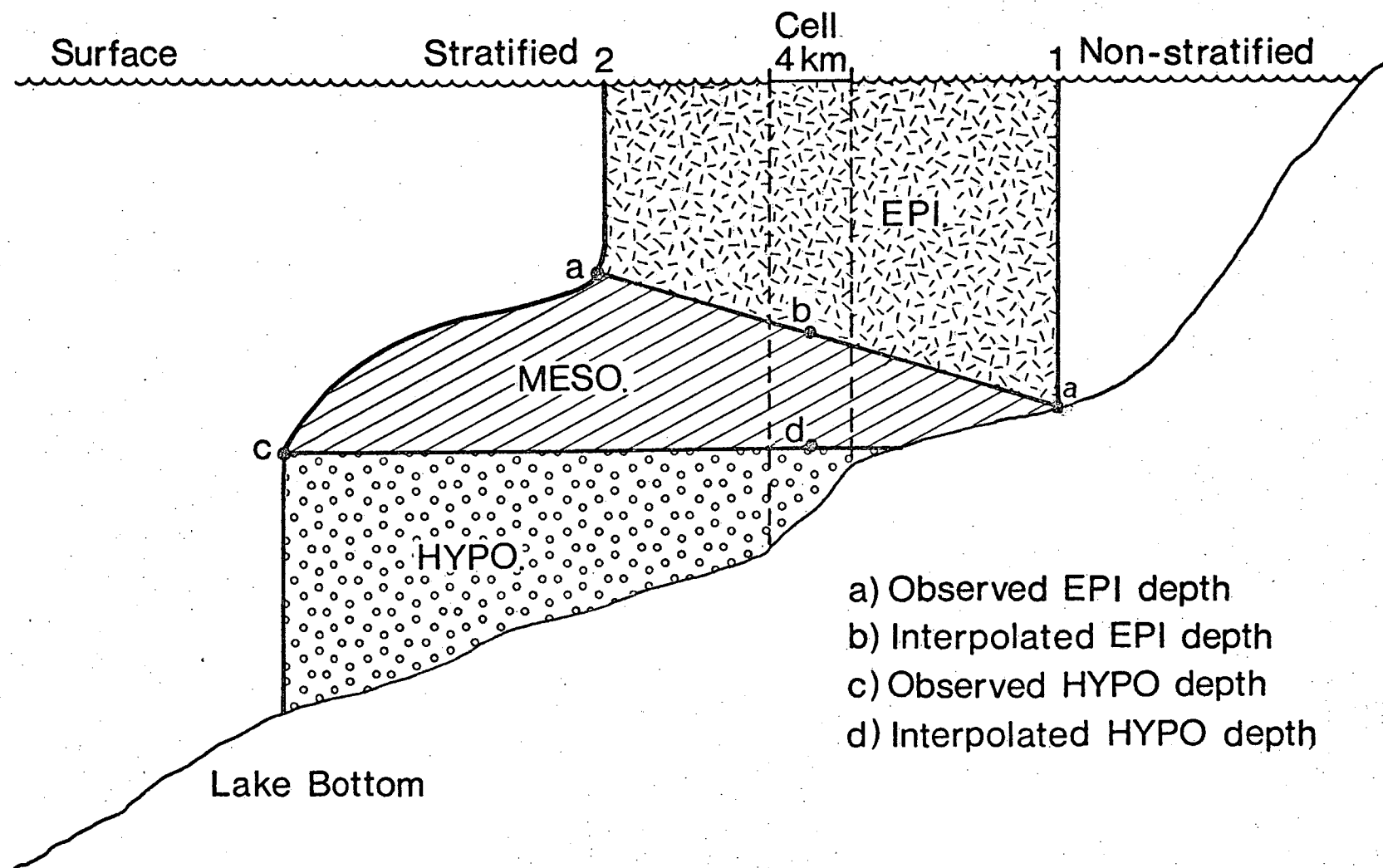
3.10.5 Rule 5

In the case that an interpolated epilimnion or hypolimnion depth C_i for a particular cell produces a value which is greater than the cell grid depth, then C_i is made equal to the cell grid depth.

3.10.6 Rule 6

Subject to the application of the above rules in the order given, basin-wide layer depths and thicknesses are computed as follows:

- a) Epi depth (thickness)
- b) Hypo depth
- c) Meso thickness = (Hypo depth) - (Epi depth)
- d) Hypo thickness = (Grid depth) - (Hypo depth)



E.B.T. Profile for Stations 1 and 2

SCHEMATIC REPRESENTATION FOR LAYER DEPTHS
INTERPOLATION OF NON-STATION CELLS.

3.11

Subroutine CONCP0 is used to print-out all concentration and grid thickness maps under appropriate headings together with various total quantities for the lake basin. See 4.12 and Partial Job example. Every second value is printed on the maps so as to reduce the output by a factor of 4. For each concentration map, first rows 1 to 27 are printed, then rows 28 to 54, then rows 55 to 57.

4. DESCRIPTION OF PROGRAM

The following is a description of the SURVEY8 program and its subroutines. Flow charts for the program and its major subroutines are produced in section 5.

- 4.1 SURVEY8 is the main-line program which initializes conditions (PREINIT) reads and prints the user control cards (SPECS); then optionally transfers the lake-wide grid depth punched-card file to disc (GRIDISC) and again optionally prints the grid on the line-printer (GRIDPO) before applying a lake-wide datum depth correction based on the year and month of the cruise required. Subroutine EROSFIL computes the layer concentrations of a particular variable by means of the sub-file of Monitor Cruise data retrieved by EROS (see 7.5) in conjunction with the station layer depth information as supplied on program control cards (see SPECS). Stations are sorted into ascending order of abscissa and ordinate values (SORT) as this type of organization greatly reduces computer time in the determination of which stations may be considered close enough to a particular cell for interpolation purposes.

Cells considered to be at the "edge" of the lake at the north and south ends of each column, are determined by subroutine CALCOL in terms of the number of "wet" cells as given by the program control card KEDGE e.g. 5 cells. Computed at this time also are coefficients to be used in the Depth Difference rule applied to shoreline cells in the interpolation procedures.

Then for every lake basin specified by the user, the basin-wide Epi, Meso and Hypo layer cell thicknesses and concentrations are interpolated together with the summation of the required running totals (INTER). Layer concentration and thickness maps are printed on the line-printer (CONCPO) where the interpolation of layer thicknesses, storage on disc and line-printer output is optional.

4.2 Subroutine PREINIT initializes necessary conditions by zeroing the lake-wide Epi, Meso and Hypo concentration arrays; sets each element of the array KSTN(200) equal to one as the first step in the count of the number of stations occupying a particular cell.

4.3 Subroutine SPECS is used to read all program control cards as described in detail in section 7.2. All cards contain a name in columns 73 to 80. Except where specified, (see 7.2) numerical values occupy columns 1 to 8, where values which do not contain a decimal point should be right justified. In general, any comments may occupy columns 9 to 72. The program control cards themselves may be presented in any order providing that they are terminated by the ENDSPEC card. See flow chart 5.2

4.4 Subroutine GRIDISC may be used at the option of the user (see 7.1.3.1) to transfer the Lake Erie grid depth punched-card file (see 7.3) to a mass storage permanent disc file. Every card contains an identification number, and a sequence error would cause a fatal error message to be printed before termination.

4.5 Subroutine GRIDPO, at the option of the user, may be used to give a line-printer map of the lake Erie grid-depth map. Under the heading of "Grid Depth Creation" followed by three (3) contiguous partitions, each beginning on a new page. To make this manageable, rows 1 to 27 are printed then rows 28 to 54 and finally rows 55 to 57; where columns are printed horizontally, and rows vertically, to avoid wastage of paper.

4.6 Subroutine EROSFIL scans through the sub-file of monitor cruise data retrieved by EROS in search of all depth/value pairs of any one of the parameters required by the user. Layer concentrations for all stations are then calculated (See subroutines LAYER and SUM) from these depth/value pairs in conjunction with the information supplied on the layer depth STATION program control cards (see fig. 3.7). The EROS sub-file is printed if sense-switch is set (7.1.3.4).

At this time also, subroutine SEED is used to convert the station latitudes and longitudes into coordinates which correspond to the axes of the Lake Erie Depth Grid.

4.7 Subroutine TILE is called by subroutine LAYER when it is found that the grid cell depth of a station is less than the sounding depth retrieved from the cruise data (EROSFIL); in which case the station may be effectively "moved" to one of the eight (8) adjoining cells which has a more appropriate depth. A corresponding flag is given within the print-out of Consecutive Station Values, as follows:

FLAG = 0 Station not used.

FLAG = 1 (Normal) indicates that the station cell depth is equal to or greater than the station sounding depth.

FLAG = 2 Indicates that the station has been moved to an adjoining cell which is greater than, but closest to the station sounding depth.

FLAG = 3 Indicates that the station has been moved to an adjoining cell which, although shallower than the station sounding depth, is the closest to that depth (see 6.0, RATIO).

4.8 Subroutine SORT. Stations and the key values associated with them, are then sorted into ascending order of abscissa and ordinate values. This type of organization greatly reduces computer time in the determination of which stations may be considered close enough to a particular cell for interpolation purposes.

Where stations are found to occupy the same cell the mean average is obtained for the following station values: Epi Depth, Hypo Depth, Sounding Depth, Epi concentration, Meso concentration and Hypo concentration.

