社会開発調査部報告書

FEDERAL DEPARTMENT OF WATER RESOURCES
MINISTRY OF AGRICULTURE,WATER RESOURCES
AND RURAL DEVELOPMENT
FEDERAL REPUBLIC OF NIGERIA

THE STUDY FOR GROUNDWATER DEVELOPMENT IN SOKOTO STATE

VOLUME 4
SUPPLEMENTARY REPORT 2

JULY,1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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TABLE OF CONTENTS

1. DATA BASE

2. GROUNDWATER SIMULATION

3. QUASI-THREE DIMENSIONAL MULTI AQUIFER MODEL BY FINITE ELEMENT METHOD

FIGURES AND TABLES

1. DATA BASE

Introduction

This database system consists of two databases. One is the hydrogeological database, to manage data related to the conditions of hydrology, meteorology, and hydrogeology. The other is the literature database, to manage literature, such as reports, maps, and other documents, related to groundwater development.

The main functions of the systems involve data entry, data retrieval, and the printing of data. Besides these, functions to search the data, to make graphs, and to display the locations of maps are also presented.

********** N O T E **********

Computers are very sensitive. So that please pay attention to:

1. Read the operating manuals before operaing the system.

2. Keep the computer room clean.

3. Cover the computer system with the vinyl covers at all times, except when being used.

4. Make sure that power is supplied only through the stabilizer.

5. When connecting connectors, do it gently.

6. The RS232C connectors are especially sensitive. Be sure that a matched right side up when connecting.

7. Never fold or bend the floppy disks. Never touch the magnetic part of the floppy disks.

8. When inserting a floppy disk in a floppy disk drive, do it gently.

9. Always store the floppy disks in the floppy disk case.

10. The floppy disk drives should be cleaned with the head cleaning diskette every two months. The cleaning diskettes, with instructions, are stored in the carton under the computer table.

11. Never place anything except paper on the digitizer.

12. Keep the floppy disks away from the plotter.

--- COMPUTER OPERATION ---

1 Starting up the computer

(1) General procedures

Please follow the following procedures.

1. Turn on the air conditioner.
2. Remove the vinyl cover from the computer.
3. Turn on the wall socket switch.
4. Push on the stabilizer switch.

(2) Starting up from the hard disk

1. Make sure the floppy disk drives are unlocked.
2. Turn on the computer power switch.
3. Wait about 10 seconds.
4. When a message in Japanese letters appears, push RETURN.
5. The M-MAIN menu will appear.
6. To enter a command, type in the name of the command and push RETURN.

```
        MAIN MENU  ( Directory  A>¥  )   M-MAIN
      ENTER THE NAME OF THE COMMAND
      DBASE    :  DATA BASE SYSTEMS
      BASIC    :  BASIC PROGRAM
      FORTRAN  :  FORTRAN PROGRAM
      OPTION   :  OPTIONAL PROGRAMS
      WSR      :  WORD STAR
      BACKUP   :  TO BACK UP FILES
   (Ex.  A>DBASE[RET])
```

(3) Starting up from the floppy disk drive

Floppy disks, prepared for your use, are stored in the floppy disk case labeled DATA BASE. They are:

```
Label : JICA DB [ No. % ]   Hydrogeological D.B
              * % = A, B, C, D, E, LOTUS
Label : JICA DB [ No. L1 ]  Literature D.B
              [ No. L2 ]       - do -

Label : JICA BASIC          BASIC PROGRAMMING
Label : JICA FORTRAN        FORTRAN PROGRAMMING
Label : JICA WS             WORD STAR
Label name : JICA OPTION         OPTIONAL PROGRAMS
```

- Turn on the computer power switch.
- Insert the selected floppy disk in the upper floppy disk drive, and lock the drive.
- Follow the instruction displayed on the screen.

(4) Turning off the computer

1. Be sure printing or plotting is complete.
2. Return to the M-MAIN menu.
3. Unlock the floppy disk drives.
4. Push the STOP key.
5. Turn off the computer power switch.
6. Turn off the stabilizer switch.
7. Turn off the wall socket switch.
8. Cover the computer with the vinyl sheet.
7. Turn off the air conditioner.

2 Backup

For the safty of the data, you are recommended to make back-ups at least monthly. The floppy disks used to start up the systems from the floppy disk drives are also used to back up the files stored in the hard disk. To do so, follow thses procedures.

1. Select M-BACKUP from the MMAIN menu. The M-BACKUP menu will appear.
2. Insert the specified floppy disk in the upper floppy disk drive, type in the appropriate command, and push RETURN.

3 Emergencies

(1) Power failure

In the event of power failure, the stabilizer will continue to supply power to the computer for about eight minutes. However, you must quit your job and shut down the computer immediately, eve if you are in the middle of printing or plotting, otherwise your data will be lost or damaged.

(2) Frozen controls

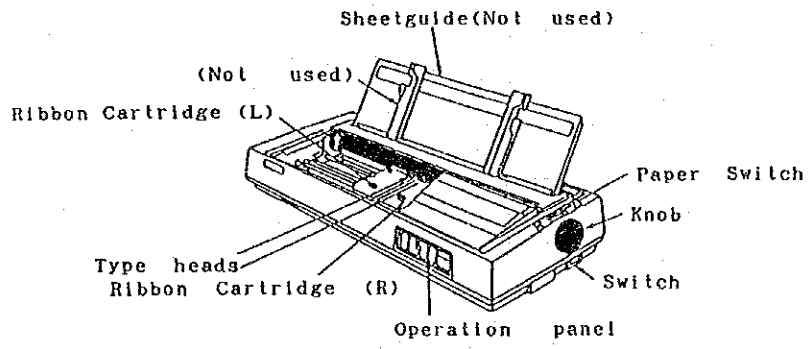
If the computer freezes, that is, if the computer will not accept any any command or key entry, unlock the floppy disk (if in use), push the STOP key, and then the RESET button, located to the lower-left on the front of the machine.

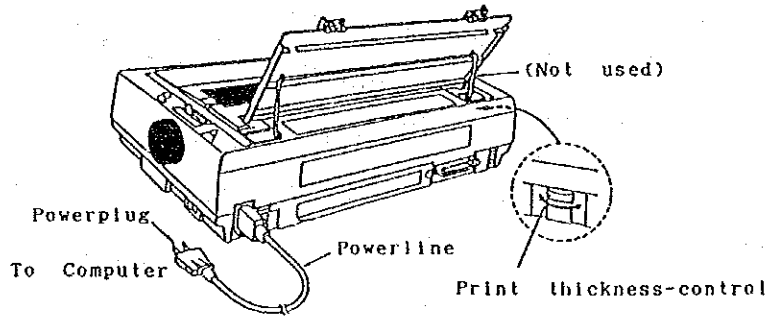
--- PRINTER OPERATION ---

1. Turning on the printer

The printer will turn on automatically upon turning on the power switch of the computer without turning on the power switch of the printer, if the printer is properly connected to the computer.

If the printer is not connected, plug the printer power line into the outlet located at the back of the computer, then turn on the printer power switch.





2. Loading paper

- Insert the paper.
- Set the paper switch to the A side.
- Turn the knob to feed the paper until the end of the paper emerges.
- Set the paper switch to the B side.
- Pull out the end of the paper gently and adjust the paper position.
- Set the paper switch to the A side again.
- Turn the knob to feed the paper until the papers perforated line is just above the ribbon cartridge.

3. Operation panel switches

(1) SEL

If the green light on the switch is on, the printer is ready to print out. If the light is off, the printer is not ready. Push the switch to turn the light on or off.

(2) L.F

This switch is in effect only if the SEL light is off.

One push of this switch feeds the paper one line. If held down, the paper feeds continuously.

(3) T.O.F

This switch is in effect only if the SEL light is off.

A push of this switch feeds the paper one page.

(4) FINE

If the orange light on the switch is on, the speed of the printer is slow, but characters are printed fine. If the light is off, the speed is fast, but the characters are of draft quality. Push the switch to turn the light on and off.

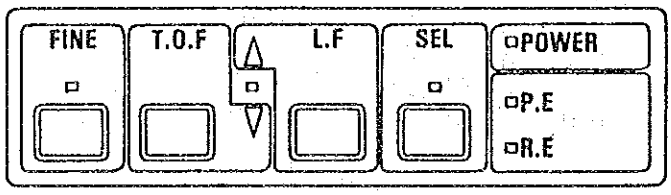
4. Error sign on the operation panel

(1) P.E

If the red light to the left of P.E is on, the paper is jammed or no paper exists.

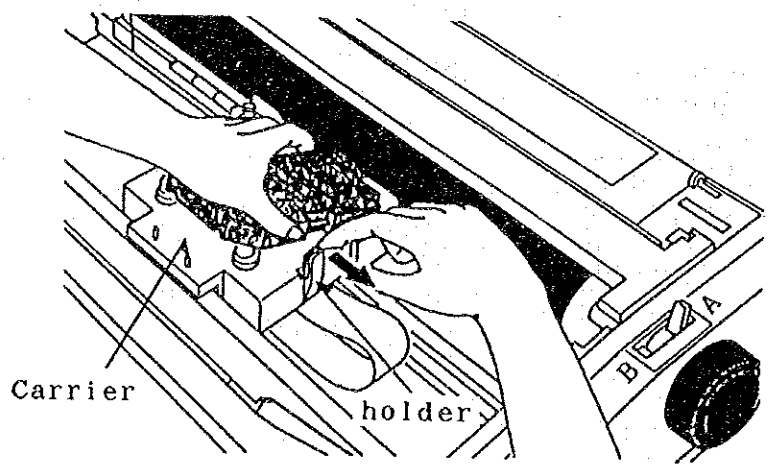
(2) R.E

If the red light to the left of R.E is on, it indicates the ink-ribbon is jammed or the ribbon is exhausted.

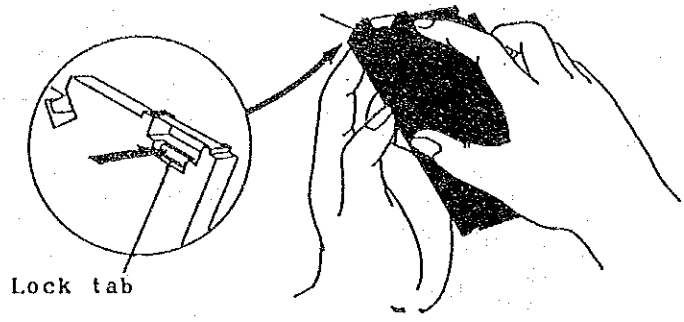


5. How to change a ribbon cartridge.

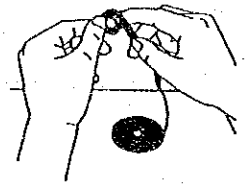
- Be sure the power is off.
- Move the ribbon cartridge carrier to the center position by hand.
- Push the holder gently outwards, and take out the ribbon cartridge.

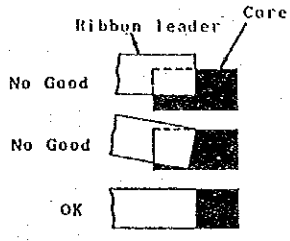


- Check the cancellation of the numbers on the R side of a cartridge to see how many times the ribbon has been changed. A cartridge must not be used for more than 10 changes of the ribbon.
- Hold the cartridge with its R side up.
- Gently open the cartridge with pushing the lock-tab with the index finger of your left hand.

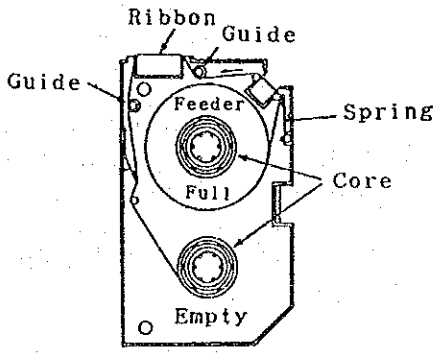


- Remove used ink-ribbon.
- Remove the ribbon from the empty core.

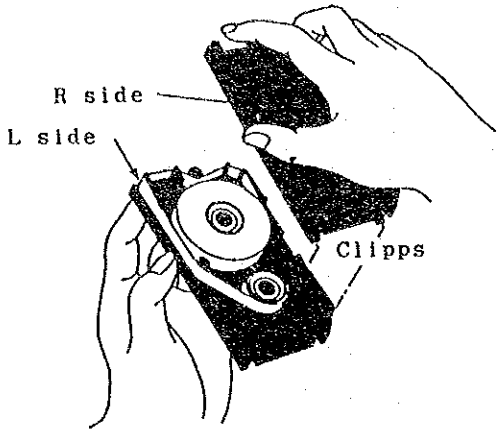


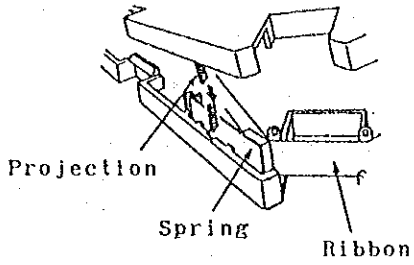


- Prepare a new ink-ribbon and spring.
- Replace the used spring with a new spring.
- Detach the transparent leader of the ink-ribbon.
- Place the ribbon leader on the empty core correctly.
- Set the full-ribbon (supply) core on the feeder.
- Thread the ribbon correctly along the transport path to the empty (take-up) core.
- Turn the empty core two revolutions counter-clockwise.

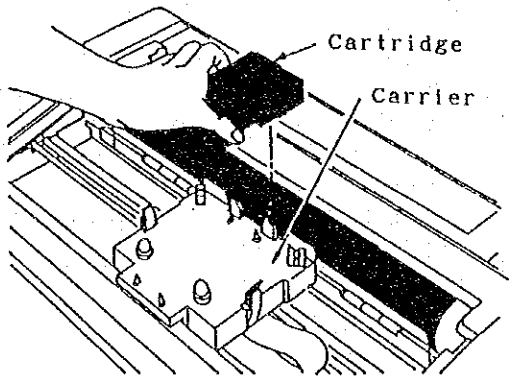


- Rejoin the two halves of the cartridge and press to close.
  Note. Be sure the projections fit between the spring and the wall of the cartridge.
- Turn the core in the direction of the arrow to take up slack.





- Place the cartridge on the carrier with its L side up if on the left, or R side up if on the right.
- Push the cartridge in gently to set it in position.



6. Cleaning the type head

If the printed characters becomes blurred, clean the printer type heads with the cleaning papers, which are stored in the carton under the computer table. The printer must be turned off, and the ribbon cartridge carrier should be moved gently by hand to right or left end of the rail, so that the printer type head appears and is cleaned easily.

--- PLOTTER OPERATION ---

!! Caution !!

Keep floppy disks away from the plotter panel and the pen stock. These magnetic parts of the plotter can damage the memory on a floppy disk.

1. Setting up the plotter
   1. Make sure the plotter power switch is off.
   2. Connect the interface cable of the plotter to the RS232C interface socket of the computer.
   3. Turn on the plotter power switch.

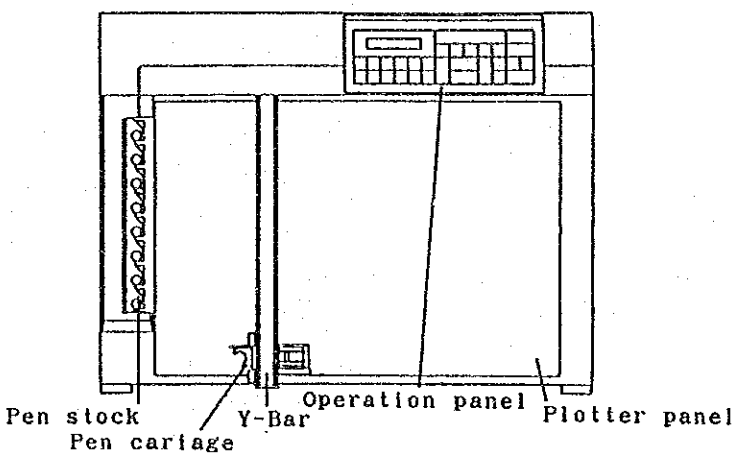
   The pen carriage will set itself to its initial position. Wait until it stops. The plotter is now ready.

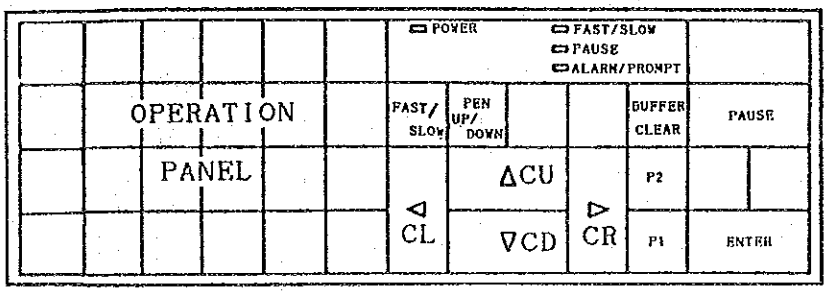
2. Set switch parameters for the plotter

   Prior to run a plotter program, enter the following command.

   A > SWITCHP

   Once given this command, you do not have to do it again unless you restart the computer or later enter the command SWITCHD.

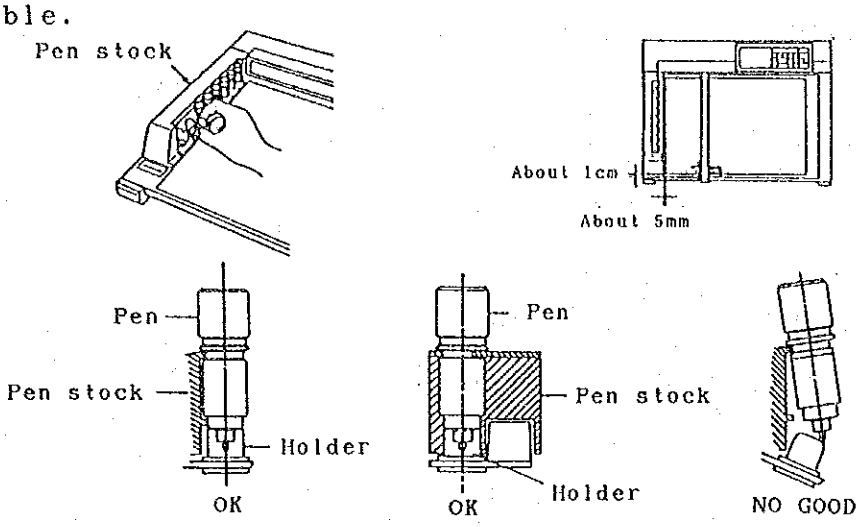




3. Pen set

1. Remove the plotter pen caps.
2. Place the plotter pens in the pen stock. Make sure the heads of the pens are correctly set in the pen-head holders.

- Spare pens are stored in the carton under the computer table.



4. Paper

1. Place a sheet of paper on the plotter panel. (Slide the paper in from the right side of the Y-bar.) Paper for the plotter is stored in the carton under the computer table.
2. Position the paper with a space of about 10mm from the bottom and about 5mm from the left end of the plotter panel.
3. Fix the paper in place with the magnetic steel strips.
4. Smooth the paper out flat.

5. To turn off the plotter

1. Turn off the power switch of the plotter.
2. Remove plotter pens from the pen stock.
3. Cap the pens.

6. Additional functions

(1) Reset

If you want to quit drawing, push the ENTER key and CU key on the operating panel of the plotter simultaneously.

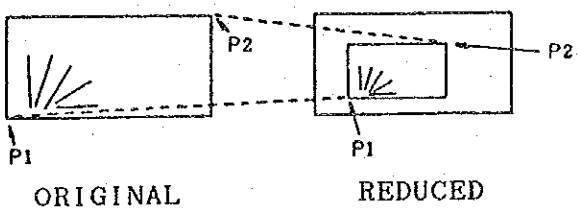
(2) Pause

If you want to stop drawing temporarily, push the PAUSE key on the operating panel of the plotter. Push the PAUSE key again to resume drawing.

(3) Manual setting of drawing scale

The scale of the drawing is automatically set to maximum given upon turning on the plotter. If you want to reduce the size of the drawing, follow these steps.

1. Push the P1 key. The pen carriage will move and stop at the original upper-right corner of the drawing field.
2. Move the pen carriage with the CU, CD, CL, or, CR keys to the new upper-right corner of the drawing field.
3. Push the ENTER key.
4. Push the P2 key. The pen carriage will move and stop at the original lower-left corner of the drawing field.
5. Move the pen carriage with the CU, CD, CL, or, CR key to the new lower-left corner of the drawing field.
6. Push the ENTER key.



--- DIGITIZER OPERATION ---

!! CAUTION !!
Do not put anything except paper on the digitizer panel.

1. Set switch parameters for the digitizer
   Prior to run a digitizer program, you need to enter the following command.
   A > SWITCHD
   Once given this command, you do not have to do it again unless you restart the computer or later enter the command SWITCHP.

2. Setting up the digitizer
   1. Uncover the digitizer and be sure the digitizer is off.
   2. Connect the interface cable of the digitizer to the RS232C interface socket of the computer.
   3. Turn on the digitizer power switch.

3. To turn off the digitizer
   1. Turn off the digitizer power switch.
   2. Cover the digitizer with the vinyl cover.

--- SOFTWARE ---

1. Software menu

Upon starting up the computer, the following software menu appears on the screen.

```
          MAIN MENU  ( Directory  A>¥ )     M-MAIN
         ENTER THE NAME OF THE COMMAND
      DBASE      :  DATA BASE SYSTEMS
      BASIC      :  BASIC PROGRAM
      FORTRAN    :  FORTRAN PROGRAM
      OPTION     :  OPTIONAL PROGRAMS
      WSR        :  WORD STAR
      BACKUP     :  TO BACK UP FILES
   (Ex.  A>DBASE[RET])
```

The functions of the command are:

DBASE : To maintain the hydrogeological data base and the literature data base
BASIC : To create BASIC programs
FORTRAN : To create FORTRAN programs
OPTION : To run optional programs
WSR : To create documents with Word Star
BACKUP : To back up existing files from the hard disk

To enter a command, type in the name of the command and push RETURN.

!!! NOTE !!!

If you are going to use the digitizer, enter SWITCHD before selecting from M-MAIN.

A > SWITCHD [RET]

If you are going to use the plotter, enter SWITCHP before selecting from M-MAIN.

A > SWITCHP [RET]

2. DBASE

An operation manual for the data base systems has been prepared. Please refer to that manual for details.

3. BASIC

Upon entering BASIC, the sub-menu (M-BASIC) appears.

```
  BASIC PROGRAM (Directory A>¥BASIC)        M-BASIC
  ENTER THE NAME OF COMMAND YOU WANT TO SELECT
 N88BASIC : TO GO TO BASIC FIELD
 SYSTEM   : TO RETURN TO MS-DOS
 END      : TO RETURN TO THE MAIN MENU
 Note; SYSTEM command is valid only in the BASIC field.

Type in the name of the command you want to select and  push RETURN.
```

Type in N88BASIC and push RETURN to create a BASIC program, the screen will change to the BASIC mode.

