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Option reservoir operation during floods

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Appendix A

Users Manual

A.1 OVERVIEW

The comprehensive Reservoir Simulation Model, RESIMO, uses an Olivetti M24, with 256K RAM and 10MB hard disk, desktop digital computer or equivalent to route floods through reservoirs on the basis of inflow (hydrograph) inputs and system (reservoir basin characteristics, spillways, flood status) characterization to predict outcomes in the form of an outflow hydrograph from the reservoir and associated water levels and storages in the reservoir.

An overview of the model structure is shown in Figure A-1. In simplest terms the program is constructed in the form of "blocks" as follows:

i. **DATA** block

This block is used to generate new data files, update data files, view data files, delete files and display disk directories. No computations are done in this block.

ii. **CALC** block

This block performs all the calculations required to simulate the progression of a flood through a reservoir. An option calculates an operating rule for manual gates to optimize the use of available storage in the reservoir and minimize the outflow hydrograph peak.

iii. **PRES** block

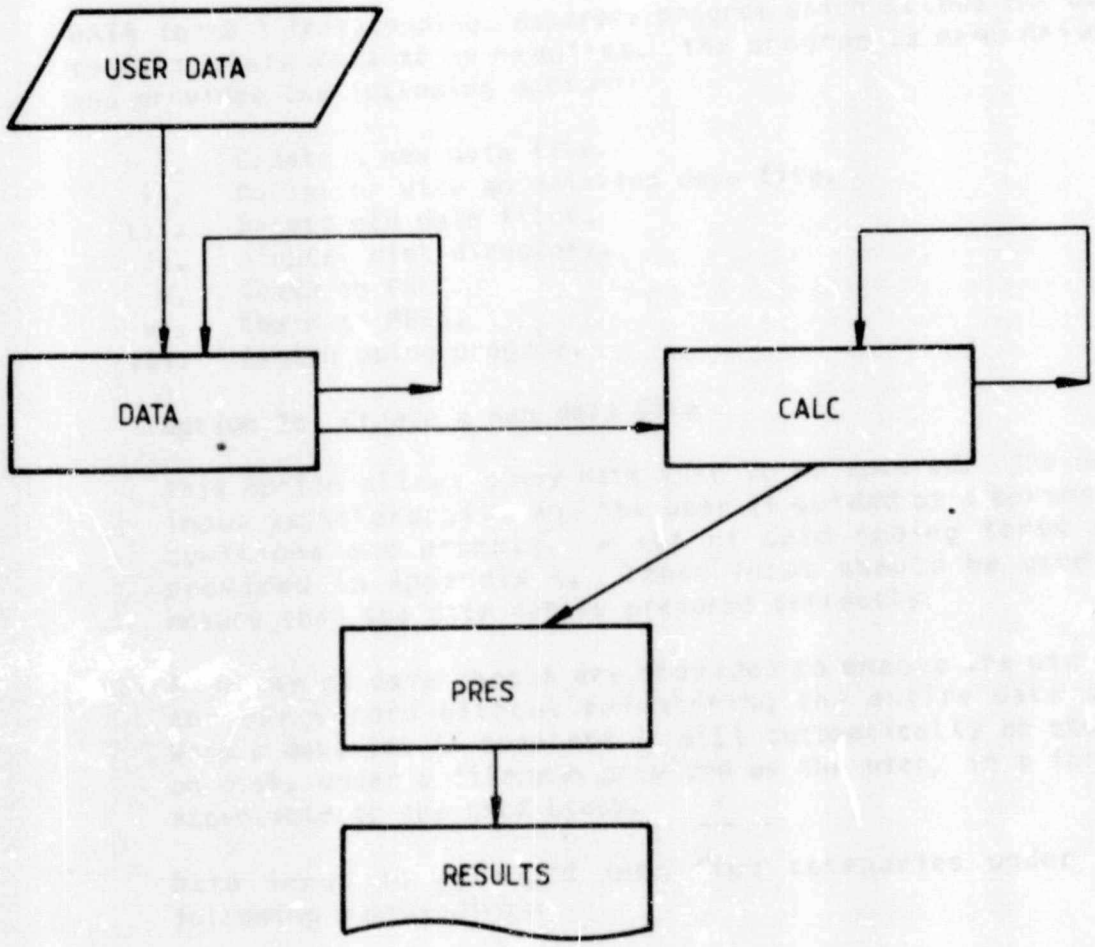
This block presents calculation results, from **CALC**, either on screen or line printer as required. No calculations are done.

As indicated in Figure A-1 all data are entered, edited and updated in the **DATA** block. Calculations, using data from **DATA** block, are done in the **CALC** block and results from **CALC** are presented by the **PRES** block.

This structure has a number of advantages. The most important are:

i. Only one block needs to be entered into the processor at a time. This has the advantage of allowing more processor space for data and calculation purposes. i.e. Larger data sets can be run on the same machine.

ii. Only one operation is done at a time and results stored progressively i.e. The user may generate a number of data files first, run them afterwards and view the results without losing any of the entered data or calculated result files.



OVERVIEW OF THE RESIMO MODEL STRUCTURE, INDICATING LINKAGES AMONG THE THREE PROGRAM BLOCKS

FIGURE A-1

A.2 SERVICE BLOCKS

A.2.1 DATA Block

DATA forms a freestanding, separate program which allows the user to manipulate data as he requires. The program is menu driven and provides the following options:

i. Create a new data file.
ii. Revise or view an existing data file.
iii. Delete old data files.
iv. Display disk directory.
v. Chain to CALC.
vi. Chain to PRES.
vii. Finish using program.