4.9 Subroutine CALCOL. For interpolation purposes, cells considered to be "shoreline" cells are determined for each of the 209 columns (of which the Lake Erie grid is composed) in terms of the string of "wet" cells at the top and bottom of the column; as

specified on the KEDGE program control card. For example, if KEDGE equals 5 (cells) this would give a 5* GRIDSIZE, or typically 10Km strip of shoreline cells around the lake.

Computed also, for each column, is a coefficient to be used in the Depth Difference Rule applied to such shoreline cells during the interpolation procedures:

$$KOEI = COEF * (KDMAX_i - KDMIN_i) + 0.5$$

Where COEF is specified on the program control card of that name typically 0.3

Where KDMAX is the deepest cell depth in column_i

Where KDMIN is the shallowest non-zero depth in column_i

Where 0.5 is used for rounding in real to integer conversion.

If sense-switch 8 is set the following are printed on the line-printer under the heading of: "COL MINJ MAXJ", being the column number; KOEF_i and row numbers of the deepest shoreline cells at the top, and bottom of the column, respectively.

Where MINJ is greater than or equal to MAXJ, or MINJ differs from MAXJ by 1, it should be interpreted as meaning that all cells within the column are considered to be shoreline cells.

4.10

Subroutine INTER - for every lake basin specified by the user, the basin-wide Epi, Meso and Hypo layer cell thicknesses and concentrations are interpolated according to the procedure and rules described in 3.10.

Subroutine CONCP0 is used to print-out both layer thicknesses and concentration maps under appropriate headings. In addition, immediately above concentration maps fundamental total quantities and means calculated by subroutine TOTAL are printed.

- 4.11 Subroutine TOTAL - At the top of each layer concentration map, values are printed under the following headings:
"Number of Cells . Volume (M^{**3}) . Total Quantity (Concs $*M^{**3}$) .
Mean Depth . Area Mean Concentration . Volume Mean Concentration".

This subroutine is called upon to print two sets of such values for each concentration map. The first is for station cells only (as computed by subroutine STNCONC), and the second for all cells; that are contained within the given layer and basin.

- 4.12 Subroutine CONCP0 is used to print-out both thickness and concentration maps for all layers and basins that are required. Every second value, for every second row, from row 3 to row 55 inclusive is printed, thus reducing the line-printer output by a factor of four. Note that each line output on the line-printer represents one column.

All thickness maps are printed as integer values in tenths of metres, and where 0 (zero) depth represents land. Station values, where printed, are preceded by '-' (dash).

Subroutine CHAR is used to convert all concentrations from integer values multiplied by FACTOR (see 7.2.10) to BCD. Station

concentrations, where printed, are preceded by an '*' (asterisk).

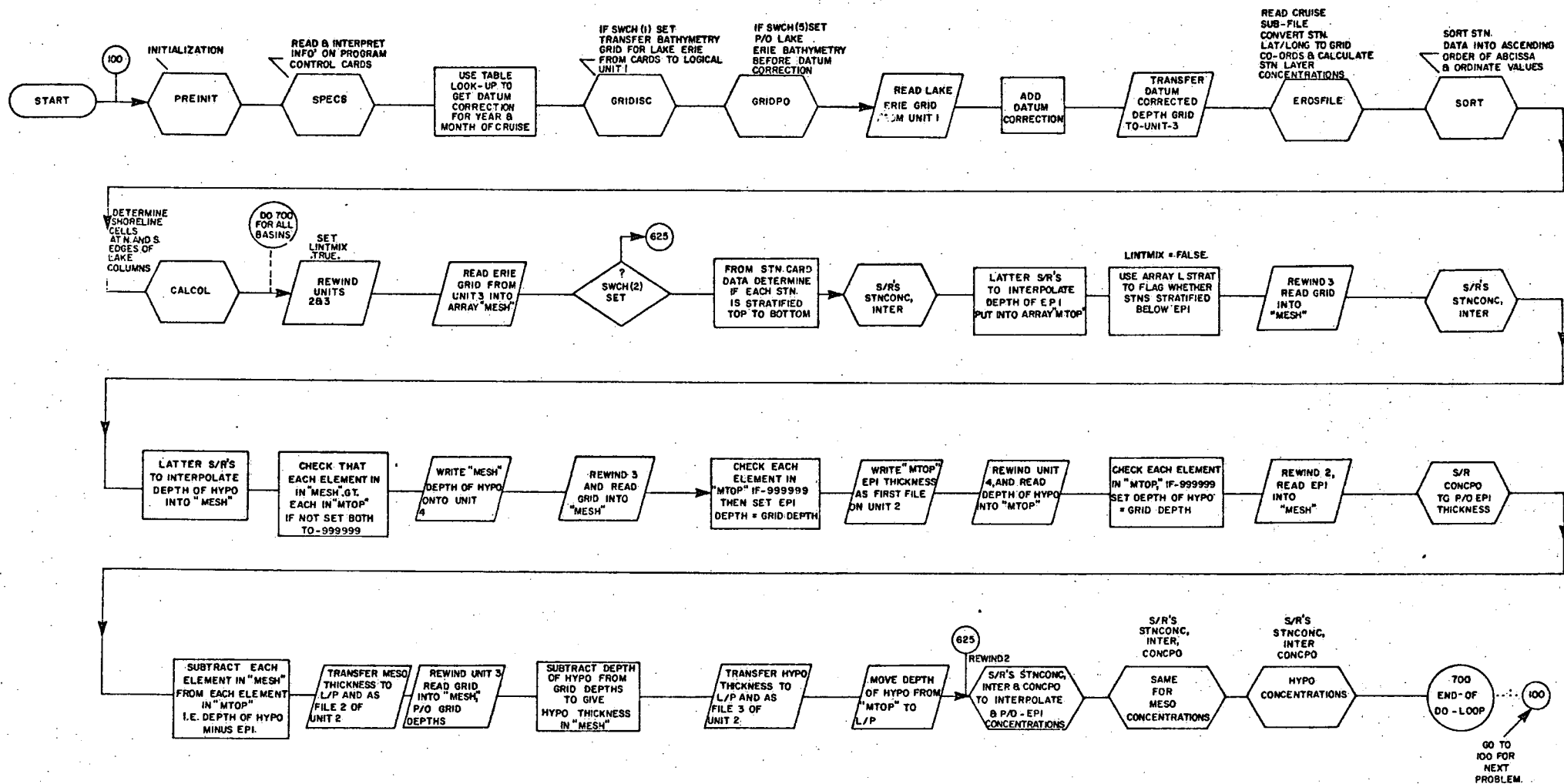
Note, thickness maps are printed as blocks extending from the minimum to maximum column numbers given by the user in the basin definition (see 7.2.14). Whereas for the concentration maps, all areas outside of the basin definition appear as blanks. No-observation at a particular station is shown as '***' and where a value of 0(zero) appears on the concentration map, it indicates that the cell in question has a distance from the nearest valid station which is greater than DISLIM (typically 15 Km) although an interpolated value will be made for such a cell for the purpose of calculating the various total quantities described in subroutine TOTAL.

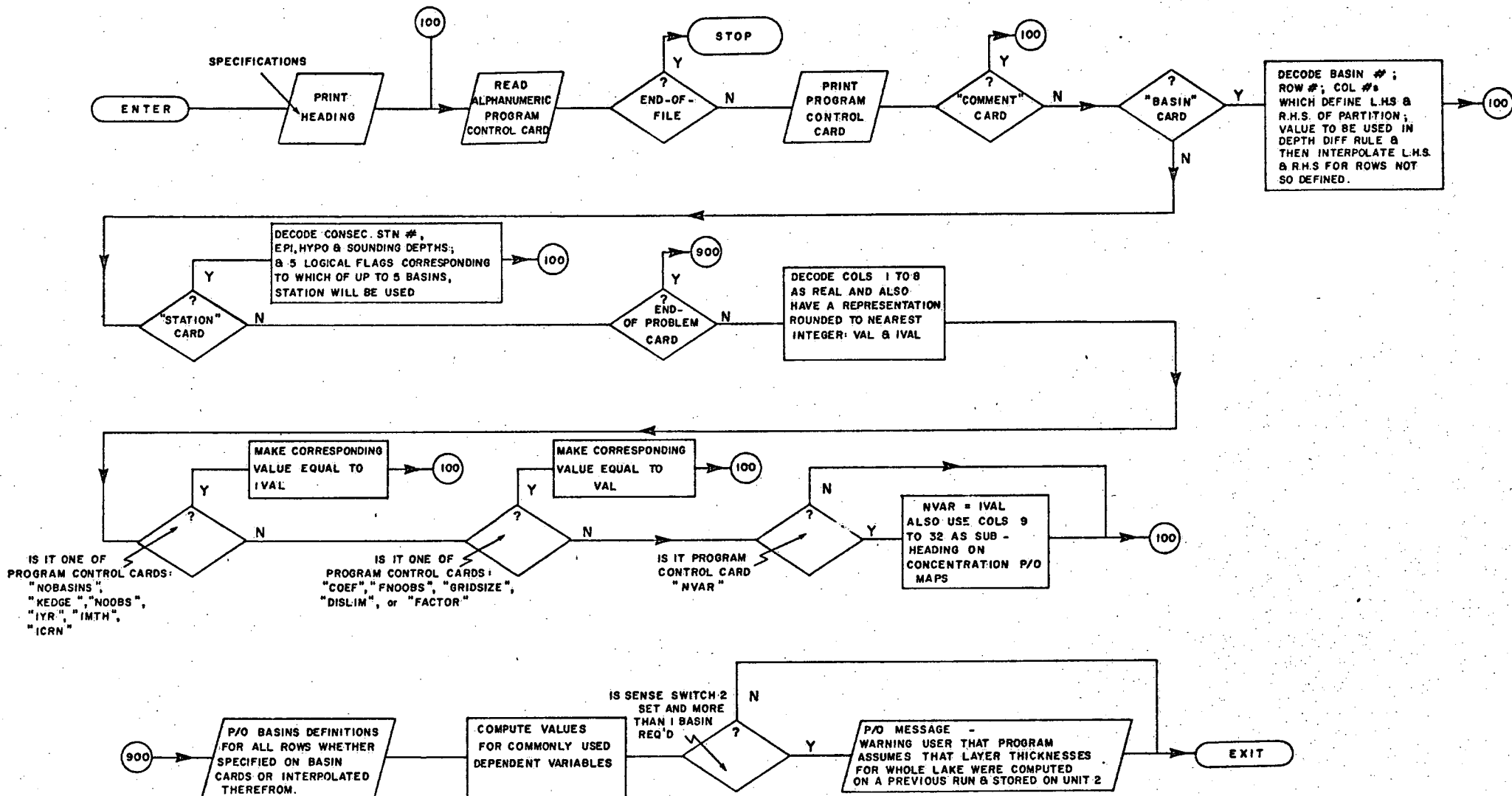
4.13 Subroutine MESS is used throughout for printing subtitles.