When operations in the BASIC mode complete, enter SYSTEM, and the screen will go back to the MS-DOS mode.

When complete, enter END to go back to the M-MAIN menu.

4. FORTRAN

Upon entering FORTRAN, the sub-menu (M-FORTRAN) appears.

```
  FORTRAN PROGRAM (Directory A>¥FORTRAN¥WORK) M-FORTRAN
  ENTER THE NAME OF THE COMMAND YOU WANT TO SELECT
EDIT     : TO CREATE OR RENEW A DATA OR PROGRAM
           Extention of Fortran program file must be .FOR.
           Extension of data file should be .DAT.
           In  order  to avoid file name confusion,  file
           names should begin with the letter "J".
           Ex. A>EDIT JTEST.FOR --: In case of program file
           A>EDIT JDATA.DAT --: In case of data file
EDITHELP : INSTRUCTION TO USE THE EDITTER
           To print out the instruction A>PRINT EDIT.HLP
FORT     : TO COMPILE AND LINK A FORTRAN PROGRAM
           (Fortran compiler and linker software  will  auto-
            matically make an objective and executable file.
            These files have same name but extentions are
            .OBJ and .EXE respectively.)
            Ex. A>FORT JTEST (Do not put Extention.)
(file name) : TO EXECUTE A FORTRAN PROGRAM
            Ex. A>JTEST (Do not put Extention.)
HELP     :  WHEN YOU NEED INSTRUCTION
END      :  TO RETURN TO THE MAIN MENU

  Type in the name of the command you want to select and  push RETURN.
```

The EDIT command is used to create a program or data file. Give the file name behind EDIT with a space as instructed in the menu. Operating instructions for the editor are found in the Appendix. These instructions will appear on the screen if you enter the command EDITHELP. Furthermore, you can print out the instructions with the command PRINT EDIT.HLP.

If it recommended that you start every file name with the letter "J", for the easy identification. An extention should be given to every file related to Fortran programming. A Fortran program file must have an extention of ".FOR". A data file should have ".DAT". at the beginning.

A Fortran program must be compiled and linked to create an executable file. The FORT command performs both functions. Type a Fortran file name to be compiled and linked behind FORT, as instructed in the menu. The file name must not be given an extention.

If errors are found in your program, the line number and an error message will appear on the screen. You need to correct the program.

When the above processes are complete, an executable file is created. Enter the name of the Fortran program, without extention, to execute the program.

The HELP command is used to display the M-FORTRAN menu on the screen.

WHEN complete, enter END to go back to the M-MAIN menu.

5. OPTION

Upon entering OPTION, the sub-menu (M-OPTION) appears.

```
        OPTION PROGRAMS (DIRECTORY A:¥OPTION)        M-OPTION
        ENTER THE NAME OF THE PROGRAM
 AREA  :  TO MEASURE AREA AND LEGTH WITH THE DIGITIZER
 THEIS :  TO DRAW THEIS STANDARD CURVE ON THE PLOTTER
 MWELL :  TO CALCULATE DRAWDOWN CAUSED BY MULTI-WELL SYSTEM
 WRECO :  TO CONVERT RECORD OF AUTOMATIC WATER LEVEL RECORDER INTO
          WATER LEVEL IN MEAN SEA LEVEL (RECORD WILL BE CORRECTED.)
  SARDA :   TO RETRIEVE RECORDS OF BOREHOLE DRILLED BY SARDA
  END   :   TO RETURN TO THE MAIN MENU

  Type in the name of the program you want to select and  push RETURN.
```

Instructions on the program will appear.

The digitizer must be set up before selection of AREA. The plotter must be set up before selection of THEIS. To set these up, refer to the section in this manual on the digitizer and plotter manual.

When complete, enter END to go back to the M-MAIN menu.

Examples--

1. To correct automatic water level records and to convert them to daily water level.

1.	Turn on computer	<-- Refer to the section on computer operation
2.	Set up printer	<-- Refer to the section on printer operation
3.	Enter OPTION	<-- To go to M-OPTION menu
4.	Enter WRECO	<-- To run WRECO
5.	Enter data	<-- Follow the program instructions
6.	Take not the results	<-- The results will be printed out
7.	Enter END	<-- To return the M-MENU
8.	Enter DBASE	<-- To go to the data base system
9.	Enter 1	<-- To select the hydrogeological D.B
10.	Push 1	<-- Refer to the data base manual
11.	Push 2	<-- Daily data
12.	Enter code name	<-- Refer the code table
13.	Enter year & month	<-- Enter year and month when recorded
14.	Enter daily data	<-- Refer the data base manual
15.	Push 0	<-- To go back to the upper menu
16.	Push 0	<-- To go back to the D.B-main menu
17.	Push 0	<-- To quit operation on the data base
18.	Enter 0	<-- To go back to the M-MAIN menu

2. To determine the area of a figure

1.	Turn on computer	<-- Refer to the section on computer operation
2.	Set up digitizer	<-- Refer to the section on digitizer operation
3.	Enter SWITCHD	<-- To set the RS232C-SWITCH for the digitizer
4.	Enter OPTION	<-- To go to M-OPTION menu
5.	Enter AREA	<-- To run AREA
6.	Follow instructions	<-- Instructions will be given on the screen
7.	Push 1 on digitizer	<-- Push at intervals to establish points. You can start from any point, but you must return to the starting point.
7.	Push 3 on digitizer	<-- Push to quit digitizing
8.	View results	<-- Area of the figure and perimeter appear on the screen.
10.	Follow instructions	<-- When complete, follow instereuctions to quit
11.	Enter END	<-- To go back to the M-MENU

3. To draw a THEIS standard curve

1.	Turn on computer	<-- refer to the section on computer operation
2.	Set up plotter	<-- Refer to the section on plotter operation
3.	Enter SWITCHP	<-- To set the RS232C-SWITCH for the plotter
4.	Enter OPTION	<-- To go to M-OPTION menu
5.	Enter THEIS	<-- To run THEIS
6.	Follow instructions	<-- Instructions will be given on the screen
7.	Drawing	<-- Plotter starts and stops automatically
8.	Enter END	<-- To go back to the M-MAIN menu

4. BACKUP

Upon entering BACKUP, the sub-menu (M-BACKUP) appears.

```
          BACK-UP SUB MENU
    ENTER THE NAME OF THE COMMAND        M-BACKUP
                                       FLOPPY DISK LABEL(S)
    BAKWS   :  TO BACK UP WORD STAR FILES  [JICA WS 17/10/89]
    BAKFO   :  TO BACK UP FORTRAN FILES    [JICA FORTRAN 17/10/89]
    BAKBA   :  TO BACK UP BASIC FILES      [JICA BASIC 17/10/89]
    BAKOP   :  TO BACK UP OPTION FILES     [JICA OPTION 17/10/89]
    BAKDB   :  TO BACK UP DATA BASE        [JICA DB NO.A 17/10/89]
                                           [JICA DB NO.B 17/10/89]
                                           [JICA DB NO.C 17/10/89]
                                           [JICA DB NO.D 17/10/89]
                                           [JICA DB NO.E 17/10/89]
                                           [JICA DB NO.L2 17/10/89]
    END     :  TO QUIT
```

The floppy disks used to back up files from the hard disk are stored in the floppy disk box labeled DATA BASE. You must use the specified floppy disk for the specified purpose

Six floppy disks (A,B,C,D,E,L2) are needed to back up the data bases. In all other backups, only one floppy disk is used.

You can also start up the computer from the floppy disk drives with the back-up floppy disks.

When complete, enter END to go back to the M-MAIN menu.

APPENDIX OPERATING INSTRUCTIONS FOR THE EDITOR

GENERAL PROCEDURE
1. TYPE IN DATA OR PROGRAM
2. INSTRUCTIONS OF CURSOR CONTROL AND FUNCTIONS TO ERASE, COPY, OR SEARCH ARE GIVEN BELOW.
3. WHEN COMPLETE, PUSH f·1 (function key). PUSH E TO SAVE THE TEXT. PUSH Q TO QUIT WITHOUT SAVING.

==========CURSOR CONTROL==========

	↑	MOVE CURSOR ONE LINE ABOVE
SHIFT+	↑	MOVE CURSOR ONE LINE ABOBE (QUICK)
	↓	MOVE CURSOR ONE LINE DOWN
SHIFT+	↓	MOVE CURSOR ONE LINE DOWN (QUICK)
	←	MOVE CURSOR ONE LETTER LEFT
SHIFT+	←	MOVE CURSOR LEFT SIDE
	→	MOVE CURSOR ONE LETTER RIGHT
SHIFT+	→	MOVE CURSOR RIGHT SIDE
ROLL UP		ROLL UP SCREEN
ROLL DOWN		ROLL DOWN SCREEN
TAB		MOVE CURSOR TO THE NINETH (9) COLUMN OF THE LINE

PUSH f·3 ----- CHOOSE ONE OF THESE OPTIONS

PUSH ESC KEY TO QUIT
T · MOVE TO THE FIRST LINE OF THE TEXT
G · MOVE TO THE LINE SPECIFIED
1 ·
2 ·
3 ·
4 ·
5 ·
U · CANCEL THE LAST COMMAND
B · MOVE TO THE END LINE OF THE TEXT

==========INSERT AND ERASE==========

PUSH INS KEY TO SELECT INSERT OR OVERWRITE MODE.

DEL	ERASE A LETTER ON THE CURSOR
BS	ERASE A LETTER TO THE LEFT OF THE CURSOR
CTRL+Y	ERASE ONE LINE
CTRL+T	ERASE ONE WORD
CTRL+K	ERASE FROM CURSOR TO THE RIGHT
CTRL+U	ERASE FROM CURSOR TO THE LEFT
CTRL+L	RESTOR CHARACTERS ERASED BY CTRL+Y, K, OR, U ERASED1 CHARACTERS WILL APPEAR AGAIN.
SHIFT+Ret	INSERT ONE LINE BELOW THE LINE CURSOR IS ON
CTRL+N	INSERT ONE LINE ABOVE THE LINE CURSOR IS ON

```
PUSH f·6  ----- TO SELECT LINES TO BE COPIED. SELECTED LINES ARE PAINTED
                WHITE.
     f·7  ----- TO STORE SELECTED LINES TEMPORARY IN A MEMORY. THE LINES
                ARE ERASED.
     f·8  ----- TO STORE SELECTED LINES TEMPORARY IN A MEMORY. THE LINES
                ARE NOT ERASE.
     f·9  ----- TO RETRIEVE STORED LINES

SHIFT+f·6 ----- TO SELECT LETTERS TO BE COPIED. SELECTED LETTERS ARE PAINTED
                WHITE.
     +f·7 ----- TO STORE SELECTED LETTERS TEMPORARY IN A MEMORY. THE LETTERS
                ARE ERASED.
     +f·8 ----- TO STORE SELECTED LETTERS TEMPORARY IN A MEMORY. THE LETTERS
                ARE NOT ERASE.
     +f·9 ----- TO RETRIEVE STORED LETTERS


====================SEARCH AND REPLACEMENT==========================

 SHIFT+f·3 -----              PUSH ESC KEY TO QUIT
                F · TO FIND SPECIFIED LETTER(S) IN THE TEXT, RANGING FROM
                    THE CURSOR TO THE END OF THE TEXT. (FORWARD SEARCHING)
                B · BACKWARD SEARCHING OF LETTER(S)
                1 ·
                2 ·
                Q · TO REPLACE SPECIFIED LETTER(S) WITH THE OTHER. QUERY IS
                    MADE TO CONFIRM THE OPERATION.
                A · REPLACEMENT IS DONE WITHOUT QUERY.
                R · REPLACEMENT IS DONE ONLY IN THE SPECIFIED RANGE.
                C · TO CONTINUE REPLACEMENT


====================FILE MANAGEMENT=============================

       f·1 -----              PUSH ESC KEY TO QUIT
                E · SAVE FILE AND QUIT EDITTING   ----> IMPORTANT
                S · SAVE FILE AND RESUME EDITTING
                Q · QUIT WITHOUT SAVING           ----> IMPORTANT
                O · EDIT OVER AGAIN FROM THE BEGINNING
                D ·
                R · CHANGE THE NAME OF THE FILE
                0 · SAVE TEXT AND QUIT
                I · INSERT ANOTHER FILE
                N · EDIT ANOTHER FILE
```

--- DATA BASE MANUAL ---

1.General Operations

1-1 Starting up the systems

(1) General procedures to turn on the computer

1. Turn on the air conditioner.
2. Remove the vinyl cover from the computer.
3. Turn on the wall socket switch.
4. Turn on the stabilizer switch.

(2) Starting up from the hard disk

1. Make sure the floppy disk drives are unlocked.
2. Turn on the computer power switch.
3. Wait about 10 seconds.
4. When a message in Japanese letters appears, push RETURN.
5. The M-MAIN menu will appear.
6. Type in DBASE (A>DBASE) and push RETURN.
7. The M-G(general menu) of the database system will appear.
8. Follow the instructions displayed on the screen.

```
          MAIN MENU  ( Directory  A>¥ )     M-MAIN
        ENTER THE NAME OF THE COMMAND
     DBASE      :  DATA BASE SYSTEMS
     BASIC      :  BASIC PROGRAM
     FORTRAN    :  FORTRAN PROGRAM
     OPTION     :  OPTIONAL PROGRAMS
     WSR        :  WORD STAR
     BACKUP     :  TO BACK UP FILES
  (Ex.  A>DBASE[RET])
```

(3) Starting up from the floppy disk drive

Floppy disks for the data base system are stored in the floppy disk case labeled "DATA BASE". Floppy disks for the database system are:

Label name :

JICA DB	[No. A]	Hydrogeological D.B.
	[No. B]	Hydrogeological D.B.
	[No. C]	Hydrogeological D.B.
	[No. D]	Hydrogeological D.B.
	[No. E]	Hydrogeological D.B.
	[No. LOTUS]	Hydrogeological D.B.

Label name :

JICA DB	[No. L1]	Literature D.B.
	[No. L2]	Literature D.B.

- Turn on the computer power switch.
- For the hydrogeogical data base : Insert the floppy disk [No. A] in the upper floppy disk drive and [No. B] in the lower floppy disk drive, and lock the drives.
- For the literature data base : Insert the floppy disk [No. L1] in the upper floppy disk drive and [No. L2] in the lower floppy disk drive, and lock the drives.
- Follow the instruction displayed on the screen.

(4) Backup

For the safty of the data, you are recommended to make back-ups at least monthly. The floppy disks used to start up the systems from the floppy disk drives are also used to back up the files stored in the hard disk. To do so, follow thses procedures.

1. Select M-BACKUP from the MMAIN menu. The M-BACKUP menu will appear.
2. Insert the specified floppy disk in the upper floppy disk drive, type in the appropriate command, and push RETURN.

```
        BACK-UP SUB MENU
ENTER THE NAME OF THE COMMAND
                                                    FLOPPY DISK LABEL(S)
1. BAKWS    :  TO BACK UP WORD STAR FILES       [JICA WS 17/10/89]
2. BAKFO    :  TO BACK UP FORTRAN FILES         [JICA FORTRAN 17/10/89]
3. BAKBA    :  TO BACK UP BASIC FILES           [JICA BASIC 17/10/89]
4. BAKOP    :  TO BACK UP OPTION FILES          [JICA OPTION 17/10/89]
5. BAKDB    :  TO BACK UP DATA BASE             [JICA DB  NO.A 17/10/89]
                                                [JICA DB  NO.B 17/10/89]
                                                [JICA DB  NO.C 17/10/89]
                                                [JICA DB  NO.D 17/10/89]
                                                [JICA DB  NO.E 17/10/89]
                                                [JICA DB  NO.L2 17/10/89]
```

(5) Turning off the computer

1. Be sure printing or plotting is complete.
2. Return to the M-MAIN menu.
3. Unlock the floppy disk drives.
4. Push the STOP key.
5. Turn off the computer power switch.
6. Turn off the stabilizer switch.
7. Turn off the wall socket switch.
8. Cover the computer with the vinyl sheet.
7. Turn off the air conditioner.

1-2 Emergencies

(1) Power failure

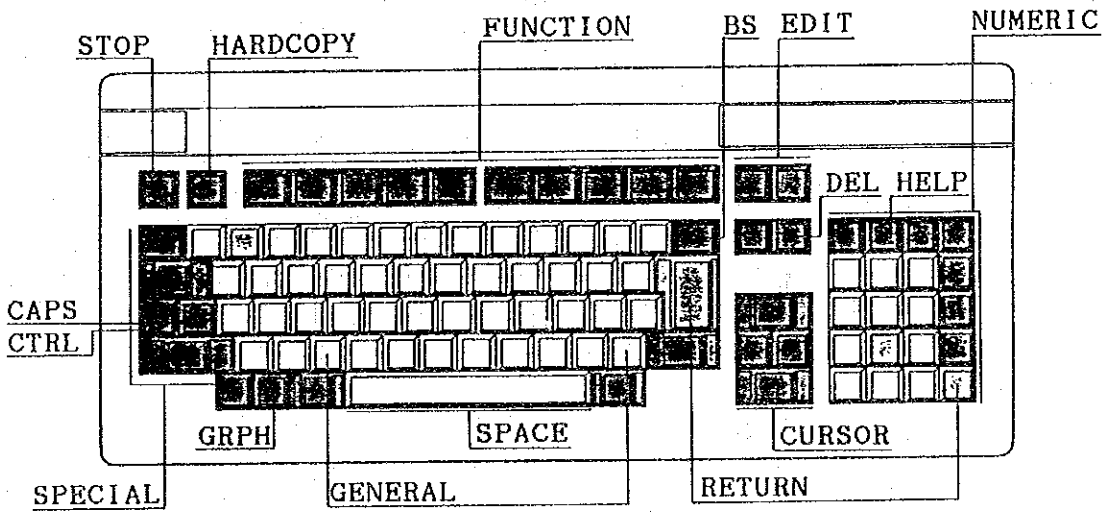
In the event of power failure, the stabilizer will continue to supply power to the computer for about eight minutes. However, you must quit your job and shut down the computer immediately, eve if you are in the middle of printing or plotting, otherwise your data will be lost or damaged.

(2) Frozen controls

If the computer freezes, that is, if the computer will not accept any any command or key entry, unlock the floppy disk (if in use), push the STOP key, and then the RESET button, located to the lower-left on the front of the machine.

1-3 Key functions

The keys used in the systems are as follows:



(1) General keys, numerical keys, caps key, space key

These are used to type in letters or numbers (characters). Typed characters will appear on the screen at the cursor position. When the caps key is locked (pushed in), capital letters appear on the screen when general keys corresponding to letters are pressed. Keep the caps key locked except when using WordStar (the word-processor).

(2) Return key

This key is pushed after typing in a command or statement. Upon pushing RETURN, the command or statement is sent to the central processing unit (CPU) of the computer. The CPU interprets the command or statement and begins processing.

(3) Cursor keys

The cursor is a small rectangle on the screen, blinking or painted in white, blue or yellow. Typed characters appear at the cursor position on the screen. The cursor keys move the cursor position in the directions marked on the arrows.

(4) Delete key, Back-space key

These keys are used to erase characters appearing on the screen. The delete key erases the character at the cursor position. The back-space key erases the character to the left of the cursor.

(5) Function keys

These keys are used to select commands.

(6) Help key

This key is used to display explanatory information.

(7) ESC key

This key is used to terminate printing.

(8) CTRL key

In combination with other keys, this key is used to select a command.

(9) COPY key and GRPH key

These keys are used to send a hard copy of the screen to the printer.

1-4 Command (menu) selection

There are three ways to send a command to the CPU.

(1) Select a command with the cursor keys and push RETURN

This way is generally applicable. When a menu appears on the screen, a command outlined in blue is called the current command. The current command is sent to the CPU upon pushing RETURN. You can select the current command with the cursor keys. When a cursor key is pushed, the blue outline moves among your choice of commands.

(2) Push a command number

This way is also generally applicable. Commands shown on a menu are generally given command numbers. Upon pushing a command number, the command is sent to the CPU. You do not have to push RETURN.

(3) Push a function key

If an instruction says "Select by Function Keys", upon pushing the function key corresponding to the command will send that command to the CPU. You do not have to push RETURN.

1-5 Data entry

(1) Data entry field

When you are required to enter data, data entry fields, where data are supposed to be given, appear on the screen. The fields are painted blue or yellow for easy identification. The field where the cursor is located is called the current entry field. If there are two or more entry fields on the screen, you can change the current entry field with the cursor keys.

(2) Data entry

Numerical keys and general keys are used to type in data. Typed characters appear in the current entry field on the screen. When finished typing in data, push RETURN. The next field will become the current entry field, or an instruction for the next operation will appear. (Under certain circumstances, the next field will become the current entry field without pushing RETURN.)

(3) Modification

The delete key, Back-space key, and cursor keys are used to erase characters or shift the cursor. If two or more entry fields exist, you can change the current entry field with a cursor key to modify data entered earlier or to skip forward to another entry field. However, once the next instruction appears, or a system process (such as the computer's automatic supplying of an organization name or an aquifer name upon your entry of a code number) takes place, you can not use these means to modify data. In such a case, answer "N" to the query "OK? (Y/N)". You will be brought back to the very first data entry field of the data entry mode. The entries you have made will still be in each field. You can now move forward to make any corrections necessary.

1-6 Code numbers

1-6-1 Hydrogeological Data Base

(1) Station code and borehole code

Every meteorological and hydrological station and borehole is given a code number when registered in the systems. Since the code number is used in all operations to specify a station or borehole, the station or borehole code number must be registered prior to any other operation (see 2.1.1). If an operation is attempted with non-registered code number, one of the following messages will appear and the operation will be rejected.

- Bad code number, or - The code does not exist

A code number can be chosen at your will, providing that the number is of four digits between 0000 and 9999. In order to classify a category of data, the letter "M" is given to the head of the code number of a meteorological station (ex. M0011), "H" is given to a hydrological station (ex. H8167), and "W" to a borehole (ex. W0123). These letters are given automatically by the program and do not have to be typed in.

The table of code numbers and their corresponding station or borehole names must be prepared for reference. You should update the table regularly.

(2) Index codes

There are four index codes: organization code, river code, aquifer code, and water use code Organizations, who own or are responsible for a station or borehole, are given a code number. River names, aquifer names and water use of a borehole are given code numbers as well.

These code numbers and corresponding contents can be modified or appended by use of the assist menu of the data base (see 2.5).

1-6-2 Literature Data Base

(1) Literature code

Upon their creation, all literature data files are automatically given a code number. Code numbers are given in chronological order of the files' creation.

(2) Indexes

Indexes are assigned to literature data files to classify their contents.

1-7 General instructions

Instructions will often appear on the screen to help you. General rules and necessary responses to the instructions are:

(1) "Enter" "Push"

In selecting a command, the term "enter" requires you to type in one or more characters and then press RETURN. The term "push" only requires you to press a single key.

(2) Enter station code

Since the system is managed with code numbers, entering a station, borehole, or literature code number is the most frequent command.

