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Hydrologic Engineering Center

HEC-IFH
Interior Flood Hydrology Package

User's Manual

January 1999

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14. ABSTRACT

User's manual for a menu driven computer program for the personal computer to assist in the analysis of leveed interior areas. The program can be used to determine runoff into a ponding area adjacent to the levee and to route the inflow through the levee utilizing gravity outlets and/or pumping capacity. The rainfall-runoff process, streamflow routing, auxiliary inflow, diversions, and seepage can be simulated as well as complex configurations of gravity outlets and pumping facilities. Period-by-period, monthly, annual and total analysis summaries are generated for all applicable parameters during simulation. Interior area elevation-frequency relationships can be determined for various alternative plans by using continuous simulation or hypothetical storm event analysis. Plan summaries and comparisons can be readily viewed in tables or graphics.

15. SUBJECT TERMS

rainfall, runoff, simulation, levee, interior area, gravity outlet, pump, diversion, ponding area, routing, elevation-frequency

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10 December 1984

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Table of Contents

List of Figures

List of Tables

Preface

The Hydrologic Engineering Center's Interior Flood Hydrology (HEC-IFH) computer program provides the capability to analyze flood characteristics on the landward side of levees and floodwalls. These flood damage reduction measures generally block the natural egress of floodwaters from the interior area and analyses of these conditions is an important part of the plan formulation process. The HEC-IFH program includes the capability to analyze gravity outlets and pumps for reducing flood damages due to interior runoff and allows the direct determination of interior stage-frequency relationships for multiple plans.

The HEC-IFH program, Version 1.0, was initially released in May 1992. This new release, Version 2.0, December 1998, includes some enhancements and numerous error corrections. The main changes to the program are listed below:

- Errors encountered when attempting to run the program under the Windows NT operating system have been corrected.
- Errors encountered when entering a user-defined gravity outlet rating have been fixed.
- Pump analysis results are now saved with the plan results instead of with the pump unit information.
- Input file date stamps are checked to assure the input data has not changed subsequent to the last time the plan interior analysis was performed. If the input has been modified, a warning message is displayed prior to displaying the plan results.
- A message has been added to warn the user when plan results will be overwritten.
- The use of metric units was never fully implemented and has been deactivated.
- Batch jobs now work for multiple studies.
- Pond routing calculations have been refined for improved accuracy.
- Numerous minor errors have been corrected based on the feed back from field offices.

Version 2.0 of HEC-IFH (a DOS program) will continue to be maintained by HEC but no additional modifications will be made to the program. It is planned that interior area analysis capabilities will become part of the Windows based Hydrologic Modeling System (HEC-HMS) which will replace HEC-IFH.

Acknowledgments

Specifications for the HEC-IFH program were developed by the Hydrologic Engineering Center (HEC). Many individuals were involved in defining program specifications and testing procedures. Robert Fitzgerald, Vicksburg District, contributed during initial design of the program. Roy Huffman, HQUSACE (Retired) was the major proponent of the project.

Many of the HEC staff contributed including Shelle Huff, Harold Kubik (deseased), Gary Brunner, Bill Charley, and Carl Franke. Project engineers were Michael Burnham, Chief, and Harry Dotson, Planning Analysis Division, HEC. Darryl Davis, Director, HEC, contributed significantly throughout the project.

The computer program routines and user's manual were written for HEC by Dodson & Associates, Inc., Houston, TX.

The program is written using Fortran 77 and compiled with the Lahey F77-EM/32 extended memory, 32-bit compiler for the IBM Personal Computer and compatibles. Graphic routines are by Sutrasoft.

Chapter 1: Introduction to HEC-IFH

1.1. GENERAL PROGRAM OVERVIEW

The Hydrologic Engineering Center's Interior Flood Hydrology (HEC-IFH) computer program is designed to make it easier to analyze areas protected by levees or flood walls. Engineers involved in the planning and design of flood damage reduction projects for such areas can use HEC-IFH.

Traditionally, large hydrologic engineering computer programs have operated as "batch" programs. That is, all input data values are generally stored in a single input data file. After the input data file is complete, the hydrologic computer program processes the input data and generates all output without the opportunity for further user interaction. Subsequent revisions are made by revising the input data file and repeating the entire sequence of computations to generate a completely new set of results.

The HEC-IFH program operates in an interactive workstation environment. The program enables full-screen interactive data entry, with data verification and plotting available prior to analysis. Analysis methods are selected using program menus. The analysis may be performed in phases or steps, with the opportunity for review and assessment of results after each step. Reports and plots may be generated from input and output data. Additional output reports may be generated later without repeating the analysis.

1.2. DESCRIPTION OF THIS MANUAL

This manual includes the following chapters and appendices:

CHAPTER 1: Introduction to HEC-IFH describes the basic purpose and capabilities of the program. This chapter introduces the most important concepts of interior studies.

CHAPTER 2: Working With HEC-IFH provides information on the program operation and user interface. It is important to review this chapter carefully before attempting to apply the program.

The following chapters explain various types of input data required for interior analyses, and illustrate how these data are input:

CHAPTER 3: Basin Average Precipitation

CHAPTER 4: Runoff Hydrographs

CHAPTER 5: Interior Pond

CHAPTER 6: Gravity Outlets

CHAPTER 7: Pump Outlets

CHAPTER 8: Exterior Stage

CHAPTER 9: Auxiliary Inflow/Outflow

CHAPTER 10: Interior Analysis summarizes the operations of the interior analysis computations.

CHAPTER 11: CSA Hydrologic Analysis Summaries describes the reports and plots which document the results of the Continuous Simulation Analysis (CSA) approach.

CHAPTER 12: HEA Hydrologic Analysis Summaries describes the reports and plots which document the results of the Hypothetical Event Analysis (HEA) approach.

CHAPTER 13: Comparison of Plans shows the reports and plots comparing the results of two or more interior analyses.

APPENDIX A: References and Bibliography lists important references for interior analyses.

APPENDIX B: Installing and Configuring HEC-IFH describes the computer hardware required for operation of HEC-IFH and documents the installation of the program. It also provides information about configuring the program to improve performance on particular computer systems.