4.14 Subroutine EXIT is used to print a self-explanatory fatal error message, and the name of the subroutine in which it occurred, before termination.

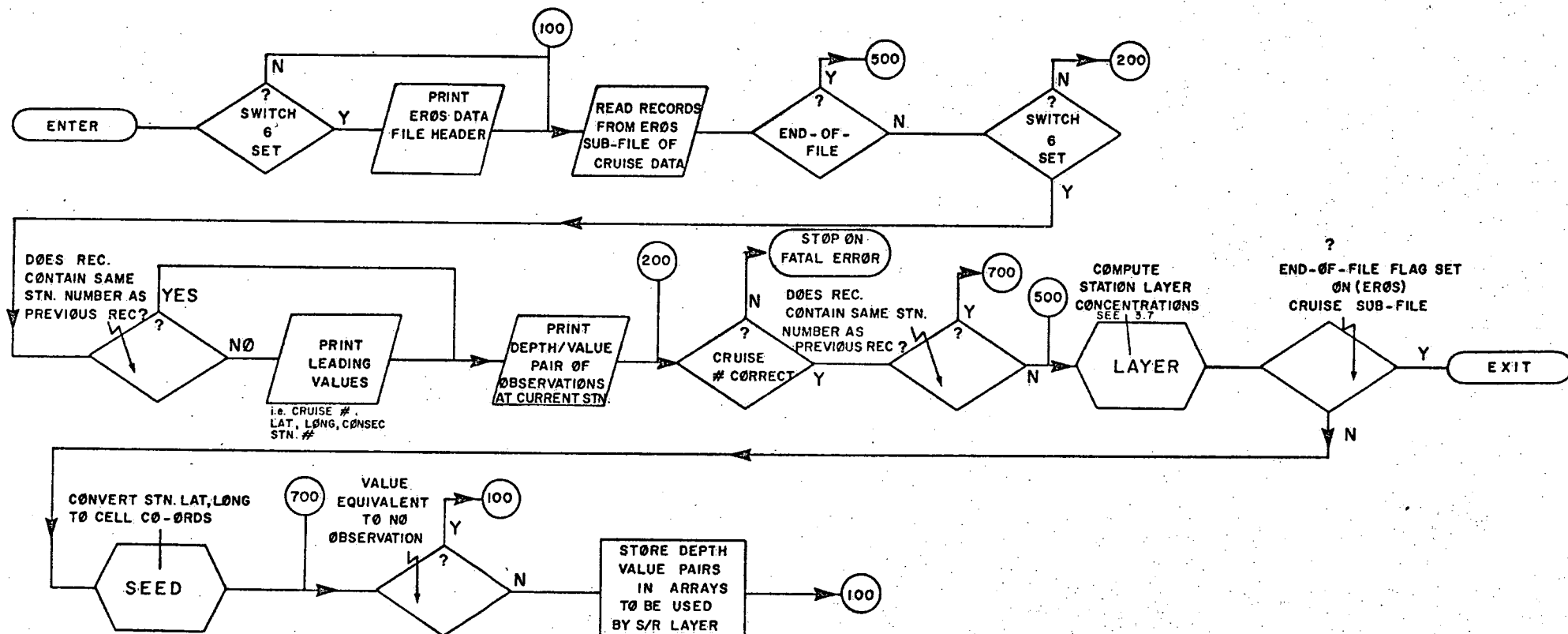
5. FLOW CHARTS

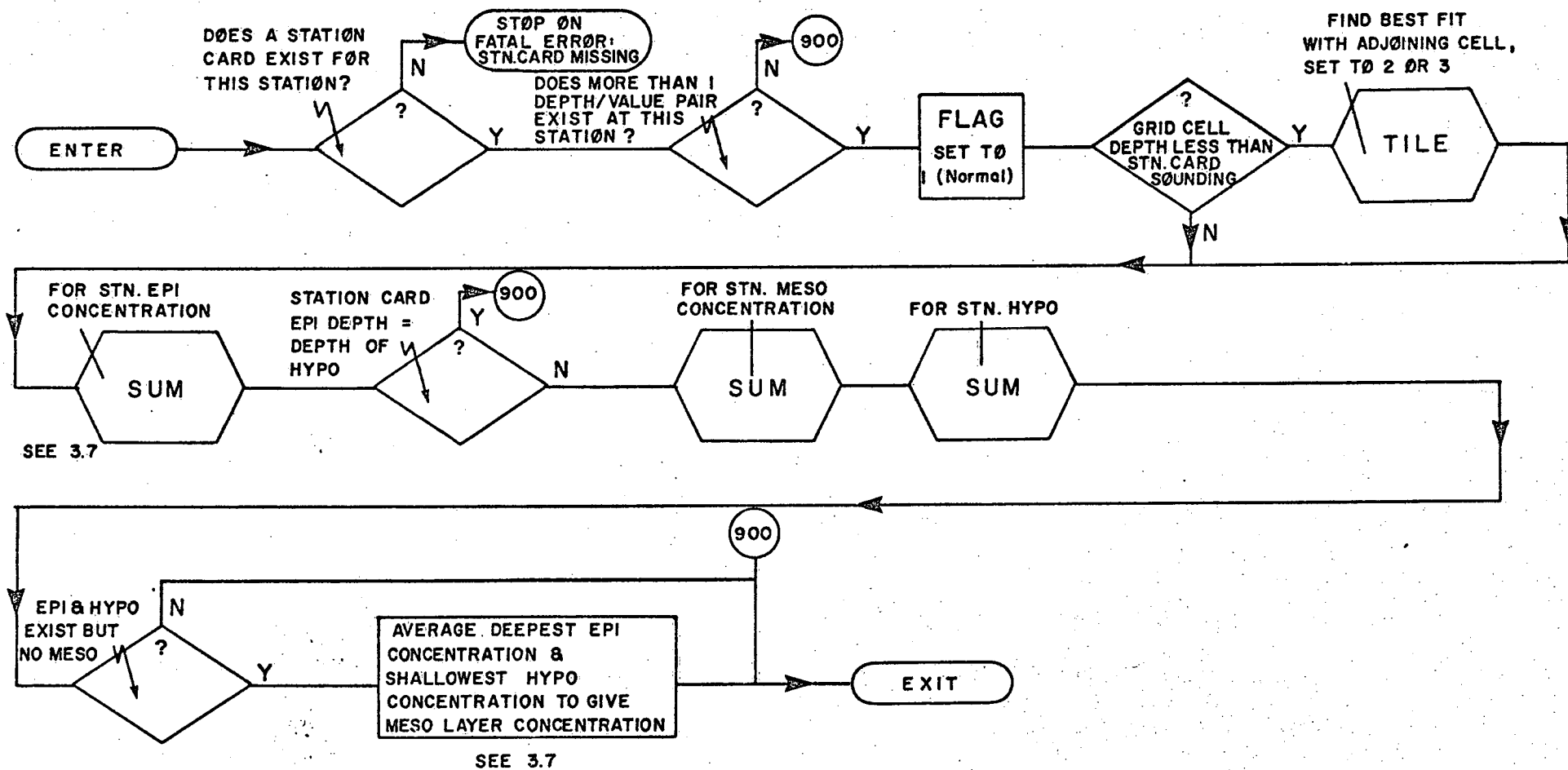
Flow charts for the major routines of SURVEY8 are given as follows:





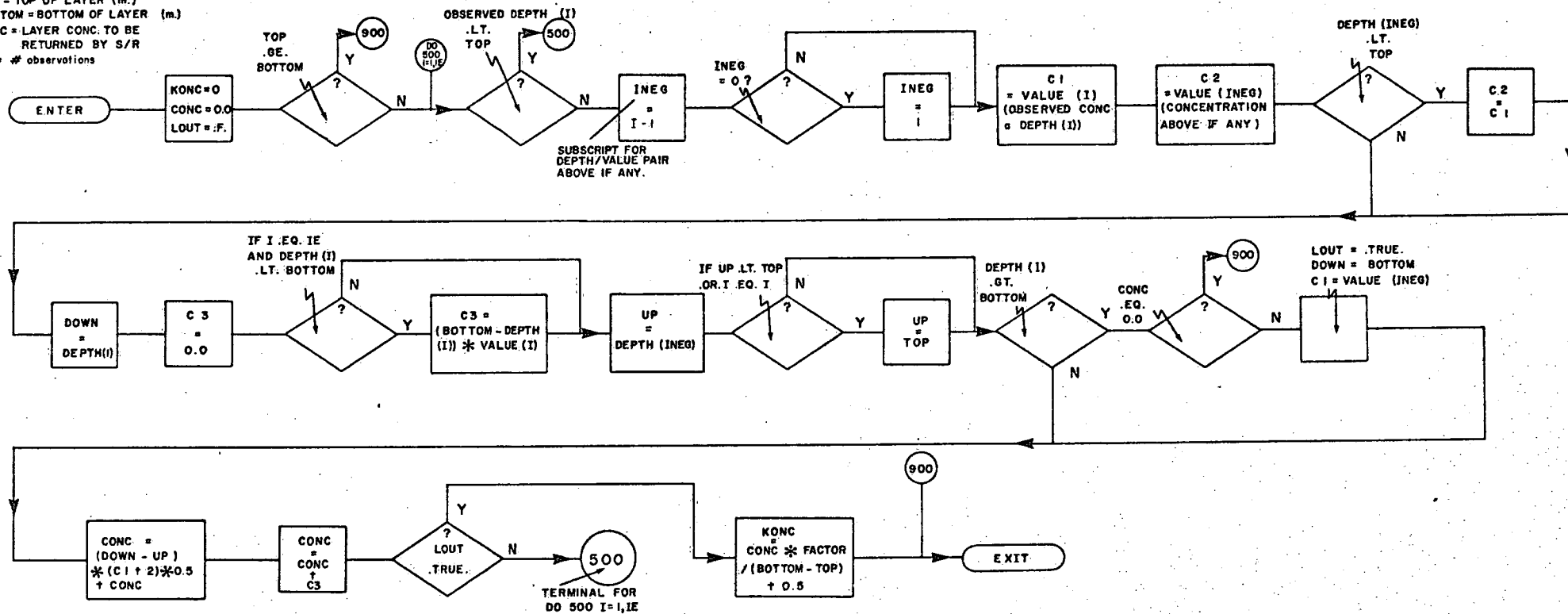
5.2 SPECS



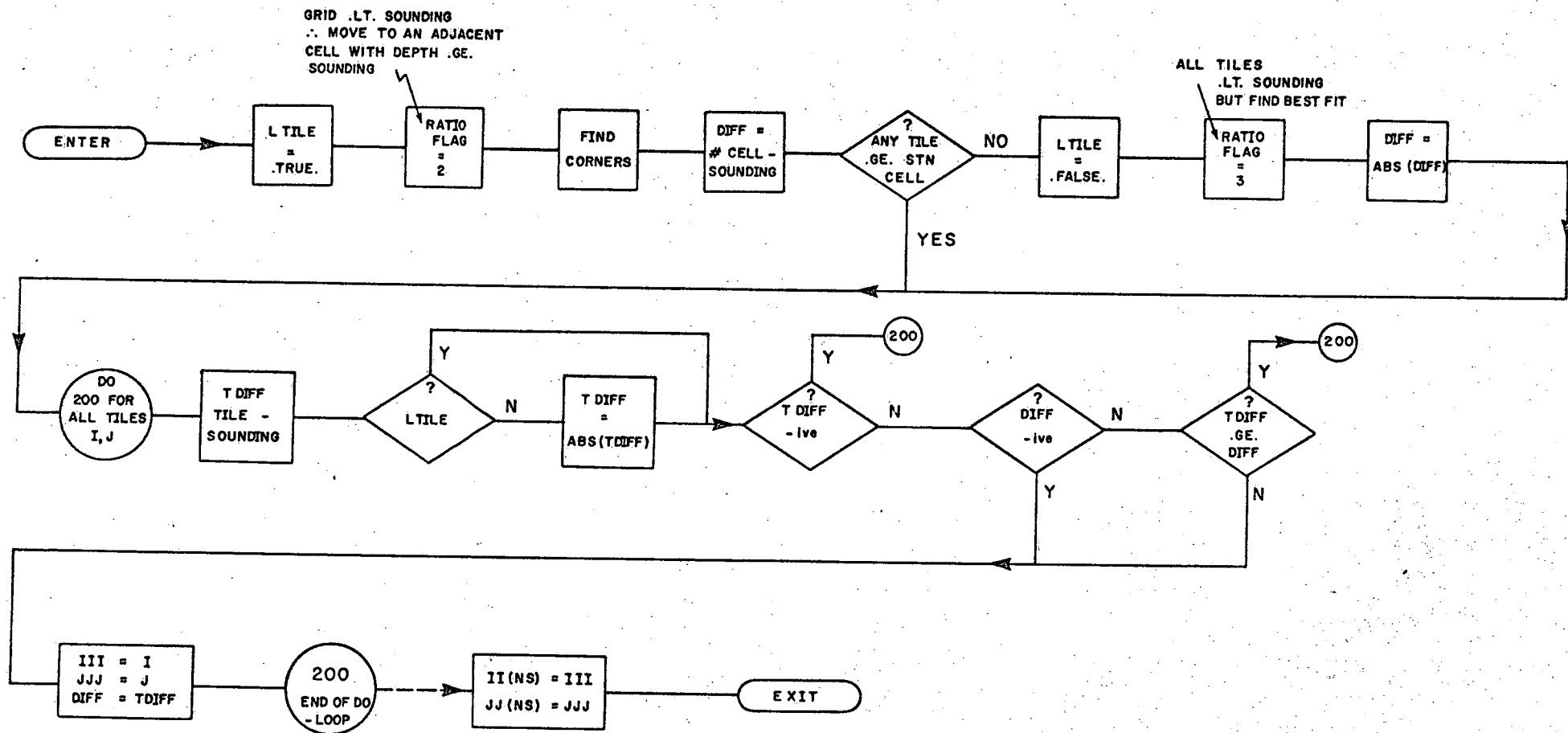


5.4 LAYER

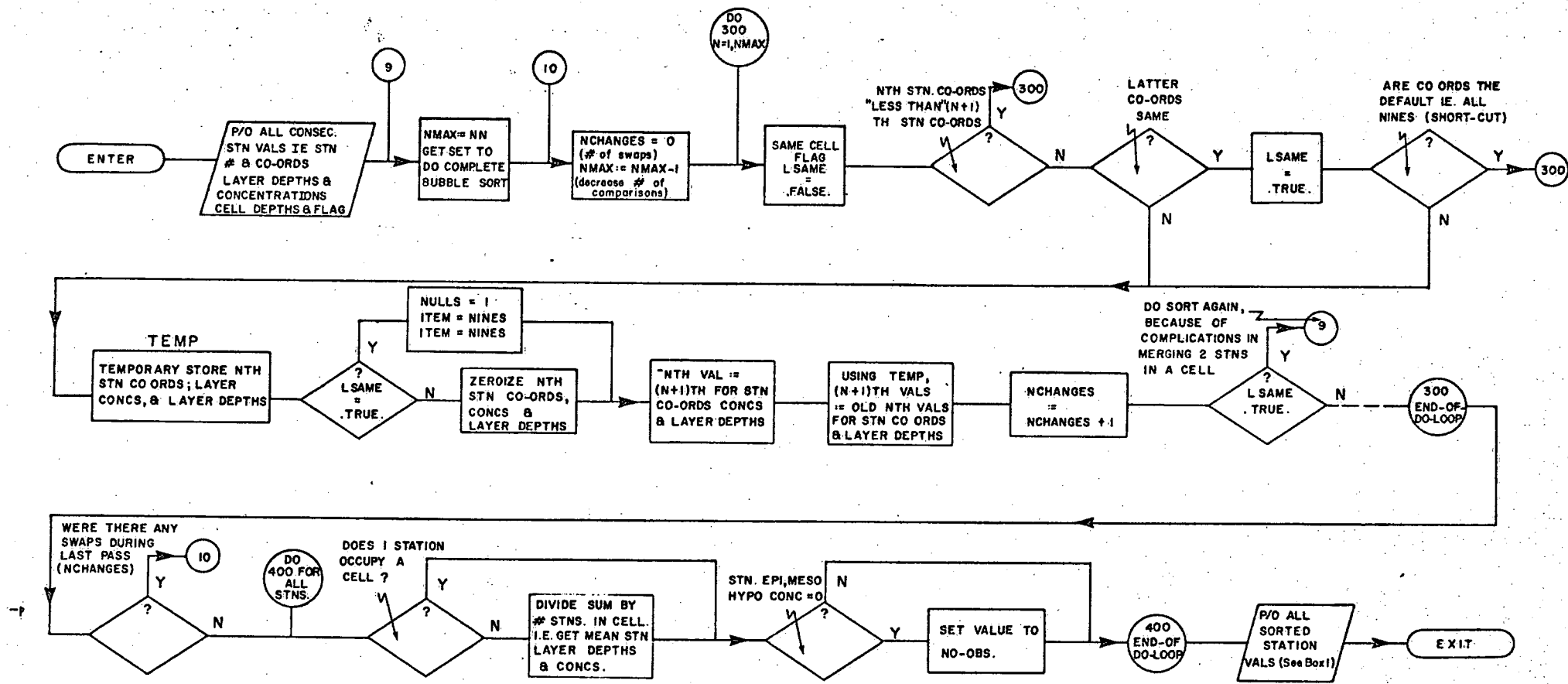
TOP = TOP OF LAYER (m.)
 BOTTOM = BOTTOM OF LAYER (m.)
 KONC = LAYER CONC. TO BE
 RETURNED BY S/R
 IE = # observations



