

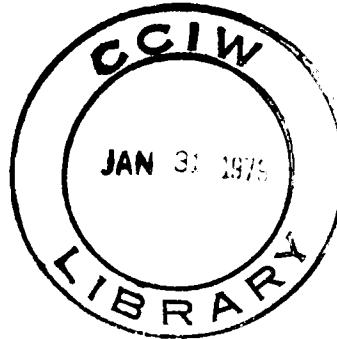


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GRIDDED DEPTH VALUES FROM RANDOMLY - LOCATED SOUNDINGS



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BURLINGTON, ONTARIO

GRIDDED DEPTH VALUES FROM RANDOMLY-LOCATED SOUNDINGS

by

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ABSTRACT

This report describes a number of computer programs which provide a means of converting a random set of sounding data in any given area into a file containing depth values for specified gridded sub-areas. The original sounding data can be provided by Hydrographic charts or tapes, or by a combination of both. Editing and display routines are included as well as a complete listing of the programs. Examples of the bathymetric outputs for the James Bay and Hudson Bay areas are shown.

The gridded bathymetric data of Hudson Bay and James Bay are obtained in order to calculate the freshwater and heat content for different salinity and temperature cruise data. Future uses of the gridded bathymetry computer program will be the tidal and estuarine modelling of these areas.

ACKNOWLEDGMENTS

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1. INTRODUCTION

The method described here consists of obtaining a tape containing positions and soundings of the area in question, creating a suitable data file, and using the "General Purpose Contouring Program" (GPCP) to compute gridded depth values. Another method, of course, would be to digitize depth contours on a chart and, at pre-set intervals, compute positions of those depths in appropriate coordinates. Also, individual soundings can be digitized from an existing chart where no data tapes are available and used as input for the GPCP program.

Although all three methods have been used to create bathymetries (gridded depth values for specific areas) for Hudson Bay and James Bay, only the method of using an existing sounding tape will be dealt with here.

Since rather large areas encompassing up to 1000 km are to be considered, a scale factor has to be introduced. The scale factor simply represents the ratio of true (geodetic) distance and the map distance between two points and is calculated for each row of the bathymetry. The Mercator projection is used as a base.

Since the GPCP program only accepts a specific number of data points, the total area may have to be divided into smaller parts with an adequate overlap provided for each area. Due to storage capacity restraint on the CDC 3170 computer used at National Water Research Institute (NWRI), separate sub-bathymetry gridded areas containing 16 x 46 cells were used. The depth array, or bathymetry, thus obtained has to be edited and updated as more information is made available. The program has a provision which enables the user to specify the number of neighbouring sounding points to be used for calculation of the depth at each grid point. It is up to the user's judgment to specify the number of neighbouring points and is dependent largely on the density of the soundings and the bottom topography of the area. Furthermore, a zero depth is an acceptable value and designates land. In some cases, it may be advantageous to add zero depths (islands, etc.) to obtain better boundary conditions.

As far as Hudson and James Bays were concerned, a common row for both bathymetries was chosen, and the cell size of any sub-bathymetry was made a multiple of the original cell size. It should be kept in mind that a certain depth value of a bathymetry represents an average depth of the entire cell. Subsequently it will happen that sub-bathymetry depth values will vary considerably, despite the fact that they appear in the same position but will influence a smaller bottom area.

The method described here produces good results for a set of input data points with a rather uniform distribution and is used as a basis for volumetric calculations. However, in areas with inadequate coverage, additional data points have to be incorporated either before the data is gridded or prior to the gridded data being edited.

For the general description and philosophy for creating gridded depth values for an area (bathymetry), the reader is referred to an unpublished technical report of NWRI, "Digital Bathymetry of Lakes Ontario, Erie, Huron, Superior and Georgian Bay", by D.G. Robertson and D.E. Jordan.

2. CREATION OF THE BATHYMETRY FILE FOR THE NORTHEAST CORNER OF JAMES BAY

In the second part of this report, the listings of the programs discussed below are included; here their general application for a particular area will be discussed. The area in question is the northeast corner of James Bay where oceanographic research to predict changes caused by the hydroelectric development of the La Grande River is in process.

A tape (RD011) containing soundings of James Bay, obtained during the winter surveys of 1975 and 1976, was obtained from the Canadian Hydrographic Service (CHS) of Central Region, Ocean and Aquatic Sciences. Depths were in decimetres and positions in UTM coordinates, zone 17, with a central meridian of 81° . Program JAMES was written to convert the UTMs to geographic coordinates and to write an input disc file for program GEØRGR.

Program GEØRGR was written mainly to select part of the total sounding area and delete those soundings which might introduce false data (nearshore, inlets, etc.).

Program CREBAT was used to modify and complete the file created by program GEØRGR. It combines those values retrieved with soundings from other sources (ship soundings, charts, etc.). This is necessary especially where soundings are not dense enough from any one source to obtain good gridded data (nearshore, islands, and channels). Output of program CREBAT is a tape in card image form, with a format specified by the GPCP program. Sounding values are in metres and their locations are given in X and Y coordinates in inches relative to the bathymetric origin. This program is used for updating and supplementing the individual soundings. It has been found to be impractical to plot the soundings at this stage for visual inspection (time factor). However, the printed output of the following program (GPCP) is usually adequate to inspect the gridded data and make further decisions as to the number of neighbouring points, additional soundings, etc.

The GPCP program was used to calculate a gridded depth array by choosing the proper dimension and grid intervals for the area concerned

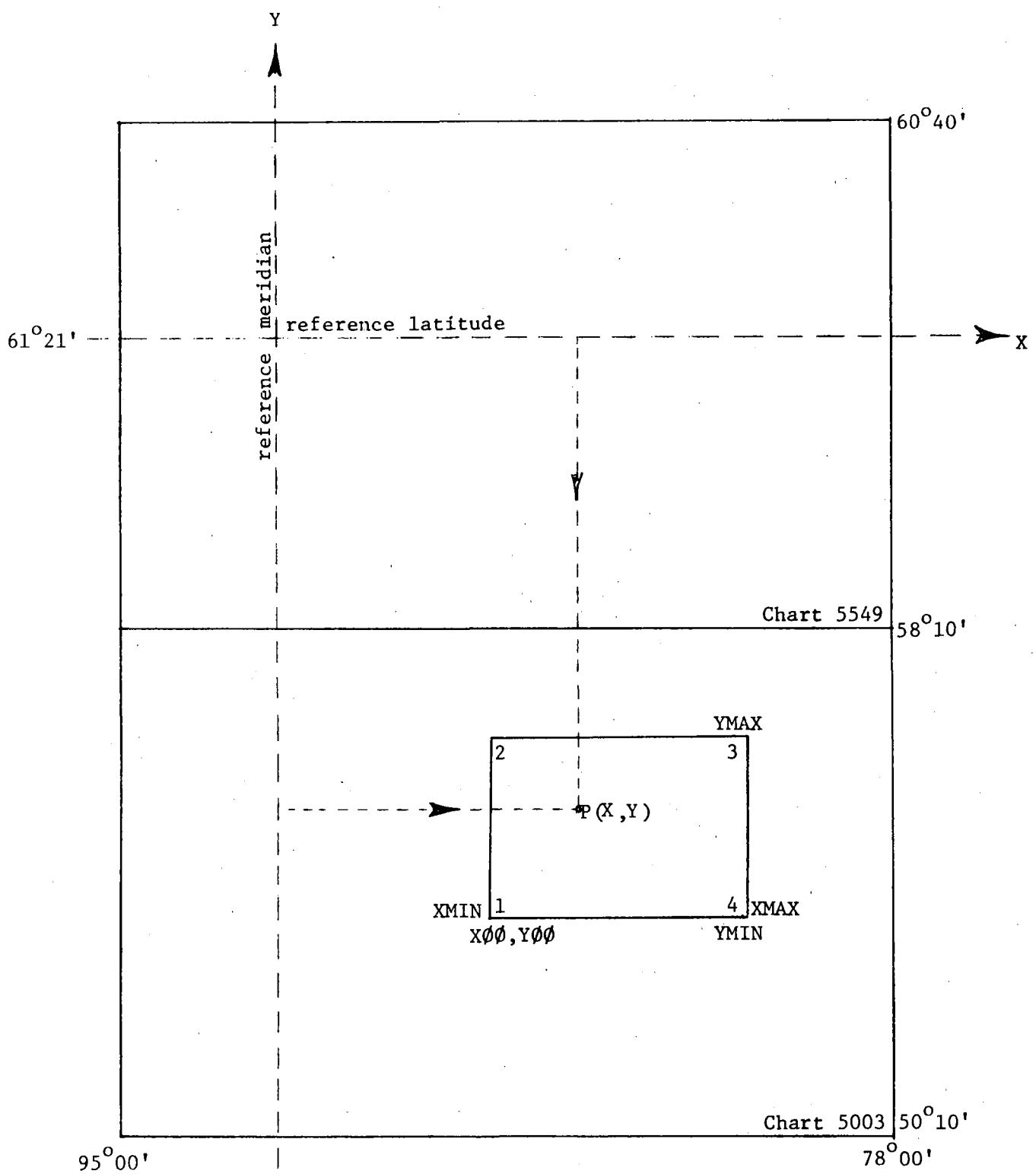
and using the individual soundings as data points. Figure 1 shows the layout of the two Hydrographic charts covering Hudson Bay; #5003 for the southern half and #5549 for the northern half. A sample area contained within latitude YMAX and YMIN and within longitude XMAX and XMIN is shown with a bathymetric sounding at point P(X,Y). All positions are referenced to the reference latitude and reference meridian and are in Mercator coordinates for the corner points of the bathymetry and subsequently its dimension. It should be emphasized that program CATMER was written as a mere convenience for the user in order to eliminate the task of scaling the coordinates by hand from an existing chart. For an explanation or for documentation of this program, the reader is referred to either the charting sub-system or some reference quote therein.