Option 1: Create a new data file

This option allows a new data file to be entered. The data input is interactive and the user is guided by a series of questions and prompts. A set of data coding forms are provided in Appendix B. These forms should be used to ensure that the data set is prepared correctly.

A number of data checks are provided to enable the user to correct errors without re-entering the entire data set. When a data set is complete it will automatically be stored on disk, under a filename provided by the user, in a format acceptable to the **CALC** block.

Data input is arranged into five categories under the following sub-headings:

i. Titles.
ii. Reservoir basin characteristics.
iii. Spillway data.
iv. Flood data.
v. Reservoir flood status.

Titles

This data sub-set serves to identify the data set and the filename under which it will ultimately by stored. The data file name is entered first and it is suggested that a directory name is prefixed to the filename to ensure that the data are stored on the correct disk drive i.e. If a data file is to be stored on drive A, under the filename "FRED" the filename entered should be "A:FRED". If the directory name is omitted data will be stored in the directory in use at the time (usually this means on the program disk).

In addition to the file name the user is allowed two titles. These titles serve to identify the data set and will be incorporated, as headings, in the final results. The first title should identify the reservoir and its flood status while the second title should describe the flood event.

Reservoir basin characteristics

This data sub-set describes the reservoir basin by means of a number of storage - elevation points. The program will interpolate linearly between points in order to calculate storages at intermediate elevations. The elevation step sizes should therefore be chosen such that the assumption inherent in interpolation, i.e. that the change in elevation and storage between two points can be approximated by straight lines, yields acceptable results. The step size need not be constant throughout. i.e. The user can increase or decrease step sizes as required in order to describe the storage - elevation curve adequately.

Spillway data

The program allows seven different spillway components. They are:-

i. Box culverts
ii. Ogee crest
iii. Automatically controlled gates.
iv. Manually controlled gates.
v. Manually controlled high pressure outlet.
vi. Fuseplug.
vii. User defined.

Any one of these components can be used individually or in combination with one or more others. Only one restriction applies when a manually controlled component is operated by the program: Any one manual component can be operated by the program on its own or in combination with any number of non-manual components, but not in combination with another manual component.

Each of these spillway components is described by specific equations with specific limitations. The user should refer to Chapter 2 of the main report for a description of these equations before he decides how to describe a specific spillway.

The sizes, parameters and coefficients required to describe each spillway type are as shown on the coding forms in Appendix B.

Flood data

This data sub-set describes the inflow hydrograph by means of a number of inflow points spaced at equal timesteps from the start of the simulation. The input timestep need not be the same as the timestep used in computations. If the input timestep differs from the computational timestep intermediate values will be obtained by means of interpolation. The user should therefore ensure that the chosen input timestep is sufficiently small for interpolation to yield results which are adequate.

Reservoir flood status

This data sub-set describes the reservoir flood status i.e. the water level in the reservoir at the start of the simulation, the maximum water level allowable during the simulation and the final water level required after simulation.

One data item requires further description: The term "analysis sensitivity" denotes a significant step size (in metres) that the user requires on the storage-indication curve. i.e. As the value of the analysis sensitivity variable decreases, the number of the points on the storage indicatior curve will increase. This facility enables the u to calculate the storage-indication curve in steps small enough to make intermediate values, obtained by interpolation, acceptably accurate. This is an important consideration for automatically controlled gates, especially if they open over a small range of reservoir levels.

Option 2: Revise or view an existing data file

This option allows the user to view the whole or part of an existing data file. The data file or part thereof can either be displayed on the screen or printed on a line printer. The option also allows the user to revise the data file or parts thereof. Data are viewed and edited in four blocks. They are:-

i. Reservoir basin characteristics
ii. Spillway data
iii. Flood data
iv. Reservoir flood status

Note that there is no separate block for changing titles. The user is given the opportunity to change title one if the reservoir flood status block is edited and to change title two if the flood data block is edited.

Data are edited in blocks. This means that an entire block should be re-entered if that block is to be edited. The program uses the same sub-routines to enter revised data blocks as is used to enter a new data file. The revision is thus also done interactively and allows several data checks to enable the user to correct input errors.

Once editing is complete the new data file is stored on disk under a filename provided by the user.

Option 3: Delete old data files

This option allows the user to delete old data files that are no longer required. The user should note that a results file is not deleted together with its associated data file. Simulation results are stored on disk by **CALC** under a file name derived from the data filename by adding ".RES" at the end of the filename. If, for example, the run "FRED" is to be deleted completely the user must delete the data file "FRED" as well as the results file "FRED.RES".

Option 4: Display disk directory

This option allows the user to display any directory available. This is useful for locating old data files and also for checking space available on a device.

Options 5&6: Chain to CALC or PRES.

These options allow the user to chain directly to the required block without physically reloading.