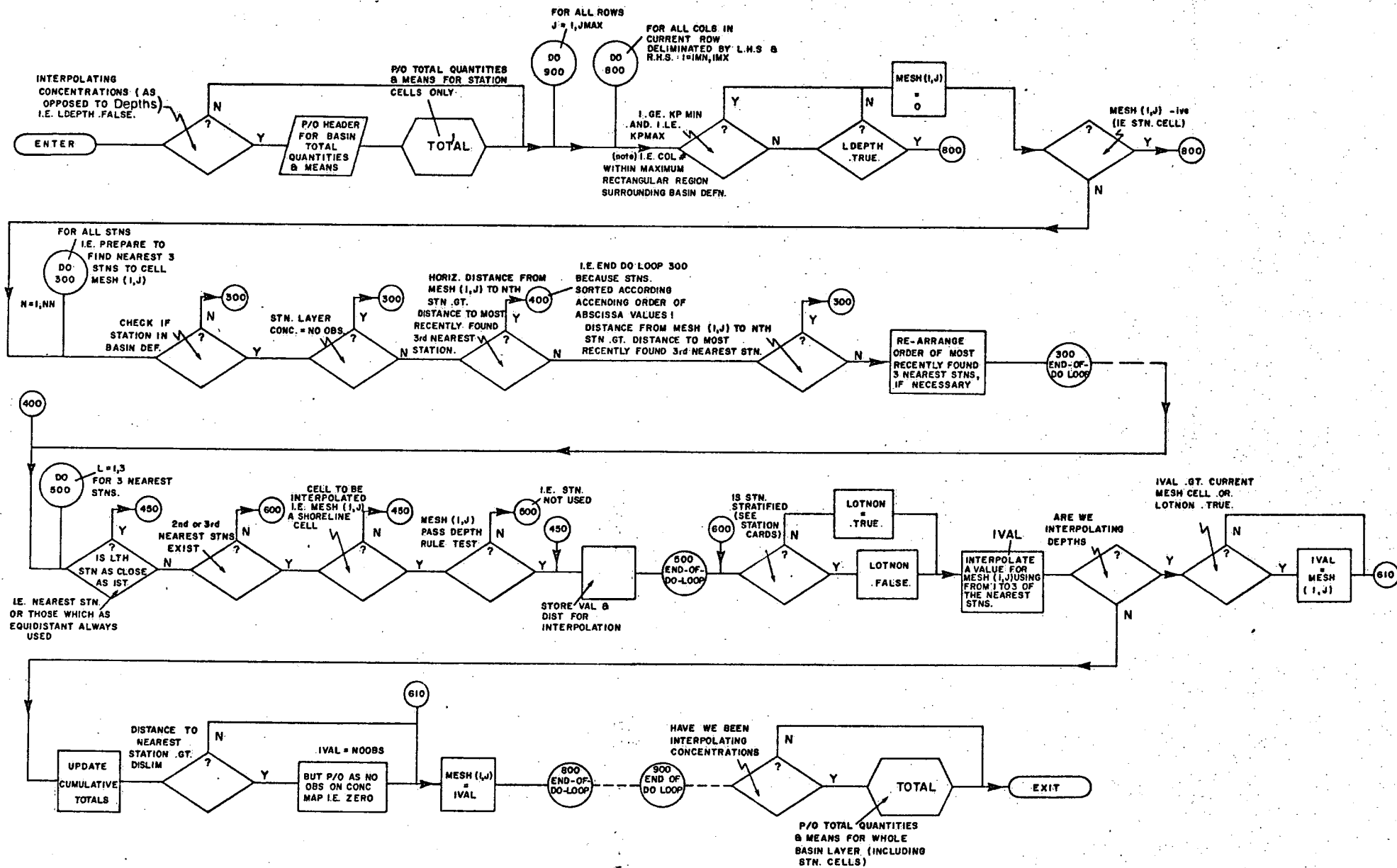
5.5 SUM



5.6 TILE



5.7 SORT



5.8 INTER

6. DESCRIPTION OF VARIABLES

The following is a description of the most important variables used within SURVEY8 and its subroutines. The integer or real mode of the variables is implicit, according to standard Fortran conventions, unless otherwise stated.

- COEF User specified values e.g. 0.3, being a coefficient used in Depth Difference rule, see 4.9 and 7.2.9.
- DEPI(200) Array containing the epi depths of each station as supplied by the user on Station program control cards, see 7.2.15.
- DEPTH(20) Array containing the depths of all observations of a particular parameter (see NVAR) at a particular station as obtained from an EROS retrieval of Monitor Cruise data. See subroutine EROSFIL 4.6.
- DHYPO(200) Array containing the sounding depth at each station as supplied by the user, see 7.2.15.
- DISLIM User specified value being the maximum distance (Km) from the nearest station within which an interpolated value must fall for print-out on the concentration maps, e.g. 15 Km. See 7.2.13
- DMESO(200) Array containing the depths to the bottom of the mesolimnion of each station as supplied by the user, see 7.2.15.
- FACTOR User specified scaling factor e.g. 10, used to multiply all interpolated concentrations to be printed out as

integers on the concentration maps, see 7.2.10.

FLAG See RATIO(200) below

FNOOBS User specified value for "no observation" e.g. -99.9 being the default value given in the EROS retrieval program, see 7.2.11.

GRIDSIZE Mesh size of grid depth file of Lake Erie in kilometres, although a user specified value, must be fixed at 2.0 kilometres for this version of SURVEY, see 7.2.12.

ICRN User specified value giving cruise number of data on EROS file, see 7.2.7.

IDATUM The particular datum correction based on year and month taken from array METER, see below.

IDEPI(200) Array containing the user specified station epidepths (see DEPI) multiplied by a factor of 10, rounded and stored as integers.

IDHYPO(200) Array containing the user specified station sounding depths (see DHYPO) multiplied by a factor of 10 rounded and stored as integers.

IDMESO(200) Array containing the user specified station "mesolimnion" (bottom of) depths (see DMESO) multiplied by a factor of 10 rounded and stored as integers.

II See JJ

III See JJJ

IMAX Number of columns in Lake Erie grid (209), column numbers proceed from left to right.

IMTH User specified value giving month of cruise,
used to extract datum correction, see 7.2.6.

IPDEPTH Contains Depth Rule for 1 of 5 basins as extracted
from BASIN control card, see 7.2.14.

IVALSROW Number of values on each punched card containing
Lake Erie grid depths = 19, see 7.3.1.

IYR User specified year of cruise, see 7.2.5.

JJ(200) Array contains station ordinate values (correspond-
ing to abscissa values in II) being the coordinates
of the stations.

JJJ Ordinate value corresponding to abscissa value III
around which subroutine TILE does it search, see
4.7.

JMAX Number of "rows" in lake grid depth array (57).
Note rows are inverted-increasing from south to
north.

KARDSROW Number of punched cards (11) required to specify one
row of values of lake grid (19). Where one row con-
sists of $IVALSROW * KARDSROW = 19 * 11 = 209$, see
7.3.1.

KEDGE User specified value giving number of cells defining
north "edge" and south "edge" of lake, e.g. 5, which
would represent a distance of $5 * 2 = 10$ Km. Strip
of "shoreline" cells around the lake, see 4.9 and
7.2.3.

KEPI(200) Array containing the station EPI concentrations calculated by subroutine LAYER and multiplied by FACTOR (e.g. 100). See fig. 3.7.

KHYPO(200) Arrays containing the station HYPO concentrations as calculated by subroutine LAYER and multiplied by FACTOR, see fig. 3.7.

KPMAX Maximum column number of the current print-line in the layer thickness or concentration print-out. See subroutine CONCP0, 4.12.

KPMIN Minimum column number of the current print-line in the layer thickness or concentration print-out. See subroutine CONCP0, 4.12.

KSTN(200) Array used to count the number of stations occupying the same cell, if greater than 1, then the respective "epi", "meso", and "hypo" depths and concentrations are averaged. See subroutine SORT, 4.8.

LAT Real variable containing the latitude formed by LATD LATM, LATS and used to calculate the cell coordinate of a particular station by subroutine SEED.

LATD Real variable containing the degree portion of latitude of a particular station.

LATM Real variable containing minutes portion of the latitude of a particular station.

LATS Real variable containing seconds portion of a latitude of a particular station.

LIMIDISQ =DISLIM*DISLIM/(GRIDSIZE*GRIDSIZE) used to determine cells which are sufficiently close to a station as to warrant the interpolated value being printed on the distribution map, see 4.12.

LIMET(5) Contains five depths (M.) for up to 5 basins as extracted from BASIN Card, to be used in Depth Rule, see 7.2.14.

LONG Real variable containing the longitude formed by LONGD, LONGM and LONGS and used in conjunction with LAT to calculate the cell coordinates of a particular station by subroutine SEED.

LONGD Real variable containing degrees portion of longitude of a particular station.

LONGM Real variable containing the minutes portion of longitude of a particular station.

LONGS Real variable containing the seconds portion of longitude of a particular station.

LSTRAT(200) Logical array where each element states whether it is TRUE or FALSE that the corresponding station is stratified.

MESH(209,57) Integer array the contents of which are multiplied by factors with base ten (10). Array size corresponds to the size of Lake Erie depth grid. Used alternately to store and transfer to a line-printer and disc: grid depth, layer thicknesses and concentrations.

METER(96) Array of constants which are datum difference values (in metres multiplied by 10) for each month for years 1966 onwards. These differences assume a Chart Datum of 568.60 feet.