The card output (depth array) of the GPCP program was converted and sequenced to a suitable card format by program INTDEP. This was necessary to convert the output cards to a standard format (also used by NWRI) since the output format of the GPCP program cannot be altered.

In order to calculate volumes and their specific contents for selected areas, a zone number had to be added to each cell. Program ADDZ \emptyset N was used for this purpose. Figure 2 shows the partition of James Bay into 6 zones used by other scientific programs which calculate geostrophic currents and variations in the salt and heat content of each zone. It is evident that ADDZ \emptyset N will only be of use if the zone layout is geometrically simple. In more complex layouts, program Z \emptyset NESEL (Gottinger, 1978) has to be used. In this case, each row of the bathymetry and its starting and end points for each zone have to be listed.

The card deck thus obtained is the final form of the bathymetry data and is written onto a permanent file with title information and the scale factor. In the present implementation, all changes and updates are made on these card decks, and the permanent files are simply re-written. No other update routines are available.

The general card deck structure for Hudson and James Bays and their associated display routines will be discussed in another user's manual.



$$YMAX = |Y(3) - Y(4)|; XØØ=YØØ = 1.0$$

$$XMAX = |X(4) - X(1)|; XMIN=YMIN = 0.0$$

X, Y are Mercator coordinates of point P in metres.

Figure 1: Geodetic Reference Layout of the Selected Bathymetric Area.

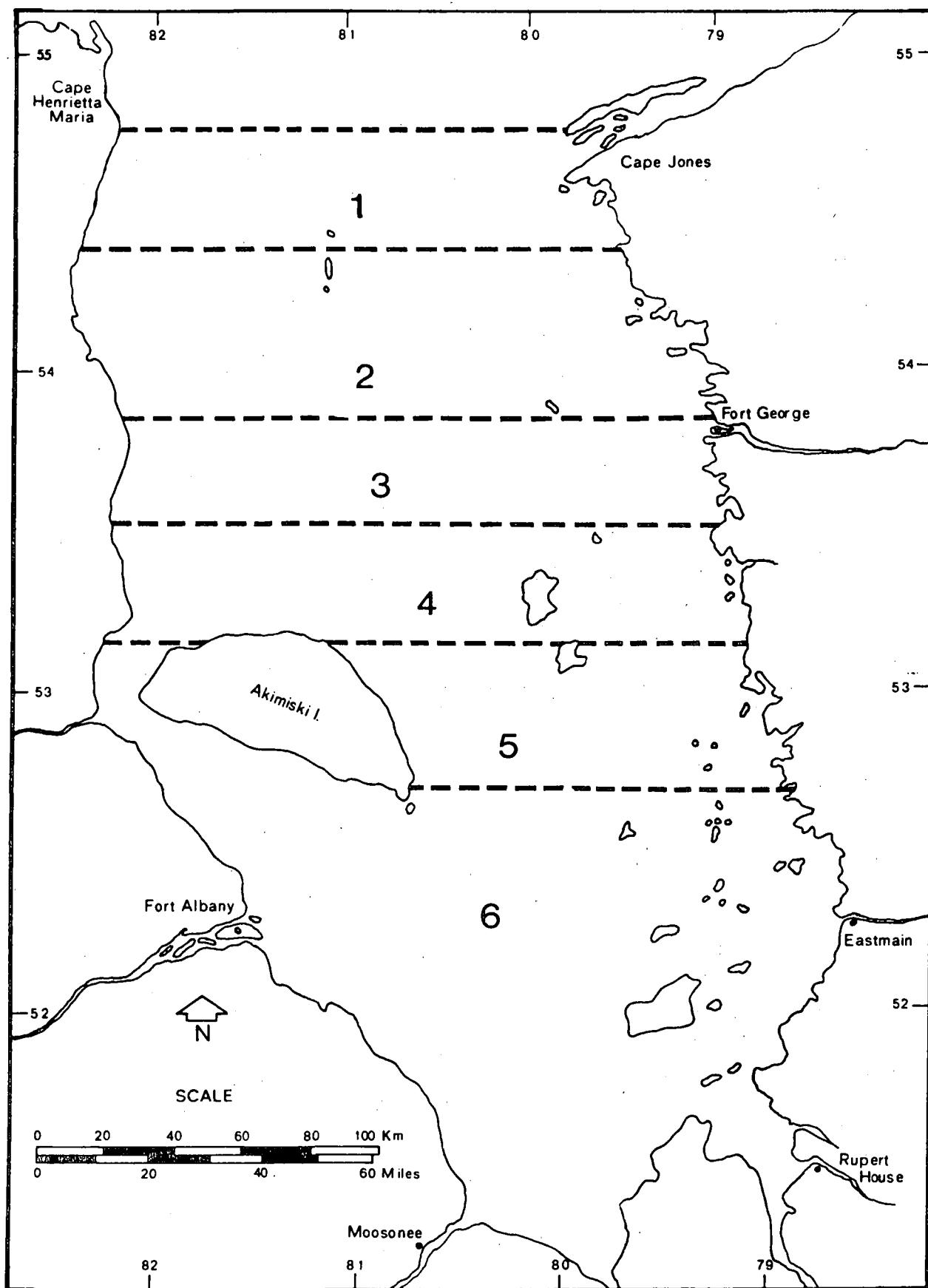


Figure 2: Zone Layout of James Bay.

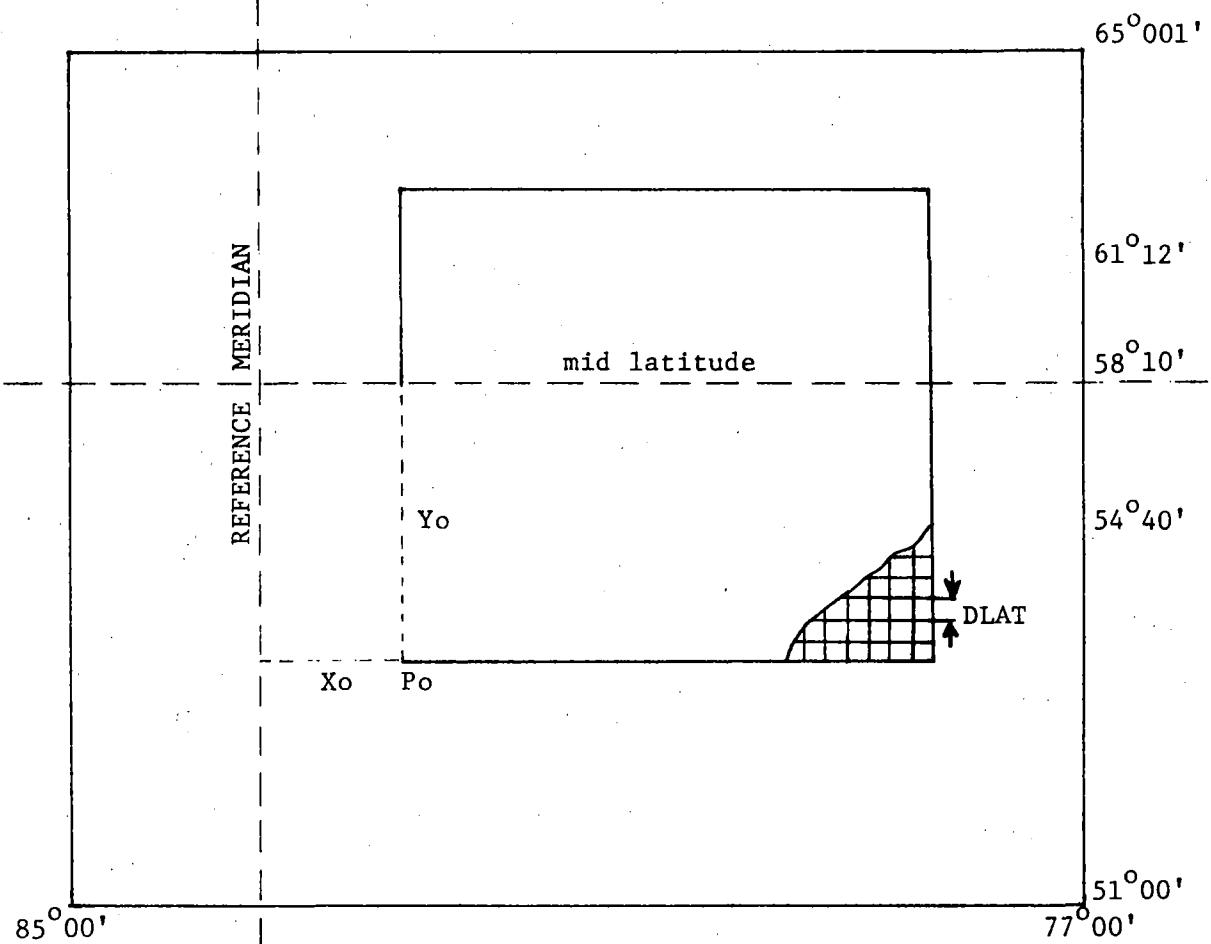
3. CALCULATING THE SCALE FACTOR FOR A GIVEN BATHYMETRY

As previously mentioned, the scale factor represents the ratio of map distance and actual (geodetic) distance between two points. On the Mercator projection at the reference latitude (mid latitude), the scale factor is equal to unity (1.00). Since the projection is conformal, the scale at any point is the same in any direction. With the parallels and meridians represented by lines mutually perpendicular, the scale is the same along the meridians and parallels at a given point. Applying the foregoing to a bathymetry, it can be seen that a scale factor is easily determined for each row by measuring a distance along the center of the row and comparing it with the true distance.