Option 7: Finish using program

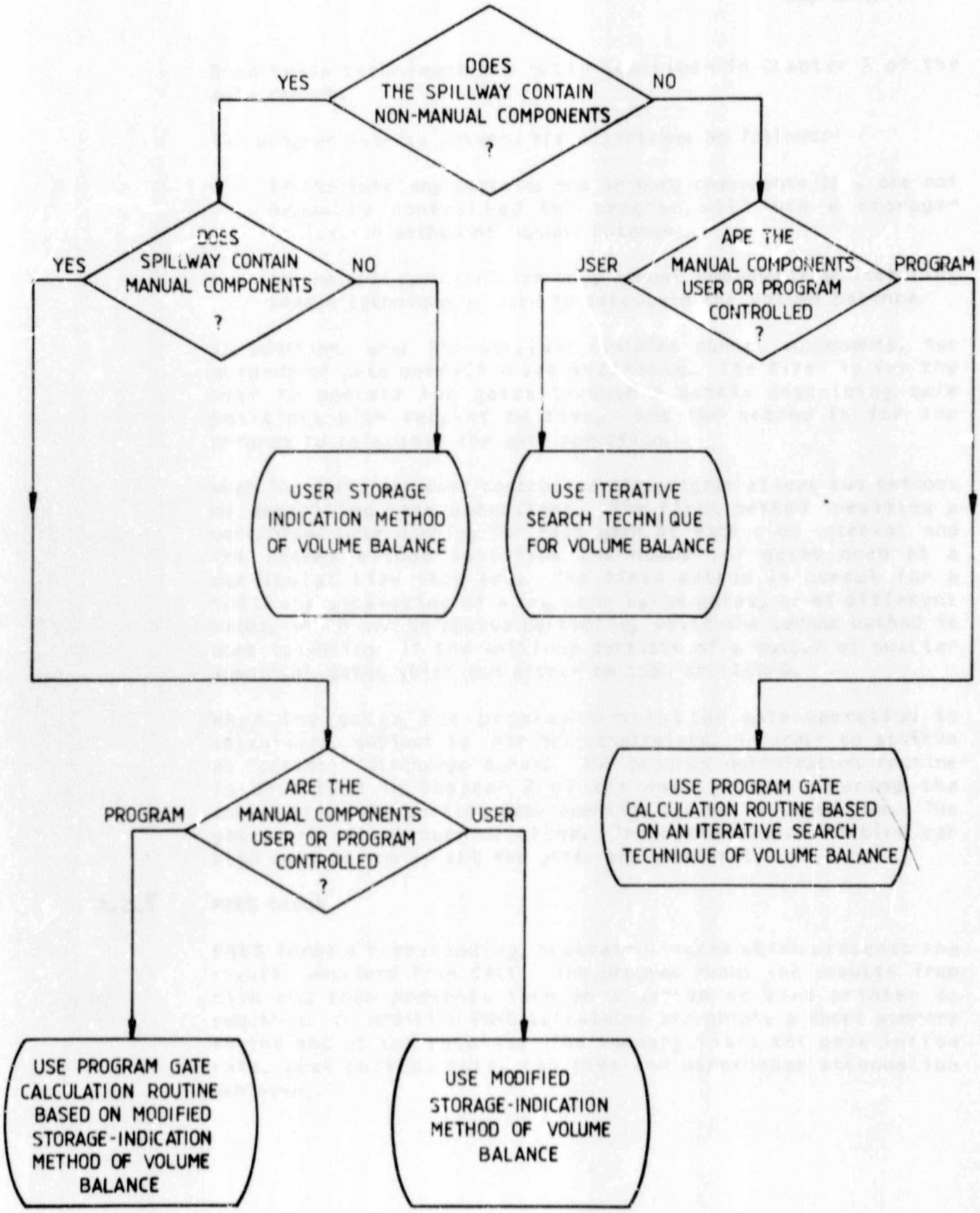
This option allows the user to exit from the program.

A.2.2 CALC block

CALC forms a separate program which contains all the equations and algorithms required to simulate a flood through a reservoir. The block operates independently reading its data, prepared by **DATA**, from disk and writing its results to disk, for **PRES**.

The block will follow one of a number of possible calculation procedures to suit the particular spillway configuration selected. An overview of the decision tree is given in Figure A-2. Two basic algorithms are available to solve the volume balance. They are:

- The storage-indication method and
- An iterative search technique using a decreasing increment.



OVERVIEW OF DECISION TREE FOLLOWED BY CALC. BLOCK TO DETERMINE THE ALGORITHM TO BE USED

FIGURE A-2

Both these techniques are fully described in Chapter 2 of the main report.

The program selects between the algorithms as follows:

- If the spillway contains one or more components that are not manually controlled the program will use a storage-indication method of volume balance.

- If the spillway contains only manual components an iterative search technique is used to calculate the volume balance.

In addition, when the spillway contains manual components, two methods of gate operation are available. The first is for the user to operate the gates through a matrix describing gate positions with respect to time, and the second is for the program to calculate the gate operation.

When the gates are user controlled the program allows two methods of describing gate operations. The first method specifies a percentage gate opening for each gate at each time interval and the second method specifies the number of gates open at a particular time step end. The first method is useful for a spillway consisting of a few very large gates, or of different sizes, which can be opened partially, while the second method is more convenient if the spillway consists of a number of smaller identical gates which can either be open or closed.

When the gates are program controlled gate operation is calculated, subject to user set constraints, in order to achieve an "optimal" discharge curve. The program optimization routine is described in Chapter 2 of the main report. During the optimization run partial gate openings are not allowed. i.e. The gates are either open or close. The optimization routine can also only be run if all the gates are identical.

A.2.3 PRES block

PRES forms a freestanding, separate program which presents the results obtained from **CALC**. The program reads the results from disk and then presents them on a screen or line printer as required. In addition **PRES** calculates and prints a short summary at the end of the results. The summary lists the peak inflow rate, peak outflow rate, lag time and percentage attenuation achieved.

Appendix B

Data Coding Forms

Appendix B

Arrangement of program input

This appendix contains a set of data coding forms to be used in the preparation of a new data set. The coding forms have been generalized to allow for all conditions. Items marked with an asterix are optional and should only be completed if they are relevant.

DATA CODING FORMS

1. TITLES

NAME OF NEW DATA FILE

TITLE 1 : Describes reservoir and its flood status.

TITLE 2 : Describes flood event.