MTOP(209,57) Integer array used in conjunction with array MESH (209,57) to calculate layer thicknesses.

NN Number of stations to be used by the program, being the count of the number of Station program control cards read by subroutine SPECS, see 7.2.15. Where more than one station occupies a cell, then NN is reduced accordingly by subroutine SORT, see 4.8.

NOBASINS Number of lake basins to be used by the program as given by the user (in the range of 1 to 5) on card NOBASINS, see 7.2.2, with further details being supplied on specification card BASIN.

NOOBS Value used to represent "no-observation" within the integer array MESH(209,57) used by subroutine INTER for interpolation purposes. This value is supplied by the user on specification card NOOBS, see 7.2.4.

NSN(200) Array containing all station numbers (consecutive) as read from the Station cards, see 7.2.15.

NVAR A number on the range of 1 to 10 corresponding to which one of the ten variables retrieved by EROS and stored within the EROSFIL, that is to be used by the program for lake-wide interpolation, see 7.2.8.

RATIO(200) This array contains the values determined by subroutine TILE (4.7) which are printed under the heading of "Consecutive Station Values", see 8.2.6.

FLAG = 0 Station not used by program

FLAG = 1 Normal

FLAG = 2 Indicates that the station has been "moved" (by the program) to an adjoining cell which has a depth greater than, but closest to, the station sounding depth.

FLAG = 3 Indicates that the station has been "moved" to an adjoining cell which although shallower than the station sounding depth, is closest to that depth.

VALUE(20) Array containing the values to be paired with depths (see DEPTH(20)) of all observations of a particular parameter (see NVAR) at a particular station, as obtained from the EROS retrieval, see subroutine EROSFIL, 4.6.

7. USAGE

Usage involves the existence of the following information: - CDC Control cards, User Program Control cards, Lake Erie Grid Depth file, EROS Retrieval file (or equivalent monitor cruise sub-file).

7.1 CDC Control Cards

The following are the CDC Master Job Control cards required by the program SURVEY8.

7.1.1 Standard JOB Control cards: \$JOB, account number, job identification, 9,3000....

7.1.2 Standard SCHED Control card: \$SCHED, CLASS=C, CORE=96, SCR=9.

7.1.3 Optional Sense-Switch Control card: \$SWCH(SET, m,n). Where m,n, etc., indicate the various options described below.

7.1.3.1 \$SWCH(SET,1) is used to specify that the Lake Erie grid depth file is to be read from punched cards for transfer to disc; generally this option is not selected because this file is assumed to already exist on disc (see 7.1.4). When the sense-switch 1 option is used the following control cards must precede the one described on 7.1.4 below:

\$*DEF(R,,owner, GRIDERIE,00,,ALL)

\$*DEF(A,,owner,GRIDERIE,00,,1280,200,expiry date)

7.1.3.2 \$SWCH(SET,2) is used to specify that layer thicknesses (Epi, Meso, Hypo) across the lake considered as 1 basin corresponding to the cruise required, were calculated on a previous run and are stored on disc and therefore need not be recalculated,

thus saving valuable central processing time; else the thicknesses are calculated and transferred to disc, (see 7.1.5).

Note that this option must not be selected for the first run of a particular cruise. It is recommended that use is made of the edition number on control card 7.1.5 for different months of the year for which cruises are selected.

7.1.3.3 \$SWCH(SET,5) is used to specify that the Lake Erie grid depth file is to be printed out together with all other line-printer output; else this output is inhibited.

7.1.3.4 \$SWCH(SET,6) is used to specify that the file retrieved by EROS i.e. EROSFIL (see 7.5) is to be printed-out with all the other line printer output; else this file is not printed.

7.1.3.5 \$SWCH(SET,3) is used to specify that the print-out of grid layer thickness maps and concentration distribution maps are to be suppressed.

Note: the various total quantities and means for each basin will continue to be printed-out, see 4.11.

7.1.3.6 \$SWCH(SET,8) is used to specify that the table of values associated with the Depth Difference rule is to be printed, as part of the line printer output, see 4.9.

7.1.4 Standard *DEF control card required to open the disc file containing the Lake Erie Grid Depths:

*DEF(0,,1,owner,GRIDERIE,00,0).

- 7.1.5 Standard *DEF control card required to open the disc file that is to contain (or already contains, see 7.1.3.2) the layer thicknesses (Epi, Meso, Hypo) across the lake for the cruise and basin under consideration, as calculated by this program:

\$*DEF(0,,2,owner,GRIDTHCK,00,0)

- 7.1.6 Standard *DEF control card required to open the disc file that contains selected parameters for all stations of a particular cruise as created by the EROS retrieval program, (or equivalent program), see 4.11. \$*DEF(0,,7,owner,EROSFILE,edition,,1).

- 7.1.7 Standard Binary Deck Task Card: \$BIN,INP followed by the binary (object) deck of SURVEY8; which is immediately followed by User Program Control Cards (see 7.2); again immediately followed by the Lake Erie Grid Depth (see 7.3) punched card deck if and only if sense-switch 1 is set (see 7.1.3.1).

- 7.1.8 Finally, the entire user job deck is ended with the standard end-of-file card: ⁷⁷₈₈ EOF.

7.2 User Program Control Cards

The function of these cards is to allow the user to control various operations performed by the program SURVEY8. All specification cards have a left justified name (cols 73 to 80) to identify the type of control required.

In general, numerical values occupy cols 1 to 8, and those values which do not contain a decimal point should be right justified. Again, in general, any comments may occupy

cols 9 to 72. The specification cards themselves may be presented in any order as long as they are terminated by the END SPEC card (see 7.2.16) and are referred to in this section by their individual names.

- 7.2.1 Any number of cards named COMMENT, may be included within the specification, with the comments themselves occupying cols 1 to 72.
- 7.2.2 The card named NOBASINS, specified (within the range of 1 to 5) the number of basins into which the lake is to be divided for the purposes of this program, this card is used in conjunction with the BASIN card, see 7.2.14 below.
- 7.2.3 The card named KEDGE, is used to define the "edge" of the lake at the north and south in terms of the number of 2 Km "wet" cells at these shorelines, for example 5 (cells), see 4.9.
- 7.2.4 The card names NOOBS, is used to specify a value which is recognized as "no-observation" prior to interpolations performed by SURVEY8, and may be considered fixed at 999 for this version of the program.
- 7.2.5 The card names IYR, is used to specify the last two digits of the year of the cruise required.
- 7.2.6 The card named IMTH, is used to specify the two digit month of the cruise required.
- 7.2.7 The card named ICRN, is used to specify the cruise reference number that is required.
- 7.2.8 The card named NVAR, is used to specify a number in the range of 1 to 10 which identifies which one of the ten (10) parameters chosen to be retrieved by EROS, is to be used at this time. A

unique feature of this card is that the contents of cols 9 to 32 serve as a sub-heading for concentration maps to be printed, e.g. TEMPERATURE DEG. C.

- 7.2.9 The card named COEF, is used to specify the value of the coefficient to be used in the Depth Difference Rule, see 3.9 and 4.9.
- 7.2.10 The card named FACTOR, is used to specify a factor, generally with base 10, used to multiply all concentrations for print-out for the reason that this is done in integer mode.
- 7.2.11 The card named FNOOBS, is used to specify the value given to "no-observation" within the EROS retrieval file (see 7.5) typically -99.9.
- 7.2.12 The card named GRIDSIZE, is used to specify the mesh size in Kilometers of the lake grid depth file, typically 2 (Km).
- 7.2.13 The card named DISLIM, is used to specify the maximum distance from the nearest station value, within which an interpolated value must fall in order for the value to be printed on a concentration map, else it is printed as zero (although the computer value is retained for other purposes), typically the limiting distance may be 15 (Km).
- 7.2.14 The cards names BASIN (cols 73 to 77), have a unique format, which allows the user to define any basins in terms of the Lake Erie grid which is composed of 57 "rows" (S-N) and 209 columns (W-E); described as follows:

7.2.14.1 (Col 80) contains the lake basin number which must be in the range specified on the NOBASINS cards, see 7.2.2.

7.2.14.2 (Col 19 and 20) contains a row number (NROW) in the range of 1 to JMAX (57).

7.2.14.3 (Col 29 and 30) contains a column number (NLHS) in the range of 1 to IMAX (209) which defines the left-hand limit of the basin partition for the row (NROW) in question.

7.2.14.4 (Col 39 and 40) contains a column number (NRHS) in the range of 1 to IMAX (209) which defines the right-hand limit of the basin partition for the row (NROW) in question.

7.2.14.5 (Col 59 and 60) contains the depth value in metres (LIMET) to be used in the Depth Rule for the current basin (see 3.10.2).

7.2.14.6 For all BASIN punch-card columns not defined above, any comment may appear, e.g.:

"PARTITION FOR ROW 01=COL 01 TO 42 DEPTH RULE(M)=2 BASIN 1"

7.2.14.7 It should be noted that a minimum of 2 and a maximum of 57 BASIN cards are required for each basin. For example two BASIN cards define a straight line basin partition, three BASIN cards define a simple "dog-leg", and 57 BASIN cards would completely define a basin in terms of 2 Km cells. In general the latter should not be necessary, and for all rows for which basin cards are missing, a simple interpolation technique is used with rounding to the nearest integer in the calculation of L.H.S. and R.H.S. column numbers. These limits, for all basins, are printed in the form of a table for reference purposes,

following the listing of the user program control cards.