APPENDIX C: HEC-IFH Example CSA Application illustrates a typical application of HEC-IFH using the Continuous Simulation Analysis (CSA) analysis approach.

APPENDIX D: HEC-IFH Example HEA Application illustrates a typical application of HEC-IFH using the Hypothetical Event Analysis (HEA) analysis approach.

APPENDIX E: HEC-IFH Data Storage provides information about the storage and format of HEC-IFH input data and results.

APPENDIX F: Errors and Warning Messages describes the messages which may be generated by the HEC-IFH program during analysis.

APPENDIX G: Index provides a complete index to the manual.

1.3. INTERIOR FLOOD HYDROLOGY

An ***interior area*** is protected from direct river, lake, or ocean flooding by levees, flood walls, or high ground. The levee or wall protecting the interior area is the ***line-of-protection***. The line-of-protection protects areas subject to flooding from the exterior, but may block the natural passage of interior runoff to the main river.

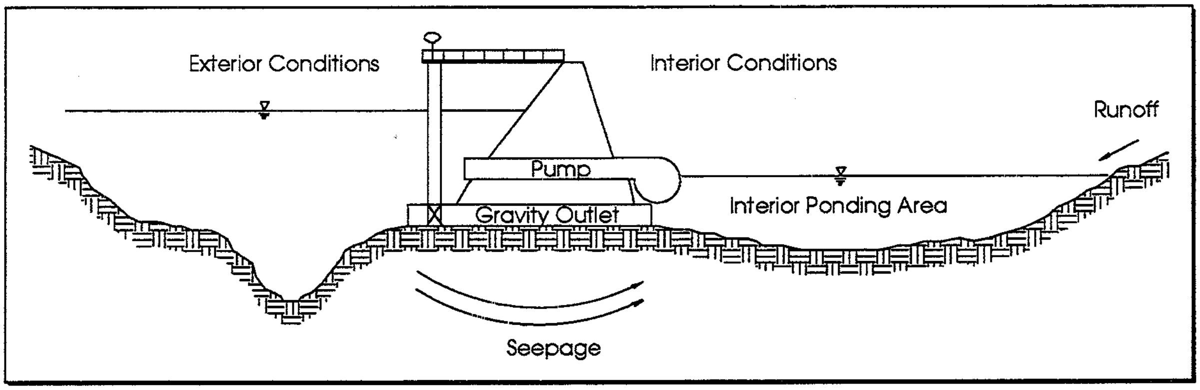


FIGURE 1.1 Cross-Section of Typical Interior System

Gravity outlets, pumping stations, interior ponding areas (detention storage basins), and diversions are measures commonly implemented within interior areas to reduce flood loss. Gravity outlets (usually culverts) may pass water through the line-of-protection when interior water levels are higher than exterior levels. The flood waters are stored or pumped through the line-of-protection when exterior stages are higher than those in the interior. Flood waters may also be diverted to other areas. Figures 1.1 and 1.2 are representations of an interior system.

Hydrologic data required for analyses of interior areas include topography, exterior stage data, historic rainfall records and/or hypothetical precipitation data, runoff parameters, and seepage data.

Topographic data are required to define watershed and sub-basin boundaries, basin slopes, stream lengths, and elevation-area-storage relationships for natural detention areas. Good topographic data should be obtained early in the study if possible.

Exterior stage data are required to define tailwater conditions for gravity outlets and pumps, and for determining seepage, if any.

Rainfall data contribute to runoff computations for interior and possibly exterior basins. Basin average values should be used. Weighted average rainfall values can be determined where more than one rain gage is located within or near the watershed. If no rainfall gage exists in the basin, records from nearby rain gages should be used in the analysis. Alternatively, depth-duration data for hypothetical rainfall events may be used to determine runoff from a storm of desired duration and frequency.

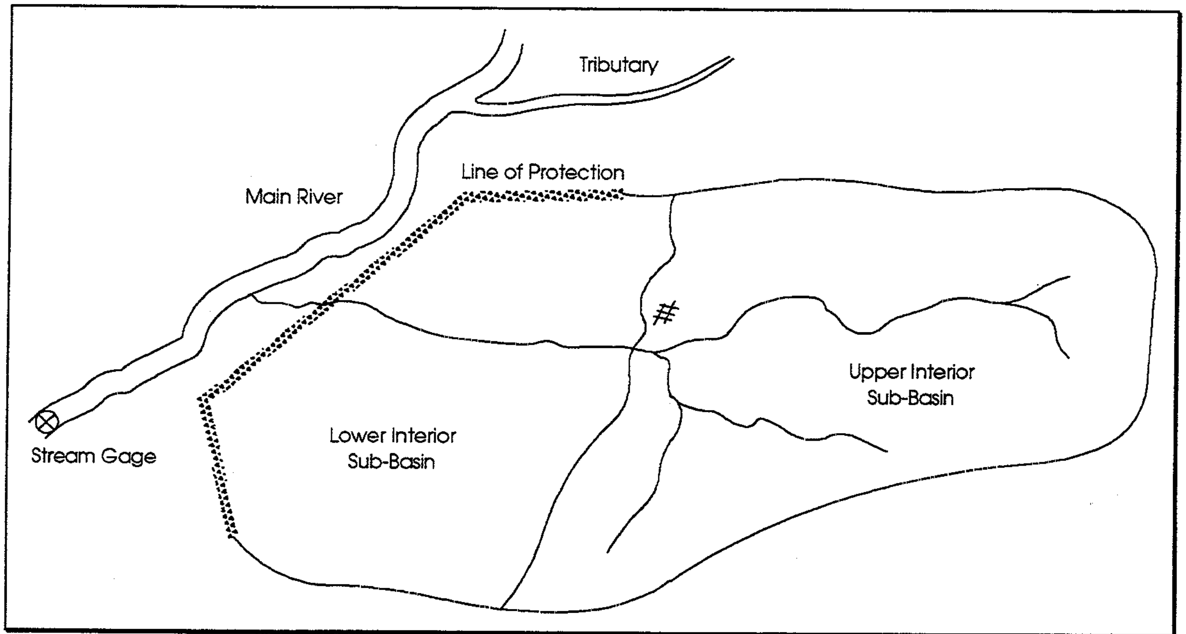


FIGURE 1.2 Typical Interior System

Loss rates affect the rate and total volume of runoff. Loss rates are generally based on land use, antecedent soil moisture condition, and physical basin characteristics. They may be initially estimated by using values from previous studies or derived through analysis of measured rainfall and runoff volumes at gages. Subtracting losses from rainfall yields **rainfall excess.**