TITLE 1

TITLE 2

2. RESERVOIR BASIN CHARACTERISTICS

NUMBER OF STORAGE - ELEVATION POINTS

STORAGE CONVERSION FACTOR , SCF

STORAGE - ELEVATION POINTS

	ELEVATION (m)	STORAGE (m^3 x SCF)		ELEVATION (m)	STORAGE (m^3 x SCF)
1			21		
2			22		
3			23		
4			24		
5			25		
6			26		
7			27		
8			28		
9			29		
10			30		
11			31		
12			32		
13			33		
14			34		
15			35		
16			36		
17			37		
18			38		
19			39		
20			40		

1. Box Culverts
2. Ogee Crest
3. Automatically controlled weir
4. Manually controlled weir
5. Manually controlled high pressure outlet
6. Fuseplug
7. User spillway

3. SPILLWAY DATA

NUMBER OF SPILLWAY COMPONENTS ☐

SPILLWAY OPTIONS REQUIRED ☐ ☐ ☐ ☐ ☐ ☐ ☐

---

*3.1 OPTION [1] : BOX CULVERTS

NUMBER OF CULVERTS ☐☐☐

CULVERT NO	WIDTH (m)	HEIGHT (m)	INVERT LEVEL (m)	UNSUBMERGED DISCHARGE COEFFICIENT	SUBMERGED DISCHARGE COEFFICIENT
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

* OPTIONAL

* 3.2 OPTION [2] : OGEE CREST

LENGTH (m) [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

INVERT LEVEL (m) [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

DISCHARGE COEFFICIENT [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

---

* 3.3 OPTION [3] : AUTOMATICALLY CONTROLLED WEIR

NUMBER OF GATES [ ][ ][ ]

GATE No.	WEIR INVERT (m)	DISCHARGE COEFFICIENT	GATE WIDTH (m)	GATE HEIGHT (m)	GATE TRAVEL (m)	WATER ELEV. AT START OF OPENING (m)	W.E. AT FULL OPENING (m)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

* OPTIONAL

* 3.4 OPTION [4] : MANUALLY CONTROLLED WEIR

NUMBER OF GATES ☐☐☐

GATE No	WEIR INVERT (m)	DISCHARGE COEFFICIENT	SPILL COEFFICIENT	GATE WIDTH (m)	GATE HEIGHT (m)	GATE TRAVEL (m)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

OPERATION MODE (U/P) ☐

* PROGRAM MOD

DELAY TIME TO FIRST OPERATION (hours) ☐☐☐☐☐☐☐☐☐☐

MAXIMUM NUMBER OF GATES OPERABLE AT ONE TIME ☐☐☐☐☐☐☐☐☐☐

MAXIMUM DESIRABLE OUTFLOW RATE (m^3/s) ☐☐☐☐☐☐☐☐☐☐

MAXIMUM ALLOWABLE OUTFLOW RATE INCREASE (m^3/s) ☐☐☐☐☐☐☐☐☐☐

*OPTIONAL

1. % OPENING FOR EACH INDIVIDUAL GATE AT EACH STEP
2. NO. OF GATES OPEN AT EACH TIME STEP.

* USER MODE

METHOD OF USER OPERATION ☐

* [1] % OPENING FOR EACH GATE / OUTLET AT EACH TIME STEP

TIME STEP \ GATE NO	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

FORM 5

* OPTIONAL

* USER MODE

* [2.] NO. OF GATES / OUTLETS OPEN AT EACH TIME STEP

TIME STEP	NO. OF GATES	TIME STEP	NO. OF GATES	TIME STEP	NO. OF GATES	TIME STEP	NO. OF GATES	TIME STEP	NO. OF GATES
1		21		41		61		81	
2		22		42		62		82	
3		23		43		63		83	
4		24		44		64		84	
5		25		45		65		85	
6		26		46		66		86	
7		27		47		67		87	
8		28		48		68		88	
9		29		49		69		89	
10		30		50		70		90	
11		31		51		71		91	
12		32		52		72		92	
13		33		53		73		93	
14		34		54		74		94	
15		35		55		75		95	
16		36		56		76		96	
17		37		57		77		97	
18		38		58		78		98	
19		39		59		79		99	
20		40		60		80		100	

FORM 6

* OPTIONAL

* 3.5 OPTION [5] : MANUALLY CONTROLLED HIGH PRESSURE OUTLET

NUMBER OF OUTLETS ☐☐☐

OUTLET NO	OUTLET INVERT (m)	DISCHARGE COEFFICIENT	OUTLET WIDTH (m)	OUTLET HEIGHT (m)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

OPERATION MODE (U/P) ☐

* PROGRAM MODE :

DELAY TIME TO FIRST OPERATION (hours) ☐☐☐☐☐☐☐☐☐☐

MAXIMUM NUMBER OF GATES OPERABLE AT ONE TIME ☐☐☐☐☐☐☐☐☐☐

MAXIMUM DESIRABLE OUTFLOW RATE (m^3/s) ☐☐☐☐☐☐☐☐☐☐

MAXIMUM ALLOWABLE OUTFLOW RATE INCREASE (m^3/s) ☐☐☐☐☐☐☐☐☐☐

* OPTIONAL

* 3.6 OPTION [6] : FUSEPLUG

ELEVATION OF START OF WASH (m) [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

ELEVATION OF SPILLWAY CREST (m) [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

LENGTH OF SPILLWAY (m) [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

WEIR DISCHARGE COEFFICIENT [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

---

* 3.7 OPTION [7] : USER SPILLWAY

NUMBER OF DISCHARGE-ELEVATION POINTS [ ][ ][ ]