- 7.2.15 Corresponding to each station in the monitor cruise under consideration (and regardless of whether or not the station is to be used by SURVEY8), a card named STATION is required, which contains important layer depths, as determined by the user, from which the lake-wide Epi, Meso and Hypo thicknesses are derived.

The STATION card has the following format:

- 7.2.15.1 (Col 6 to 8) contains the integer, right-justified, Consecutive Station Number.
- 7.2.15.2 (Col 11 to 20) contains the Epilimnion depth in metres, with a decimal point included, as determined by the particular user.
- 7.2.15.3 (Col 21 to 30) contains the Hypolimnion depth in metres, with a decimal point included, as determined by the user.
- 7.2.15.4 (Col 31 to 40) contains the Sounding depth in metres, with a decimal point included.
- 7.2.15.5 (Col 1 to 5) is an optional field, where, if left blank, the station will be considered for use in the interpolation of all cells and all basins, subject to the interpolation procedure described in 3.10. If anything whatsoever is punched in cols 1 to 5, then each of the five columns corresponds to one of the possible five (5) basins defined by the user (see BASIN card above), in the following manner: only for those basins for which a T (true) is punched will the station be used. For example, if T is punched in cols 2 and 3 only, that station will be used for the interpolation of cells in basins 2 and 3 only, regardless of what is punched in cols 1, 4 and 5.

- 7.2.16 Finally, the User Specifications are terminated by means of the END SPEC card.

7.3 Lake Erie Grid Depth File

This file exists in a form of a punched card or disc file, as described below:

- 7.3.1 The six hundred and twenty seven (627) punched card file contains the depth (m) over on a rectangular 2 Km grid of Lake Erie. Each card contains nineteen (19) integer depths plus a consecutive card number. One row of the grid is represented on eleven (11) consecutive punched cards, for a total of fifty-seven (57) rows. Thus, the whole grid forms the integer array (MESH (209,57), where the "Cartesian" rather than Matrix convention is used by SURVEY8. The punched card deck is only used in conjunction with the optional CDC Control Card \$SWCH(SET,1). See 7.1.3.1.
- 7.3.2 Selection of the above option also causes the lake grid depth file to be written onto permanent disc as a binary file for all future use, see 7.1.4.

7.4 Eros Retrieval File

This is a sub-file of the Monitor Cruise Data DISC. retrieved by EROS. Each record of this file (see 7.1.6) consists of nineteen (19) floating-point numbers as follows:

- 7.4.1 Two digit year and cruise number combined, e.g., 73101.0 repre-

senting cruise 101 of year 1973.

- 7.4.2 Consecutive Station Number.
- 7.4.3 Station Latitude (Degrees).
- 7.4.4 Station Latitude (Minutes).
- 7.4.5 Station Latitude (Seconds).
- 7.4.6 Station Longitude(Degrees).
- 7.4.7 Station Longitude(Minutes).
- 7.4.8 Station Longitude(Seconds).
- 7.4.9 Depth of Observation (M).
- 7.4.10 Ten (10) floating-point values of those parameters chosen for retrieval by the user. "No-observation" must correspond to the dummy floating-point constant given on the Program Control Card FNOOBS (see 7.2.11).

8. OUTPUT

Output from this program is displayed on the line-printer, with some use of scratch disc and with the possibility of creating permanent disc files, as follows:

8.1 Output to Disc

8.1.1 Grid Depth Permanent Disc File -

This file is created only in conjunction with the sense-switch 1 option (see 7.1.3.1) together with the grid punched and card deck (see 7.3.1). It need only be recreated if the latter file is amended.

8.1.2 Lake-Wide Layer Thickness Disc File -

GRIDTHCK in fact consists of three files of "Epi", "Meso" and "Hypo" thicknesses, which must be computed by the program at least once for each cruise, thereafter being available on permanent disc file (see 7.1.5) for use in the interpolation of different parameters for the same cruise, and same basin.

8.2 Line-Printer Output

8.2.1 Subroutine BLURB is used to produce a CCIW Data Management header.

8.2.2 Under the sub-heading "SPECIFICATIONS" all the user Program Control cards are printed, immediately followed by the basin definition tables described in 7.2.14.7.

8.2.3 Next the lake datum correction is printed (metres * 10) being the amount by which the lake Grid Depth values are to be

modified according to the month and year of the cruise. The lake-wide Grid Depth file, with datum correction, is now printed at the option of the user, see 7.1.3.

8.2.4 Spare.

8.2.5 At the option of the user (see 7.1.3) the sub-file created by EROS (see 7.4) is printed under self-explanatory headers.

8.2.6 Under the general heading of "Consecutive Station Values", and under particular sub-headings, the following basic values to be used in the interpolation procedure are printed-out for each station:

8.2.6.1 Consecutive Station Number.

8.2.6.2 Coordinate values (II,JJ) of the station, with respect to the Grid Depth file.

8.2.6.3 The Epi concentration as calculated by the program.

8.2.6.4 The Meso concentration as calculated by the program.

8.2.6.5 The Hypo concentration as calculated by the program.

8.2.6.6 The Epi depth as given as the Station Layer Depth Control cards, see 7.2.15.

8.2.6.7 The Meso (to bottom of) depth as given on the Layer Depth cards.

8.2.6.8 The sounding depth as given on the Station Layer Depth Control cards.

8.2.6.9 The actual depth (multiplied by 10) at the station according to Grid Depth file.

8.2.6.10 A four value flag, see RATIO (200) in section 6.0.

- 8.2.7 Under a new heading of "Sorted Station Values" but with the same sub-headings as 8.2.6. All stations to be used in the interpolation procedure are printed-out after being sorted into ascending order of abscissa and then ordinate values of (II, JJ) and where more than one station occupies a cell, the depths and concentrations are averaged, and the actual number of stations occupying the same cell is also provided.
- 8.2.8 At the option of the user (see 7.1.3) information relating to the Depth Difference Rule is printed under appropriate headings, see 4.9.
- 8.2.9 Next the Epi, Meso, Hypo thicknesses and Depth of Hypo are interpolated from the station Layer Depth information and the values (metres * 10) printed by subroutine CONCPO (see 4.12) with station values preceded by a dash (-), and "no values" appear as zero (0).
- 8.2.10 Next the interpolated Epi, Meso, Hypo concentrations are printed (metres* FACTOR) with station values preceded by an asterisk (*) and cells with "no value" appear as blank, hence the outline of the lake basin(s) tend to be shown. In addition the following total quantities are formed and printed for all basins (see 4.11) under the following headers:
- "Number of Cells"; "Volume (M**3)"; "Total Quantity (Concs. *M**S); Mean Depth (Sum Depth/No Cells)"; "Area Mean Conc (Sum Concs/No Cells)"; "Vol Mean Conc (Total Quantity/Vol)".

9. RESOURCES

9.1 Program Size

Ninety-two (92) quarter pages (CDC3170) or approximately 50,000 computer words (24 bits) word size.

9.2 Timing

Typically, this program requires less than ten (10) minutes of Central Processing Time.

9.3 Line Printer

Typically, this program produces 3,000 lines of line printer output, approximately 50 pages.

9.4 Disc Space

(Note one track contains 14 sectors of 640 characters).

9.4.1 The file GRIDERIE containing Lake Erie grid depth (see 7.1.4) requires 14 tracks of permanent disc space.

9.4.2 The file EROSERIE containing sub-file of values retrieved from the Monitor cruise data (see 7.1.6) typically requires 40 tracks of permanent disc space.

9.4.3 The file GRIDTHCK containing the computed layer thicknesses across the lake (see 7.1.5) requires 42 tracks of permanent disc spaces.