Runoff transforms provide methods of computing runoff from rainfall excess. Unit hydrographs are common runoff transforms. Initial values for unit hydrograph parameters may be estimated from land use and physical basin characteristics using published values or regression equations, or from analysis of observed events. The importance of volume rather than peak discharge in many studies permits the use of simplified runoff methods with acceptable results. Assumptions should be verified as needed. Results may be verified by high water marks, discharge-frequency relationships, or from reconstitution of observed historical events.

Interior analyses normally require information on physical and operational characteristics of existing or proposed flood loss reduction measures. For example, information on gravity and/or pump outlet locations, capacity, and operational procedures enable a simulation analysis to reproduce the historic record. Data on ponding areas, stormwater collection systems, and any hydraulic controls affecting water movement are also often necessary.

1.4. INTERIOR ANALYSIS APPROACHES

Using the HEC-IFH program, an engineer may use either of two different analysis approaches, each of which is appropriate for certain types of studies. The following approaches are available:

1. ***Continuous Simulation Analysis*** (also called a ***period-of-record analysis***), which uses continuous historic precipitation and streamflow records. HEC-IFH is designed to accommodate complete continuous simulations for at least 50 years of hourly records. However, these are not the absolute limits of the program's capabilities. For example, total periods of up to 100 years and time increments as small as 5 minutes may be used, although significant increases in data storage requirements and computation time will result. Section 1.4.1. Continuous Simulation Analysis below presents additional details.
2. ***Hypothetical-Event Analysis***, is generally applicable when interior and exterior flood events are *dependent*. The analysis can be conducted so that the same series of synthetic storm events occur over both the interior and exterior areas. This analysis method can also be applied using a constant exterior stage or for any "blocked" or "unblocked" gravity outlet condition. See Section 1.4.2. Hypothetical Event Analysis on page 1-7 for details.

1.4.1. Continuous Simulation Analysis

The continuous simulation method involves the analysis of continuous historic records of hydrologic events. The procedure consists of sequential hydrologic simulation of inflow, outflow, and change in storage. The objective is to derive interior water surface elevations given exterior stages and interior rainfall for the entire period-of-record.

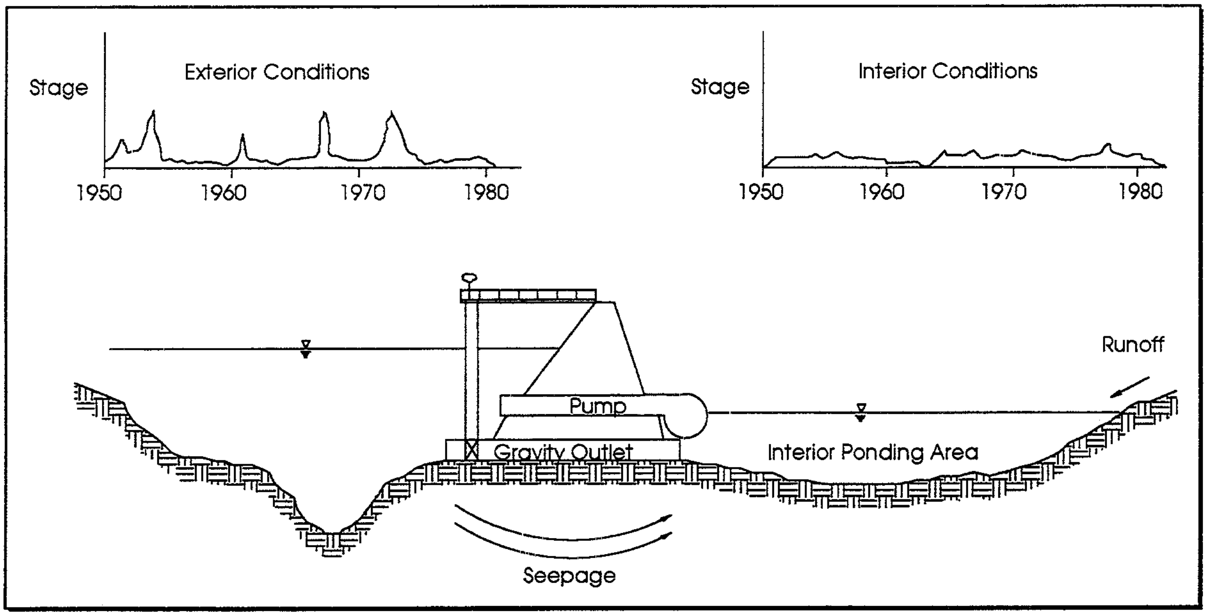


FIGURE 1.3 Continuous Simulation Analysis Concepts

Figure 1.3 presents an overview of the concepts involved in the continuous simulation approach. Historic precipitation data are applied to sub-basin loss rates, runoff transforms, and base flow parameters to yield runoff hydrographs at sub-basin outlets. Hydrographs are combined and routed through the system (as appropriate) to yield period-of-record inflows for the interior ponding area. These data are used with period-of-record exterior stage data to simulate the expected operation of the system. The primary result is a continuous stage hydrograph for the interior ponding area.

The continuous procedure is attractive because it preserves the seasonality, persistence, and dependence or independence of exterior stages and interior flooding. The method enables the performance of the project to be displayed in a manner easily understood by the other study participants and the public. The procedure is particularly useful for evaluating crop damage of single sub-basin watersheds (in which ponding is adjacent to the line-of-protection) in agricultural areas. System operational and maintenance costs may be calculated directly.