One approach would be to calculate, by geodetic inverse, the distance between two points along the mid latitude and compare that distance between the same two points along the center latitude of each row. On the other hand, a distance obtained by using polyconic tables (or equivalent) would be sufficient for the accuracy required. The following example will demonstrate the use of those tables.

Assuming the mid latitude of $58^{\circ}10'$ (see Figure 3) with a scale factor of 1.00, the Polyconic Tables (U.S. Department of Commerce, 1946) give the arc of the parallel for 5 minutes as 4905.0 m. Similarly, at latitude $54^{\circ}40'$, a value of 5377.2 m for 5 minutes of arc is obtained, giving a scale factor of 0.912185 at that latitude. At latitude $61^{\circ}12'$, a scale factor of 1.094671 ($K = 4905.0/4480.8$) is obtained. Using inverse computation, scale factors of 0.912129 and 1.094747, respectively, are obtained.

In conclusion, it should be mentioned that it is not necessary to calculate the scale factor for each row. Interpolating between several rows is sufficient.



Po = Bathymetry origin;
 Xo, Yo = Mercator coordinates of origin (metres);
 DLAT = cell size in kilometres;
 M = chart scale;
 FLAT = cell size at chart scale [(DLAT/M) * 1000.]; and
 C₁ = Xo/FLAT | coordinates of bathymetry,
 C₂ = Yo/FLAT | origin in cell units.

Figure 3: Geodetic Layout of a Gridded Cell relative to a Bathymetric Origin.

4. CONCLUDING REMARKS

This completes the creation of a zone bathymetry card deck. It is a simple matter to re-run the entire sub-system, using different areas, specifying different cell sizes, or re-creating the source bathymetry with updated or revised sounding tapes. All depth changes, shoreline corrections, and minor zone changes are usually done on this card deck, using the line printer plot or a Calcomp plot as a guide.

In general the card deck and file structure of the bathymetric data is the same as those files used by the Applied Research Division, NWRI, and allows the interchange of existing programs with only minor modifications.

As an example, line printer plots as well as a Calcomp plot of the Hudson/James Bay region are included in this report (Figures 4, 5, and 6). The line printer plot was produced by program HUDMAP. Program GEØBAT produced the Calcomp plot and is to be described in a subsequent report.

The line printer plot (Figure 4) shows the zone layout of the cells for the Hudson/James Bay region. The entire James Bay region is contained in zone 6. For the same cell layout, Figure 5 shows the line printer plot of the individual cell depths. This plot is used as an aid to update and revise bathymetric depths if new soundings become available. A final display of the bathymetry shown by the line printer plot (Figure 5) is obtained by the Calcomp plotter and is shown in Figure 6.

This set of programs was specifically written to create gridded depth values for large geographic areas. They can be modified to obtain gridded (physical or chemical) parameter values such as salinity using randomly-located parameter values from existing data bases.

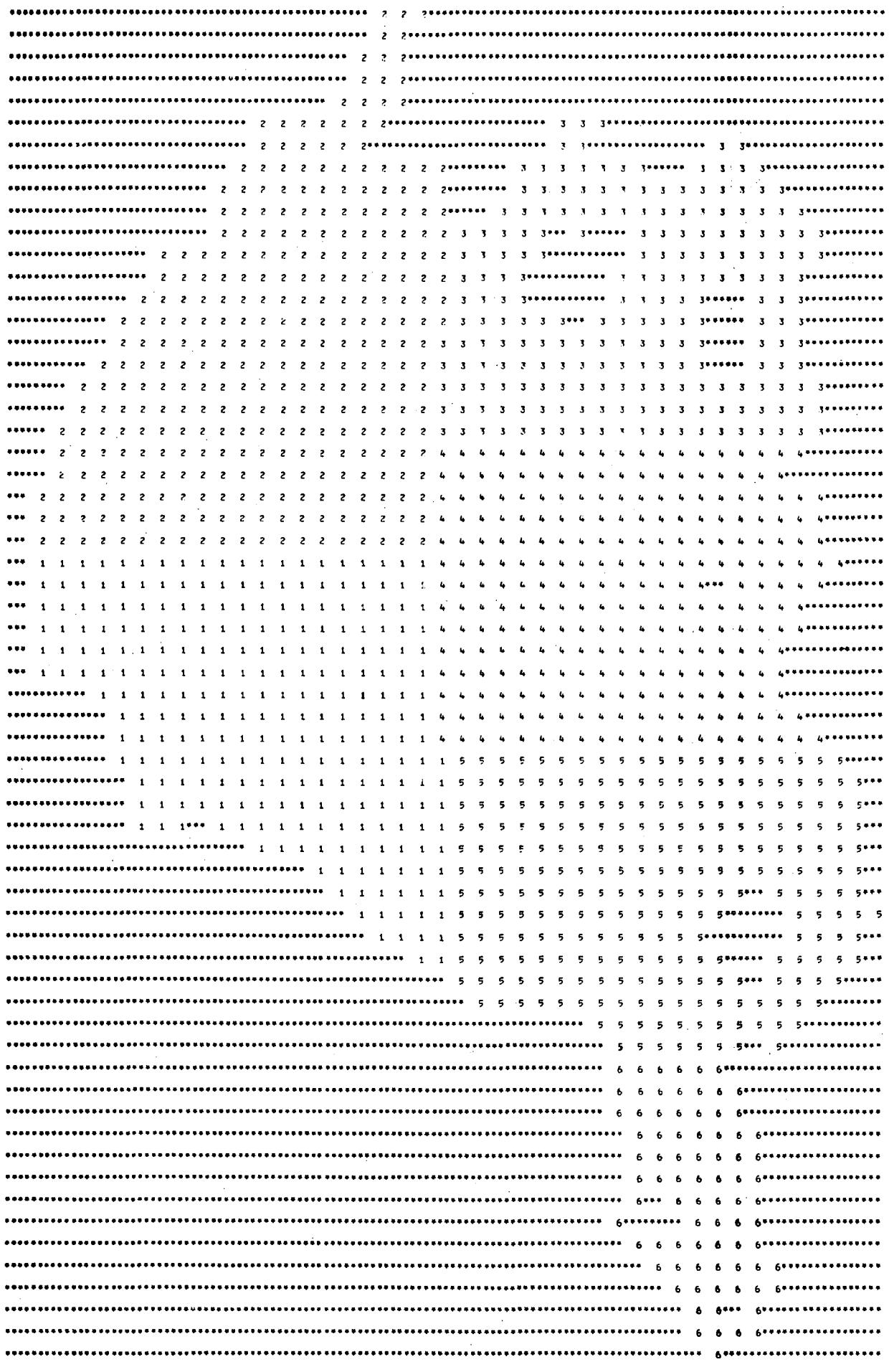


Figure 4: Zone Layout of Hudson and James Bays.