In the Hydrogeological Data Base, when you are required to enter a code number, one of the following statements appear:

- Enter METEOROLOGICAL STATION code M____
- Enter HYDROLOGICAL STATION code H____
- Enter Well code W____

You must type in the code number correctly. If the number is M0015, type in 0015. Do not type in 15, or M15, for the system will interpret these as different code numbers.

(3) Query

A query which asks you to confirm your intention will appear upon entry of a command or completion of data entry. Enter Y to confirm. Enter N to modify or cancel the command or data. Queries include:

- OK? (Y/N)
  Generally used after completion of data entry.
- Enter this data? (Y/N), - This data? (Y/N),
- Modify this data? (Y/N), - Print this data? (Y/N)
  Upon entering a station or borehole code number, these statements, along with the station or borehole name corresponding to the code number, will appear on the screen for your confirmation
- Append new data? (Y/N)
  This statement appears when you are about to enter a new station code or new data.
- Continue to edit? (Y/N), - Continue to next month? (Y/N),
- Enter another data? (Y/N)
  These statements ask you whether you wish to continue to enter the data or not.

(4) Cancellation

When the following statements appear, you can quit the operation by entering E, 0, or 00 in accordance with an instruction. The preceding menu will appear on the screen.

- Enter (E) to quit, - Enter (0) to quit, - Enter (00) to quit,
- Enter (00) - (00) to quit

(5) Floppy disk exchange

A message instructing you to exchange floppy disks will appear when necessary. If the system is run from the floppy disks, you must observe these instructions. If the system is run from the hard disk, you can ignore these instructions and simply push RETURN. In the example shown below, you are requested to take out the floppy disk in drive B (lower disk drive) and to insert the floppy disk with label number No. D,

- Change drive:B->floppy [No. D], then hit RETURN KEY.
  If you use HARDDISK, Hit RETURN KEY.

(6) Printer

The following statement will appear when data is to be printed out by the printer.

- Set Printer, and Hit RETURN key!

Follow the following procedures

1. Make sure the printer power switch is on.
2. Make sure the green light on the SEL button is on.
   If not, push the SEL button to turn on the light.

If you want to feed paper

1. Turn off the light on the SEL button.
2. Push the T.O.F button to feed one page, or
   push the L.F button to feed one line.

2. Hydrogeological DataBase

When the command DBASE is entered from the M-MAIN menu, the general menu of the data base system (M-G) appears.

```
< TYPE IN THE NUMBER OF THE COMMAND YOU WANT TO SELECT, AND RETURN >
+------------------------------------------------------------------------+

        1. HYDROGEOLOGICAL DATA BASE

        2. LITERATURE DATABASE

        0. END

+------------------------------------------------------------------------+

  If you have selected the GRAPH menu in the Hydrogeological Data Base
 and this menu text was shown upon completion of data entry, please
 type in (G) and hit RETURN to display a graph on the screen.


A>
```

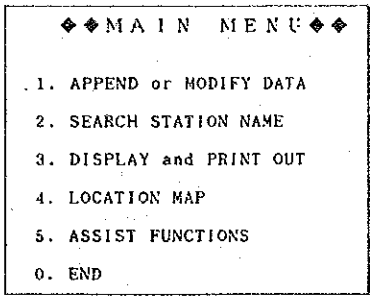
M-G

Enter 1 to start the hydrogeological database, then push RETURN when the messages (M-S) appears.

```
                dBASE III PLUS  Version 2.0J
              本ソフトウェアは次の者にライセンスされている。
                        Nigeria
                        Nigeria
                      3968426-19

    Copyright (c) Ashton-Tate 1985, 1986, 1987.  All Rights Reserved.
HYDROGEOLOGICAL DATA BASE FOR SOKOTO STATE  NIGERIA     CREATED BY JICA


                Hit RETURN KEY, then start dBASE III PLUS.
```

M-S

After about 20 seconds, the main menu of the hydrogeological database appears.



M1000

The functions of the commands shown in the M1000 menu are:

1. APPEND or MODIFY DATA
   - To register a new station or borehole code number
   - To enter information about a station or borehole
   - To enter daily data, monthly data, and other data
   - To modify data already stored in the database
2. SEARCH STATION NAME
   - To find stations according to specified data
   - To find out stations located in specified ranges
   - To print out information about such stations
3. DISPLAY and PRINT OUT
   - To print out information about stations and boreholes
   - To print out monthly and daily data
   - To print out other data stored in the database
4. LOCATION MAP
   - To display the locations of stations and boreholes
   - To give the coordinates of stations and boreholes
5. ASSIST FUNCTIONS
   - To append or modify index (organization, aquifer, river, and water-use) code numbers and their contents
   - To draw graphs of monthly or daily data

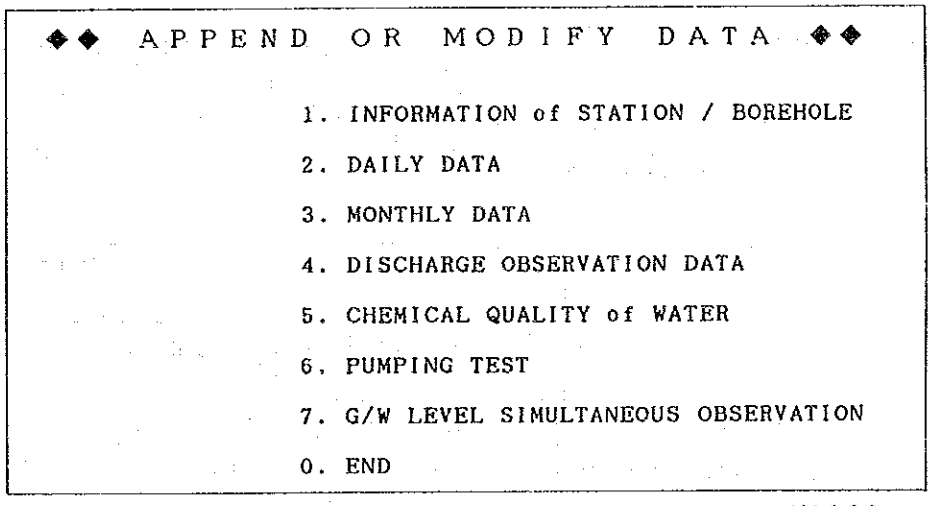
Two ways are commonly available to select commands:

1. Push the number of the command, or
2. Push the cursor keys to select the command and then push RETURN

2.1 APPEND OR MODIFY

The sub-menu M1100 appears when 1 is chosen from the M1000 menu. The functions of the commands are:

1. INFORMATION of STATION / BOREHOLE
   - To register a new station or borehole code number.
   - To enter information about a station or borehole.
2. DAILY DATA
   - To enter daily records. The following data can be entered: precipitation, discharge, and water level
3. MONTHLY DATA
   - To enter monthly records. The following data can be entered: precipitation, evaporation, discharge, water level temperature (min., max., ave.) humidity (min., max., 9:00, 15:00), sunshineduration windvelocity (min., max., ave.)
4. DISCHARGE OBSERVATION DATA
   - To enter records of discharge measurement. This includes date of observation, water level, and discharge.
5. CHEMICAL QUALITY OF WATER
   - To enter records of chemical quality tests. This includes date of sampling and principal ion concentrations.
6. PUMPING TEST
   - To enter records of pumping tests. This includes date of test, static and dynamic water levels, yield specific capacity, transmissibility, permeability, coefficient of storage, and pumping duration.
7. G/W LEVEL SIMULTANEOUS OBSERVATION
   - To enter records of groundwater level simultaneous observation.
     These are duration of observation and water level.



M1100

2.1.1 INFORMATION OF STATION / BOREHOLE

The sub-menu M1110 appears when 1 is chosen from the M1100 menu.

```
◆◆ INFORMATION DATA --- APPEND and MODIFY --- MENU ◆◆

        1. METEOROLOGICAL STATION DATA
        2. HYDROLOGICAL STATION DATA
        3. WELL and BOREHOLE DATA
        0. END
```

M1110

2.1.1.1 Sub-menus

The sub-menus M1111, M1112, and M1113 appear upon selection of a command in the sub-menu (M1110). In each, the functions of the commands are:

1. CODE, NAME, AGENCY-NAME, RIVER-BASIN/RIVER-NAME -- PRINT
   - To print out a table of code numbers and their corresponding station names and other information
   Note: This command should be selected when you need the latest table.
2. APPEND OR MODIFY DATA
   - To register a station code number if the station is new.
   - To enter information about a station.

```
◆◆ METEOROLOGICAL STATION DATA  APPEND, MODIFY and PRINT MENU ◆◆

        1. CODE,NAME,AGENCY NAME,RIVER BASIN/RIVER NAME -- PRINT
        2. APPEND or MODIFY DATA
        0. END
```

M1111

```
◆◆ HYDROLOGICAL STATION DATA  APPEND, MODIFIFY and PRINT MENU ◆◆

        1. CODE,NAME,AGENCY NAME,RIVER BASIN/RIVER NAME -- PRINT
        2. APPEND or MODIFY DATA
        0. END
```

M1112

```
◆◆ WELL and BORING DATA  APPEND, MODIFIY and PRINT MENU ◆◆

        1. CODE,NAME,AGENCY NAME,RIVER BASIN/RIVER NAME -- PRINT
        2. APPEND or MODIFY DATA
        0. END
```

M1113

2.1.1.2 Entry of Information

(1) Station or borehole code

Upon selection of the command "APPEND OR MODIFY DATA", you will be asked the code number of the station. If the code number has been registered in the system, the name of the station or borehole corresponding to the code number will appear on the screen. If not, you will be asked whether you wish to append a new station or borehole with the code number.

(2) Data entry fields

Upon entry of a station or borehole code number, the screen displays a data entry mode. Data entry modes consist of statements and data entry fields. Data entry fields are painted blue. Existing data is displayed in respective data entry fields. If the station or borehole is new, all data entry fields are empty.

(3) Meteorological station data entry mode

```
METEOROLOGICAL STATION CODE:M____  <- code number appears
                       NAME:       <- enter station name
AGENCY CODE:    <-  enter code number of responsible agency
       NAME:    <-  agency name appears upon agency code entry
PLACE NAME :    <-  enter village or town name
LOCAL GOVERN.: <-  enter local government name
STATE :         <-  enter state name
RIVER BASIN OR RIVER CODE: <- enter river code number
                      NAME: <- river name appears
ALTITUDE :                  <- enter altitude in M.S.L. m
MAP SHEET No. :             <- enter 1/250000 map No.
SECTOR(NE,NW,SE,SW) :       <- enter location on the map
LATITUDE :, LONGITUDE :     <- enter coordinates
```

Note: 1. You do not have to fill in all of the data entry fields.
2. The RIVER BASIN OR RIVER CODE for meteorological stations is 1 (one), which indicates "SOKOTO-RIMA BASIN".

```
  ==METEOROLOGICAL STATION DATA==

METEOROLOGICAL STATION CODE: M0078
                      NAME: GORONYO DAM

AGENCY CODE:      3
       NAME:    S.R.B.D.A.

PLACE NAME:     GORONYO DAM
LOCAL GOVERN. :
STATE:          SOKOTO

RIVER BASIN or RIVER CODE:  1
                     NAME: SOKOTO-RIMA

ALTITUDE:       282.0 m

MAP SHEET No.:   4          SECTOR(NE,NW,SE,SW):  4

LATITUDE:       13° 30'
LONGITUDE:       5° 53'
```

(4) Hydrological station data entry mode

```
HYDROLOGICAL STATION CODE:H-----  <- code number appears
                     NAME:        <- enter station name
AGENCY CODE:    <-  enter code number of responsible agency
       NAME:    <-  agency name appears upon agency code entry
PLACE NAME :    <-  enter village or town name
LOCAL GOVERN.: <-  enter local government name
STATE :         <-  enter state name
RIVER BASIN OR RIVER CODE: <- enter river code number
                     NAME: <- river name appears
ALTITUDE :                 <- enter altitude in M.S.L m
MAP SHEET No. :            <- enter 1/250000 map No.
SECTOR(NE,NW,SE,SW) :      <- enter location on the map
LATITUDE :, LONGITUDE :    <- enter coordinates
```

Note: You do not have to fill in all of the entry fields. But the river code must be given for all station information.

```
    ==HYDROLOGICAL STATION DATA==

HYDROLOGICAL STATION CODE: H0005
                     NAME: ZAURO

AGENCY CODE:       1
       NAME:    F.D.W.R.

PLACE NAME:     ZAURO
LOCAL GOVERN. :
STATE:

RIVER BASIN or RIVER CODE: 28
                     NAME: RIMA

ALTITUDE:       203.7 m

MAP SHEET No.:   0          SECTOR(NE,NW,SE,SW):

LATITUDE:       12° 34'
LONGITUDE:       4° 17'
```

(5) Borehole record data entry modes

Four borehole redord data entry modes are presented in succession. The four deal, respectively, with general data, borehole specifications, lithology, and pumping test data.

a) First data entry mode: general data

Upon entry of the borehole code, the first data entry mode appears.

```
WELL CODE:W----   <- code number appears
     NAME:        <- enter borehole name
AGENCY CODE:    <-  enter code number of responsible agency
       NAME:    <-  agency name appears upon agency code entry
PLACE NAME :    <-  enter village or town name
LOCAL GOVERN.: <-  enter local government name
STATE :         <-  enter state name
RIVER BASIN OR RIVER CODE: <- enter river code number
                      NAME: <- river name appears
ALTITUDE :                  <- enter altitude in M.S.L. m
MAP SHEET No. :             <- enter 1/250000 map No.
SECTOR(NE,NW,SE,SW) :       <- enter location on the map
LATITUDE :, LONGITUDE :     <- enter coordinates
```

Note: 1. You do not have to fill in all of the entry fields.
2. The RIVER BASIN OR RIVER CODE for every borehole record is 1 (one), which indicates "SOKOTO-RIMA BASIN".

```
   ==  W E L L    D A T A  ==

WELL CODE:       W0001
     NAME:       NEPA SOKOTO (Power Sta.)

AGENCY CODE:       2
       NAME:     S.S.W.B./S.S.M.W.E.

PLACE NAME:      NEPA SOKOTO (Power Sta.)
LOCAL GOVERN. : SOKOTO
STATE:

RIVER BASIN or RIVER CODE:  1
                      NAME: SOKOTO-RIMA

ALTITUDE:           .  m

MAP SHEET No.:              SECTOR(NE,NW,SE,SW):

LATITUDE:          °   '
LONGITUDE:         °   '
```

b) Second data entry mode: borehole specifications

Upon completion of the first data entry mode, the second data entry mode appears.

```
WELL CODE:W----,  NAME:---------- <- borehole name and code appear
DATE(dd/mm/yy) :  <- enter date of borehole completion
DEPTH OF BORE  :  <- enter depth of borehole
DIAMETER  AT TOP :      <- enter diameter of casing top
DIAMETER AT BOTTOM :  <- enter diameter of casing bottom
PERMANENT LINING TUBES : <- enter casing and screen position
                            and their material
WATER STRUCK AT DEPTH OF:<- enter water struck depth
AQUIFER CODE : <-  enter code number of aquifer borehole taps
        NAME : <-  aquifer name appears upon aquifer code entry
USE WELL FOR : <-  enter code number of water use
     CONTENT : <-  water use appears upon water use code entry
REM. : <-  enter remarks regarding borehole or its record
```

Note: -The aquifer code should be given for every borehole record.
- In giving DATE, if the number of the day or month is less than 10, put 0 in front of the number. (ex. 05)

```
    ==BOREHOLE  SPESIFICATION  DATA==

      WELL;      CODE: W0001          NAME: NEPA SOKOTO (Power Sta.)
      DATE(dd/mm/yy):10/08/75         TOTAL DEPTH  :   137.2 m
      DIAMETER AT TOP:  152.4 mm      AT BOTTOM:  127.0 mm

      PERMANENT  LINING TUBES:
             TOP(m)    BOTTOM(m)      MATERIAL
        1)     0.0       121.9    GRP Plain Tubes Fibre Glass
        2)   121.9       131.1    5" Johnson Screens (Blanked off)
        3)     0.0         0.0
        4)     0.0         0.0
        5)     0.0         0.0
      WATER STRUCK at DEPTH of:    1)   118.9 m  to    131.1 m
                                   2)     0.0 m  to      0.0 m
                                   3)     0.0 m  to      0.0 m
      AQUIFER;       CODE:     NAME:
      USE WELL FOR; CODE:      CONTENT:

  REM.:Pump?
```

c) Third data entry mode: lithology

Upon completion of the second data entry mode, the third data entry mode appears. The data entry mode to append new borehole information and that to modify existing information differ.

```
- APPEND MODE -
CODE  W----    <- borehole code number appears
Stratum No.    <- stratum numbers appear in numerical order
Nature of Strata  <- enter lithology
Bottom Depth      <- enter depth to the bottom of stratum
 Note:
```

- Terms available to describe lithology are given in Tab.1.
- Type in a term and push RETURN.
- If the term is not listed in the table, the following message appears. Push RETURN and correct the term, or push the HELP key to view the table.

```
  Error! No such name  [RETURN] to continue [HELP] to show --
```

- A maximum of nine terms can be given to one stratum.
- If the number of terms is less than nine, push RETURN a second time after the last term entered to complete the entry.
- The table of lithology will appear line by line below the entry fields as each line is entered.

Tabl S T R A T A N A M E

BASEMENT	FINE	MICA	SILT
BIG	FRACTURED	ORANGE	SILTS
BLACK	GRANITIC	PALE	SILTSTONE
BLUE	GRAVEL	PINK	SILTY
BOULDER	GRAVELS	PLASTIC	SOIL
BOULDERS	GREEN	PURPLE	SOILD
BROWN	GREENISH	PYRITE	SURFACE
BROWNISH	GREY	QUARTZ	TOP
CALCAREOUS	GREYISH	RED	TOPSOIL
CHALKY	HARD	REDDISH	TOPSOILS
CLAY	LARGE	ROCK	VERY
CLAYER	LATERITE	ROCKS	W.BEARING
CLAYS	LATERITIC	SAND	WATER BEARING
CLEAN	LIGHT	SANDS	WEATHERED
COARSE	LIMESTONE	SANDSTONE	WHITE
COMPACT	LIMESTONES	SANDSTONES	WHITISH
COMPLEX	MATERIAL	SANDY	YELLOW
CREAM	MED.	SCHIST	
DARK	MEDIUM	SHALE	
DIORITIC	METAMORPHICS	SHALES	

HIT RETURN TO return

- MODIFICATION MODE -

The existing table of lithology will appear along with the following instructions:

```
                D E T A I L E S   O F   S T R A T A

 CODE   W0001

 Stratum No.  7

 Nature of Strata FINE          YELLOW        SAND

 Bottom Depth    70.1 m

No.  Nature of Strata                                  Depth(m)
  4  CLAYS,LATERITE                                       27.4
  5  YELLOW,CLAYS                                         36.6
  6  YELLOW,WHITE,CLAYS                                   64.0
  7  FINE,YELLOW,SAND                                     70.1
  8  WHITE,CLAYS                                          79.2
  9  BLACK,CLAYS                                          97.5
 10  YELLOW,WHITE,FINE,SAND                              106.7
 11  BLACK,SILTY,CLAYS                                   125.0
 12  WHITE,FINE,SAND                                     137.2

   Modify->(M) Append->(A) End->(E) Delete->(D)   Scroll-> ↑ / ↓
```

These commands mean:

- Push M to modify lithology of specified stratum.
- Push A to append new stratum after the last stratum.
- Push D to delete specified stratum.
- Push E to quit the process
- Use the cursor keys to move within the table of lithology.

Procedures to enter data are the same as those in the APPEND MODE.

d) Fourth data entry mode : pumping test data

Upon completion of the third data entry mode, the following query will appear.

- Enter PUMPING TEST DATA ? (Y/N)

The fourth data entry mode appears when Y is chosen.

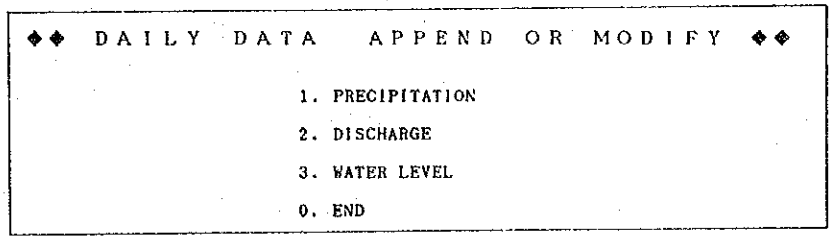
```
    WELL CODE :W----    <- code number of borehole appears
         NAME :         <- name of borehole appears
DATE(dd/mm/yy):         <- enter date test was performed
STATIC WATER LEVEL :    <- enter static water level
DYNAMIC WATER LEVEL:    <- enter dynamic water level
YIELD :                 <- enter yield of the borehole
SPECIFIC CAPACITY:      <- enter specific capacity
TRANSMISSIBILITY:       <- enter transmissibility
PERMEABILITY:           <- enter permeability
COEFFICIENT OF STORAGE:<- enter storativity
PUMPING DURATION:       <- enter duration of pumping test
```

Note: In giving DATE, if the number of day or month is less than 10, put 0 in front of the number. (ex. 13/01/86)

```
        ==PUMPING TESTS DATA==

WELL;     CODE: W0001       NAME: NEPA SOKOTO (Power Sta.)

          DATE(dd/mm/yy): 10/08/75

          STATIC  WATER LEBEL:        13.7 m
          DYNAMIC WATER LEBEL:        30.5 m

          YIELD:                     151.5 m^3/day
          SPECIFIC CAPACITY:             . m^3/day/m

          TRANSMISSIBILITY:              . m^2/day
          PERMEABILITY:                  . m/day
          COEFFICIENT of STORAGE:        .

          PUMPING DURATION:  20 hours
```

2.1.2 DAILY DATA

The sub-menu M1120 appears when 2 is chosen from the M1100 menu.



M1120

(1) Station or borehole code

Upon selection of a command, you will be asked the station or borehole (well) code number as follows:

```
Enter METEOROLOGICAL STATION code. M____  <-For 1. PRECIPITATION
Enter HYDROLOGICAL STATION code. H____    <-For 2. DISCHARGE
Enter WELL code. W____                    <-For 3. WATER LEVEL
```

Upon entry of the code number, its corresponding station or borehole name appears as in this example:

```
Enter METEOROLOGICAL STATION code. M____  <-- Enter code.
  METEOROLOGICAL STATION name     _____  <-- Name appears.
```

If the code number does not exist, an error message appears.

(2) Entry of year and month

Upon confirming the code number, you will be asked the year and month as follows:

```
  Enter year       0
  Enter month      0
```

Reply as follows:

```
  Enter year   1965  <- Four digits are required. (e.g. not "65")
               6   <-  Jan.:1,  Feb.:2, Mar.:3  -  -  - Dec,:12
```

If daily data for the specified month and year already exists in the database, the first daily data entry mode appears.

```
  Append new data ? (Y/N)
```

If no data already exists for the specified year and month, the following message first appears. Upon confirming, the first daily data entry mode appears.