9.4.4 In addition the program requires 30 tracks of "scratch": disc space.

9.5 This program requires no magnetic tapes.

10. ACKNOWLEDGEMENTS

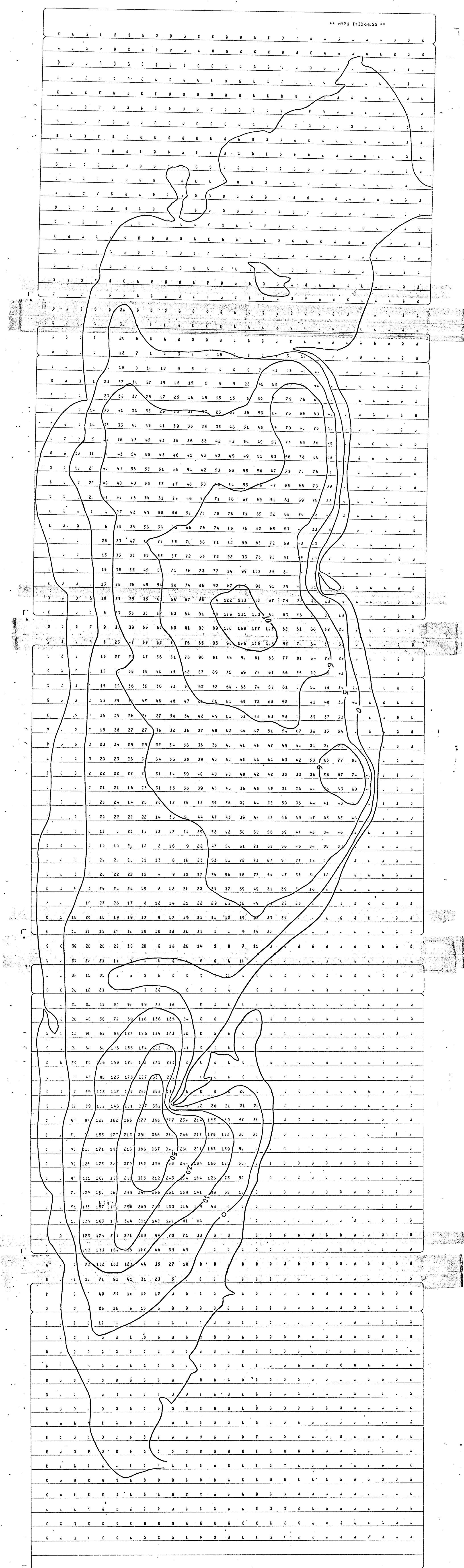
- 10.1 Dr. N.M. Burns and Mr. F. Rosa of C.C.I.W. provided the original ideas for the lake-wide physical and chemical relationships, and established the rules which govern the results produced by program SURVEY8.
- 10.2 Mr. F.M. Boyce of C.C.I.W. provided routine "SEED" used to convert geographical positions (latitude and longitude) of observation stations to x and y co-ordinates in Kilometres, compatible with the bathymetry grid described below.
- 10.3 Mr. D.G. Robertson of C.C.I.W. provided the Lake Erie 2 Km. grid bathymetry file, with a chart datum of 173.31 metres. The grid was aligned on chart 882 of the Canadian Hydrographic Service. To minimize the size of the grid matrix required to cover the lake, the grid with y-axis initially parallel to the central meridian, was rotated counter-clockwise 27.3333° about the origin at $40.970000^{\circ}\text{N}$, 82.98345°W . For further information see C.C.I.W. unpublished report: "Digital Bathymetry of Lakes Ontario, Erie, Huron, Superior and Georgian Bay", by D.G. Robertson and D.E. Jordan.
- 10.4 Mean monthly water levels of Lake Erie, for the period Jan. 1966 to Nov. 1977 were obtained from: Tides and Water Level Section, Canadian Hydrographic Service (Central Region).

10.5 Mr. A.S. Fraser of C.C.I.W. made the request for the modification of the program to allow user supplied basin definitions. This work was carried out under project 76-IW-ARD-065.

				** SPECIFICATIONS **	
NUMBER OF COLS IN LAKE ERIE GRID = 209 (IMAX)				(COMMENT)	
NUMBER OF ROWS IN LAKE ERIE GRID = 57 (JMAX)				(COMMENT)	
NUMBER OF PUNCHED CARDS IN ROBERTSON BATHYMETRY FILE = 527				(COMMENT)	
NUMBER OF PUNCHED CARDS/PER ROW = 11 (IVALSRGW)				(COMMENT)	11. PARTIAL JOB EXAMPLE
NUMBER OF VALUES PER CARD = 19 (KARDSROW)				(COMMENT)	
5 = NUMBER OF CELLS DEFINING LAKE EDGE AT NORTH AND SOUTH				(KEDGE)	
999 = NO OBSERVATION-INTEGER				(NOOBS)	
70 = YEAR OF CRUISE				(IYR)	
107 = CRUISE REF. NUMBER				(ICRN)	
08 = MONTH OF CRUISE				(IMTH)	
01 TEMPERATURE (DEG. C)				(INVAR)	
0.3 = COEFFICIENT USED IN DEPTH DIFFERENCE RULE				(COEF)	
10 = FACTOR USED TO MULTIPLY ALL CONCENTRATIONS FOR P/O				(FACTOR)	
1 = NUMBER OF BASINS				(NOBASINS)	
-99.9 = NO OBSERVATION-FLOATING POINT				(FN00BS)	
2 = MESH SIZE OF CELLS IN GRID				(GRIDSIZE)	
15 = KM. INTERP. CELL MUST BE WITHIN THIS DIST TO STN FOR P/O				(DISLIN)	
PARTITION FOR ROW 1 = COL 1 TO 209 DEPTH RULE(M) = 3				(BASIN 1)	
PARTITION FOR ROW 57 = COL 1 TO 209 DEPTH RULE(M) = 3				(BASIN 1)	
				(CUT SUMS)	
COL 1 TO 5 OF EACH STATION CARD BELOW IS USED TO INDICATE (BY MEANS OF				(COMMENT)	
T AND F WHICH OF THE 5 POSSIBLE BASINS ARE TO CONSIDER THOSE VALUES				(COMMENT)	
ASSOCIATED WITH THAT STATION. -NOTE BLANK IS CONSIDERED TO BE FALSE.				(COMMENT)	
EXCEPT IN THE CASE WHERE THE WHOLE 5 CHAR FIELD IS BLANK IN WHICH CASE				(COMMENT)	
THE STATION WILL BE CONSIDERED FOR ALL BASINS REQUIRED.				(COMMENT)	
				(COMMENT)	
CONSEC	FPT	HYPD	SOUNDING	(COMMENT)	
12345STN	DEPTH	DEPTH	(M.)	(COMMENT)	
001	18.00	18.00	18.00	()	
002	21.00	21.00	21.00	()	
003	25.00	27.00	27.00	()	
004	23.70	23.70	23.70	()	
005	22.50	26.50	32.50	()	
006	24.50	27.00	27.00	()	
007	24.50	24.50	24.50	()	
008	24.00	27.00	27.00	()	
009	21.50	26.00	28.50	()	
010	20.50	26.50	26.50	()	

** SORTED SIN. VALUES **

STN	*II*	*JJ*	*EPI* *CONC*	*MESO* *CONC*	*HYPO* *CONC*	*CELL* *STNS*	*GRID* *DEPTH*	*EPI* *DEPTH*	*HYPO* *DEPTH*	*SQUID* *DEPTH*	*FLAG*
28	15	41	85	999	999	1	71	7.00	7.00	7.00	
27	18	51	94	999	999	1	80	8.00	8.00	8.00	
29	22	19	89	999	999	1	107	10.00	10.00	10.00	
26	25	50	79	999	999	1	91	9.00	9.00	9.00	
31	31	23	96	999	999	1	141	14.00	14.00	14.00	
30	31	34	90	999	999	1	91	9.00	9.00	9.00	
32	31	13	107	999	999	1	125	12.00	12.00	12.00	
25	31	44	90	999	999	1	111	11.00	11.00	11.00	
23	41	22	87	999	999	1	177	17.00	17.00	17.00	
24	41	32	99	999	999	1	111	11.00	11.00	11.00	
22	51	11	103	43	5	1	173	13.00	13.00	13.00	
21	51	21	99	63	42	1	201	16.00	17.00	20.00	
24	52	42	93	66	41	1	159	8.00	10.00	10.00	
21	51	11	94	53	27	1	191	19.00	17.00	21.00	
25	51	31	91	74	38	1	231	23.00	17.00	20.00	
19	63	3	85	999	999	1	121	12.00	12.00	12.00	
21	51	5	83	999	999	1	161	16.00	16.00	16.00	
28	63	1	89	999	999	1	131	13.00	13.00	13.00	
17	68	3	93	999	999	1	111	11.00	11.00	11.00	
16	71	9	92	999	999	1	191	19.00	19.00	19.00	
35	71	13	92	61	41	1	271	27.00	27.00	27.00	
14	73	41	99	62	42	1	161	11.00	12.50	16.00	
37	51	6	68	999	999	1	151	15.00	15.00	15.00	
25	93	23	99	72	50	1	251	25.00	25.00	25.00	
13	94	39	95	65	45	1	211	21.00	15.00	22.00	
12	94	46	99	78	999	1	131	9.00	12.00	13.00	
23	92	18	92	75	999	1	251	19.00	20.00	22.00	
19	93	28	69	64	49	1	251	17.50	13.00	24.00	
40	34	39	87	65	41	1	231	25.00	17.00	22.00	
11	93	49	81	999	999	1	111	11.00	11.00	11.00	
8	102	7	94	999	999	1	161	16.00	16.00	16.00	
9	104	27	91	76	68	1	231	17.50	19.00	22.00	
21	114	35	92	46	46	1	211	21.00	19.00	22.00	
41	115	48	97	87	33	1	141	5.00	9.00	14.00	
7	113	16	94	82	999	1	221	22.00	21.00	22.00	
12	115	37	103	75	21	1	171	7.00	12.00	16.00	
45	122	5	97	999	999	1	151	15.00	15.00	15.00	
44	124	26	94	61	999	1	211	16.50	13.00	20.00	
43	125	36	99	73	66	1	161	9.00	14.00	16.00	
46	133	4	101	999	999	1	101	10.00	10.00	10.00	
47	134	14	95	91	999	1	211	7.00	13.00	21.00	
6	135	25	98	999	999	1	151	15.00	15.00	15.00	
5	143	4	111	999	999	1	151	15.00	15.00	15.00	
49	144	22	96	56	68	1	251	5.00	23.00	24.00	
50	146	34	97	999	999	1	71	7.00	7.00	7.00	
4	155	12	96	77	100	1	461	11.00	3.00	46.00	
49	153	23	96	103	107	1	461	14.00	2.00	46.00	
51	155	31	94	97	99	1	141	5.00	3.00	15.00	
52	165	6	99	66	999	1	241	17.50	24.00	24.00	
3	156	22	93	83	82	1	341	22.00	23.00	32.00	
53	174	27	93	999	999	1	131	13.00	13.00	13.00	
54	176	15	87	70	71	1	275	23.00	25.00	25.00	
51	196	11	96	999	999	1	171	17.00	17.00	17.00	
55	197	19	87	999	999	1	201	20.00	19.00	20.00	
55	196	13	96	999	999	1	111	11.00	11.00	11.00	
56	198	16	96	999	999	1	121	12.00	12.00	12.00	



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