Short historic records may be unrepresentative, and may therefore yield inappropriate sizes and mixtures of measures and operation specifications of the system. If lengthy historic records are not available, continuous series of rainfall or streamflow records may also be generated stochastically. However, stochastic generation of continous series is not a feature of the HEC-IFH program, and is therefore beyond the scope of this manual.

In the past, continuous simulations have been tedious to apply because of the large amount of hydrologic data analyzed. The procedure requires a significant volume of information and extensive calibration. The extensive data needs and model calibration requirements often result in a continuous analysis that is unduly simplistic. For example, the analysis may include only a single sub-basin adjacent to the line-of protection. This level of detail may be adequate for agricultural areas, but not for more complex drainage systems in urban areas. One of the objectives of the HEC-IFH program is to automate much of the tedious work involved in continuous simulations and allow more realistic continuous simulations to be completed.

The continuous simulation analysis aspect of the HEC-IFH program may also be applied to simulate individual historical flood events by entering precipitation for the storm event.

Figure 1.4 illustrates the sequence of analytical procedures used by HEC-IFH in continuous simulation analyses. These procedures are summarized below:

1. **Rainfall:** Enter long-term historical data for a single rainfall gage or for several individual gages. If appropriate, compute the composite basin average precipitation for a sub-basin as the weighted average of measurements from two or more individual rainfall gages. Chapter 3 describes rainfall data entry.

2. **Rainfall Excess:** Compute rainfall excess values for each interior sub-basin using either of two methods: Generalized Runoff Coefficients or the Initial-Uniform-Recovery method. Chapter 4 describes these methods.

3. **Runoff:** Transform rainfall excess into a runoff hydrograph for each interior sub-basin using unit hydrographs input by the user, or computed using the Clark, Snyder, or SCS Dimensionless unit hydrograph methods. Add base flows, if any, to the computed runoff hydrographs. Chapter 4 discusses the available unit hydrograph methods.

4. **Auxiliary Flows**: Determine auxiliary inflows, such as overflow from adjacent areas. Consider diversions from the upper interior drainage area, overflow from the lower area, or seepage. Chapter 9 describes auxiliary flows.

5. **Channel Routing**: The Modified Puls, Muskingum, or Lag streamflow routing methods route the total discharge hydrograph from the upper portion of the interior area to the interior ponding area. Channel routing is discussed in Chapter 4.

6. **Exterior Stages**: Define exterior stage data through the use of an exterior stage hydrograph or an exterior discharge hydrograph and channel rating curve. Exterior discharge hydrographs may also be computed using the same rainfall-runoff

methods described for interior discharge hydrographs. Chapter 8 describes exterior stage data.

7. **Pond Routing**: Route interior inflow through the interior ponding area and discharge it through the line-of-protection by way of the gravity outlets and/or pumping stations. Consider seepage inflows through the line-of-protection, as well as overflows from the interior ponding area. Chapter 10 describes the interior pond routing computations. The capacity of the gravity and pump outlets are specified as described in Chapters 6 and 7. Chapter 9 describes seepage and overflows.

8. **Frequency Analysis**: Develop elevation-frequency relationships, duration of flooding, and other pertinent hydrologic information. Chapter 11 documents the frequency analysis computations and results.