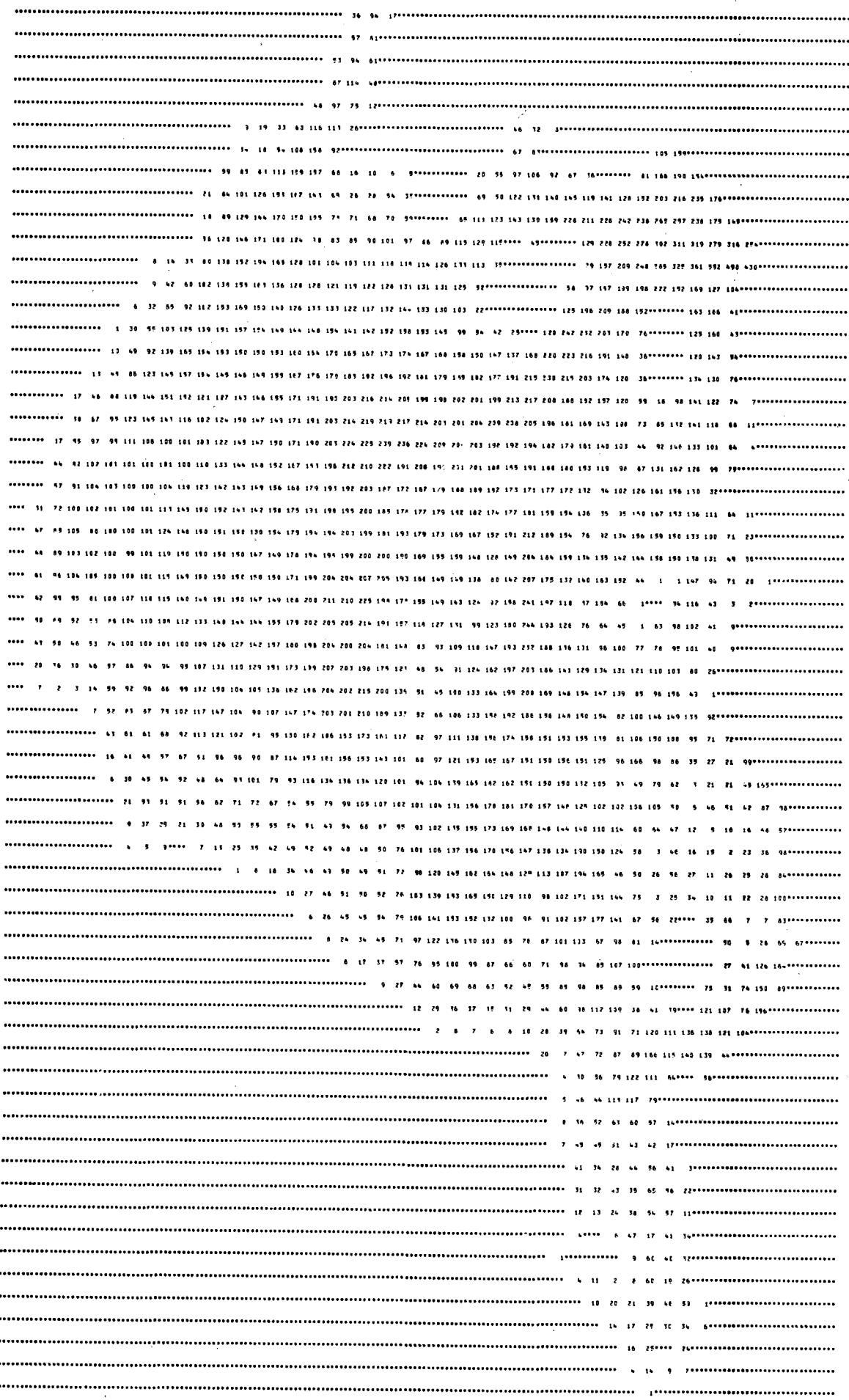


Figure 5: Line Printer Plot of Hudson Bay
and James Bay Bathymetry.

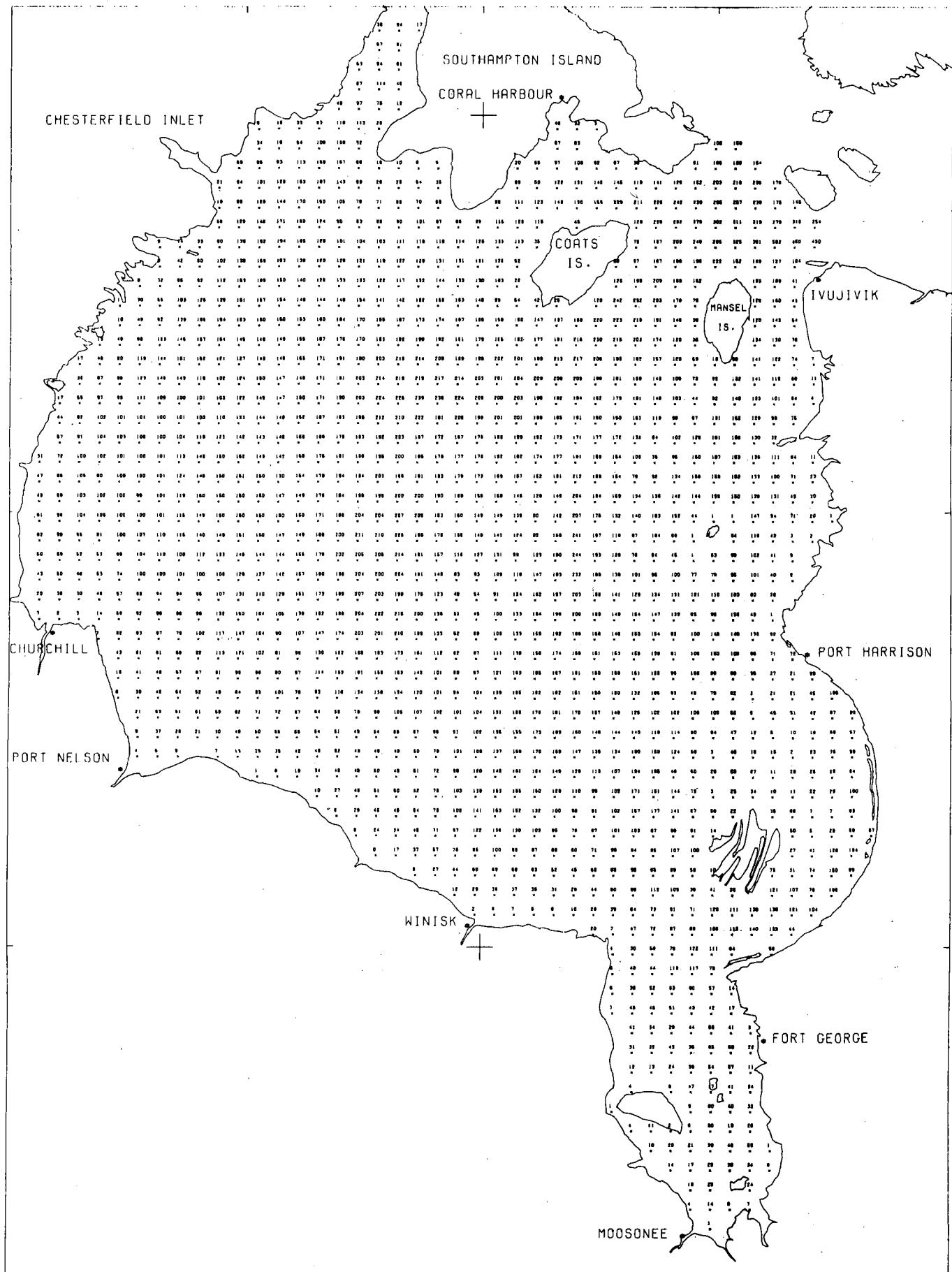


Figure 6: Calcomp Plot of Hudson Bay and James Bay
Bathymetry (25 km x 25 km grid size).

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Gottinger, R. and A.C. Zingaro. Charting Sub-System. Applied Research Division, National Water Research Institute, Burlington, Ontario, to be published.

Robertson, D.G. and D.E. Jordan. 1978. Digital Bathymetry of Lakes Ontario, Erie, Huron, Superior and Georgian Bay. National Water Research Institute, Burlington, Ontario, CCIW unpublished report.

U.S. Government. 1946. Tables for A Polyconic Projection of Maps and Lengths of Terrestrial Arcs of Meridian and Parallels, Sixth Edition, Special Publication No. 5. U.S. Department of Commerce, Coast and Geodetic Survey.

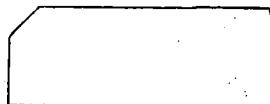
APPENDIX

This Appendix contains the program subroutines and their general descriptions and listings of the following programs:

- A1) Program JAMES;
- A2) Program GEØRGR;
- A3) Program CREBAT;
- A4) Program CPLØT;
- A5) Program INTDEP;
- A6) Program ADDZØN;
- A7) Program PERMA;
- A8) Program HUDMAP;
- A9) Program CATMER; and
- A10) Subroutine MERCAT.

A general flowchart (Figure 7) shows the order by which the programs are used. The input and output symbols used are:

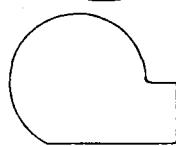
1) cards,



2) disc,



3) tape,



4) printer, and



5) data record.