(3) Daily data entry modes

For each of three data entry modes, data entry fields corresponding to the days of the specified month appear on the screen. You can shift the current data entry field among these days with the cursor keys. To calculate total and complete your entry of data, use the cursor keys to move the cursor beyond the last entry field. The three data entry modes are:

--CAUTION-- Never use the RETURN key to move the cursor among the data fields except when intentionally entering data. Without keying a value in, pressing the RETURN key will enter a 0 for the field in which the cursor is located.

a) Precipitation

Unit: mm
Data type: Integer
Total: Monthly precipitation (mm) is calculated upon completion of data entry.

```
          D A I L Y   P R E C I P I T A T I O N   D A T A   ★E D I T★

METEOROLOGICAL STATION CODE: M0026
                      NAME: GUSAU AERODROME

YEAR: 1970      MONTH:  8

DAY    1     2     3     4     5     6     7     8     9    10
       0    36     0     0     2     0     1     0    24     0

      11    12    13    14    15    16    17    18    19    20
       4    21     0     0    26    70     0     6     0     0

      21    22    23    24    25    26    27    28    29    30
       0     0    16    23     0     1     0     0    19    48

      31
       2                              Unit: mm/day

TOTAL   299
```

b) Discharge

Unit: m^3 (cubic meters)/sec. (daily average discharge)
Data type: Number with two decimal places (ex. 1.23)
Total: Monthly total discharge (m^3/month) is calculated upon completion of data entry.

```
          D A I L Y    D I S C H A R G E    D A T A    ★E D I T★

HYDROLOGICAL STATION CODE: H0012
                      NAME: SABON BIRNI

YEAR: 1968      MONTH:  5

DAY    1      2      3      4      5      6      7      8      9     10
     -1.00  -1.00  -1.00  -1.00  -1.00   1.22   1.13   0.82   0.74  -1.00

      11     12     13     14     15     16     17     18     19     20
     -1.00  -1.00  -1.00  -1.00  -1.00  -1.00  -1.00  -1.00  -1.00  -1.00

      21     22     23     24     25     26     27     28     29     30
     -1.00  -1.00  -1.00   1.08   1.02  -1.00  -1.00  27.61  22.31  18.12

      31
     10.62                          Unit: m^3/s

TOTAL       -1 ten thousand m^3/month
```

c) Water level

Unit: m (M.S.L.) (daily average groundwater level)
Data type: Number with two decimal places (ex. 3.45)
Average: Monthly average water level (m) is calculated upon completion of data entry.

Note:

- Enter -1 for missing values
- Monthly total or average value will not be calculated if daily data includes missing value(s).

2.1.3 MONTHLY DATA

The sub-menu M1130 appears when 3 is chosen from the M1100 menu.

```
        ◆ MONTHLY DATA   APPEND OR MODIFY ◆

          1. PRECIPITATION          9. MAXIMUM HUMIDITY
          2. DISCHARGE              a. HUMIDITY at 9:00
          3. WATER LEVEL            b. HUMIDITY at 15:00
          4. MINIMUM TEMPERATURE    c. SUNSHINE DURATION
          5. MAXIMUM TEMPERATURE    d. MINIMUM WIND VELOCITY
          6. AVERAGE TEMPERATURE    e. MAXIMUM WIND VELOCITY
          7. EVAPORATION            f. AVERAGE WIND VELOCITY
          8. MINIMUM HUMIDITY       0. END
```

M1130

(1) Station or borehole code

Upon selection of a command, you will be asked the station or borehole (well) code number as follows:

```
                                          Command chracters
Enter METEOROLOGICAL STATION code. M____ <-  1,4,5,6,7,8,9,
                                             a,b,c,d,e,f
Enter HYDROLOGICAL STATION code. H____   <-  2
Enter WELL code. W____                   <-  3
```

Upon entry of the code number, its corresponding station or borehole name appears as in this example:

```
Enter HYDROLOGICAL STATION code. M____    <--- Enter code.
      HYDROLOGICAL STATION name  _______  <--- Name appears.
```

If the code number does not exist, an error message appears.

(2) Entry of year

Upon confirming the code number, you will be asked the year as follows:

```
   Enter year      0
```

Reply as follows:

```
   Enter year   1965  <- Four digits are required. (e.g. not "65")
```

If monthly data for the specified year already exists in the database, the first monthly data entry mode appears.

If no data already exists for the specified year, following message appears.

```
   Append new data ? (Y/N)
```

Upon confirming, the first monthly data entry mode appears.

(3) Monthly data entry modes

For each of eight data entry modes, data entry fields corresponding to the months of the specified year appear on the screen. You can shift the current data entry field among these months with the cursor keys. To calculate total and complete your entry of data, use the cursor keys to move the cursor beyond the last entry field. The eight data entry modes are:

a) Precipitation

Unit: mm
Data type: Integer
Total: Annual total value (mm) will be calculated upon completion of data entry.

```
MONTHLY PRECIPITATION DATA  ★EDIT★

METEOROLOGICAL STATION CODE: M0066
                      NAME: SOKOTO AERODROME

YEAR  1975

MONTH     1     2     3     4     5     6
          0     0     0     4    89    85

          7     8     9    10    11    12
        123   147   109     0     0     0

TOTAL         557          Unit: mm/month
```

b) Evaporation

Unit: mm
Data type: Integer
Total: Annual total value (mm) will be calculated upon completion of data entry.

c) Discharge

Unit: 10000m^3(cubic meters)/month (monthly total)
Data type: Integer
Total: Annual total discharge (10000m^3/year) is calculated upon completion of data entry.

d) Water level

Unit: m (M.S.L.) (monthly average water level)
Data type: Number with two decimal places (ex. 4.56)
Average: Annual average water level (m) is calculated upon completion of data entry.

e) Temperature (Minimum, Maximum, Average)

Unit: degree C (monthly average temperature)
Data type: Number with one decimal place (ex. 27.8)
Average: Annual average temperature is calculated upon completion of data entry.

f) Humidity (Minimum, Maximum, at 9:00, at 15:00)

Unit: % (monthly average humidity)
Data type: Number with one decimal place (ex. 27.8)
Average: Annual average humidity is calculated upon completion of data entry.

g) Sunshine duration

Unit: hour/day (monthly average daily duration)
Data type: Number with one decimal place (ex. 7.8)
Average: Annual average daily sunshine duration is calculated upon completion of data entry.

h) Wind velocity (Minimum, Maximum, Average)

Unit: m/sec. (monthly average wind velocity)
Data type: Number with one decimal place (ex. 10.8)
Average: Annual average wind velocity is calculated upon completion of data entry.

Note:
- Enter -1 for missing values
- Annual total or average value will not be calculated if monthly data includes missing value(s).

2.1.4 DISCHARGE OBSERVATION DATA

The following will occur when 4 is chosen from the M1100 menu.

(1) Station code

You will be asked the code number of the station where the discharge observation was carried out.

```
Enter HYDROLOGICAL STATION code. H____
```

Upon entry of the code number, its corresponding station name appears as follows:

```
Enter HYDROLOGICAL STATION code. M-----   <--- Enter code.
      HYDROLOGICAL STATION name  -------   <--- Name appears.
```

If the code number does not exist, an error message appears.

(2) Date

Upon confirmation, you will be asked the date when the observation was carried out.

```
   Enter Date  (dd/mm/yy):    /   /   <- day, month, year
  Note. If the number of day or month is less than 10, put 0
        in front of the number. (ex. 01/09/89  1st. Sept. 1989)
```

(3) Water level, discharge

Water level (gauge height of the station) and observed discharge are entered next.

```
     WATER LEVEL :            <- enter water level
     DISCHARGE   :            <- enter observed discharge
```

2.1.5 CHEMICAL QUALITY OF WATER

The following will occur when 5 is chosen from the M1100 menu.

(1) Station or borehole code

You will be asked the code number of the station or borehole where the water sample was taken.

Enter HYDROLOGICAL STATION or WELL code.

HYDROLOGICAL STATION --- (H)
WELL --- (W)

In order to distinguish between hydrological station and borehole, H and W must be put in front of the code number of hydrological station and borehole, respectively.

(2) Date

Upon confirmation, you will be asked the date when the water sample was taken.

Enter Date of sampling / / <- day, month, year
(dd/mm/yy)

Note. If the number of day or month is less than 10, put 0 in front of the number. (ex. 09/05/89 9th May 1989)

(3) Data entry mode

Upon entry of the date, the data entry mode for the chemical quality of water appears. Abbreviations used in the mode to indicate principle ion concentration and the unit of concentration are:

Ca:	Calcium	(++)	mg/l	Mg:	Magnesium	(++)	mg/l
Na:	Sodium	(+)	mg/l	K:	Potassium	(+)	mg/l
HCO3:	Bicarbonate	(-)	mg/l	SO4:	Sulfate	(--)	mg/l
Cl:	Chloride	(-)	mg/l	NO3:	Nitrate	(-)	mg/l
F:	Fluoride	(-)	mg/l	TDS:	Dissolved solids		mg/l
Fe:	Iron	(++,+++)	mg/l				

CHEMICAL QUALITY of WATER DATA ★EDIT★

WELL CODE: W0626
WELL NAME: BIRNIN KEBBI BH2483

DATE(dd/mm/yy): 01/12/62

Ca	35.2 mg/L	Mg	22.7mg/L	Na	11.9mg/L	K	10.00 mg/L
HCO3	167.0 mg/L	SO4	70.8mg/L	Cl	5.2 mg/L	NO3-	7.5 mg/L
F	0.00mg/L	TDS	258 mg/L	PH	6.5	Fe	0.04 mg/L

2.1.6 PUMPING TEST

The following will occur when 6 is chosen from the M1100 menu.

(1) Borehole code

You will be asked the code number of the borehole where the pumping test was carried out.

```
Enter WELL code. W____
```

(2) Data entry mode

Upon entry of the borehole (well) code, the data entry mode to enter pumping test data appears.

```
    WELL CODE :W----   <- code number of borehole appears
         NAME :        <- name of borehole appears
DATE(dd/mm/yy):        <- enter date test was performed
STATIC WATER LEVEL :   <- enter static water level
DYNAMIC WATER LEVEL:   <- enter dynamic water level
YIELD :                <- enter yield of the borehole
SPECIFIC CAPACITY:     <- enter specific capacity
TRANSMISSIBILITY:      <- enter transmissibility
PERMEABILITY:          <- enter permeability
COEFFICIENT OF STORAGE:<- enter storativity
PUMPING DURATION:      <- enter duration of pumping test
```

Note: In giving DATE, if the number of day or month is less than 10, put 0 in front of the number. (ex. 13/01/86)

2.1.7 G/W LEVEL SIMULTANEOUS OBSERVATION

The following will occur when 7 is chosen from the M1100 menu.

(1) Duration of the observation

You will be asked the duration of the observation (beginning and ending date of the observation).

Enter date of beginning and end (dd/mm/yy)
/ / - / /

(ex. 19/07/88 - 01/08/88 <- The observation was carried out from Jul. 19th to Aug. 1st, 1988)

(2) Borehole code

You will be asked the borehole (well) code number of the borehole where the water level was measured.

Enter WELL code: W____

(3) Water level

Upon confirmation, you will be asked the water level.

WATER LEVEL: <- enter water level of the borehole

2.2 SEARCH STATION NAME

The sub-menu M1200 appears when 2 is chosen from the M1000 menu. The functions of the commands are:

1. Designate an extent of LATITUDE and LONGITUDE
   Specify the range within which the station search is to be made.
2. Search from all data
   The station search is made from among all data.

```
        ◆◆SEARCH  DATA◆◆

   1. Designate an extent of LATITUDE and LONGITUDE

   2. Search  from  all  DATA

   0. END
```

M1200

If you select the first command, you will be asked the range of the search.

```
Enter range of Latitude and Longitude
 LATITUDE          -
 LONGITUDE         -
```

Upon entry of the coordinates, sub-menu M1210 appears. If you select the second command, sub-menu M1210 appears immediately.

```
      ◆SEARCH MENU◆     Move cursor key and RETURN, or Push numb
er  1. DAILY   PRECIPITATION      d. HUMIDITY at 9:00
    2. MONTHLY PRECIPITATION      e. HUMIDITY at 15:00
    3. DAILY   DISCHARGE          f. SUNSHINE DURATION
    4. MONTHLY DISCHARGE          g. MINIMUM WIND VELOCITY
    5. DAILY   WATER LEVEL        h. MAXIMUM WIND VELOCITY
    6. MONTHLY WATER LEVEL        i. AVERAGE WIND VELOCITY
    7. MINIMUN TEMPERATURE        j. SIMULTANEOUS OBSERVATION
    8. MAXIMUM TEMPERATURE        k. PUMPING TEST
    9. AVERAGE TEMPERATURE        l. CHEMICAL QUALITY of WATER
    a. EVAPORATION                m. DISCHARGE OBSERVATION
    b. MINIMUM HUMIDITY           n. ALL
    c. MAXIMUM HUMIDITY           0. END
```

M1210

(1) Select item

You will be asked to select an item of observation from the menu. Stations which have record of carrying out that item of observation will be found and their names displayed.

Note: If you choose n from sub-menu M1210, the system will search for files which have any one of the items of observation, l through m.

(2) Print out

Upon selection of the item of observation, sub-menu M1211 appears, from which you can select information on the stations or boreholes to be printed out.

```
◆◆SEARCH and PRINT◆◆ 1. CHEMICAL QUALITY of WATER

      1.  CODE,NAME,AGENCY NAME

      2.  CODE,PLACE NAME,LOCAL-GOVER.,STATE,RIVER BASIN or RIVER

      3.  CODE,NAME,ALTITUDE,MAP SHEET No.,SECTOR,LATITUDE,LONGITUDE

      4.  CODE,ITEMS of OBSERVATION

      5.  CODE,NAME,TERM of OBSEVATIONAL DATA

      0.  END
```

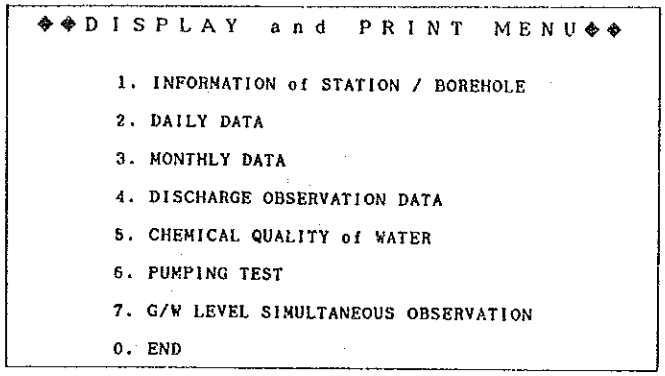
M1211

Note:

- 4. CODE, ITEMS OF OBSERVATION will print out station code numbers and all items of observation carried out at those stations.
- 5. CODE,NAME, TERM OF OBSERVATIONAL DATA will print out station code numbers and period of observation for the item chosen from sub-menu M1210. This command can only be used when the selected item of observation is daily or monthly data and cannot be used for items j through n sub-menu M1210.

2.3 PRINT OUT

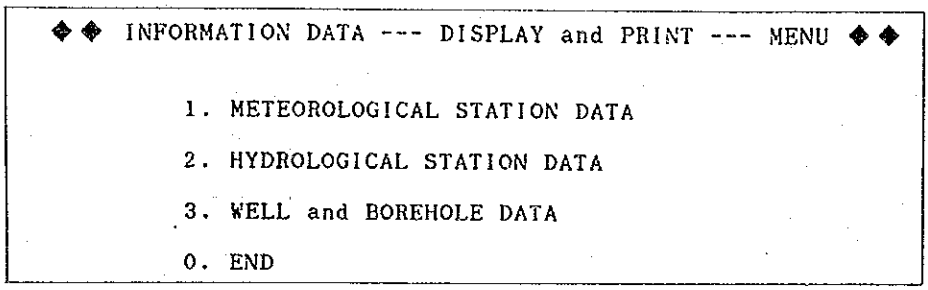
The sub-menu M1300 appears when 3 is chosen from the M1000 menu.



M1300

2.3.1 INFORMATION OF STATION / BOREHOLE

The sub-menu M1310 appears when 1 is chosen from the M1300 menu.



M1310

2.3.1.1 METEOROLOGICAL STATION AND HYDROLOGICAL STATION

```
◆◆HYDROLOGICAL STATION----DISPLAY and PRINT MENU◆◆

        1. PRINT INFORMATIONS BY CODE
        2. PRINT BY RIVER BASIN OR RIVER-NAME
        3. PRINT INFORMATIONS OF EVERY STATION
        0.  END
```

M1311

Sub-menus for meteorological or hydrological stations appear, respectively, when either 1 or 2 is chosen from the M1310 menu. Sub-menu M1311 is an example. In both sub-menus, the functions of the commands are:

1. PRINT INFORMATION BY CODE
   Choose this to print out all information on a particular station. You will be asked the code number of the station. If the code you enter does not exist, an error message will appear.
2. PRINT BY RIVER BASIN OR RIVER-NAME
   Choose this to print out data on every station which belongs to a particular river or river-basin.
   The sub-menu M1311R appears upon selection of this command. You will be asked to select river or river basin.

```
◆◆RIVER BASIN or RIVER NAME LIST◆◆
SELECT NAME.

SOKOTO-RIMA   BOBO        BUNSURU     CHOFA      DABIRAN
DAMA          DAMACHI     DAMINAWAL   DANRAHI    GADA
GAGARE        GAMINDA     GAWON       GEGE       GULBI
INGAWA        KA          KADUSA      KARADUWA   KORAMA
L.KAINUWA     L.KALMALO   L.KWARE     MAKURDI    MARADI
MUDURU        MUSURUDU    RIMA        SHELLA     SHINACHE
SOKOTO        TAGWAI      TURAME      YAMADAWA   ZAMFARA
NIGER         END
```

M1311R

The sub-menu M1311P appears upon selection of the river or river-basin. You will be asked to select the information to be printed out (ex. If you need names and locations, select 3).

```
◆◆SEARCH and PRINT◆◆  SOKOTO-RIMA

1.  CODE,NAME,AGENCY NAME
2.  CODE,PLACE NAME,LOCAL-GOVER.,STATE,RIVER BASIN or RIVER
3.  CODE,NAME,ALTITUDE,MAP SHEET No.,SECTOR,LATITUDE,LONGITUDE
4.  CODE,ITEMS of OBSERVATION
0.  END
```

M1311P

3. PRINT INFORMATIONS OF EVERY STATION
   The sub-menu M1311P appears upon selection of this command. You will be asked to select the information to be printed out.

2.3.1.2 WELL AND BOREHOLE DATA

Sub-menu M1312 appears when 3 is chosen from the M1310 menu. The functions of the commands are:

```
◆◆WELL----DISPLAY and PRINT MENU◆◆

1. PRINT INFORMATIONS BY CODE
2. PRINT BY EACH AQUIFER
3. PRINT INFORMATIONS OF EVERY BOREHOLE
0.  END
```

M1312

1. PRINT INFORMATION BY CODE

Choose this to print out all information on a particular borehole. You will be asked the code number of the borehole. If the code you enter does not exist, an error message will appear.

2. PRINT BY AQUIFER

Choose this to print out data on every borehole which taps a particular aquifer.

The sub-menu M1312A appears upon selection of this command. You will be asked to select the aquifer.

```
◆◆AQUIFER NAME LIST◆◆
SELECT NAME.

GUNDUMI      RIMA
SOKOTO       GWANDU
ILLO         BASEMENT
              END
```

M1312A

The sub-menu M1312P appears upon selection of the aquifer. You will be asked to select information to be printed out (ex. If you need depth of borehole, water level, and yield, select 4).

```
◆◆SEARCH and PRINT◆◆  ILLO

1.  CODE,NAME,AGENCY NAME,USE FOR
2.  CODE,AQUIFER-NAME,PLACE-NAME,LOCAL-GOVER.,STATE
3.  CODE,NAME,ALTITUDE,MAP SHEET No.,SECTOR,LATITUDE,LONGITUDE
4.  CODE,AQUIFER,DEPTH,DIAMETER,STATIC W.L.,DYNAMIC W.L.,YIELD
0.  END
```

M1312P

3. PRINT INFORMATIONS OF EVERY BOREHOLE

The sub-menu M1312P appears upon selection of this command. You will be asked to select the information to be printed out.

2.3.2 DAILY DATA

The sub-menu M1320 appears when 2 is chosen from the M1300 menu.

```
◆◆DAILY DATA PRINT◆◆

      1. PRECIPITATION
      2. DISCHARGE
      3. WATER LEVEL
      0. END
```

M1320

Upon entry of a command, you are asked to enter the code number of a station or borehole. Upon entry of the code number, you are asked to enter the period to be covered by the data to be printed out.

Enter beginning year ---- - ----
and ending year to print

2.3.3 MONTHLY DATA

The sub-menu M1330 appears when 3 is chosen from the M1300 menu.

```
◆MONTHLY DATA PRINT◆

1. PRECIPITATION          9. MAXIMUM HUMIDITY
2. DISCHARGE              a. HUMIDITY at 9:00
3. WATER LEVEL            b. HUMIDITY at 15:00
4. MINIMUM TEMPERATURE    c. SUNSHINE DURATION
5. MAXIMUM TEMPERATURE    d. MINIMUM WIND VELOCITY
6. AVERAGE TEMPERATURE    e. MAXIMUM WIND VELOCITY
7. EVAPORATION            f. AVERAGE WIND VELOCITY
8. MINIMUM HUMIDITY       0. END
```

M1330

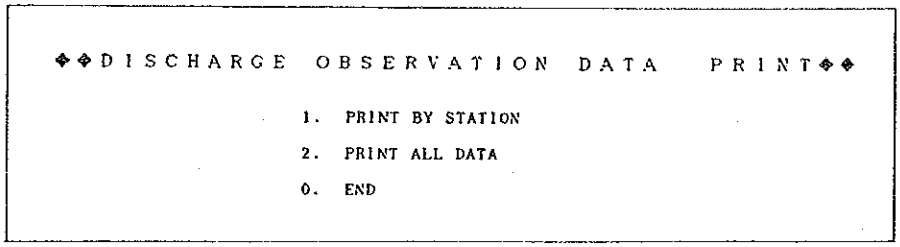
Upon entry of a command, you are asked to enter the code number of a station or borehole. Upon entry of the code number, you are asked to enter the period to be covered by the data to be printed out.

Enter beginning year ---- - ----
and ending year to print

2.3.4 DISCHARGE OBSERVATION DATA

The sub-menu M1340 appears when 4 is chosen from the M1300 menu. The functions of the commands are:

1. PRINT BY STATION
   Choose this to print out discharge observation data on a particular station. You will be asked the station code number.
2. PRINT ALL DATA
   Choose this to print out discharge observation data on all stations.