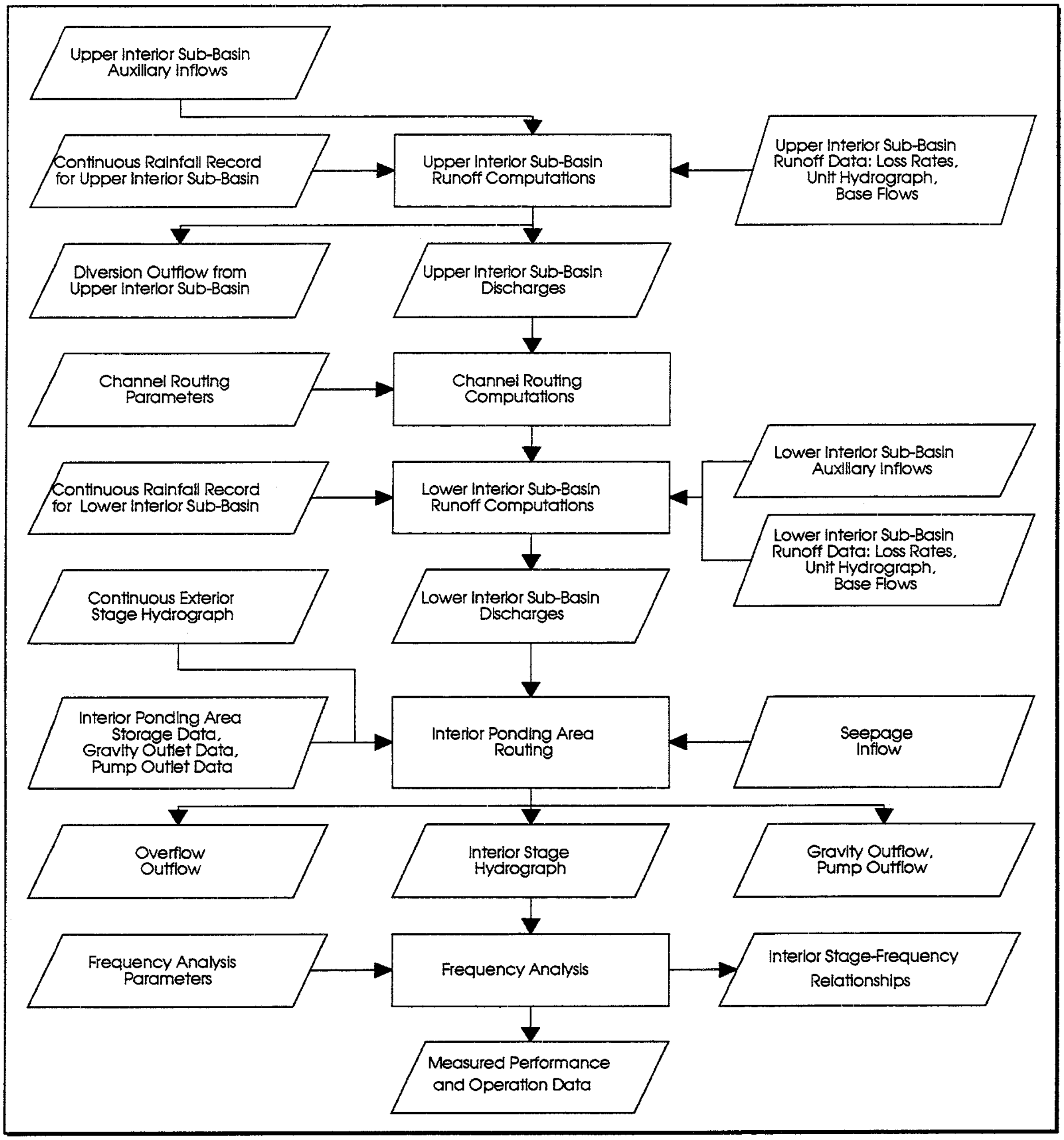


FIGURE 1.4 Continuous Simulation Analysis Schematic

1.4.2. Hypothetical Event Analysis

The Hypothetical-Event analysis approach may be used to analyze conditions in which interior and exterior storms are dependent on the same meteorologic events. A single series of storm events can be assumed to occur over both the interior and exterior areas. A constant exterior stage, "blocked" or "unblocked" exterior conditions can also be evaluated using a series of hypothetical storm events on the interior area.

Figure 1.5 contains an overview of the Hypothetical-Event Analysis. Synthetic precipitation data are applied to sub-basin loss rates, runoff transforms, and base flow parameters to yield runoff hydrographs at sub-basin outlets. Hydrographs are combined and routed through the system (as appropriate) to yield an inflow hydrograph for the interior ponding area. These data are used with exterior stage data for the event being analyzed to simulate the expected operation of the system. The primary results are stage hydrographs for each event and an elevation-frequency relationship for the interior area.

The hypothetical-event method typically requires less data than the continuous record technique. The method enables the performance of the project to be displayed in a manner easily understood by other study participants and the public. In general, the procedure is easier to apply for urban interior analyses than methods involving continuous record simulations. The amount of hydrologic data analyzed is relatively small, thus keeping computer run time to a minimum.

Hypothetical-event analyses generate hypothetical frequency hydrographs in which the peak flow rate, runoff volume, and all durations are assumed to be statistically consistent with the percent chance exceedance assignment of the rainfall events. This reduces the opportunity for statistically nonrepresentative results that might occur from procedures using historic records.

Antecedent soil moisture conditions and initial interior ponding levels may be more difficult to adequately account for using Hypothetical Event analyses.

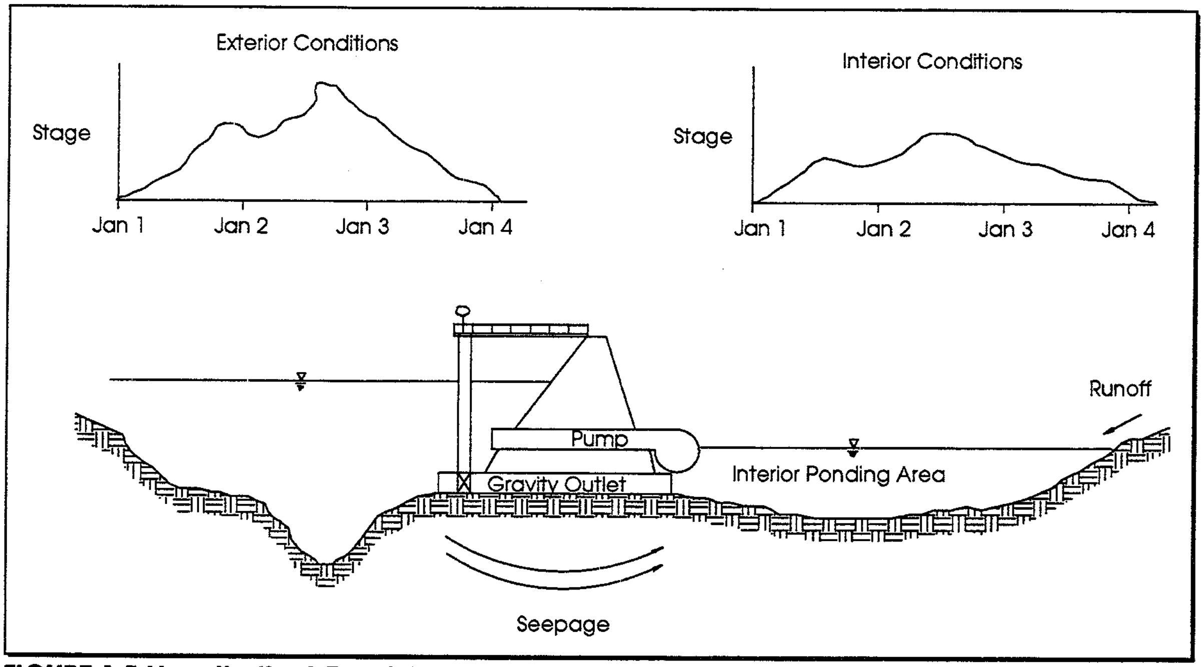


FIGURE 1.5 Hypothetical-Event Analysis Concepts

Figure 1.6 depicts the general processes completed during an analysis of interior areas using the Hypothetical-Event method. The general steps completed by the HEC-IFH program are as follows:

1. **Rainfall:** Enter hypothetical storm depth-duration-frequency data for individual or multiple hypothetical events and/or a Standard Project Storm (SPS). Chapter 3 describes rainfall data entry.
2. **Rainfall Excess**: Compute rainfall excess values for each interior sub-basin using any of the following methods: SCS Curve Number, Holtan, Green-Ampt, or the Initial-Uniform method. Chapter 4 describes these methods.
3. **Runoff**: Transform rainfall excess into a runoff hydrograph for each interior sub-basin. Unit hydrographs may be input by the user, or computed using the Clark, Snyder, or SCS Dimensionless unit hydrograph methods. Consider base flow and base flow recession when computing runoff hydrographs. Chapter 4 discusses the available unit hydrograph methods.
4. **Auxiliary Flows**: Determine auxiliary inflows such as overflow from adjacent areas. However, be sure that auxiliary inflows do not cause the total hydrograph to be statistically inconsistent with the rainfall event. Consider any diversions from the upper interior drainage area, overflow from the lower area, or seepage. Chapter 9 describes auxiliary inflows and diversions.
5. **Channel Routing**: Route the total discharge hydrogrpah from the upper portion of th interior area to the interior ponding area. The Modified Puls, Muskingum, Muskingum-Cunge, or lag streamflow routing methods are available. Streamflow routing is discussed in Chapter 4.
6. **Exterior Stages**: Define exterior stage data through the use of an exterior stage hydrograph or an exterior discharge hydrograph and channel rating curve. Exterior discharge hydrographs may be computed using the same methods described for interior discharge hydrographs. Chapter 8 describes exterior stage data.
7. **Pond Routing**: Route interior inflow through the interior ponding area and discharge it through the line-of-protection by way of the gravity outlets and/or pumping stations. Consider seepage inflows through the line-of-protection, as well as overflows from the interior ponding area. Chapter 10 describes the interior pond routing computations. The capacity of the gravity and pump outlets are specified as described in Chapters 6 and 7. Chapter 9 describes seepage and diversions.
8. **Frequency Analysis**: Determine interior elevation-frequency relationships from a series of hypothetical events.

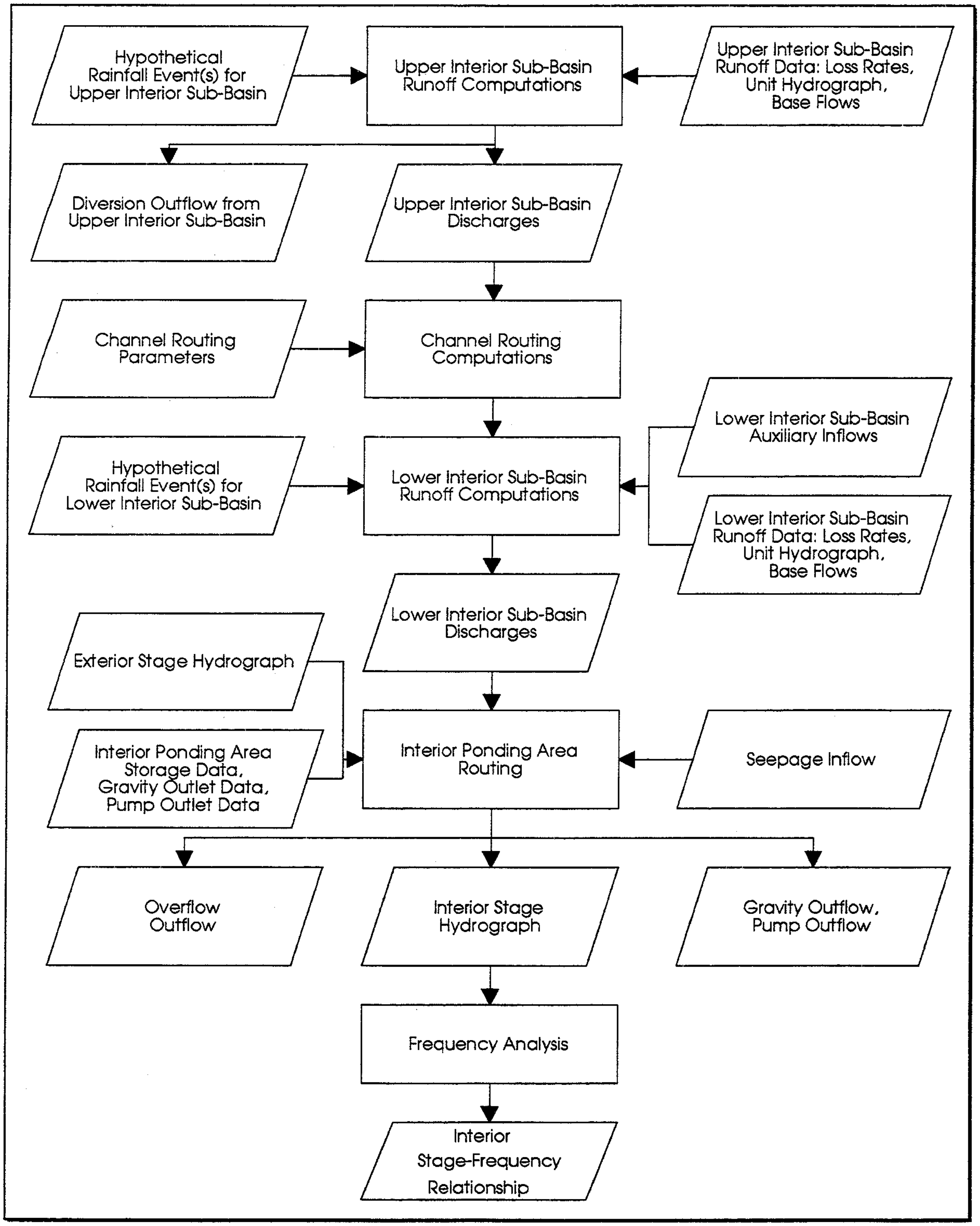


FIGURE 1.6 Hypothetical-Event Analysis Schematic

Chapter 2.
Working with HEC-IFH

2.1. INTRODUCTION

HEC-IFH can operate in interactive mode or in batch mode. ***Interactive mode*** provides full access to program features through a convenient menu-driven interface. Working in interactive mode, the program can receive input data from the user, import data from other sources, display plots, perform computations, display results, and print reports. Most of this manual describes the interactive mode of operation.