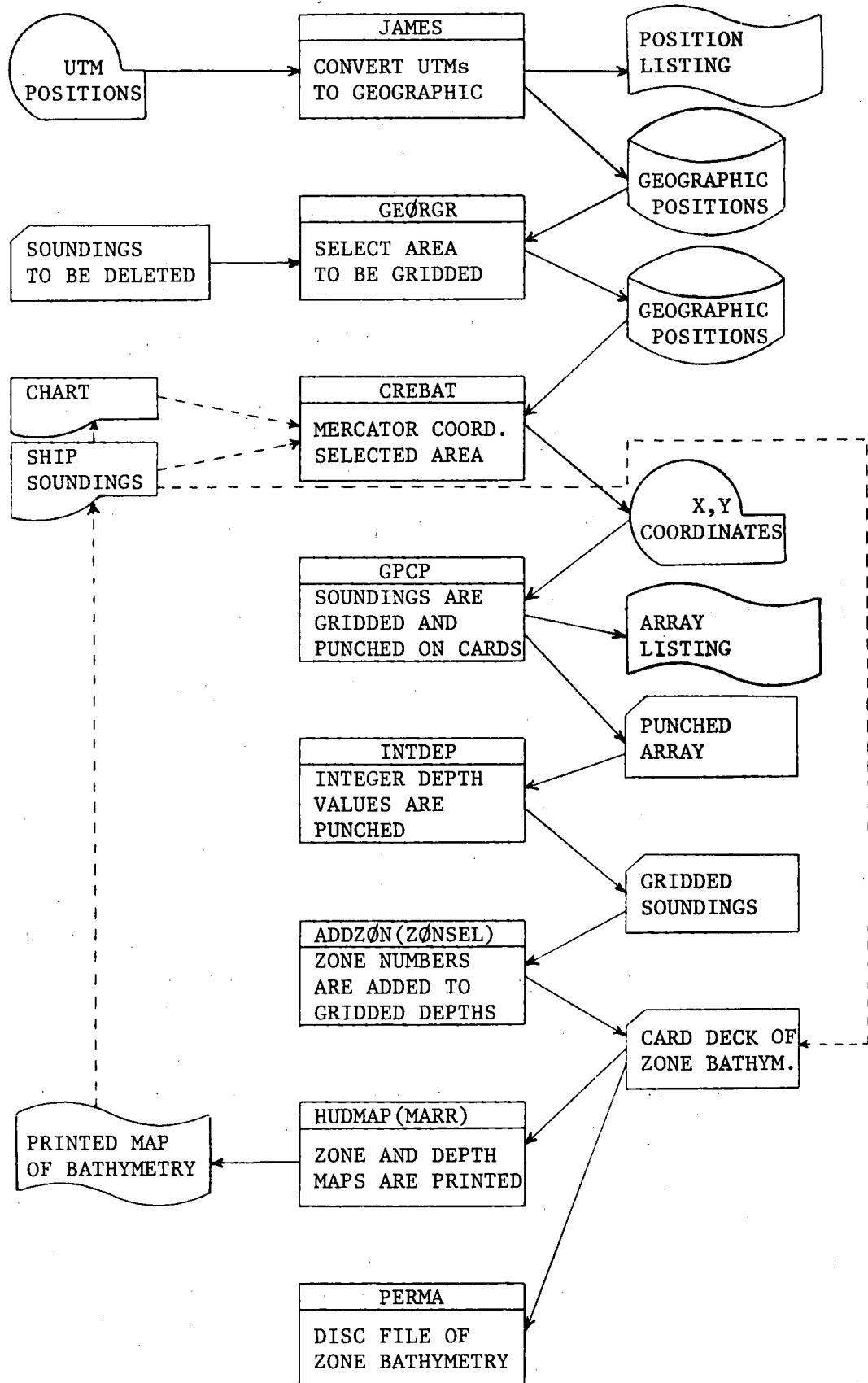


Figure 7: System Flowchart.

Program JAMES

This program converts hydrographic sounding data in UTMs to geographic positions, sequences the printed output, and writes a disc file. A subroutine converting UTM coordinates to geographic coordinates can be obtained from the Nautical Geodesy Section, Hydrographic Service, Ottawa. In JAMES, a similar program (B51211) was used and is available through the NWRI computer library.

Input

Hydrographic tape containing soundings in decimetres and UTMs in Zone 17.

Output

Listing with added sequence numbers and a permanent file (003/096 JAMES BAY SØUNDINGS,01,RØBT) written in binary with 25 soundings per record. All disc files written for either this system or the charting sub-system will have essentially the same format.

Main Parameters

ICM = Central meridian in degrees;

IK = sequence number of individual soundings;

X,Y = northings and eastings (UTM);

FLAT = latitude of sounding (dec. degrees);

FLØN = longitude of sounding (dec. degrees); and

IB = one-dimensional array containing sounding values and their respective coordinates (UTMs).

PROGRAM JAMES

*** PROGRAM READS HYDROGRAPHIC SOUNDING VALUES AND POSITIONS IN
*** UTM S AND WRITES A PERMANENT FILE WITH SOUNDINGS HAVING
*** GEOGRAPHIC COORDINATES (DEC. DEGREES). SEQUENCE NUMBERS HAVE
*** BEEN ADDED FOR DELETION OF SOUNDINGS IN PROGRAM GEORGR, IF
*** REQUIRED. THE PERMANENT FILE WRITTEN IS USED AS INPUT
*** FOR PROGRAM GEORGR.

C DIMENSION IB(3000), FLAT(500), FLON(500), IOPT(500)

C *** ICM = CENTRAL MERIDIAN

C ICM = 81
READ (60,100) ITITLE
WRITE (61,110) ITITLE
WRITE (30) ITITLE
BUFFER IN (1,0) (IB(1),IB(3000))
II = IFUNIT(1)+2
IK = 1
20 DO 30 M=1,3000
30 IB(M) = 4H
DO 40 N=1,500
FLAT(N) = 0.0
FLON(N) = 0.0
IOPT(N) = 0
40 CONTINUE

C *** ONE DATA RECORD IS BUFFERED IN
C BUFFER IN (1,0) (IB(1),IB(3000))
II = IFUNIT(1)+2
GO TO (50,60,90), II
50 STOP 666

C *** IEND = NUMBER OF SOUNDINGS PER RECORD
C 60 IEND = LENGTH(1)/5
L = 1
I = 1
DO 70 K=1,IEND
DECODE (20,120,IB(L)) X,Y,IOPT(I)
L = L+5

C *** SUBROUTINE UTM IS A SHORT VERSION OF PROGRAM B51211. IT WILL
*** CONVERT GRID TO GEOGRAPHIC ON THE CLARKE SPHEROID 1866, STANDARD
*** UTM 6 DEGREE ZONES WITH A FALSE EASTING OF 500000 METRES.
*** FOR ANY OTHER SPHEROID OR DIFFERENT ZONE LAYOUT, THE COMPLETE
*** VERSION OF B51211 HAS TO BE USED.

C CALL UTM (X,Y,FLAT(I),FLON(I),ICM)

C IFD = FLAT(I)
FYH = (FLAT(I)-IFD)*60.
IFM = FYH
FS = (FYH-IFM)*60.
IGD = FLON(I)
FGM = (FLON(I)-IGD)*60.
IGM = FGM
GS = (FGM-IGM)*60.

C *** LATITUDE LONGITUDE AND UTM S OF A SOUNDING ARE PRINTED
C WRITE (61,130) IK,X,Y,IFD,IFM,FS,IGD,IGM,GS,IOPT(I)
IK = IK+1
T = T+1
70 CCNTINUE

C *** OUTPUT DISC FILE IS WRITTEN
C
J = 1
M = 25
DO 80 N=1,4
WRITE (30) (FLAT(I),FLON(I),IDPT(I),I=J,M)
J = J+25
M = M+25
80 CONTINUE
GO TO 20
90 END FILE 30
WRITE (61,140) IEND
STOP
C
100 FORMAT (20A4)
110 FORMAT (//10X,20A4//)
120 FORMAT (2F7.0,2X,I4)
130 FORMAT (10X,I5,4X,F14.3,1X,F11.3,4X,2(I4,I3,F7.3),I6)
140 FCRMAT (////5X,I10//)
END

Program GEØRGR

This program selects the soundings located in the area for which the gridded depth values are required, deletes soundings, and writes a permanent file to be used as input for program CREBAT (003/090, GEØRGE-RIVER-SØUND-MERC,01,RØBT). Soundings to be deleted are physically set to zero and eliminated in program CREBAT.

Input

Permanent file written by program JAMES.

Output

Listing of soundings and their respective Mercator coordinates and a disc file (binary) in standard format.

Main Parameters

M = Chart scale;
ØL,ØN = reference latitude and longitude of chart in decimal degrees; and
IDEL = one-dimensional array for soundings to be deleted (max.16).

Note

Parameters C₁, C₂, and DLAT, in common block MER, are constants unique to the bathymetry and are not used in the foregoing calculations (left blank).

PROGRAM GEORGR

C *** PROGRAM SELECTS A PARTICULAR AREA, FOR WHICH THE BATHYMETRY
C *** IS TO BE CREATED, FROM THE FILE WRITTEN BY PROGRAM JAMES.
C *** IT ALSO PROVIDES FOR UP TO 16 SOUNDING VALUES TO BE DELETED.
C *** TO DELETE, BOTH THE SEQUENCE NUMBER(IDEL) OF THE SOUNDING AS
C *** WELL AS THE VALUE(ICK) TO BE DELETED HAVE TO BE LISTED.
C *** IF NO AGREEMENT IS FOUND, THE RECORD IN QUESTION IS RETAINED.
C *** AND A MESSAGE IS WRITTEN ACCORDINGLY. THE FILE WRITTEN IS THE
C INPUT TO PROGRAM CREBAT.

REAL LATMIN,LATMAX,LONMIN,LONMAX
DIMENSION FLAT(25), FLON(25), IDPT(25), IDEL(16), ICK(16)
DIMENSION GX(46), GY(46), FBO(46), NSTAT(46)
COMMON /MER/ M,OL,ON,C1,C2,DLAT

C *** IOSI = UNIT NUMBER OF INPUT FILE
C
IOSI = 40
M = 1000000
OL = 61.333333
ON = 85.939792

C *** MINIMUM AND MAXIMUM VALUES OF BOTH LATITUDE AND LONGITUDE
C *** ARE READ IN. (DECIMAL DEGREES WITH FORMAT F10.4)
C
READ (60,120) LATMIN,LATMAX,LONMIN,LONMAX

C *** SEQUENCE NUMBERS AND VALUES OF THOSE SOUNDINGS TO BE DELETED
C *** ARE READ IN. (USUALLY LEFT BLANK)
C
READ (60,130) (IDEL(K),ICK(K),K=1,16)
IND = 0
DO 10 I=1,16
IF (IDEL(I).EQ.0) GO TO 10
IND = IND+1
10 CONTINUE

C *** INPUT DISC FILE IS READ IN
C
IC = 1
KC = 0
READ (IOSI)
20 READ (IOSI) (GX(I),GY(I),NSTAT(I),I=1,25)
IF (IFE OF (IOSI).EQ.-1) GO TO 100
30 ICOUNT = ICOUNT+1
IF (ICOUNT.GT.25) GO TO 70
KC = KC+1

C *** SOUNDINGS OUTSIDE THE SPECIFIED AREA ARE REJECTED
C
IF (GX(ICOUNT).LT.LATMIN.OR.GX(ICOUNT).GT.LATMAX) GO TO 30
IF (GY(ICOUNT).LT.LONMIN.OR.GY(ICOUNT).GT.LONMAX) GO TO 30
GLAT = GX(ICOUNT)
GLON = GY(ICOUNT)
ILAT = GLAT
LAT = (GLAT-ILAT)*600.+5+ILAT*1000
GLON = GY(ICOUNT)
ILON = GLON
LON = (GLON-ILON)*600.+5+ILON*1000