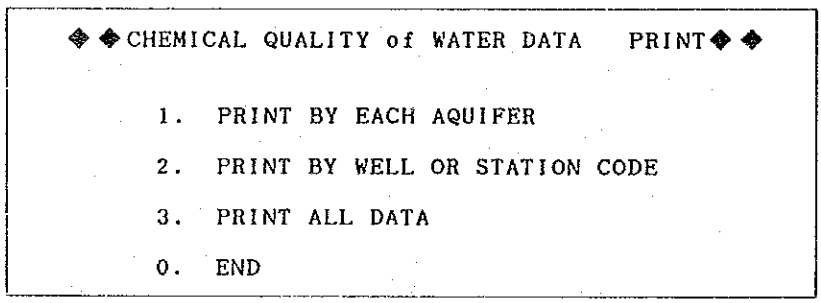


M1340

2.3.5 CHEMICAL QUALITY OF WATER

The sub-menu M1350 appears when 5 is chosen from the M1300 menu. The functions of the commands are:

1. PRINT BY AQUIFER
   Choose this to print out chemical quality data on a particular aquifer. You will be asked to select an aquifer.
2. PRINT BY WELL OR STATION CODE
   Choose this to print out data on a particular station or borehole.
3. PRINT ALL DATA
   Choose this to print out data on all aquifers and all stations or boreholes.

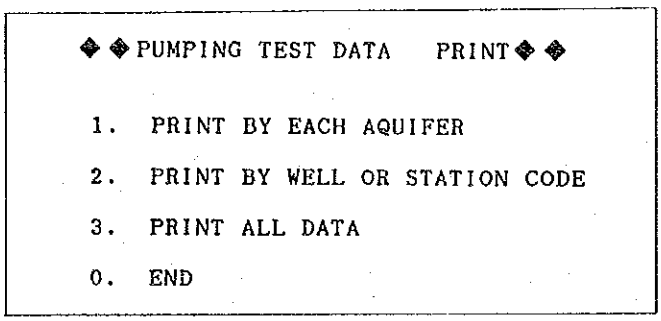


M1350

2.3.6 PUMPING TEST

The sub-menu M1360 appears when 6 is chosen from the M1300 menu. The functions of the commands are:

1. PRINT BY AQUIFER
   Choose this to print out pumping test data performed at the boreholes in a particular aquifer. You will be asked to select an aquifer.
2. PRINT BY WELL
   Choose this to print out data on a particular borehole.
3. PRINT ALL DATA
   Choose this to print out data on all aquifers and boreholes.



M1360

2.3.7 G/W LEVEL SIMULTANEOUS OBSERVATION

The following statements appear when 1 is chosen from the M1300 menu.

1) 31/05/88 - 15/07/88 2) 19/07/88 - 01/08/88
3) 23/01/89 - 31/01/89 4) 16/05/89 - 21/05/89

These are the periods (terms) of the simultaneous observations whose data have been stored in the data base.

The following statements and data entry fields appear at the bottom of the screen.

Type in the number of term to print and RETURN (Within 10 terms)
When complete, RETURN again.

___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Type in the numbers of the periods of observation. You can select up to ten periods, there are only four periods stored.

When your selection is complete, push the RETURN key without typing in any letter to quit the selection and print out the results.

Ex. To print out the results of the observations carried out from 19/07/88 to 01/08/88 and from 16/05/89 to 21/05/89:

Type in the number of term to print and RETURN (Within 10 terms)
When complete, RETURN again.

2 4 RET ___ ___ ___ ___ ___ ___ ___

2.4 LOCATION MAP

The sub-menu M1400 appears when 4 is chosen from the M1000 menu.

```
1. METEOROLOGICAL STATION
2. HYDROLOGICAL STATION
3. WELL AND BOREHOLE
0. END
```

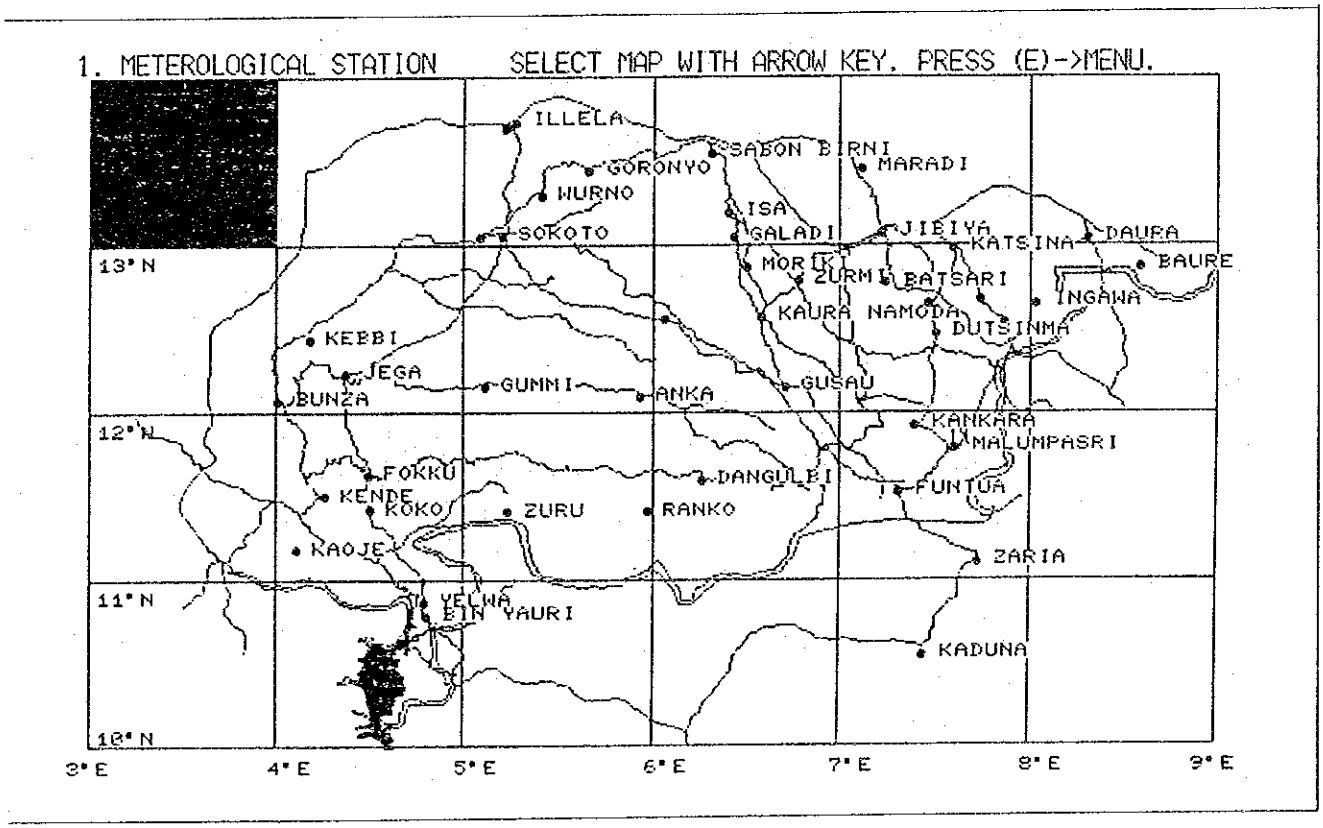
M1400

For commands 1 through 3, a map of the Sokoto-Rima basin with principal drainages and town names appears on the screen.

Select the map section you want to enlarge with the cursor keys by moving the painted rectangle among the map sections When the section you want to enlarge is painted, push RETURN.

An enlarged map with locations of stations and boreholes appears. If you want to view a list of the coordinates of the stations and boreholes, push the HELP key.

Note: If you want to make a hard copy of the screen, hold the GRPH key down and press the COPY key.



2.5 ASSIST FUNCTIONS

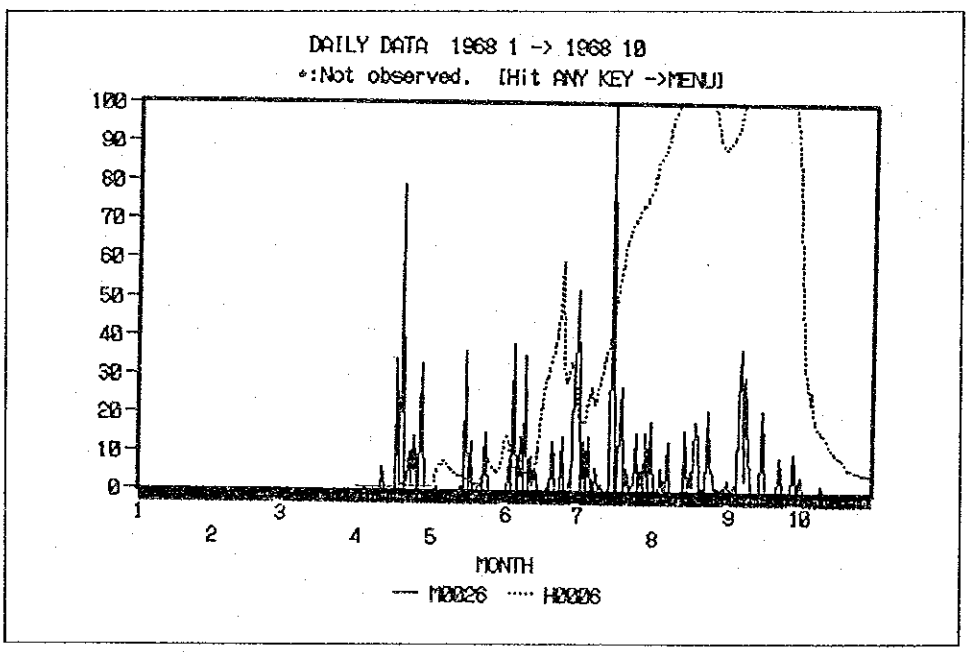
The sub-menu M1500 appears when 5 is chosen from the M1000 menu. The functions of the commands are:

1. APPEND AND MODIFY INDEX CODE
   Choose this to append and modify index codes. Index codes include agency code, river code, aquifer code, and water use code.

```
◆◆ A S S I S T  M E N U ◆◆

1.  APPEND and MODIFY Index code

2.  GRAPH

0.  END
```

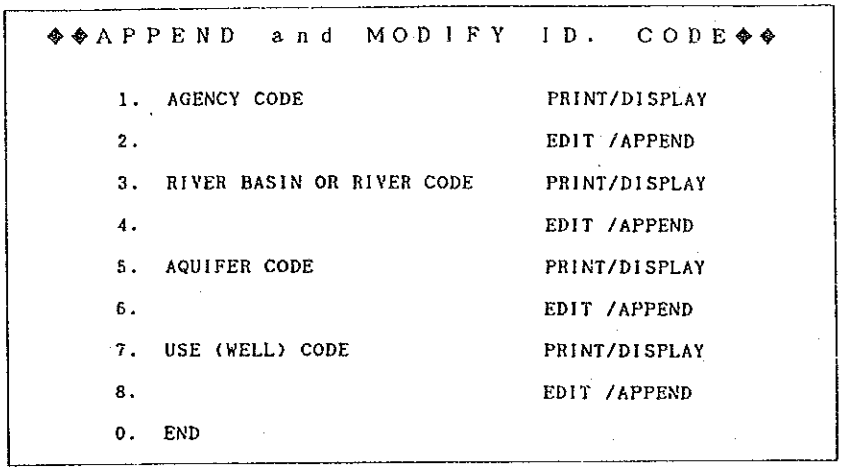
M1500

2. GRAPH
   Choose this to draw a graph of daily or monthly data.



2.5.1 APPEND and MODIFY INDEX CODE

The sub-menu M1510 appears when 1 is chosen from the M1500 menu. Select 1, 3, 5, or 7 to print out or display an index code table. Select 2, 4, 6, or 8 to append or modify an index code.



M1510

2.5.1.1 PRINT/DISPLAY

When command number 1, 3, 5, or 7 is selected, the following instruction appears.

Enter (P) to print out, enter (S) to display on the screen

The index table will be printed out or displayed on the screen in accordance with your command (P or S).

2.5.1.2 APPEND and MODIFY

When command number 2,4,6, or 8 is selected, the following instruction appears.

Enter Index code number to edit. _____

Enter the index code. If the number exists, the following message appears.

The code indexes below meaning. RETURN to confirm, push E to quit
2 S.S.W.B/S.S.M.W.E <- code number and its contents

If you need to see the index table, enter 999.

Upon confirmation, you will be asked to type in the contents of the index.

EDIT CONTENTS: _____

Upon completion of typing, push RETURN to quit. The following instruction will appear.

Hit RETURN to confirm. Push (E) to edit again. Push (D) to delete this Index.

To confirm, push RETURN. If you need to correct your entry, push E to type in again. If you want to delete the index, push D.

2.5.2 GRAPH

The sub-menu M1520 appears when 2 is chosen from the M1500 menu. You can make a graph of daily data or monthly data. Up to five stations and/or types of data can be drawn in a graph.

```
◆◆GRAPH    MENU◆◆

   1.  DAILY DATA

   2.  MONTHLY DATA


   0.  END
```

M1520

2.5.2.1 Data entry mode

(1) Data type and station code

The sub-menu M1521, for daily data, or M1522, for monthly data appears when 1 or 2, respectively, is chosen from the M1520 menu. Data entry procedures are:

1. Type in the number of the data type (ex. enter 2 to select discharge).
2. Type in the code number of the station (ex. enter 0006 to select ARGUNGU). The station name will appear.
3. Continue 1. and 2.
4. When you have completed selection of data type and station, enter 9 (daily data) or 99 (monthly data) in the entry field for data type.

```
        Enter observation item number and station code number

          DATA PLACE CODE     PLACE NAME

     1.

     2.

     3.

     4.

     5.

        DATA   1. DAILY PRECIPITATION
               2. DAILY DISCHARGE
               3. DAILY WATER LEVEL


               Enter (9) to complete selection
```

M1521

```
        Enter observation item number and station code number.

          DATA PLACE CODE     PLACE NAME

     1.

     2.

     3.

     4.

     5.

     DATA  1. PRECIPITATION      2. DISCHARGE          3. WATER LEVEL
           4. MIN. TEMPERATURE   5. MAX. TEMPERATURE   6. AVE. TEMPERATURE
           7. EVAPORATION        8. MIN. HUMIDITY      9. MAX. HUMIDITY
          10. HUMIDTY at 9:00   11. HUMIDITY at 15:00 12. SUNSHINE
          13. MIN. WIND VELO.   14. MAX. WIND VELO.   15. AVE. WIND VELO.

          Enter (99) to complete selection.
```

M1522

(2) Year and month

You will then be asked the beginning and ending month of the graph.

```
Enter beginning and end month and year to display graph.
Duration must be within one year (daily data).
Duration must be within thirty years (monthly data).
YEAR  MONTH    ->   YEAR MONTH
```

Ex. If you want to draw a graph of monthly discharge at ARGUNGU and precipitation at GUSAU from June 1968 to Sept. 1970, your data entry becomes:

```
      DATA  PLACE CODE    PLACE NAME
1.     2     H0005        ARGUNGU
2.     1     M0026        GUSAU AERODROME
3.    99
4.
5.

          YEAR  MONTH   ->   YEAR  MONTH
          1968    6          1970    9
```

2.5.2.2 Graph Mode

Upon completion of data entry, you are required to change the floppy disk and push RETURN, if you are using floppy disks, or simply to push RETURN if you are using the hard disk.

The general MENU (M-G) of the data base systems will then appear. Enter G to enter the graph mode, and wait two or three minutes for the following menu to appear.

```
  < TYPE IN THE NUMBER OF THE COMMAND YOU WANT TO SELECT, AND RETURN >
+-------------------------------------------------------------------+

        1. HYDROGEOLOGICAL DATA BASE

        2. LITERATURE DATABASE

        0. END

+-------------------------------------------------------------------+

  If you have selected the GRAPH menu in the Hydrogeological Data Base
  and this menu text was shown upon completion of data entry, please
  type in (G) and hit RETURN to display a graph on the screen.


A>
```

M-G (The General menu)

```
        Select graph type by cursor or push No.
        1 LINE CHART   2 BAR CHART   0 END
```

Select the desired chart, and the following menu will appear.

```
    Do you want to designate minimum and maximum of graph?
    1 AUTO    2 MANUAL
```

If you select 1, the graph size will be automatically determined by the system. If you select 2, you will be asked the minimum and maximum values for the graph.

MINIMUM ?
MAXIMUM ?

Upon completion of your selections, the graph will appear on the screen. If you want to make a hard copy of the screen, hold the GRPH key down and push the COPY key.

Push the space key to quit the display, and the following menu will appear.

```
    Do you want to change duration
    1 No    2 Yes
```

If you select 2, you can change the duration of the graph provided, that the new duration is within the original duration.

If you select 1, the following menu appears again.

```
        Select graph type by cursor or push No.
        1 LINE CHART   2 BAR CHART   0 END
```

If you want to quit, select 0. The general menu (M-G) of the data base system appears again.

Select 1 to continue in the hydrogeological data base.

3. LITERATURE DATA BASE

-- NOTE -- Some menus for the literature data base are not described in this section. However, these menus are similar to those found in the hydrogeological data base and their principles of operation are the same.

3.1 Starting up the data base

Type 2 and push ENTER to start the data base from the general menu (M-G). (See page 9.)

Push RETURN when messages (M-S on page 9) appears.

The main menu of the literature data base M2000 appears.

```
Literature Data Base System


1. APPEND / MODIFY
2. SEARCH / PRINT OUT
0. END
```

M2000

3.2 APPEND AND MODIFY

The sub-menu M2100 appears when 1 is chosen from the M2000 menu. The function of the commands are:

```
Literature Data Base System


1. DISPLAY INDEXES / PRINT OUT
2. APPEND / MODIFY INDEX
3. APPEND LITERATURE DATA
4. MODIFY LITERATURE DATA
0. RETURN TO THE MAIN MENU
```

M2100

1. DISPLAY INDEXES / PRINT OUT
   Indexes are used to classify the contents of the literature. With this command, the table of indexes will appear on the screen and can be printed out.
2. APPEND / MODIFY INDEX
   With this command, you can append or modify the indexes.
3. APPEND LITERATURE DATA
   With this command, you can append new literature data files to the data base. The literature code number will be given automatically.

4. MODIFY LITERATURE DATA

With this command, you can modify existing literature data files. You are asked to enter the literature code number.

The data entry fields discribed below appear when selecting 3 or 4 above.

```
LITERATURE CODE:            )
Literature Name:
THE STUDY FOR GROUNDWATER DEVELOPMENT IN SOKOTO STATE PROGRESS REPORT 1

Auther / Investigated by:    JAPAN INTERNATIONAL COOPERATION AGENCY

Issued year-month: 1988-9

Available at:   1) F.D.W.R SOKOTO
                2) S.S.W.B
                3) KOKUSAI KOGYO CO. LTD., CHIYODAKU TOKYO JAPAN

Indexes:          A-03    A-05    A-06    B-02    B-03

                  B-04    B-05    C-01    C-02    C-03
Abstract
                  MEMO
```

Data entry fields (example)

When entering data, follow the instructions shown on the screen.

(1) General Data

Literature Name : <- Enter literature name
Author / Investigated by : <- Who carried out the work
Issued year-month : <- Enter like this: 1989-09
Available at : <- Organizations or persons who have the data

(2) Indexes

Enter indexes appropriate to the contents of the data.
Ex. Indexes for the JICA study are:
A-03 HYDROGEOLOGICAL STUDY
A-06 REGIONAL DEVELOPMENT STUDY
B-01 TEST DRILLING AND/OR PUMPING TEST
B-02 GEOPHYSICAL PROSPECTING
B-03 CHEMICAL QUALITY TEST
B-04 WATER LEVEL OBSERVATION
B-05 DISCHARGE OBSERVATION
C-01 GROUNDWATER POTENTIAL
C-03 WATER SUPLY SYSTEM DESIGN

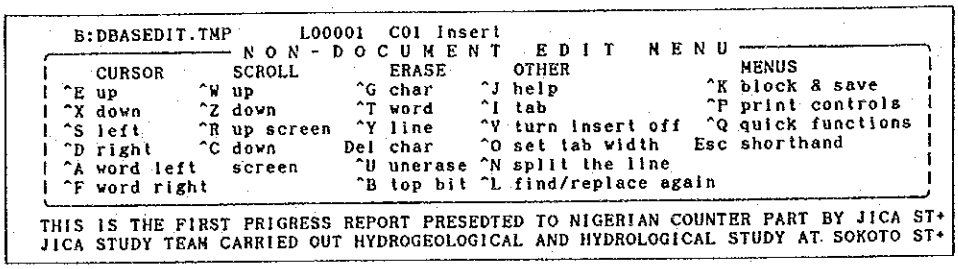
Up to ten (10) indexes can be entered when the entry of indexes is complete, enter 1-11.

(3) Abstract

You may enter an abstract of the data. Follow the instruction shown on the screen.
When the following messages appear, hold the CTRL key down and push the] key (located to the left of the RETURN key).

```
Abstract:
      ABSTRACT      MEMO
PUSH CTRL+] TO EDIT ABSTRACT
PUSH CTRL+W TO QUIT
```

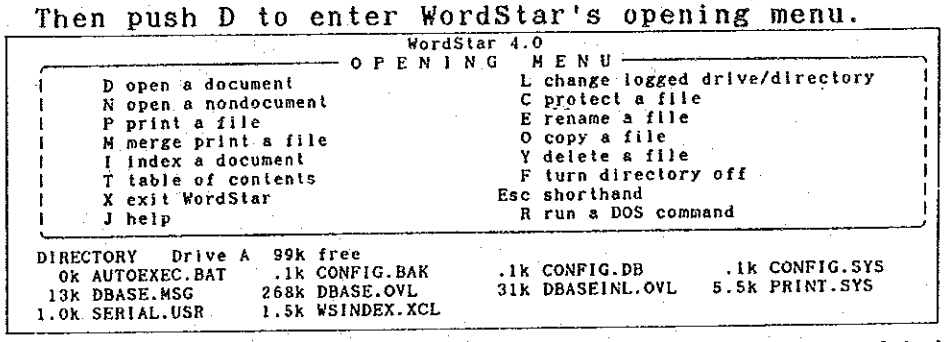
You will enter the non-document edit menu of WordStar, the word processing software by which entry of abstracts is performed. Refer to the WordStar operating manual, which is



WordStar non-document edit menu

found in the computer room.
When abstract entry is complete, be sure to observe the following procedures.

Push CTRL+K The letter K appears at the top-left corner of the screen.
Then push D to enter WordStar's opening menu.



WordStar opening menu

Push X to exit WordStar, and the messages which appeared upon selecting the abstract entry menu appear again.
Push CTRL+W to quit the operation and return to the data entry fields display.