POINT NO	ELEVATION (m)	DISCHARGE(m^3/s)	POINT NO	ELEVATION (m)	DISCHARGE(m^3/s)
1			21		
2			22		
3			23		
4			24		
5			25		
6			26		
7			27		
8			28		
9			29		
10			30		
11			31		
12			32		
13			33		
14			34		
15			35		
16			36		
17			37		
18			38		
19			39		
20			40		

* OPTIONAL

4. FLOOD DATA

NUMBER OF INFLOW HYDROGRAPH POINTS

INPUT TIME STEP (HOURS)

INFLOW AT START OF SIMULATION (m^3/s)

PT NO	INFLOW (m^3/s)	PT NO	INFLOW (m^3/s)	PT NO	INFLOW (m^3/s)
1		21		41	
2		22		42	
3		23		43	
4		24		44	
5		25		45	
6		26		46	
7		27		47	
8		28		48	
9		29		49	
10		30		50	
11		31		51	
12		32		52	
13		33		53	
14		34		54	
15		35		55	
16		36		56	
17		37		57	
18		38		58	
19		39		59	
20		40		60	

5. RESERVOIR FLOOD STATUS

WATER LEVEL IN RESERVOIR AT START (m)

WATER LEVEL REQUIRED AFTER FLOOD (m)

MAXIMUM ALLOWABLE WATER LEVEL DURING FLOOD (m)

ANALYSIS SENSITIVITY REQUIRED (m)

TIME AT START OF ANALYSIS (hours)

COMPUTATIONAL TIME STEP (hours)