C *** S/R MERCAT IS CALLED TO CALCULATE THE MERCATOR COORDINATES
C *** X AND Y OF THE SOUNDINGS WITH RESPECT TO CHART SCALE M
C *** AND CHART ORIGIN OL AND ON.
C
CALL MERCAT (X,Y,IO,JO,LAT,LON)

```

FLAT(IC) = X
FLON(IC) = Y
IF (IND.EQ.0) GO TO 60
DO 50 J=1,16
IF (IDEL(J).EQ.0) GO TO 50
IF (KC.NE.IDEL(J)) GO TO 50
IF (NSTAT(ICOUNT).NE.ICK(J)) GO TO 40
NSTAT(ICOUNT) = 0
GO TO 60

C *** IF THE SOUNDING DEPTH OF THE FILE DOES NOT AGREE WITH THE
C *** VALUE SPECIFIED, A MESSAGE IS WRITTEN. NO OTHER ACTION IS
C *** TAKEN. DELETED SOUNDING IS SET TO ZERO.
C
40 WRITE (61,140) KC,NSTAT(ICOUNT),ICK(J)
WRITE (61,150) KC,IC,LAT,LON,X,Y
GO TO 60
50 CONTINUE
60 IDPT(IC) = NSTAT(ICOUNT)
IC = IC+1
IF (IC.GT.25) GO TO 80
GO TO 30
70 ICOUNT = 0
IF (IC.LE.25) GO TO 20
C *** OUTPUT DISC FILE IS WRITTEN
C
80 IC = 1
WRITE (30) (FLAT(I),FLON(I),IDPT(I),I=1,25)
WRITE (61,160) (FLAT(I),FLON(I),IDPT(I),I=1,25)
DO 90 K=1,25
FLAT(K) = 0.0
FLON(K) = 0.0
IDPT(K) = 0
90 CONTINUE
GO TO 30
100 IF (IC.EQ.1) GO TO 110
WRITE (30) (FLAT(I),FLON(I),IDPT(I),I=1,25)
WRITE (61,160) (FLAT(I),FLON(I),IDPT(I),I=1,25)
110 END FILE 30
WRITE (61,170) KC
STOP

C
120 FORMAT (4F10.4)
130 FORMAT (16I5)
140 FORMAT (//5X,22HERROR: DEPTH ON RECORD,I5,1H=,I5,18H DEPTH ON UPDA
      $TE = I5)
150 FORMAT (10X,4I8,2F10.6)
160 FORMAT (2X,5(2F10.6,I5))
170 FCRMAT (10X,I5)
END

```

Program CREBAT

This program writes a tape in card image format to be used as input to the GPCP program. Additional soundings may be added to this tape in Mercator coordinates (see program CATMER).

Input

Permanent file written by program GEØRGR and cards containing additional soundings (optional).

Output

Card image tape with soundings to be used as input for GPCP program and line printer listing of the soundings.

Main Parameters

ISUPP	= Control variable for additional soundings;
XBASE YBASE	= Mercator coordinates of bathymetry origin;
IDUM	= one-dimensional array (blank), specifying 13 quantities as required by GPCP program; and
IC	= total number of points (used for planning the GPCP input).

Note

This program eliminates zero values created by program GEØRGR. However, these zero values are not "genuine" because they do not designate land. If some true zero values are to be added, it can be done at the end of this program.

PROGRAM CREBAT

C *** PROGRAM WRITES A TAPE, IN CARD IMAGE, TO BE USED AS INPUT
C *** TO THE GENERAL PURPOSE CONTOURING PROGRAM (GPCP).
C *** INPUT: PERMANENT FILE WRITTEN BY PROGRAM GEORGR IN
C *** MERCATOR COORDINATES (TO SCALE).
C *** OUTPUT: A TAPE, IN CARD IMAGE, CONTAINING X AND Y COORDINATES
C *** IN INCHES RELATIVE TO THE BATHYMETRY ORIGIN, SOUNDING VALUES
C *** AND 13 FLANKS AS REQUIRED BY THE GPCP PROGRAM.
C *** THERE IS ALSO PROVISION FOR ADDITIONAL POINTS TO BE ADDED
C *** TO THE AREA CONCERNED.
C
C DIMENSION GX(25), GY(25), NSTAT(25), IDUM(13)
C IDSI = 40
C
C *** ISUPP = 1 DIRECTS THE PROGRAM TO THE CARD READER TO READ
C *** IN ADDITIONAL POINTS.
C
C ISUPP = 0
C IC = 0
C
C *** XBASE AND YBASE ARE MERCATOR COORDINATES OF THE LOWER LEFT
C *** HAND CORNER OF THE BATHYMETRY FROM THE REFERENCE LATITUDE
C *** AND LONGITUDE (MID LATITUDE)
C
C XBASE = -0.281986
C YBASE = +0.785371
C CONV = 39.37
C DO 10 K=1,13
C 10 IDUM(K) = 1H
C
C *** INPUT DISC FILE IS READ IN
C
C 20 READ (IDSI) (GX(I),GY(I),NSTAT(I),I=1,25)
C IF (IFEEOF(IDSI).EQ.-1) GO TO 50
C 30 ICOUNT = ICOUNT+1
C IF (ICOUNT.GT.25) GO TO 40
C X = GX(ICOUNT)
C X = X+XBASE
C X = X*CONV
C Y = GY(ICOUNT)
C
C *** X AND Y ARE COORDINATES OF THE SOUNDINGS IN INCHES RELATIVE
C *** TO THE BATHYMETRY ORIGIN
C
C Y = Y+YBASE
C Y = Y*CONV
C DPT = NSTAT(ICOUNT)
C
C *** ZERO DEPTHS CREATED IN PROGRAM JAMES AND GEORGR ARE
C *** DELETED AND A CARD IMAGE TAPE IS WRITTEN
C
C IF (DPT.LE.0.0) GO TO 30
C WRITE (30,80) X,Y,DPT,IDUM
C WRITE (61,90) X,Y,DPT,IDUM
C IC = IC+1
C GO TO 30
C 40 ICOUNT = 0
C GO TO 20

```
C *** SUPPLEMENTARY POINTS ARE READ IN AT THIS POINT
C
 50 IF (ISUPP.EQ.0) GO TO 70
 60 READ (60,80) X,Y,DPT,IDUM
    IF (IFE OF(IDSI).EQ.-1) GO TO 70
    WRITE (30,80) X,Y,DPT,IDUM
    GO TO 60
C *** X=0.0,Y=0.0 AND DPT=0.0 WILL ACT AS END OF JOB IN
C *** THE GPCP PROGRAM
C
 70 X = 0.0
    Y = 0.0
    DPT = 0.0
    WRITE (30,80) X,Y,DPT,IDUM
    WRITE (61,90) X,Y,DPT,IDUM
    ENDFILE 30
    REWIND 30
    WRITE (61,100) IC
    STOP
C
 80 FORMAT (3F12.7,13A1)
 90 FORMAT (10X,3F12.7,13A1)
100 FORMAT (10X,I5)
END
```

Program CPL0T

The program name is used only on the job card of the GPCP program. All input parameters are described in the manual "GPCP. A GENERAL PURPOSE CONTOURING PROGRAM" (see NWRI Computer Applications Library). The reader is referred to section 2 "GPCP FORMULATION" with special emphasis on "Map Format" and "Contour Generation".

Input

Tape written by program CREBAT.

Output

Card deck with gridded depth values in E-format.

Main Parameters

XSCALE, YSCALE, X00, Y00

XMIN, XINC, XMAX

YMIN, YINC, YMAX

Described in GPCP Manual.

Note

XINC = YINC = cell size, XMIN, XMAX, YMIN, and YMAX determine the dimension of the bathymetry area (see Figure 1).

\$JOB,090,003CPL0T,4,3000,1000,,, R GOTTINGER
\$SCHED,CORE=64,607=1,TIME=4,SCR=6
\$*DEF(1,,24,607,WB40,0,0,H,I)
\$*DEF(0,,XQT,001/017,GP0P=ABS,01}
\$SOCR(A,10,30,420)
\$GP0P,XQT

JOB TO OBTAIN THE CONTOURED DEPTHS AT EACH GRID POINT
FLEX
SIZE 1.0 1.0 0.0 0.0 0.0 .2112 3.5904 0.0 .2112 5.491
EDIT 24
CNTL .05 .1 -1 7
CNTL (3F12.7,13A1)
CNTL 1 2 3
BEND
PRNT
PNCH
END

\$JOB,090,003CPLT,4,3000,1000,,, R GOTTINGER
\$SCHED,CORE=64,607=1,TIME=4,SCR=6
\$*DEF(t,,24,607,WB40,0,0,0,I)
\$*DEF(0,,XQT,001/017,GPCT=ABS,01,I)
\$SOCR(A,10,30,420)
\$GPCP,XQT

JOB TO OBTAIN THE CONTOURED DEPTHS AT EACH GRID POINT
FLEX
SIZE 1.0 1.0 0.0 0.0 0.0 .2112 3.5904 0.0 .2112 5.491
EDIT 24
CNTL .05 .1 -1 7
CNTL (3F12.7,13A1)
CNTL 1 2 3
BEND
PRNT
PNCH
END

Program INTDEP

The purpose of this program is to convert the card output of the GPCP program to integer format and sequence the cards. The card format is the same as that used by NWRI with no zone numbers added. Since the card format of the GPCP program cannot be altered, it was necessary to write this program to enable the user to display the bathymetry obtained on the line printer for editing, zone layout, and depth checks.