3.3 SEARCH / PRINT OUT

The sub-menu M2200 appears when 2 chosen from the M2000 menu.

```
      Literature  Data  Base System

  1. SEARCH BY INDEXES /PRINT OUT
  2. SEARCH BY LITERATURE NAME,ETC. /PRINT OUT
  3. PRINT OUT
  0. RETURN TO THE MAIN MENU
```

M2200

The functions of the commands are:

1. SEARCH BY INDEXES / PRINT OUT

   Choose this to find literature classificed by particular indexes.
   Matching files will be displayed on the screen and can be printed out. If you choose to print out the file(s), sub-menu M2210 will appear for your selection of data items to print.

```
  1. ALPHABETICAL ORDER   => LITERATURE NAME
  2. ALPHABETICAL ORDER   => AUTHOR/INVESTIGATED BY
  3. CHRONOLOGICAL ORDER  => ISSUED YEAR MONTH
  4. ALPHABETICAL ORDER   => AVAILABLE ORGAN
  5. PRINT OUT DISPLAY IMAGE.
```

SORTING

M2210

2. SEARCH BY LITERATURE NAME, ETC. / PRINT OUT

   Choose this to find literature classified by name, author, date of issue, or location where literature is available. Matching files will be displayed on the screen and can be printed out. If you choose to print out the file(s), sub-menu M2220 will appear for your selection of data items to print.

```
  1. LITERATURE CODE + NAME
  2. LITERATURE CODE + AUTHOR +ISSUED YEAR,MONTH
  3. LITERATURE CODE + ORGAN DATA AVAILABLE AT
  4. LITERATURE CODE + CONTENTS OF INDEXES
  5. LITERATURE CODE + ABSTRACT
  6. END THIS JOB
```

DATA ITEM SELECTION

M2220

3. PRINT OUT

Choose this either to print out a single file or to print out all files. If you choose to print a single file by literature code number, the contents of all data fields in that file will be printed. If you choose instead to print all files, the sub-menu M2210 will appear.

From the sub-menu M2210, if you choose command 5, the contents of all data fields for all files will be printed, and the files will be printed in order of literature code number. If instead you choose from commands 1 through 4, the files will be printed in alphabetical or chronological order,as indicated, and sub-menu M2220 will appear, from which only a limited selection of data fields are available for printing.

INDEX CODE FOR HYDROGEOLOGICAL DATA BASE

AGENCY CODE

0	
1	F.D.W.R.
2	S.S.W.B./S.S.M.W.E.
3	S.R.R.B.D.A
4	K.S.W.B.
5	MET. SERVICE
6	A.B.U.
7	IMPRESIT
8	S.A.R.D.A

RIVER CODE

0	
1	SOKOTO-RIMA
2	BOBO
3	BUNSURU
4	CHOFA
5	DABIRAN
6	DAMA
7	DAMACHI
8	DAMINAWAL
9	DANRAHI
10	GADA
11	GAGARE
12	GAMINDA
13	GAWON
14	GEGE
15	GULBI
16	INGAWA
17	KA
18	KADUSA
19	KARADUWA
20	KORAMA
21	L.KAINUWA
22	L.KALMALO
23	L.KWARE
24	MAKURDI
25	MARADI
26	MUDURU
27	MUSURUDU
28	RIMA
29	SHELLA
30	SHINACHE
31	SOKOTO
32	TAGWAI
33	TURAME
34	YAMADAWA
35	ZAMFARA
36	NIGER

AQUIFER CODE

0	
1	GUNDUMI
2	RIMA
3	SOKOTO
4	GWANDU
5	ILLO
6	BASEMENT
7	
8	

WATER USE CODE

0	
1	DOMESTIC USE
2	LIVESTOCK
3	INDUSTRY
4	WATER SUPPLY
5	AGRICULTURE

INDEX CODE FOR LITERATURE DATA BASE

A-01 GEOLOGICAL INVESTIGATION
A-02 HYDROLOGICAL INVESTIGATION
A-03 HYDROGEOLOGICAL INVESTIGATION
A-04 METEOROLOGICAL INVESTIGATION
A-05 SOCIAL ECONOMIC STUDY
A-06 REGIONAL DEVELOPMENT STUDY
B-01 TEST-DRILLING AND/OR PUMPING TEST
B-02 GEOPHYSICAL PROSPECTING
B-03 CHEMICAL QUALITY TEST
B-04 WATER LEVEL OBSERVATION
B-05 DISCHARGE OBSERVATION
C-01 GROUNDWATER POTENTIAL
C-02 SURFACE-WATER POTENTIAL
C-03 WATER SUPPLY SYSTEM DESIGN

CODE TABLE OF HYDROLOGICAL STATIONS (1)

Code	Name	Agency Name	River(Basin) Name
H0001	KENDE	F.D.W.R.	RIMA
H0002	BUNZA	F.D.W.R.	RIMA
H0003	BANGANA	F.D.W.R.	RIMA
H0004	BIRNI KEBBI	F.D.W.R.	RIMA
H0005	ZAURO	F.D.W.R.	RIMA
H0006	ARGUNGU	F.D.W.R.	RIMA
H0007	BUBUCHE	F.D.W.R.	RIMA
H0008	WAMAKO	F.D.W.R.	RIMA
H0009	SOKOTO RIMA BRIDGE	F.D.W.R.	RIMA
H0010	DIMBISO	F.D.W.R.	RIMA
H0011	GORONYO	F.D.W.R.	RIMA
H0012	SABON BIRNI	F.D.W.R.	RIMA
H0013	SOKOTO BRIDGE	F.D.W.R.	SOKOTO
H0014	GIDAN DOKA		SOKOTO
H0015	BAKURA	F.D.W.R.	SOKOTO
H0016	GUSAU (CABLEWAY)	F.D.W.R.	SOKOTO
H0017	KAURA NAMODA	F.D.W.R.	GAGARE
H0018	MORIKI	F.D.W.R.	GAGARE
H0019	ISA	F.D.W.R.	GAGARE
H0020	SHINKAFI	F.D.W.R.	BUNSURU
H0021	ZURMI	F.D.W.R.	BUNSURU
H0022	ZOBE A (AT BRIDGE)	K.S.W.B.	BUNSURU
H0023	KM 104		KARADUWA
H0024	YARGAMJI	F.D.W.R.	MARADI
H0025	JIBIYA	K.S.W.B.	MARADI
H0026	BUBUCHE	F.D.W.R.	GAMINDA
H0027	FOKKU		KA
H0028	RAHA	F.D.W.R.	ZAMFARA
H0029	KALGO	F.D.W.R.	ZAMFARA
H0030	JEGA	F.D.W.R.	ZAMFARA
H0031	GUMMI	F.D.W.R.	ZAMFARA
H0032	ANKA	F.D.W.R.	ZAMFARA
H0033	TALATA MAFARA	F.D.W.R.	BOBO
H0034	KALGO	F.D.W.R.	SHELLA
H0035	MARU		KADUSA
H0036	SAINYINA		GAWON
H0037	SURU		RIMA
H0038	MARU		SOKOTO
H0039	CHAFE	F.D.W.R.	SOKOTO
H0040	FASKARI	F.D.W.R.	SOKOTO

CODE TABLE OF HYDROLOGICAL STATIONS (2)

Code	Name	Agency Name	River(Basin) Name
H0041	KANKARA		GAGARE
H0042	ZOBE B (CONFLUENCE)		BUNSURU
H0043	ZOBE (CONFLUENCE)		KARADUWA
H0044	BANAGA		KA
H0045	MAGA		KA
H0046	ROMO	F.D.W.R.	ZAMFARA
H0047	WARWAKAZA	K.S.W.B.	TURAME
H0048	NASARAWA MILE 21		GADA
H0049	BAKOLORI		SOKOTO
H0050	TALATA MAFARA		SOKOTO
H0051	ZOBE DAM RELEASE		KARADUWA
H0052	NASARAWA KM30		MARADI
H0053	MALUMFASHI		SHINACHE
H0054	AJIWA	K.S.W.B.	MAKURDI
H0055	ALJANAWA	K.S.W.B.	DAMACHI
H0056	B GOGA	S.R.R.B.D.A	GAGARE
H0057	DAN-MUSA	K.S.W.B.	MUSURUDU
H0058	DAYE(1)	K.S.W.B.	DAMINAWAL
H0059	DAYE(2)	K.S.W.B.	DAMINAWAL
H0060	DUSTIN-MA	K.S.W.B.	KORAMA
H0061	GORONYO DAM		RIMA
H0062	HUCHI		RIMA
H0063	INGAWA	K.S.W.B.	INGAWA
H0064	LAKE KAINUWA		L.KAINUWA
H0065	YARGAMJI	K.S.W.B.	GEGE
H0066	LAKE KALMALO	F.D.W.R.	L.KALMALO
H0067	LAKE KWARE		L.KWARE
H0068	ZOBE A DAM	K.S.W.B.	KARADUWA
H0069	MAIKAWA	S.R.R.B.D.A	RIMA
H0070	MAIRUWA	K.S.W.B.	SOKOTO
H0071	MAKURDA	K.S.W.B.	TAGWAI
H0072	MILE62,FUNTUA-YOSHI RD.	K.S.W.B.	DANRAHI
H0073	MILE65	K.S.W.B.	KARADUWA
H0074	MILE67	K.S.W.B.	DAMA
H0075	MUDURU	K.S.W.B.	MUDURU
H0076	RIMA BRIDGE		RIMA
H0077	RUMA	K.S.W.B.	GULBI
H0078	SHIRASHIRI	K.S.W.B.	CHOFA
H0079	TAMBU	K.S.W.B.	YAMADAWA
H0080	TAMBU	K.S.W.B.	DABIRAN
H0081	DOLE	F.D.W.R.	NIGER

CODE TABLE OF METEOROLOGICAL STATIONS

CODE	NAME
M0001	BAKORI L A SCHOOL
M0002	BAKURA
M0003	BATAGARAWA PRY SCHOOL
M0004	BATSARI ELEMENTARY SCHOOL
M0005	BICHI ELEMENTARY SCHOOL
M0006	BINDAWA JNR PRY SCHOOL
M0007	CHAFE
M0008	CHERANCHI ELEMENTARY SCHOOL
M0009	DANKAMA ELEMENTARY SCHOOL
M0010	DAN MUSA EDUCATION OFFICE
M0011	DAUDAWA GOVT FARM
M0012	DAUDAWA JUNIOR PRIMARY SCHOOL
M0013	DAURA FARM CENTRE
M0014	DAURA JNR PRY SCHOOL
M0015	DAURA SNR P SCHOOL
M0016	DUTSIN MA PRY SCHOOL
M0017	DUTSI JNR PRIMARY SCHOOL
M0018	FASKARI JNR P SCHOOL
M0019	FUNTUA JNR P SCHOOL
M0020	FUNTUA C A P GINNERY
M0021	CADA
M0022	GAFAI JNR P SCHOOL
M0023	GIDADO CENTRAL SCHOOL
M0024	GOBARAN P SCHOOL
M0025	GORONYO
M0026	GUSAU AERODROME
M0027	GUSAU AGRIC
M0028	GWADABAWA
M0029	ILLELA
M0030	INGAWA ELEMENTARY SCHOOL
M0031	ISA PRIMARY SCHOOL
M0032	JIBIYA JNR P SCHOOL
M0033	KADANDANI
M0034	KAFINSOLT AGRIC STATION
M0035	KAITA ELEMENTARY SCHOOL
M0036	KANKIYA PRIMARY SCHOOL
M0037	KANKARA ELEMENTARY SCHOOL
M0038	KASARAWA
M0039	KATSINA AERODROME
M0040	KATSINA TRAINING COLLEGE

CODE	NAME
M0041	KAURA NAMODA D D
M0042	KETARE JNR PRIMARY SCHOOL
M0043	KIRA PRY SCHOOL
M0044	KOTORKOSHI AGRIC
M0045	KURFI EDUCATION OFFICE
M0046	KWARE
M0047	KUSADA ELEMENTARY SCHOOL
M0048	MAIDUWA ELEMENTARY SCHOOL
M0049	MAI INCHI
M0050	MALLAMAWA PRY SCHOOL
M0051	MALUMFASHI PRY SCHOOL
M0052	MORIKI
M0053	MUSAWA L A SCHOOL
M0054	MATAZU PRY SCHOOL
M0055	RAFINDADI ELEMENTARY SCHOOL
M0056	RIMI JNR PRY SCHOOL
M0057	MANI ELEMENTARY SCHOOL
M0058	MARU T T C
M0059	MASHI ELEMENTARY SCHOOL
M0060	SABON BIRNI
M0061	SAFANA PRY SCHOOL
M0062	SHINKAFE
M0063	SHINKAFE N T C
M0064	SOKOTO FORESTRY DEPARTMENT
M0065	SOKOTO GATE BLUFF
M0066	SOKOTO AERODROME
M0067	TALATA MAFARA C M C
M0068	TALATA MAFARA D C
M0069	TANGAZA
M0070	TSAGERO ELEMENTARY SCHOOL
M0071	TURETTA
M0072	WURNO
M0073	YANDAKI JNR P SCHOOL
M0074	ZANGO ELEMENTARY SCHOOL
M0075	BUNSURU AT ZURMI
M0076	SOKOTO AT GUSAU
M0077	YELWA
M0078	GORONYO DAM
M0079	KALNALO
M0080	ARGUNGU
M0081	ZOBE DAM
M0082	KATSINA AJIWA
M0083	BIRNI KEBBI

CODE TABLE OF BOREHOLES (1)

CODE	NAME
W0001	NEPA SOKOTO (Power Sta.)
W0002	GUSAU ROAD SOKOTO
W0003	ALHAZAI
W0004	GIDAN DAWAI
W0005	Gada No.A
W0006	KYADAWA
W0007	RAFIN DUMA NO1
W0008	BACAKA
W0009	GAWA
W0010	GONZA
W0011	TAKAKUMA
W0012	BANACH (BIJHIY)
W0013	KIRARE
W0014	KELKELE ZANGUNA No.1
W0015	KELKELE ZANGUNA No.2
W0016	KWALAWA-BACAKA
W0017	TAKE TSABA NO.2
W0018	RAFAWA (45)
W0019	SHUYAR MAKWAFASLI Nos 1; 2; 3;
W0020	DON K/HALBAWA (39)
W0021	GIDON GADO (42)
W0022	KWARE IRRIGATION No.1
W0023	KWARE No.5
W0024	KWAKE No.5A
W0025	KWARE No.5B
W0026	KWARE No.4
W0027	KWARE No.3
W0028	KWARE IRRIGATION No.2
W0029	KWARE TOWNSHIP 1
W0030	KWARE TOWHSHIP No.2
W0031	BINASA IRRIOATION
W0032	T/MAFARA TOWN No.1
W0033	TALATA MAFARA No.2
W0034	GADOMATA (GORONYO) Nos.1 & 2
W0035	GARKI No.1 (50)
W0036	GARKI No.2 (50)
W0037	KUZARI No.1 (53)
W0038	KUZARI No.2 (53)
W0039	KATUMA No.1 (54)
W0040	KWATSAL (52)
W0041	DOGON MARKB (55)
W0042	DABUGI (57)
W0043	KAIFINASKA (71)
W0044	KATUMA (54)
W0045	SABON T/MAGEJIDAWA (36)
W0046	PARUNA (44)
W0047	GARIN KANE (66)
W0048	DIJIRA ALLAZEYI (70)
W0049	BURUKOSUMA (65)
W0050	GARI IDI (60)
W0051	UNGWALELE (51)
W0052	GAITACE (58)
W0053	LAJINGE (68)
W0054	DANTUDU (KADU) (69)

CODE	NAME
W0055	GIDAN PAJI (43)
W0056	NASARAWA NO.1(59)
W0057	NASARAWA NO.2 (59)
W0058	ZANGO ARAB (48)
W0059	TAMINDANA (72)
W0060	DANMASHAKU (67)
W0061	GIDAN MIKO (49)
W0062	TULU RUDU (56)
W0063	DADIN KOWA (63)
W0064	ZANGO (64)
W0065	GIDAN DAMA (61)
W0066	MADATTAI (62)
W0067	SHINKAFI (8.8)
W0068	GIDAN MAIBABA (37)
W0069	GORE (31)
W0070	SABON GARI (29)
W0071	GIDAN MAGAJIA (33)
W0072	MASAMA (23)
W0073	DABAKIN SALU (SALA)(21)
W0074	GIDAN FURA (9)
W0075	DAN ABBA (5)
W0076	MUNWADATA (4)
W0077	GIDAN TUDU (11)
W0078	TOZAI
W0079	DAN TULLE (DAN TUBE) (12)
W0080	DABAGIN TANKORI (7)
W0081	GIDAN DAGGO (2)
W0082	TAKE TSABA (8)
W0083	GIDAN KARE (1)
W0084	BAUDU (10)
W0085	SOKOTO TOWN NO.6
W0086	SOKOTO TOWN No.5
W0087	SOKOTO CANTEEN/BYPASS ROAD No.
W0088	SOKOTO/ILLELA BYPASS LOAD NO.3
W0089	SOKOTO BYPASS NO.2
W0090	SOKOTO BYPASS RD. No.1 River s
W0091	SULTAN'S PALACE
W0092	ARGUNGU TOWN
W0093	B/KEBBI TOWN (No.2)
W0094	JEGA Town No.2
W0095	TAMBUWAL NO.2
W0096	TAMBAWEL TOWN NO.1
W0097	B/KEBBI NO.6
W0098	B/KEBBI (TOWN) NO.5
W0099	B/KEBBI (TOWN) NO.4
W0100	B/KEBBI NO.2
W0101	B/KEBBI.Town No.3
W0103	SOKOTO NO.2B KALAMBAINA ROAD
W0104	B/KEBBI NO.1
W0105	KANGIWA NO.2
W0106	KANGIWA No.1
W0107	SOKOTO NO.2A KALAMBAINA ROAD
W0108	KALAMBAINA RD. NO.2
W0109	GUBETAWA (16)

CODE TABLE OF BOREHOLES (2)

CODE	NAME
W0110	SABIYAL (15)
W0111	GADABO (14)
W0112	Kyadawa (Ghadawa) (75)
W0113	KADASAKA (17)
W0114	SAGERA MAJAJI (DIKKO) (13)
W0115	WAURU (18)
W0116	KAGARE
W0117	RIMAWA
W0118	HOLAI
W0119	DUMAJI
W0120	GAYERI
W0121	BOTO-TANGAZA LOCAL GOVERNMENT
W0122	AMBRUSA TOWN
W0123	GIYAWA
W0124	KAFFA
W0125	KIRI
W0126	MANA
W0127	ZARA
W0128	AUGI
W0129	GIGANE
W0130	DERUSA-ATTO(TANGAZA LOCAL GOVE
W0131	KILGORI
W0132	KADASAKA.
W0133	BACHIRI
W0134	TAKE TSABA
W0135	KELKELE ZANGUNA
W0136	KELKELE ZANGUWA NO.2
W0137	KWALAWA-BACAKA
W0138	TAKE TSABA NO.2
W0139	RAFAWA
W0140	SHUYAR MAKWAFASLI Nos 1; 2; 3;
W0141	TAKE TSUBA NO.2
W0142	KOTORKOSHI
W0143	HOUSE OF ASSEMBLY RESIDENTIAL
W0144	RAWUYA
W0145	BULAN YAKI
W0146	PILGRIM'S CAMP BOREHOLE
W0147	BINJIN MUSA
W0148	DUKAMAJE
W0149	ASARA
W0150	WANKE
W0151	LUKINGO
W0152	GAJIRA
W0153	BERKEJE
W0154	BAKURA
W0155	CHADAWA
W0156	KANOMA NO.3
W0157	SANGI
W0159	NGASKI NO.5
W0160	KYADAWA
W0161	UNGUSHI
W0162	CHILAS, SILAME LOCAL GOVERNMEN
W0163	MAKOYA, SILAME LOCAL GOVERNMEN
W0164	SHATOKA,SILAME LOCAL GOVERNMEN

CODE	NAME
W0165	DENDI MAHE
W0166	RUMBUKI.
W0167	BIRNI TSABA. NEAR KAURA NAMODA
W0168	MAINCHI
W0169	ZAGGA
W0170	DUGU
W0171	YAN DOTON DAJI
W0172	WONAKA
W0173	RIBAH
W0174	YANKUZAU
W0175	KESOJE
W0176	ARABA
W0177	TORONKA
W0178	FARU NO 1
W0179	MAI-INCHI
W0180	KURYA MADARO
W0181	WASAGU BOREHOLE 1
W0182	WASAGU BOREHOLE 2
W0183	KALBANGA BOREHOLE 1
W0185	ZUGU
W0501	ISA DUGWELL
W0502	ISA
W0503	SHINKAFE
W0504	KUNAWA
W0505	MALAM BUZU
W0506	GAJIT
W0507	MASHAYA
W0508	KURU KURU
W0509	GORONYO COMPLEX
W0510	GORONYO
W0511	GADA
W0512	RAFIN DUNA
W0513	GIDAN CIWAKE
W0514	ILLELA .
W0515	MAMAN SUKA
W0516	GWADABAWA
W0517	KWARE
W0518	TANGAZA
W0519	GIDAN MADI
W0520	SOKOTO YAURI RD1
W0521	SOKOTO YAURI RD2
W0522	SOKOTO YAURI RD3
W0523	SOKOTO POLO CLUB
W0524	BARAN ZAKI
W0525	WURNO
W0526	WURNO
W0527	GIDAN TUDU
W0528	RABBAH
W0529	ACHIDA
W0530	KANDAN
W0531	CHIMOLA 1
W0532	CHIMOLA 2
W0533	TALATA MAFARA
W0534	LAMBA BAKURA

CODE TABLE OF BOREHOLES (3)

CODE	NAME
W0535	TURETTA
W0536	DANGE
W0537	YABO
W0538	SANYINA
W0539	HELENDE
W0540	ALWASA
W0541	BAYAWA
W0542	KOKO POLICE
W0543	KOKO(NO1)
W0544	KENDE
W0545	GIWATAZO
W0546	UMBUTU
W0547	KEBBE
W0548	BARDOKI
W0549	HINGILLA
W0550	KAMBA
W0551	FANNA
W0552	DAKIN GARI
W0553	KWANDAGE
W0554	BUNZA
W0555	JEGA
W0556	BIRNIN KEBBI
W0557	ALIERO
W0558	TAMBAWAL
W0559	DOGON DAJI
W0560	KAJIJI
W0561	SHAGARI..
W0562	BODINGA
W0563	DAN TASAKO
W0564	RIJIA HIDO
W0601	GUSAU-SOKOTO ROADBORE
W0602	GUSAU-SOKOTO ROAD3702
W0603	KWATARKWASHI WELL NO4
W0604	KWATARKWASHI WELL NO5
W0605	KAURA NAMODA A-2
W0606	DAURAN
W0607	MAGA
W0608	RUWAN BORE
W0609	TUNGA ARDO
W0610	YAMBUKI
W0611	DANGE 3512
W0612	GIRAWSI 3704
W0613	GUSAU-SOKOTO ROAD3526
W0614	GUSAU-SOKOTO ROAD3524
W0615	GUSAU-SOKOTO ROAD3703
W0616	GUSAU-SOKOTO ROAD3522
W0617	GUSAU-SOKOTO ROAD3520
W0618	GUSAU-SOKOTO ROAD3519
W0619	ISA 3514
W0620	KALOYE 3708
W0621	MUNGADI 3707
W0622	RABAH 2490
W0623	SABON BIRNI 3513
W0624	SALNYINAN DAJI 3709

CODE	NAME
W0625	KUKAKOGO
W0626	BIRNIN KEBBI BH2483
W0627	SOKOTO TOWN BH 933
W0628	BALLE BH3053
W0629	BIRNIN KEBBI BH2484
W0630	RABAH BH2488
W0631	BODINGA 3508
W0632	DANGE WELL
W0633	DOGWANDAJI WELL
W0634	GIRAWSI 3705
W0635	GUSAU-SOKOTO ROAD3517
W0636	KALOYE 3708
W0637	SHUNI 3511
W0638	SOKOTO,ECN 3706
W0639	SOKOTO,GRA 2856
W0640	SOKOTO,GRA 3505
W0641	HORO BIRNI
W0642	ANGWAH TUDU SPRL
W0643	BODINGA WELL
W0644	CHIMOLA WELL
W0645	DANGE WELL
W0646	KWARE WELL
W0647	MUNGADI WELL
W0648	SOKOTO WELL
W0649	SOKOTO
W0650	- WELL
W0651	MAMANSKA D-1
W0652	BIRNIN KEBBI BH2481
W0653	BALLE BH3051
W0654	BALLE BH3054
W0655	BALLE BH3055
W0656	KURDULA BH3056
W0657	TANGAZA BH3059
W0658	YELDU BH3063
W0659	KARFJN SARKI BH3069
W0660	RUAWRI BH3070
W0661	SAFLA BH3501
W0662	DANZOMU BH3502
W0663	ARGUNGU BH2485
W0664	RAFIN KUBU BH2499
W0665	BACAKA BH2674
W0666	BIRNIN KEBBI BH2481
W0667	RALLE WELL
W0668	GWANDU WELL
W0669	KURDULA WELL
W0670	KWAKWARA WELL
W0671	YELDU WELL
W0672	TANGAZA F-3
W0673	SORO
W1581	NGASKI NO.1
W1582	NGASKI NO.2
W1583	NGASKI NO.3
W1584	NGASKI NO.4

2. GROUNDWATER SIMULATION

INTRODUCTION

Groundwater is increasingly being exploited as both a primary and supplementary source of water supply in a variety of regions and nations. However, groundwater is essentially a hidden resource, the effects of groundwater often causes land subsidence in urban areas and seawater intrusion in coastal areas, which in 1960-1970 become a social problem in Japan. In view of the importance of groundwater and the uncertainties associated with its use, "Simulation" a a mathematical tool is necessary in order to foster more efficient groundwater resource management. The purpose of the report on groundwater simulation is to summarize the state-of-the-art in computer modeling in Japan and its utilization in groundwater basin management studies.