NUMBER OF TIMESTEPS TO BE ANALYSED

Appendix C

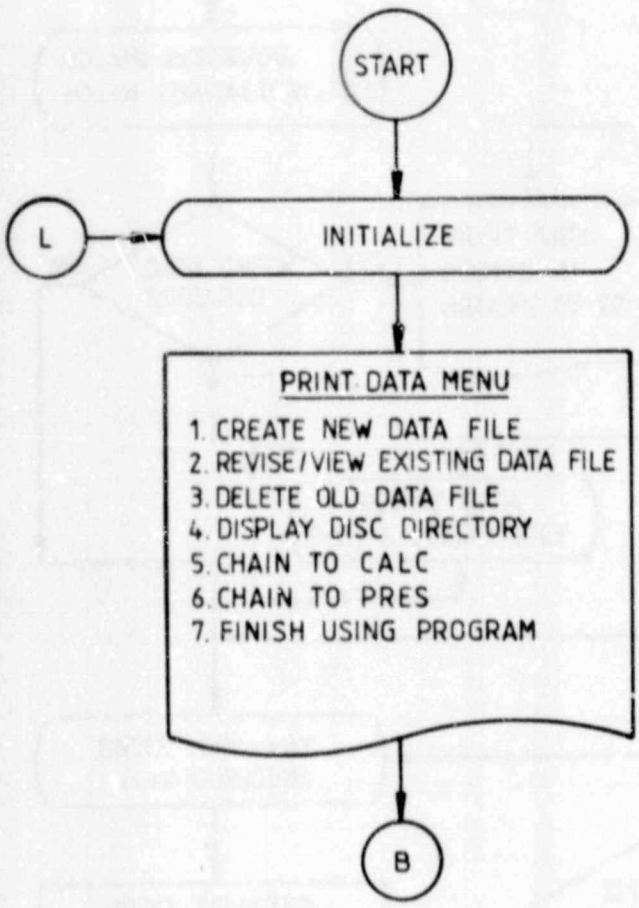
Program Flow Charts

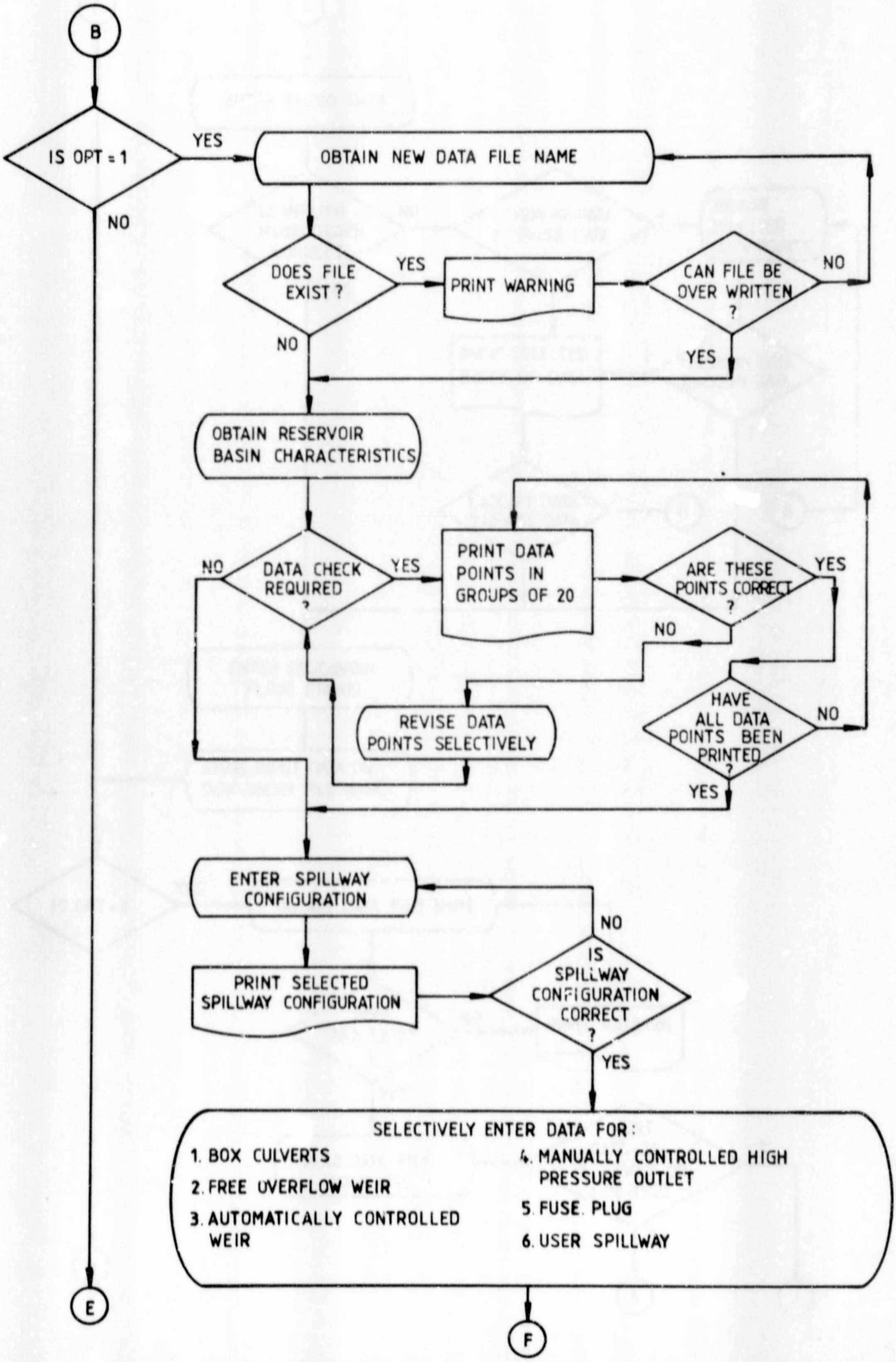
Appendix C

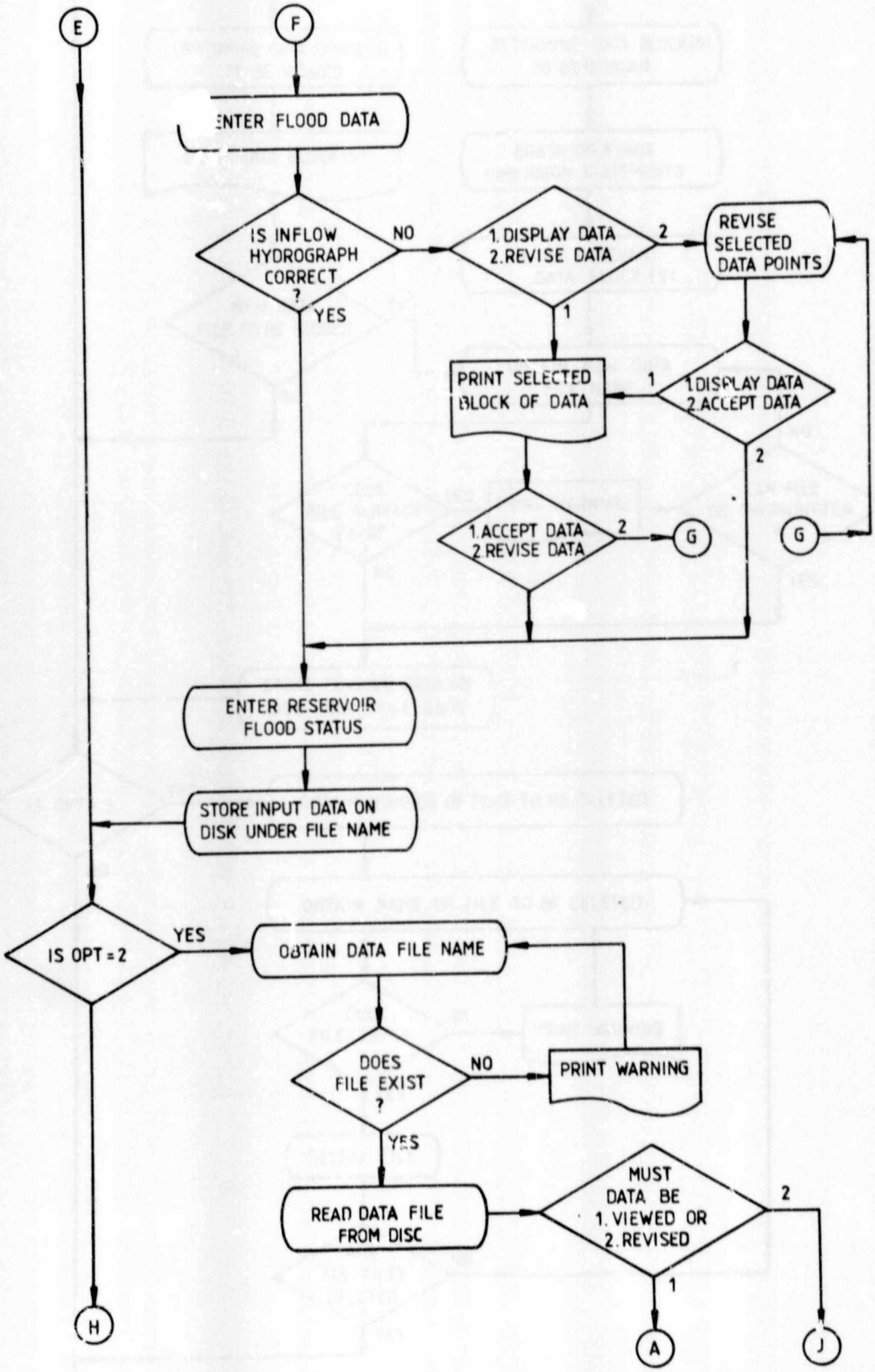
Flow charts

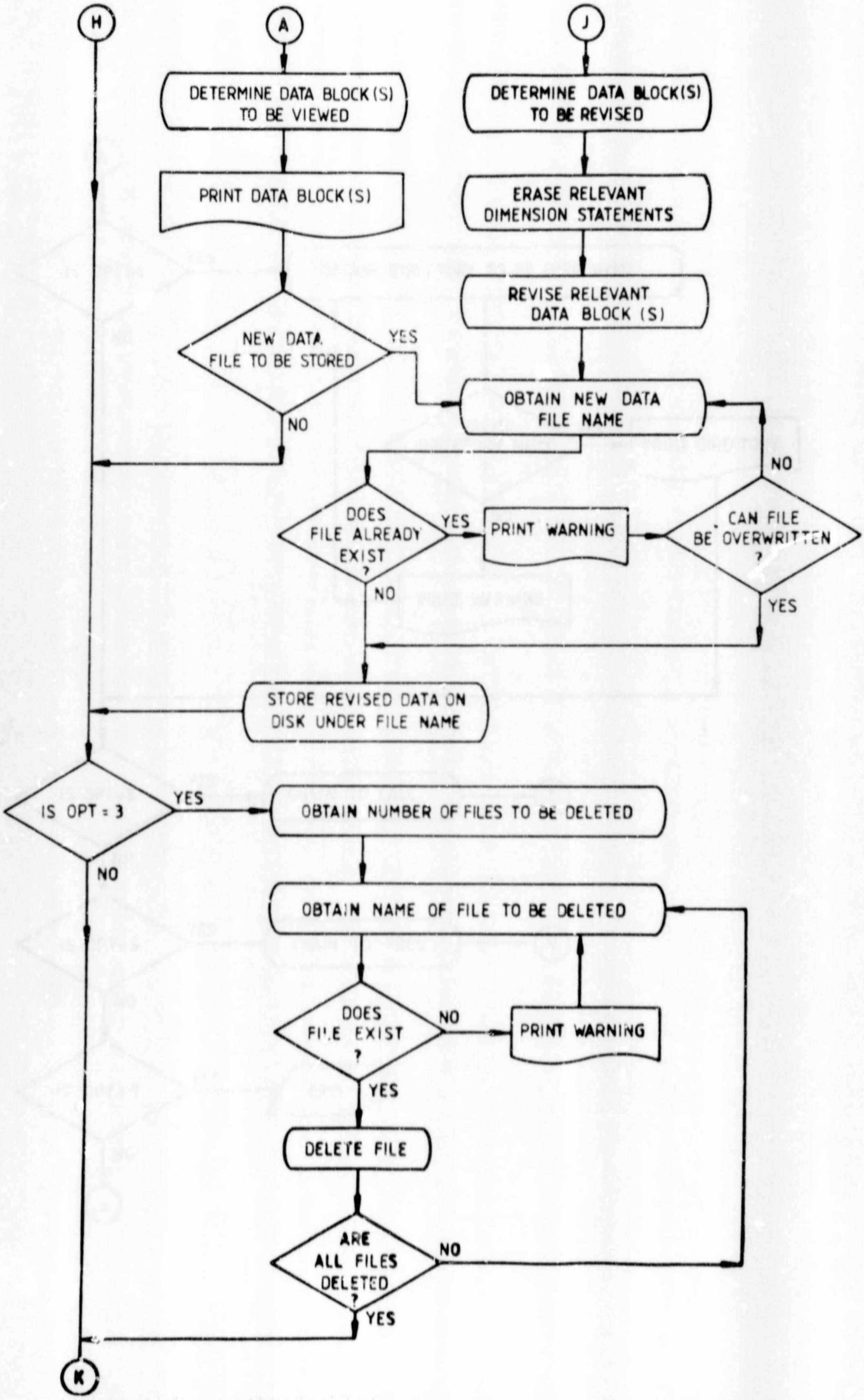
This appendix contains a logic flow chart for all three blocks of the program. The flow chart contains none of the equations or theory used in the calculations. For a detailed description of the theory see Chapter 2 of the main report.