Batch mode provides access to interior analysis computational procedures only. Using batch mode, a single command from the operating system initiates program operations and performs interior analysis computations using data already entered using the program's interactive mode of operation. By using batch mode, the HEC-IFH user can enter the data necessary for several analyses, then create a batch file containing the commands necessary to perform the computations for each analysis. Under the control of the batch file, the program can then perform the computations for all analyses without further user intervention. These computations can be performed during a lunch break, overnight, or even over a weekend, depending upon the complexity and length of the analysis. The HEC-IFH batch mode is described in more detail in Chapter 10.

2.2. WORKING WITH HEC-IFH IN INTERACTIVE MODE

To execute HEC-IFH in interactive mode, simply type `HECIFH` from the operating system command line. (See Appendix B for information on HEC-IFH installation and configuration). As the HEC-IFH program begins operating, the first program screen displays the introductory screen shown in Figure 2.1. The program version number is displayed in the upper left-hand corner of the screen. A screen reference number ("screen ID") is shown in the upper right-hand corner of the screen if `ID` is included after the program name on the operating system command line. Press the [F10] key to display the next screen, Figure 2.2, which shows the name and version number of the program. This screen allows you to name a new study or select an existing study for further analysis.

A ***study*** is an analysis of a particular interior system. The purpose of the study is generally to propose changes to the interior system to improve performance under existing or future conditions. During the course of the study, several different ***plans*** will be formulated for analysis. Each plan represents a unique combination of precipitation, runoff, pond storage, and outflow conditions. Comparing the results of various plans determines the most effective flood protection measures.

In HEC-IFH, a ***Study ID*** is used to identify all study data. Figure 2.2 illustrates the data entry screen used to specify the Study ID and descriptions. The HEC-IFH program creates a sub-directory under the HEC-IFH program directory (the current directory) having the same name as the Study ID. All data for the study, and for plans associated with the study, are stored in this sub-directory.

Data for several different Studies may be entered (subject to available storage capacity on the computer), with each having a unique **Study ID**. When the cursor is on the Study ID field, the [F3] key displays a list of previously-defined IDs (see the discussion of the F3 Index key later in this chapter for more details). Any of these previous Study IDs may be selected, and the corresponding study data will be available for editing or processing.

```
IFH 01.01.00                                                 INTR01

         H.E.C. INTERIOR FLOOD HYDROLOGY ANALYSIS PROGRAM
         Requires 4Mb of memory (1Mb base + 3Mb extended)

                  US Army Corps of Engineers
                Hydrologic Engineering Center
                      609 Second Street
                   Davis, California  95616
                       (916) 756-1104

                Written in Lahey Fortran F77L-EM/32
           Uses Ingraf Graphics, (C) 1987-90 SutraSoft

1      2PrtScr 3      4      5      6DOS    7      8      9     10Exit
    Press <Esc> to Quit program; or <F10> to Proceed to the next screen
```

FIGURE 2.1 HEC-IFH Introductory Screen

```
IFH 01.01.00                                                     M+

                          H.E.C. INTERIOR FLOOD
                        HYDROLOGY ANALYSIS PROGRAM
                            Version 01.01.00

       Study ID:          RBENDZ
       Short Description: Analysis of River Bend Interior Area

       Full Description:  This is the example problem discussed in
                          Appendix C. It includes two plans -
                          a "minimum conditions" plan with only a
                          single gravity outlet, and an improved
                          conditions plan with 1 gravity outlet
                          and a pump.

       System of Measurement:      [English/Imperial] Metric/S.I

1Help  2PrtScr 3Index  4      5      6DOS    7      8      9     10Exit
         Press <Esc> to Quit program; or <F10> to Proceed to the Menu
```

FIGURE 2.2 Study ID and Descriptions

The 40-character **Study Description** is used to provide a short, meaningful description of the Study. The **Full Description** is used to provide additional descriptive informtaion, if desired. The system of measurement units to be used throughout the Study is specified using the horizontal menu at the bottom of the screen. Use the left and right arrow keys to highlight the desired system, then press the space bar to complete the selection.

2.3. HEC-IFH MENUS

Figure 2.3 illustrates the HEC-IFH Main Menu, which follows the Study ID and description. As shown, several options are available on the HEC-IFH Main Menu:

A) **Program Configuration Options**: the customizing options described in Appendix B.

B) **Data Management Utilities**: the options for managing HEC-IFH data, described in Appendix E.

C) **Continuous Simulation Analysis (CSA)**: the data entry, computation, and reporting options relating to continuous or period-of-record analyses. (See Chapter 1.)

D) **Hypothetical Event Analysis (HEA)**: the data entry, computation, and reporting options relating to the analysis of hypothetical rainfall events. (See Chapter 1.)