Numerical groundwater models simulate the behavior of groundwater systems and their response to stress, which includes: flow, subsidence, mass transport and heat transport. However, in this report mainly flow and subsidence models are described. Other models are being developed or are undergoing improvements.

2-1 SIMULATION FOR GROUNDWATER BASIN MANAGEMENT

2-1-1 THE ROLE OF GROUNDWATER SIMULATION

Groundwater development is considered similar to the operation of a huge integrated system. Groundwater is exploited as a useful water resource. However, undesirable effects such as sea water intrusion and land subsidence may occur as counteractions.

The behavior of groundwater is subjected not only to the characteristics of the groundwater basin, itself, but also to the activities of human beings, such as pumping, artificial recharging and so on.

The groundwater basin is regarded as a system and characterized by the following three items

a. is of a huge scale
b. is made up of components of a complicated and codependent relation
c. playing an important role in economy of the related region

Thus, the simulation approach to the groundwater basin by using various modeling techniques, has widely been employed in solving management problems of groundwater basins since the mid-1960's.

2-1-2 FUNDAMENTAL PROCEDURE OF GROUNDWATER SIMULATION

The simulation procedure for an artesian groundwater basin is basically same as that which is usually employed, and is described as follows (Figure 2-1).

a. The integrated system of the groundwater basin is comprised of area units and aquifer system units referred to as subsystems. A subsystem is further divided into elements (aquifer constants). The scale and accuracy of these elements are subject to the purpose and complexity of the system.

b. The interrelated nature of the subsystems and elements allows quantification of the groundwater simulation model once the computer program has been written.

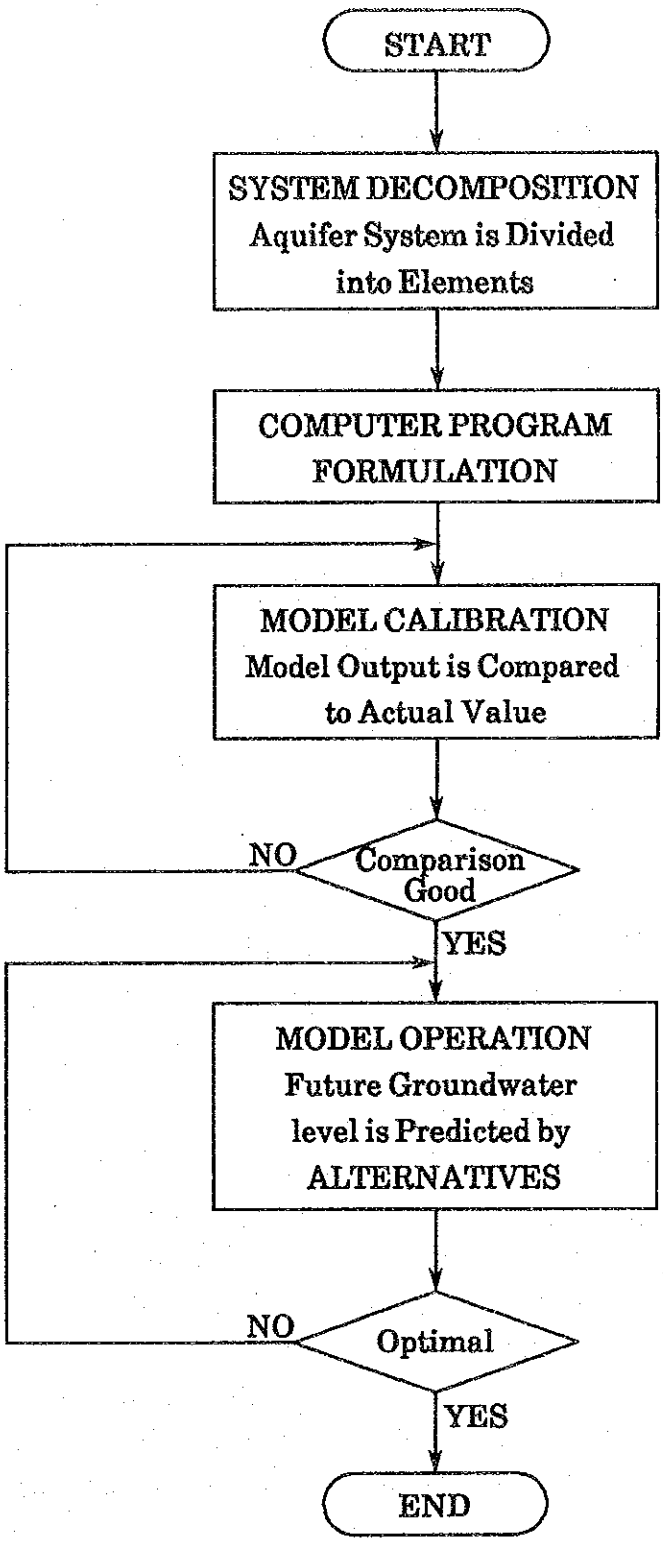


Fig. 2-1 General Procedure of Simulation

c. Initial and boundary conditions, as well as historical data (e.g. withdrawal) are incorporated into the groundwater simulation model. The model is then checked to see whether it represents actual conditions or not. (For example, outputs on groundwater levels are compared with actual observed data). Through this process, boundary conditions and given parameters are identified.

d. By applying future withdrawal of groundwater to the new model, the decline of groundwater levels are predicted.

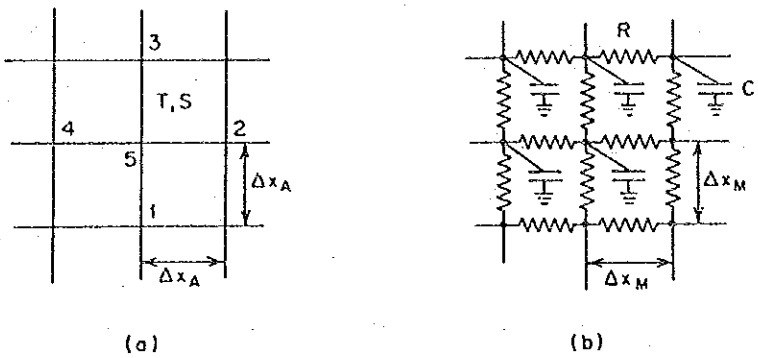
e. The optimal exploitation plan is determined in consideration of factors for safe yield.

2-2 PRESENT STATUS OF GROUNDWATER SIMULATION

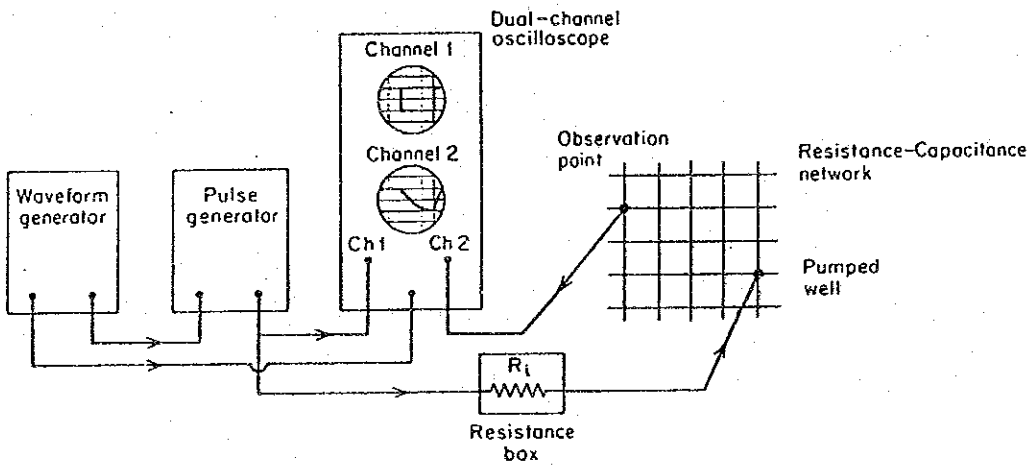
Humans' extensive and varied interference with the groundwater system has fostered the development of formal mathematical tools to aid in simulating groundwater conditions and predicting the response of the system. At the simplest level, these mathematical tools include analytical methods or models which deal with idealized aquifers assumed to exhibit uniform conditions, steady flows, and regular geometrical boundaries. Analytical solutions to groundwater problems can be carried out with the aid of paper and pencil and perhaps a calculator, and generally do not require expensive hardware such as computers.

For more complex aquifer situations where heterogeneous and dynamic conditions including irregular boundaries prevail or where more accurate simulations are desired, the use of more sophisticated techniques and technology becomes necessary. Historically, the first such technique to be developed was the analog model. As its name implies, the analog model is a physical replica of the groundwater system by a medium which is capable of reproducing the processes occurring in an aquifer. For example, analogs which have been employed for groundwater systems include the flow of viscous fluids of the passage of electrical currents through resistance capacitance networks (Figure-2-2).

$$T(h_1 + h_2 + h_3 + h_4 - 4h_5) = S\,\Delta x_A^2 \frac{\partial h_5}{\partial t_A}$$



Small homogeneous portion of discretized aquifer and analogous resistor-capacitor network (after Prickett, 1975).



Excitation-response apparatus for electrical-analog simulation using a resistance-capacitance network.

Fig. 2-2 Resistance-capacitance network and Analog model

While the introduction of analog models enabled the analysis of more complex groundwater problems, they proved to be cumbersome, difficult to maintain, and inflexible with regard to application to different problems. Over the past decade, therefore, analog models have been largely replaced by numerical models which depend on the solution of algebraic equations on the digital computer. Numerical models are capable of analyzing more complex situations than are the analog models. In addition, numerical models have proved to be far more versatile than their predecessors. Research in the late 1960's produced hybrid models which attempted to combine the best features of the digital computer with visual display and immediate outputs of the analog model. Hybrid models have not, however, been widely used.

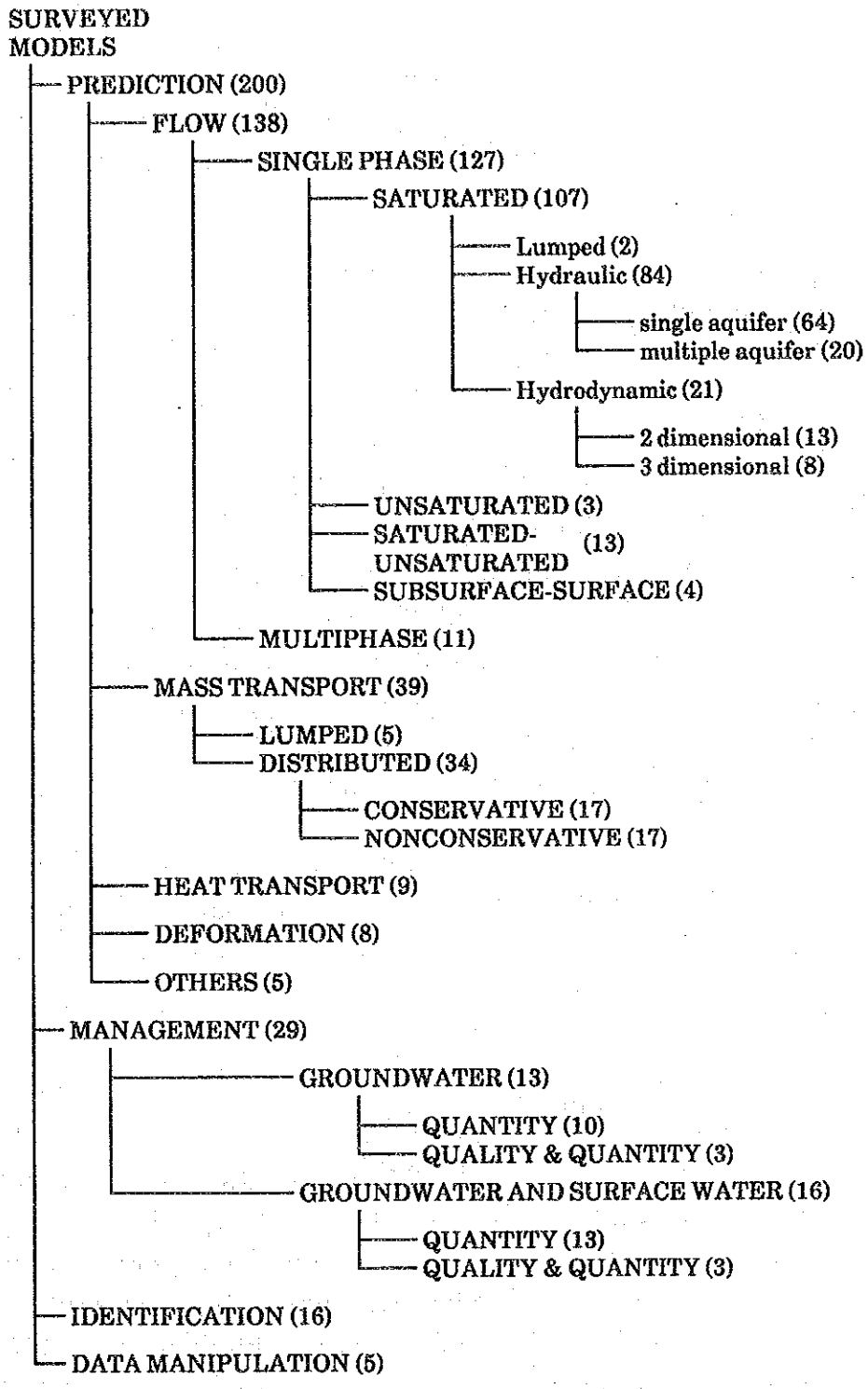
In 1976, SCOPE Groundwater Modeling Steering Committee surveyed the numerical models related to groundwater management. The results of the survey were published in 1980, entitled "Groundwater Management: The Use of Numerical Models". According to their report, among the numerical groundwater models, four different major purposes can be distinguished. These are: 1) prediction models, which simulate the behavior or the groundwater system and its response to stress; 2) resource management models, which integrate prediction with the objectives of water management to indicate appropriate decisions; 3) identification models, which determine input parameters for both of the above; 4) data manipulation models, which process and manage input data for all the above (Figure 2-3).

2-2-1 PREDICTION MODELS

Most of the models produced by data are prediction models which may be subdivided into four major categories: flow, subsidence, mass transport and heat transport.

Flow models utilize information on aquifer parameters, boundary conditions, precipitation, and human-induced development, to solve mathematical equations for determining quantitative aspects of groundwater flow such as direction and rate of flow, change in water level, stream-aquifer interactions and interference effects of wells. While most of these models simulate flow in aquifers, flow models have also been developed for the unsaturated zone, and for coupled saturated-unsaturated-surface system. Flow models are the most commonly used, as well as generally the best developed of the groundwater models

Figure 2-3 TAXONOMY OF SURVEYED MODELS



(The number in parentheses indicates the number of model reports) Yehuda Bachmat et al. (1977): The use and Utility of Numerical Models in Groundwater Resource Management, Draft Final Report, SCOPE.

Subsidence or deformation models attempt to describe the phenomenon of land subsidence which may be caused by excessive withdrawal of groundwater. Groundwater withdrawals lower the fluid pressure in the aquifer, and consequently reduce the aquifer's capability to sustain the load of the ground above it. The result is vertical compression of the land. Subsidence models are needed to predict deformation-related impacts of various pumping schemes in affected areas.

Mass transport models are based on a flow component, but they deal primarily with questions of groundwater quality. They are thus used to predict the movement and concentration in the aquifer of various pollutants including radionuclides, leached solids from landfill and irrigated area, and salt water intruding in coastal areas. To accomplish this, the models incorporated mathematical approximations of the transport, by means of fluid flow (convection), and/or mixing of one or more chemical constituents in the groundwater. Because of these considerations, mass transport models in general tend to be more complicated than flow models. Transport models that describe only the movement of pollutants are called conservative; models that also take into account chemical and biological reactions are termed non conservative. The oil industry has been active in developing transport models for two substances, oil and water, which are immiscible.

Heat transport models attempt to predict the flow of heat or water or steam in situations where thermal effects are important. In practice, these have been applied to problems associated with hot springs, geothermal reservoirs and waters flowing between aquifers under the influence of heat.

2-2-2 RESOURCE MANAGEMENT MODELS

Management models have been developed in an attempt to indicate courses of action which will be consistent with stated management objectives and constraints. The objectives may be, for example, to maximize net economic benefits, to minimize costs, or to ensure adequate water supply at all times for all users. Management models may employ the techniques of both simulation and optimization in deriving their outputs. In contrast to purely physically-based prediction models, management models incorporate economic, technological, political and institutional aspects to the problems or situations

being analyzed.

2-2-3 IDENTIFICATION MODELS

Parameter identification models have been developed in response to the need to calibrate and validate prediction and management models. Although engineering techniques have long existed for calculating parameters through pumping tests, the identification of parameters for regional groundwater systems must be augmented by regular observations of wells throughout the regional system. As a result, parameter identification models are being developed which attempt to derive parameter values for regional groundwater models through the analysis of long-term historical data — technically known as solving the inverse problem. The quality of such parameters is still, of course, only as good as the data from which they are derived.

2-2-4 DATA MANIPULATION MODELS

The difficulties involved in estimating parameters are closely linked with the more general issue of data collection for groundwater models. Models can be run with any amount of available data, but the actual amount of quality of these data directly affect the reliability of the model's results. The task of collecting appropriate amounts of accurate data to ensure model reliability thus implies the need for a fourth class of model — data manipulation model. This model can be used in various ways, including specifying data collection procedures, designing data collection networks, identifying critical data, and storing and processing data for use in other models.

2-3 GROUNDWATER SIMULATION MODEL ON FLOW AND SUBSIDENCE PROBLEM

As mentioned in the opening statement, flow and subsidence models are widely used in Japan and other advanced nations. Other prediction models, such as the mass-transport or heat transport models, are not well developed at present. They are adequate for obtaining first order estimates. However, some major technical and conceptual difficulties will habe to be overcome before they will be as easily applied and useful as the flow and subsidence models.

In this section, simulation models on flow and subsidence are briefly introduced. In particular, land subsidence due to over pumpage and its control are important groundwater management problems in Japan.

Therefore, concept and equation of the motion of flow and the subsidence mechanism are discussed in particular in this report.

The purpose of the simulation study on land subsidence based on groundwater balancing is to forecast the number of centimeters of settlement expected for the number of meters of groundwater level decline caused by a volume of withdrawal in an area.

In order to answer this, it was necessary to reproduce the groundwater balancing and groundwater flow system in a confined groundwater basin by simulation. At the initial stage of this investigation, the simulation of groundwater behavior was executed based on the "unit-basin" model as a lumped parameter system and two dimensional single aquifer models on a horizontal plane which were provided by Tyson and Weber (1964).

As the investigation proceeded, the simulation model was revised to the quasi three-dimensional model and the two-dimensional multi-aquifer model in vertical cross section. They were applied to study groundwater flow and settlement of the multi-aquifer system. The revised models give satisfactory results in actual fields of land subsidence.

2-3-1 QUASI THREE-DIMENSIONAL MODEL

It is well known that land subsidence is caused by the squeezing of water from the confining clayey bed into the confined aquifer due to decline in the groundwater pressure in the main confined aquifer.

Quantitative analysis of squeezing is very important in study on land subsidence.

At the first stage of investigation, it was pointed out that calculated leakage is mutually related to actual subsidence, by the authors (Shibasaki, Kamata and Shindo, 1969). Then, at the middle stage of the investigation, calculated leakage rate was divided into leakage and squeeze by changing the leakage parameter in the study of the land subsidence of the Niigata Lowland (Shibasaki, Kamata and Wada, 1971).

At present, squeeze and leakage can be analyzed by the simultaneous equation of the motion of the groundwater flow in the confined aquifer and the confining clayey beds by a complete three-dimensional model. However, this solution is not easily obtained because the procedure requires a digital computer of huge capacity and a long running time.

2-3-1-1 Single Confined Aquifer Model

The provided quasi three-dimensional single aquifer model is composed of an unconfined aquifer, a confining clayey bed, a main confined aquifer and an impermeable base rock, in descending order, as shown in Figure 2-4.