Input

Card deck produced by GPCP program.

Output

Card deck with integer depth values and sequence numbers.

Main Parameters

Self-explanatory.

Note

For the time being, the limits of the Do Loops have to be changed within the program.

```

PROGRAM INTDEP
*** THIS PROGRAM READS THE CARD OUTPUT OF THE GPCP PROGRAM,
*** PUNCHES ANOTHER CARD DECK AND SEQUENCES IT. THE LIMITS
*** ARE SET FOR THE AREA OF THE N.E. CORNER OF JAMES BAY.

DIMENSION ARRAY(5), IDEP(24,27)
L = 1

*** THERE ARE 24 GRID COLUMNS AND 27 GRID ROWS
DO 30 I=1,27
DO 20 J=1,16,5

*** THE DEPTHS ARE READ IN E FORMAT, 5 DEPTHS TO A CARD, AND
*** 4 CARDS TO A GRID ROW
READ (60,60) (ARRAY(L),L=1,5)
DO 10 M=1,5

*** ANY NEGATIVE DEPTHS (WHICH SIGNIFY LAND) ARE SET TO ZERO
IF(ARRAY(M).LT.0.0)ARRAY(M) = 0.0

*** THE DEPTH IS CHANGED TO AN INTEGER AND STORED BY
*** GRID COLUMN AND ROW
INDEX = J+M-1
IDEPE(INDEX,I) = IFIX(ARRAY(M)/10.+0.5)
10 CONTINUE
20 CONTINUE
30 CONTINUE

*** M IS THE CARD SEQUENCE NUMBER
M = 0

*** THE GRID ARRAY OF DEPTHS IS WRITTEN ONTO THE PRINTER AND THE
*** CARD PUNCH
DO 50 L=1,27
DO 40 K=1,24,12
M = M+1
N = K+1
WRITE (61,70) (IDEPE(I,L),I=K,N),M
WRITE (62,80) (IDEPE(I,L),I=K,N),M

*** THERE ARE 12 DEPTHS TO A CARD, FOLLOWED BY THE CARD SEQUENCE
*** NUMBER. EACH GRID ROW STARTS ON A NEW CARD
40 CONTINUE
50 CONTINUE
STOP

60 FORMAT (5X,5(1X,E13.6))
70 FORMAT (1H0,12I6,4X,I4)
80 FORMAT (12I6,4X,I4)
END

```

Program ADDZON

The purpose of this program is to add zone numbers to an existing bathymetry.

Input

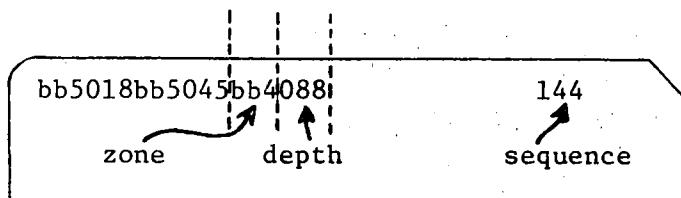
Card deck produced by program INTDEP.

Output

Punched card deck with integer and zone numbers. This card deck is in the proper format to create a permanent file for the bathymetry, except for header records and scale factors. For zone boundaries following along meridians and/or parallels, program ADDZON can be used. In more complicated zone configurations, program ZONSEL has to be used (see Introduction). Figure 2 gives an example of a zone layout of the northeast corner of James Bay (George River) that was used by ADDZON.

Main Parameters

IDEP = Two-dimensional array for bathymetry;
Do Loop 20 limits the number of rows; and
Do Loop 10 reads one complete row (12 depths at a time) of the bathymetry.



Input Card for A Bathymetry

```

C      PROGRAM ADDZON
C
C      *** THIS PROGRAM PUNCHES THE ZONE NO. FOLLOWED BY THE INTEGER
C      *** DEPTH FOR EACH GRID CELL FOR THE AREA OF THE N.E. CORNER
C      *** OF JAMES BAY.
C
C      DIMENSION IDEP(24,27)
C      DO 20 L=1,27
C      DO 10 K=1,24,12
C      N = K+11
C
C      *** THE INTEGER DEPTHS PUNCHED BY PROGRAM INTOEP ARE READ IN
C
C      READ (60,90) (IDEP(I,L),I=K,N),M
C      10 CONTINUE
C      20 CONTINUE
C      DO 60 L=1,27
C      DO 50 K=1,24
C
C      *** THE ZONE OF EACH DEPTH IS DETERMINED BY ITS
C      *** GRID COLUMN AND ROW
C
C      IF (IDEP(K,L).EQ.0) GO TO 50
C      IF (L.GT.15) GO TO 30
C      IF(L.GE.8)NZONE = 2
C      IF(L.LT.8)NZONE = 3
C      GO TO 40
C      30 NZONE = 1
C
C      *** THE ZONE NUMBER IS PLACED IN FRONT OF THE 3-DIGIT DEPTH
C
C      40 IDEP(K,L) = NZONE*1000+IDEP(K,L)
C      50 CCNTINUE
C      60 CONTINUE
C      M = 0
C
C      *** THE ZONES AND DEPTHS ARE PUNCHED IN THE SAME FORMAT THAT THE
C      *** INTEGER DEPTHS WERE READ IN
C
C      DO 80 L=1,27
C      DO 70 K=1,24,12
C      M = M+1
C      N = K+11
C      WRITE (61,100) (IDEP(I,L),I=K,N),M
C      WRITE (62,110) (IDEP(I,L),I=K,N),M
C      70 CONTINUE
C      80 CONTINUE
C      STOP
C
C      90 FORMAT (12I6,4X,I4)
C      100 FORMAT (1H0,12I6,4X,I4)
C      110 FORMAT (12I6,4X,I4)
C      END

```

Program PERMA

The purpose of this program is to create a bathymetric disc file for a particular area (zone) from a card deck. There is a program attached to each card deck, and all of these programs are essentially the same, except for the area limits. As mentioned earlier, all updates and changes are made on these card decks and any sub-bathymetry created will reflect on these decks.

Main parameters

ICODE = Not used presently (reserved for multiple input);
IMAX = number of cells per column;
JMAX = number of rows;
IZMAX = maximum number of zones;
DLAT = cell size in km at mid latitude;
SCALE = one-dimensional array (JMAX) with a scale factor for each row; and
M = chart scale.

Output of these programs is a binary disc file having a header record and one row of bathymetry values per binary write.

PROGRAM PERMA

```
*** THIS PROGRAM WRITES A PERMANENT FILE FOR THE GEORGE RIVER
*** ZONE BATHYMETRY. INPUT IS A CARD DECK CONTAINING THE ZONE
*** BATHYMETRY OF GEORGE RIVER. UPDATE OF THE BATHYMETRY
*** VALUES WILL BE DONE ON THE INPUT DECK.
*** THE PERMANENT FILE CREATED IS USED AS INPUT TO THE HEAT AND
*** FRESHWATER BUDGET PROGRAM(SALT)

C DIMENSION IBO(24), ITITLE(20), SCALE(32)

C *** THE HEADER RECORD ITITLE CONTAINS DIMENSIONS OF THE
C *** BATHYMETRY (IMAX, JMAX), THE NUMBER OF ZONES (IZMAX),
C *** CHART SCALE (M), AND SCALE FACTORS FOR EACH ROW OF THE BATHYMETRY
C *** AS WELL AS THE CELL SIZE (DLAT IN KM**2) AT CHART ORIGIN.

C READ (60,30) ITITLE
C READ (60,20) ICODE,JMAX,IMAX,IZMAX,DLAT,M
C *** READ IN THE SCALE FACTORS FOR THE CELLS FROM CARDS
C
C READ (60,40) SCALE
C WRITE (20) ITITLE,ICODE,JMAX,IMAX,IZMAX,DLAT,M,SCALE
C WRITE (61,50) ITITLE
C WRITE (61,60) IMAX,JMAX,IZMAX,M,DLAT
C WRITE (61,70) SCALE
C DO 10 K=1,25
C READ (60,80) (IB0(I),I=1,24)
C WRITE (20) (IB0(L),L=1,24)
10 CCONTINUE
C ENDFILE 20
C STOP

C
20 FORMAT (I2,3X,3I5,F6.2,I10)
30 FORMAT (20A4)
40 FORMAT (8F10.7)
50 FORMAT (10X,20A4/)
60 FORMAT (10X,3I5,I10,F10.2/)
70 FORMAT (10X,8F10.7)
80 FORMAT (12I6)
END
```

Program HUDMAP

The purpose of this program is to display the zone number and depth of each cell for a given bathymetry on the line printer. The dimensions of this program have been set for the James Bay-Hudson Bay zone bathymetry, and the program is used in this report as an example only. There is another display program of this nature available, to be presented in another report, which will display a bathymetry by specifying the number of cards per row and the number of blank spaces between the rows. Sequence numbers for both rows and columns are also displayed. Since bathymetric values are conventionally read starting at the bottom row, one row at a time, the entire array has to be stored to display a map (see Figures 4 and 5).

Input

Card deck containing zone bathymetry.

Output

Line printer map of zone layout and cell depths for the zone bathymetry.