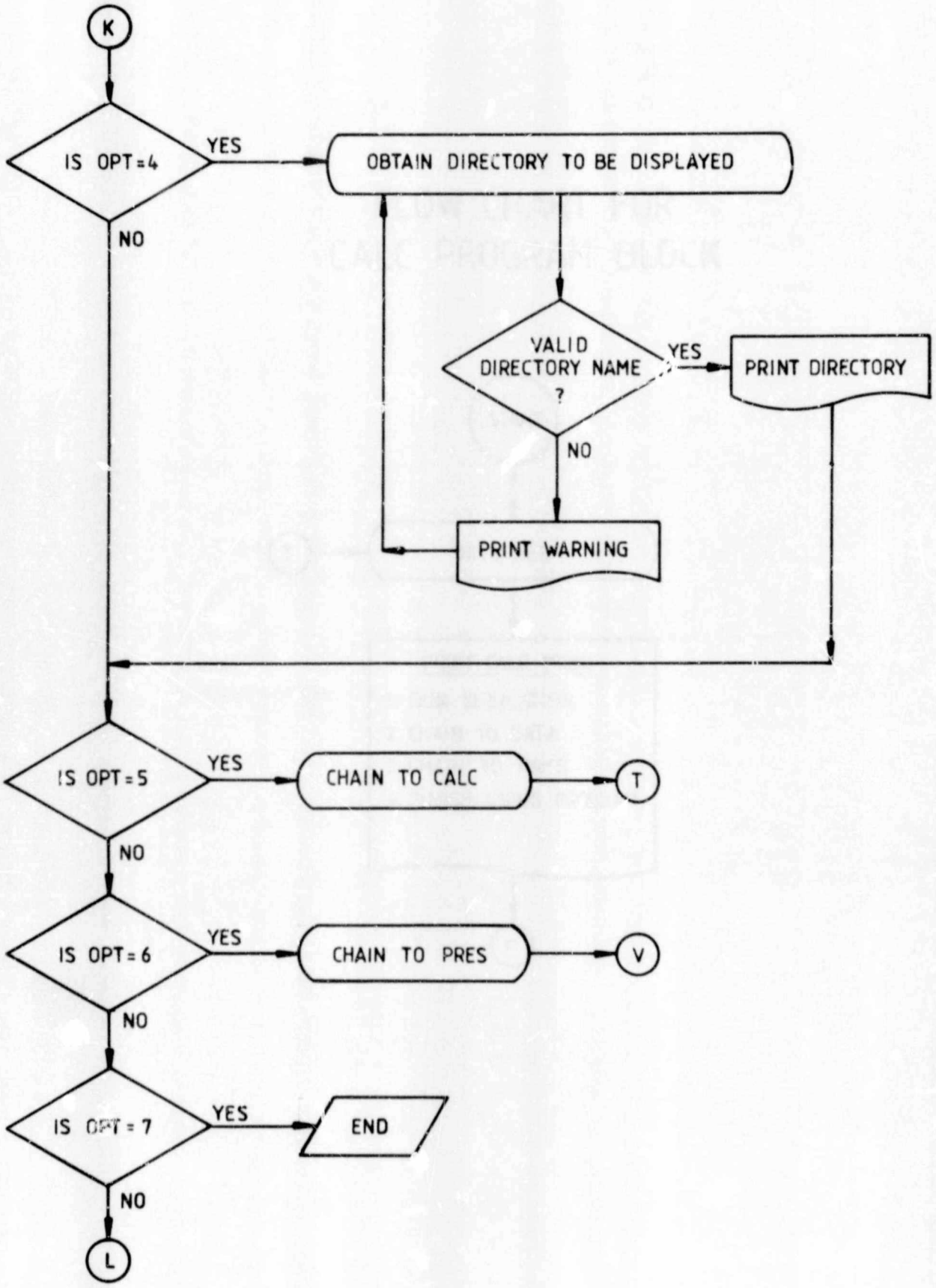
FLOW CHART FOR DATA PROGRAM BLOCK




B
IS OPT = 1
YES
NO
OBTAIN NEW DATA FILE NAME
DOES FILE EXIST ?
YES
NO
PRINT WARNING
CAN FILE BE OVER WRITTEN ?
NO
YES
OBTAIN RESERVOIR BASIN CHARACTERISTICS
DATA CHECK REQUIRED ?
NO
YES
PRINT DATA POINTS IN GROUPS OF 20
ARE THESE POINTS CORRECT ?
YES
NO
REVISE DATA POINTS SELECTIVELY
HAVE ALL DATA POINTS BEEN PRINTED ?
NO
YES
ENTER SPILLWAY CONFIGURATION
PRINT SELECTED SPILLWAY CONFIGURATION
IS SPILLWAY CONFIGURATION CORRECT ?
NO
YES
SELECTIVELY ENTER DATA FOR:
1. BOX CULVERTS
2. FREE OVERFLOW WEIR
3. AUTOMATICALLY CONTROLLED WEIR
4. MANUALLY CONTROLLED HIGH PRESSURE OUTLET
5. FUSE PLUG
6. USER SPILLWAY
E
F


E
F
ENTER FLOOD DATA
IS INFLOW HYDROGRAPH CORRECT ?
NO
YES
1. DISPLAY DATA 2. REVISE DATA
2
1
REVISE SELECTED DATA POINTS
PRINT SELECTED BLOCK OF DATA
1
1. DISPLAY DATA 2. ACCEPT DATA
2
1. ACCEPT DATA 2. REVISE DATA
2
G
G
ENTER RESERVOIR FLOOD STATUS
STORE INPUT DATA ON DISK UNDER FILE NAME
IS OPT = 2
YES
OBTAIN DATA FILE NAME
DOES FILE EXIST ?
NO
PRINT WARNING
YES
READ DATA FILE FROM DISC
MUST DATA BE 1. VIEWED OR 2. REVISED
2
1
H
A
J


H
A
J
DETERMINE DATA BLOCK(S) TO BE VIEWED
DETERMINE DATA BLOCK(S) TO BE REVISED
PRINT DATA BLOCK(S)
ERASE RELEVANT DIMENSION STATEMENTS
REVISE RELEVANT DATA BLOCK (S)
NEW DATA FILE TO BE STORED
YES
NO
OBTAIN NEW DATA FILE NAME
NO
DOES FILE ALREADY EXIST ?
YES
PRINT WARNING
CAN FILE BE OVERWRITTEN ?
NO
YES
STORE REVISED DATA ON DISK UNDER FILE NAME
IS OPT = 3
YES
OBTAIN NUMBER OF FILES TO BE DELETED
NO
OBTAIN NAME OF FILE TO BE DELETED
DOES FILE EXIST ?
NO
PRINT WARNING
YES
DELETE FILE
ARE ALL FILES DELETED ?
NO
YES
K


K
IS OPT=4
YES
OBTAIN DIRECTORY TO BE DISPLAYED
NO
VALID DIRECTORY NAME ?
YES
PRINT DIRECTORY
NO
PRINT WARNING
IS OPT=5
YES
CHAIN TO CALC
T
NO
IS OPT=6
YES
CHAIN TO PRES
V
NO
IS OPT=7
YES
END
NO
L

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