If each layer is uniform in permeability, the partial differential equation governing the two-dimensional nonsteady flow of groundwater for a horizontal aquifer is

$$T\left(\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial y^2}\right)=S\frac{\partial h}{\partial t}+w(x,y,t) \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

where h is the head (L), S is the storage coefficient (dimensionless), T is the aquifer transmissivity (L^2/T), t is the time (T), w(x, y, t) is the source or sink (L/T), and x, y are the rectangular coordinate. w(x, y, t) is recharging or discharging rate in a unit area in unit time, in other words. w(x, y, t) is also expressed as

$$w(x,y,t)=L(x,y,t)+Ar(x,y,t)-Qd(x,y,t,) \quad \cdots\cdots\cdots\cdots \quad (2)$$

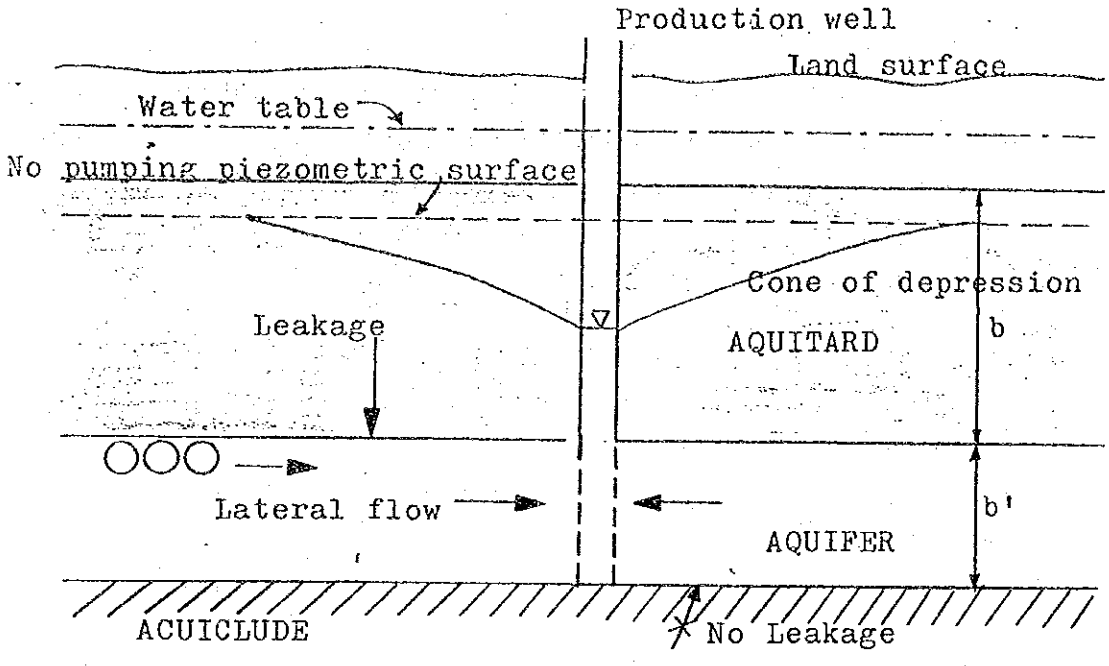


Fig. 2-4 Quasi Three-Dimensional Single Aquifer Model

in which L(x, y, t) is the leakage including squeeze Sq(x, y, t), Ar(x, y, t) is the artificial recharge, and Qd(x, y, t) is the discharge, in a unit area in unit time. The leakage which flows through the confining layer is expressed as

$$L(x, y, t) = \frac{k'}{b'}(h(t) - H(t)) \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (3)$$

where, k' is the permeability coefficient (L/T) of the confining clayey bed, b' is the thickness of the confining clayey bed (L), h(t) is the head of confined aquifer (L) and H(t) is the head of the unconfined aquifer (L).

Beside this, hydrodynamics in the confining clayey bed corresponding to the change of the head of the confined aquifer are shown as

$$\frac{\partial^2 h'}{\partial x^2} + \frac{\partial^2 h'}{\partial y^2} + \frac{\partial^2 h'}{\partial z^2} = \frac{S's}{k'} \frac{\partial h'}{\partial t} \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (4)$$

in which h' is the excess head (L), S's is the specific storage (l/L) and k' is the permeability coefficient (L/T) of the confining clayey bed.

In such a case, the permeability of the confining clayey bed is far smaller than that of main confined aquifer, the direction of the groundwater flow in the confining bed can be assumed to be vertical. Then Eq. (4) is replaced by

$$\frac{\partial^2 h'}{\partial z^2} = \frac{S's}{k'} \frac{\partial h'}{\partial t} \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

The analytical solution of Eg. (6) was given by Carsraw and Jaeger (1954) as follows.

The initial and boundary conditions are

$$\begin{aligned} h'(z, o) &= 0 \qquad t \leq o \\ h'(o, t) &= 0 \qquad t > o \\ h'(b', t) &= \Delta h \qquad t > o \end{aligned} \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (6)$$

where Δh is the change of groundwater head of the main confined aquifer.

The solution is expressed as

$$h' = \Delta h \sum_{n=0}^{\infty} \mathrm{erf}\left[\frac{(2n+1)+z/b'}{(4k't/S'sb')^{1/2}}\right] - \mathrm{erf}\left[\frac{(2n+1)-z/b'}{(4k't/S'sb')^{1/2}}\right] \quad .. \quad (7)$$

At the boundary between the confining layer and the aquifer, the vertical groundwater flow is calculated as

$$k' \frac{\partial^2 h'}{\partial z^2}\bigg|_{z=b'} = \frac{k'\Delta h}{b'(nk't/b'^2 S's)^{1/2}} \{1 + 2\sum_{n=0}^{\infty} \exp(-n^2/(k't/b'^2 S's)) \} \quad .. \quad (8)$$

which is composed of leakage and squeeze.

The squeeze rate Sq is derived easily as

$$Sq = \int_0^{b'} S'\, sh'(z)dz \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

This analytical solution is considered as applicable for the model in simple hydrogeological conditions.

2-3-1-2 Squeeze and Land Subsidence

Squeezing from the confining clayey bed has been studied analytically by many hydrogeologists. Hantush (1960, 1967) first developed the Leakage and Squeeze Theory of the coupled two-confined aquifer system. Neuman and Witherspoon (1969) expanded the theory to cover multiple-leaky aquifer systems and derived analytical solutions. In addition, Wadachi (1939) pointed out that land subsidence is caused by squeezing from the confining clayey bed to the main confined aquifer.

The concept in understanding this phenomenon is that groundwater in a clayey bed flows vertically due to the excess head gradient caused by the decline in the groundwater head of the main confined aquifer. This process of squeezing is equal to Tezaghi's Consolidation Theory.

If the squeezing process is governed by Equation (4), the simultaneous solution should be obtained from the three-dimensional equation of flow which, in order to obtain, would require a core-size digital computer of huge capacity.

Therefore, the numerical method based on Equation (5), is provided for practical purpose to obtain approximations.

The squeeze rate is calculated by the excess head change in the clayey bed from the numerical solution of Eq. (5). The squeeze rate is given by the following equation in time increment "Δt".

$$Sq\,\ell = S's\,\Delta h'\,\ell\,\Delta Z \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (10)$$

where Sq ℓ is the squeeze rate at node ℓ and $\Delta h'\ell$ is the change in the excess head at node ℓ. Δz is the thickness of the clayey slice. (Figure 2-5)

Thus, the total squeeze from the clayey confining bed at each node is expressed as

$$Sq = \sum_{\ell=1}^{m} S's.\Delta h'\,\Delta z \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (11)$$

The total squeeze rate is expected to agree with the land subsidence.

2-3-1-3 Multi-Aquifer Model

The provided quasi three-dimensional multi-auqifer model is composed of multi-layered aquifer-aquitard systems.

Neglecting the vertical flow component in aquifers and the horizontal flow component in aquitard, the basic equation of the motion of these systems is expressed as follows. (Figure 2-6)

$$\frac{\partial}{\partial x}\left(Tix\frac{\partial hi}{\partial x}\right)+\frac{\partial}{\partial y}\left(Tix\frac{\partial hi}{\partial y}\right)=Si\frac{\partial hi}{\partial t}+Wi \qquad \cdots\cdots\cdots\cdots \quad (12)$$

Where hi is the head(L), Si is the storativity (dimensionless), Tix, Tiy are the aquifer transmissivity (L^2/T), t is the time (T), Wi is the source or sink (L/T), and x,y are the spatial coordinates. Suffix i denotes the aquifer in descending order.

Wi is also expressed as

$$W_i = Q_i - (L_{i+1}+L_i) \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (13)$$

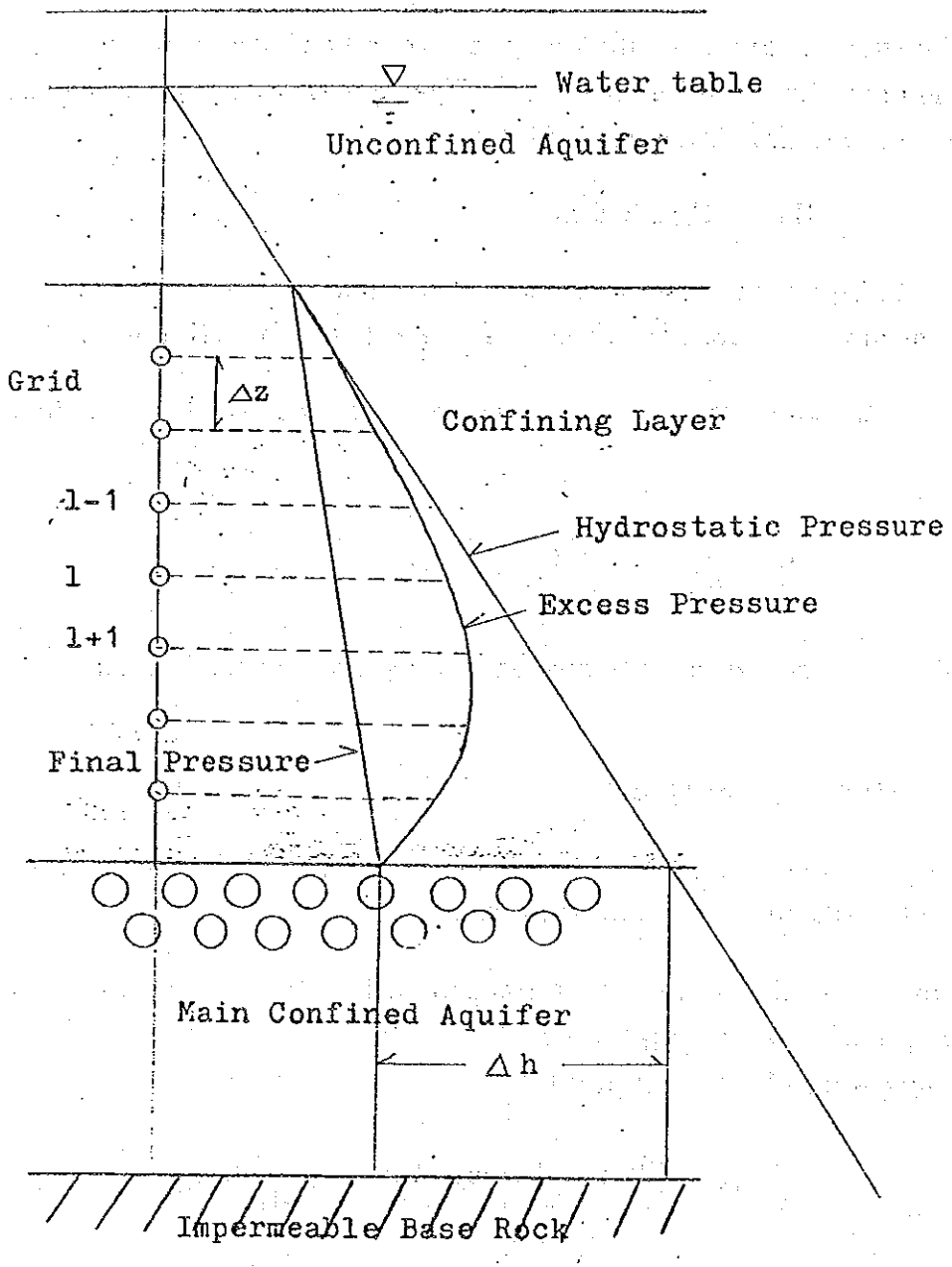


Fig. 2-5 One-Dimentional Finite Difference Grid of the Confining Layer

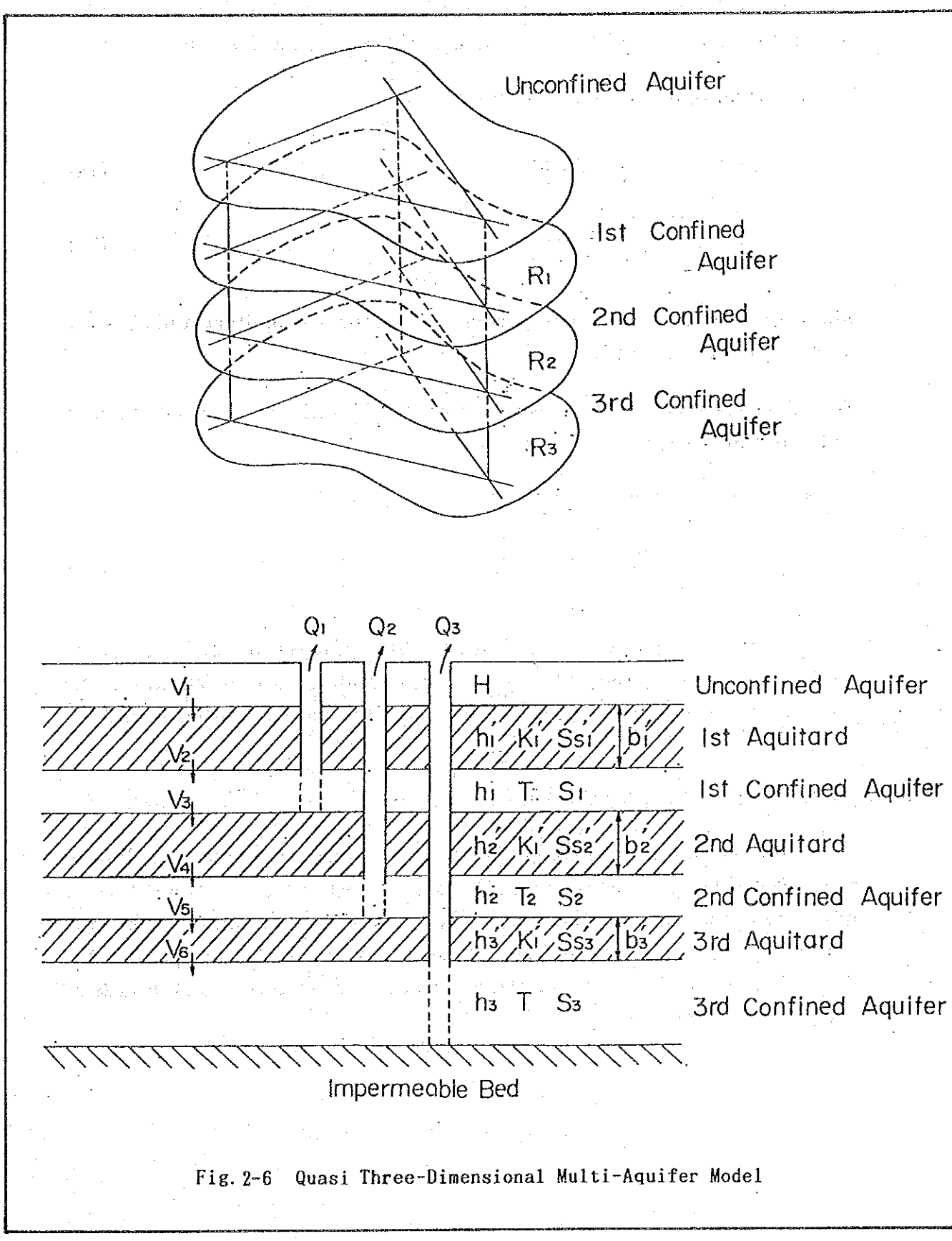


Fig. 2-6 Quasi Three-Dimensional Multi-Aquifer Model

where Qi is the pumping discharge or recharge rate, Li is the leakage which flows into i-th aquifer, Li + 1 is the leakage which flows into i + 1-th aquifer.

Leakage from aquifer to aquifer expressed as

$$Li = \frac{k'i}{b'i}(hi - hi_{-1}) \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (14)$$

$$Li_{+1} = \frac{k'i+1}{b'i+1}(hi - hi_{+1}) \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (15)$$

where k'i is the permeability coefficient (L/T) of the i-th aquitard and b'i is the thickness of i-th aquitard.

Eq. (12) can be solved simultaneously in conjunction with aquifer and aquitard by the leakage factor.

The squeezing rate is expressed as the following simple formula.

$$\Delta Sqi = \frac{(\Delta hi + \Delta hi_{+1})}{2} b'iS'si \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (16)$$

where ΔSqi is the squeezing rate of the i-th aquitard, b'i is the thickness, Ss'i is the specific storage of the i-th aquitard, Δhi and Δhi + 1 are the change in the groundwater head in the upper and lower aquifers adjacent to i-th aquitard.

2-3-2 TWO-DIMENSIONAL MULTI-AQUIFER MODEL

It was noticed through the study that the rate of vertical groundwater flow to the confined aquifer was considerable as compared to that of lateral flow in heavy developed areas. Due to this fact, the two-dimensional multi-layered aquifer system model in vertical cross section was devised to represent the dynamic groundwater flow and the deformation of aquifers and aquitards in the groundwater basins.

2-3-2-1 Mathematical Basis of the Model

The basic equation governing the three-dimensional groundwater flow is expressed as

$$K_{xx}\left(\frac{\partial^2 h}{\partial x^2}\right)+K_{yy}\left(\frac{\partial^2 h}{\partial y^2}\right)+K_{zz}\left(\frac{\partial^2 h}{\partial z^2}\right)=s\frac{\partial h}{\partial t}+W(x,y,z,t) \quad \cdots\cdots \quad (17)$$

where K_{xx}, K_{yy}, K_{zz} are the permeability coefficients in the x, y and z directions, respectively, and Ss is the specific storage, W(x, y, z, t) is the source or sink term. Other notations are same as Eq. (1).

If two-dimensional groundwater flow is assumed in a vertical cross section which has the thickness Δy for y direction , Eq. (17) can be written as

$$\left[K_{xx}\frac{\partial^2 h}{\partial x^2}\right]_\ell+K_{zz}\left[\frac{\partial^2 h}{\partial y^2}\ell\right]=\left[Ss\frac{\partial h}{\partial t}\right]+W(x,z,t) \quad \cdots\cdots\cdots \quad (18)$$

in which [ ]$_\ell$ indicates the properties of the ℓ-th member layer in the multi-layered aquifer system. (Figure 2-7)

2-3-2-2 Compression of Deep Aquifers

The settlement in the deep stratum was pointed out and studied by Hayami (1955) and Lohman (1961). According to Lohman, the deformation of an aquifer caused by the lowering of groundwater pressure is shown as

$$\Delta m=\left(\frac{S}{\rho g}-n\beta m\right)\Delta p. \quad \cdots\cdots\cdots\cdots\cdots \quad (19)$$

where Δm is the change in the thickness of the aquifer of an original thickness m(L), Δp is the change in groundwater pressure (M/L^2), and S is the storativity of the aquifer (dimensionless), ρ is the density of water ($M.T^2/L^4$), g is the acceleration due to gravity (L/T^2), n is the porosity of the aquifer (dimensionless), β is the compressibility of the water (L^2/M). The change in the head in the multi-layered aquifer system is obtained by the solution of Eq. (18) at each node of the cell. Then, the change in the groundwater pressure is given by

$$\rho=\gamma\omega.\Delta h \quad \cdots\cdots\cdots\cdots\cdots \quad (20)$$

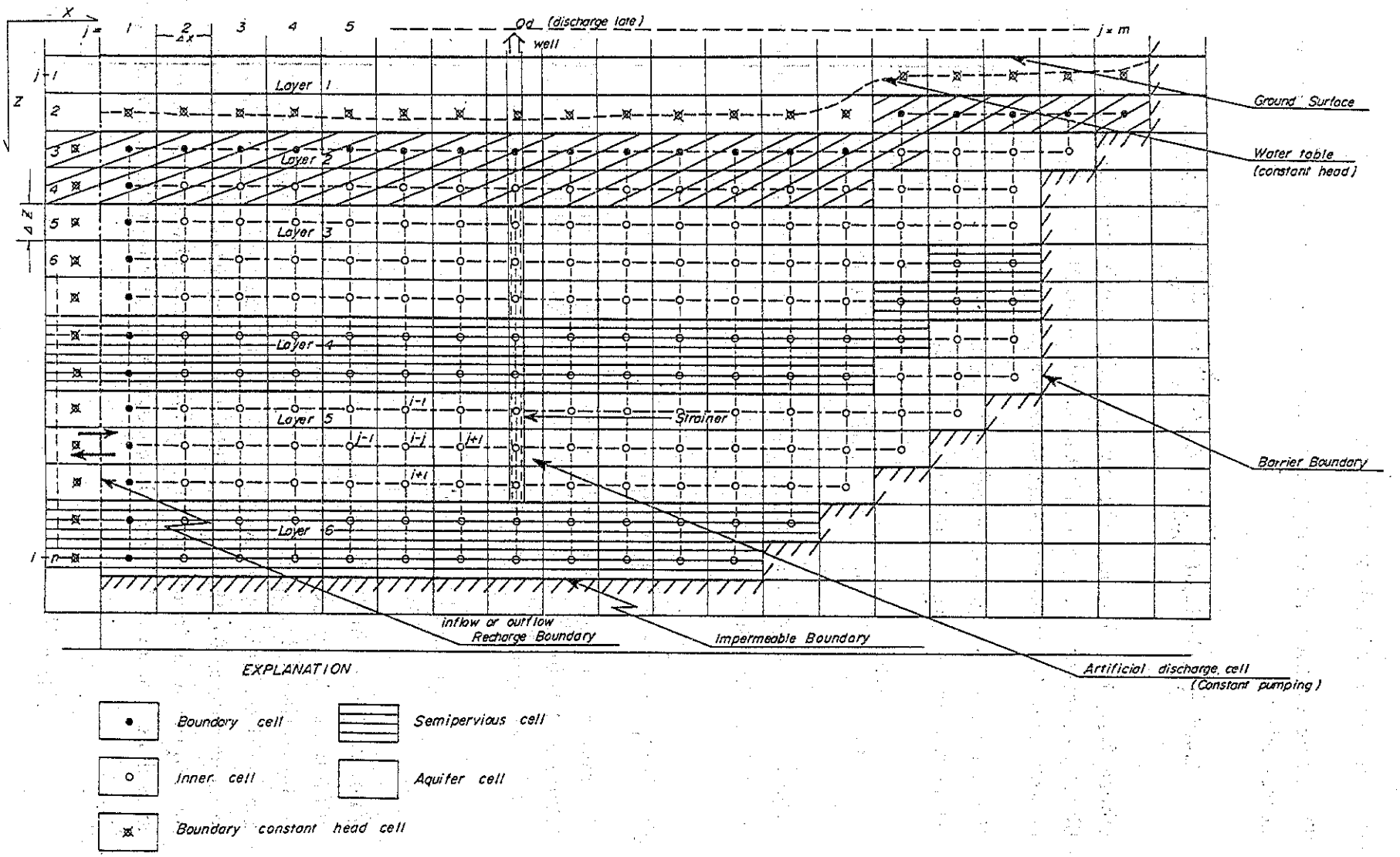


Fig. 2-7 Finite Difference Model of Multi-layered Ground-Water System