Main Parameters

IDEPZ = Two-dimensional array containing zone bathymetry;
NZ = two-dimensional array containing zone numbers;
ND = two-dimensional array containing depths; and
L = row delimiter.

```

PROGRAM HDMAP
C
C *** THIS PROGRAM PRINTS TWO MAPS OF HUDSON BAY, ONE SHOWING THE
C *** ZONE FOR EACH GRID CELL, AND THE OTHER SHOWING THE DEPTHS
C
C      DIMENSION IDEPZ(46,63), NZ(46,63), ND(46,63)
C      WRITE (61,80)
C      DO 40 L=1,63
C      DO 20 K=1,46,12
C      N = K+11
C
C *** THE DECK PRODUCED BY PROGRAM ADDZON IS READ IN. IT CONTAINS
C *** THE INTEGER DEPTH AND ZONE OF EACH CELL
C
C      READ (60,30) (IDEPZ(I,L),I=K,N).M
C      20 CONTINUE
C      DO 30 K=1,46
C
C *** THE FIRST THREE DIGITS CONTAIN THE ZONE AND THE LAST THREE
C *** CONTAIN THE DEPTH
C
C      NZ(K,L) = IDEPZ(K,L)/1000
C      ND(K,L) = MOD(IDEPZ(K,L),1000)
C
C *** IF EITHER THE ZONE OR THE DEPTH IS 0, THIS INDICATES LAND,
C *** SO THE ZONE AND DEPTH ARE SET TO -10000. WHEN PRINTED, THIS
C *** WILL PRODUCE *
C
C      IF(NZ(K,L).EQ.0)NZ(K,L) = -10000
C      IF(ND(K,L).EQ.0)ND(K,L) = -10000
C      30 CONTINUE
C      40 CONTINUE
C
C *** THE ZONE MAP IS PRINTED. THE ROW ORDER MUST BE REVERSED,
C *** SINCE THE ROWS WERE READ FROM THE BOTTOM TO THE TOP OF THE BAY
C
C      L = 63
C      WRITE (61,100)
C      50 WRITE (61,110) (NZ(K,L),K=1,44)
C      L = L-1
C      IF (L.GT.0) GO TO 50
C
C *** THE DEPTH MAP IS PRINTED. SINCE IT IS TOO WIDE TO PRINT ON
C *** ONE PAGE, IT IS SPLIT UP
C
C      L = 63
C      WRITE (61,100)
C      60 WRITE (61,120) (ND(K,L),K=1,30)
C      L = L-1
C      IF (L.GT.0) GO TO 60
C
C *** THE SECOND PART OF THE DEPTH MAP IS PRINTED
C
C      L = 63
C      WRITE (61,100)
C      70 WRITE (61,130) (ND(K,L),K=21,46)
C      L = L-1
C      IF (L.GT.0) GO TO 70
C      STOP
C
C      80 FFORMAT (1H0)
C      90 FFORMAT (12I6,4X,I4)
C      100 FFORMAT (1H1)
C      110 FFORMAT (1H0,4+I3)
C      120 FORMAT (/1H0,5X,30I4)
C      130 FFORMAT (/1H0,10X,2E14)
C      END

```

Program CATMER

This program converts geographic coordinates to Mercator coordinates at scale.

Input

Cards with geographic coordinates.

Output

Listing of geographic coordinates (input) and their respective Mercator coordinates at scale.

Main Parameters

LAT,LATM = Degrees and minutes of mid latitude;

LONG,LONGM = degrees and minutes of reference longitude; and

X,Y = Mercator coordinates at scale in metres.

For theory and documentation, see the charting sub-system.

```

STOP
C      PROGRAM CATMER
C      *** PROGRAM CONVERTS GEOGRAPHIC COORDINATES TO MERCATOR
C      *** COORDINATES AT CHART SCALE (CLARKE 1866).
C
K=60
L=61
DEG=.4848136811E-5
RAD=57.295779513
GE1=.67686579973E-2
BLN=2.718281828
PI2=1.570796327
A=6378206.4
C
C      *** REFERENCE LATITUDE (MID LATITUDE), LONGITUDE AND
C      *** CHART SCALE ARE READ IN.
C
10  READ(KR,10) LAT,LATM,LON,LONM,M
    FFORMAT(4I5,10X,110)
    OL=(LAT*3600 + LATM*60)*DEG
    ON=(LON*3600 + LONM*60)*DEG
    SO=SIN(OL)
    CO=COS(OL)
    S02=SO*SO
C
C      *** LATITUDE AND LONGITUDE OF THE INDIVIDUAL POINTS ARE READ IN.
C      *** PROGRAM ACHIEVES PLOTTING ACCURACY.
C
1  READ(KR,30) ILA,ILAM,FS,ILO,ILOM,GS
30  FFORMAT(2(2I3,F7.3,1X))
    IF(IFEOF(60).EQ.-1) GO TO 55
    AL=(ILA*3600.+ILAM*60.+FS)*DEG
    AO=(ILO*3600.+ILOM*60.+GS)*DEG
    EX1=SQRT(1.-GE1*S02)
    C=(A*CO)/(M*EX1)
    X0=OL-(.0033939028*SIN(2.*OL)-0.0000047997*SIN(4.*OL))
    XI=AL-(.0033939028*SIN(2.*AL)-0.0000047997*SIN(4.*AL))
    X=C*(ON-AO)
    ART=(PI2-XI)*0.5
    BAT=(PI2-X0)*0.5
    TP=(COS(ART)/SIN(ART))/(COS(BAT)/SIN(BAT))
    Y=C*ALOG(TP)
    WRITE(61,40) ILA,ILAM,FS,ILO,ILOM,GS,X,Y
40  FFORMAT(10X,2(2I3,F7.3,1X),5X,2F11.7)
    GO TO 1
55  STOP
    END

```

SUBROUTINE MERCAT

This subroutine is part of the charting sub-system and is used to calculate Mercator coordinates X and Y of geographic coordinates with respect to chart scale M and origin $\emptyset L$ and $\emptyset M$. Subsequently, it can be used to assign cell numbers to those Mercator coordinates. The cells are numbered starting from the lower left-hand corner of the bathymetry. This corner is located C_1 cell units up (or down) and C_2 cell units right (or left) from the chart origin, the intersection of reference latitude and reference meridian.

For theory and documentation, see the charting sub-system.

SUBROUTINE MERCAT (X,Y,IO,JO,LAT,LONG)

*** S/R CONVERTS GEOGRAPHIC COORDINATES TO MERCATOR COORDINATES AT
 *** CHART SCALE AND SUBSEQUENTLY TO CELL NUMBERS IO AND JO.
 *** GE1,BLN, AND A ARE GEODETIC CONSTANTS FOR CLARKE SPHEROID 1866.
 *** CONSTANTS TO EVALUATE XO AND XI WERE PRECOMPUTED. THIS VERSION
 *** OF MERCAT IS USED TO ASSIGN CELL NUMBERS TO PROFILE STATIONS.
 *** REF.: US COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO 67.

***** DESCRIPTION OF VARIABLES *****

*** OL,ON = LATITUDE AND LONGITUDE OF CHART ORIGIN IN DECIMAL DEG.
 *** DLAT = BATHYMETRY CELL SIZE AT CHART ORIGIN (KM)
 *** FLAT = GRID SIZE AT CHART SCALE
 *** X,Y = MERCATOR COORDINATES AT CHART SCALE
 *** C1,C2 = DIFFERENCE IN CELLS BETWEEN CHART AND BATHYMETRY ORIGIN
 *** M = NATURAL SCALE OF CHART
 *** XO,XI = CONFORMAL LATITUDES

COMMON /MER/ M,OL,ON,C1,C2,DLAT

*** THE PARAMETERS IN COMMON BLOCK /MER/ ARE CHART DEPENDENT
 *** AND WILL HAVE TO BE CHANGED FOR EACH CHART

```
DATA IP/1/
IF (IP.GT.1) GO TO 20
GE1 = .67686579973E-2
BLN = 2.718281828
A = 6378206.4
DEG = .0174532925
RAD = 57.295779513
PI2 = 1.570796327
```

*** IF SUBROUTINE IS ONLY USED TO CALCULATE X AND Y, DLAT IS SET
 *** TO 10.0 BY DEFAULT

```
IF(DLAT.LE.0.0) DLAT=10.0
FLAT = (DLAT/M)*1000.
OL = OL*DEG
ON = ON*DEG
SO = SIN(OL)
CO = COS(OL)
SO2 = SO*SO
EX1 = SQRT(1.-GE1*SO2)
C = (A*CO)/(M*EX1)
XO = OL-(.0033939028*SIN(2.*OL)-0.0000047997*SIN(4.*OL))
20 ILAT = LAT*0.001
ALAT = (LAT-ILAT*1000)*0.1
AL = (FLOAT(ILAT)+ALAT/60.)*DEG
XI = AL-(.0033939028*SIN(2.*AL)-0.0000047997*SIN(4.*AL))
ILON = LONG*0.001
DLON = (LONG-ILON*1000)*0.1
AO = (FLOAT(ILON)+DLON/60.)*DEG
X = C*(ON-AO)
ART = (PI2-XI)*0.5
BAT = (PI2-XO)*0.5
TP = (COS(ART)/SIN(ART))/(COS(BAT)/SIN(BAT))
Y = C* ALOG(TP)
```

*** MERCATOR COORDINATES X AND Y ARE CONVERTED TO
 *** CELL NUMBERS IO AND JO

```
IO = (X/FLAT)+C1
JO = (Y/FLAT)+C2
IP = IP+1
RETURN
END
```

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