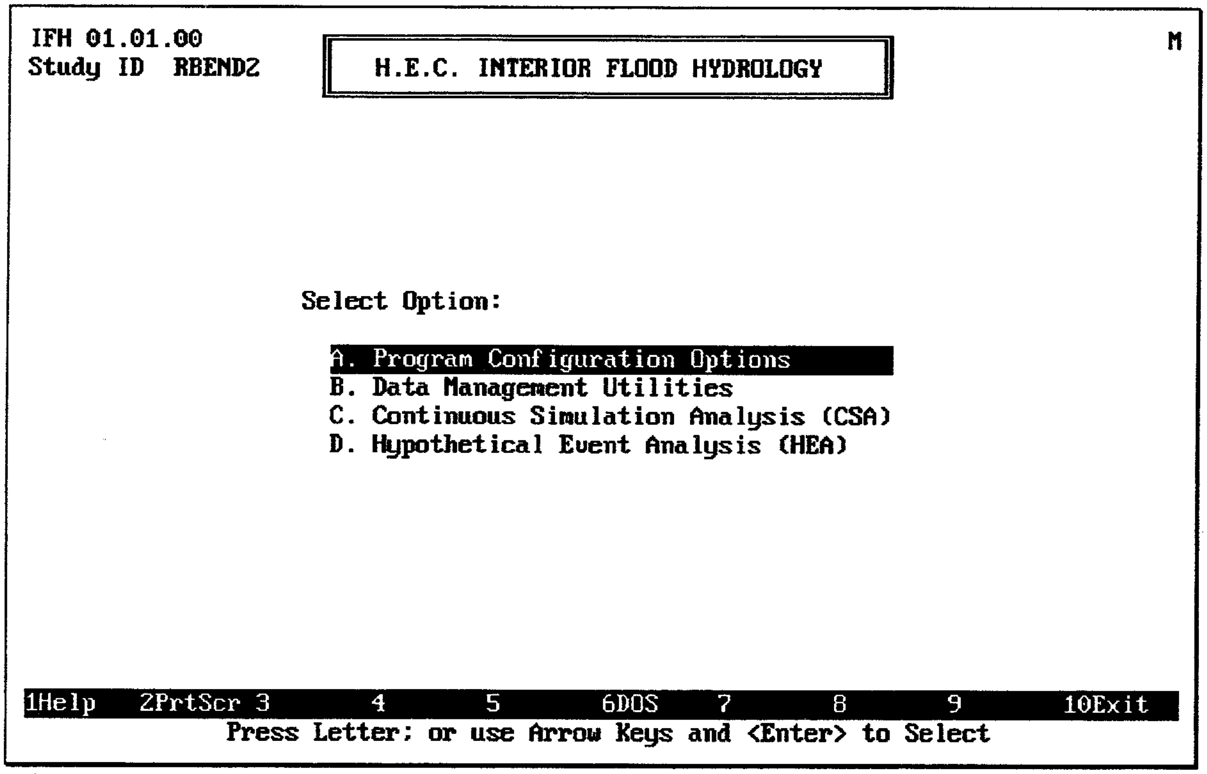


FIGURE 2.3 HEC-IFH Main Menu

Menus similar to the HEC-IFH Main Menu are used to select different options for use by the HEC-IFH program. These menu screens form a hierarchical (tree-like) structure which provides access to program functions such as data entry, computations, and reports. Figure 2.4 illustrates the HEC-IFH program menu structure or hierarchy.

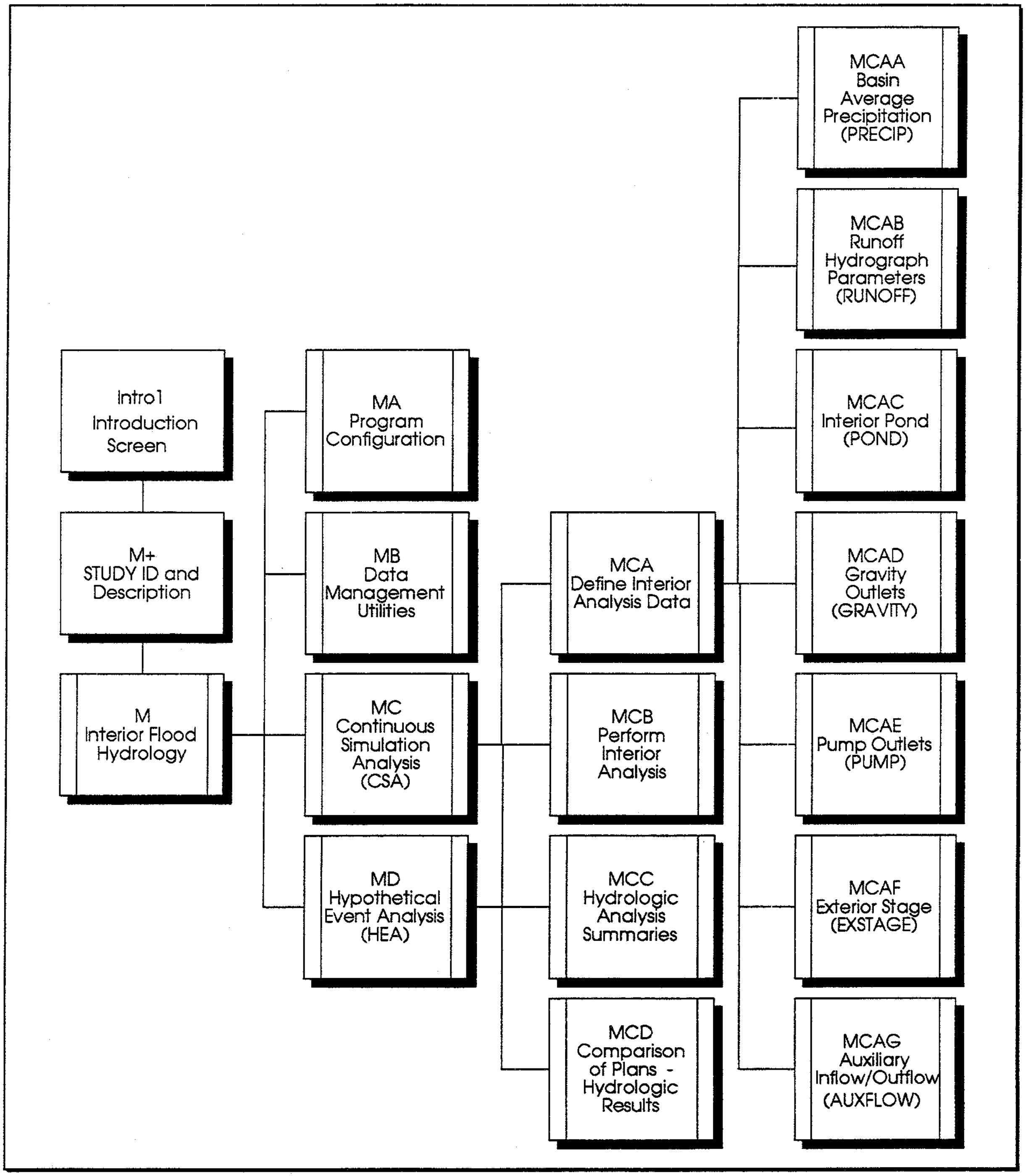


FIGURE 2.4 HEC-IFH Program Menu Hierarchy

All HEC-IFH program menus list selections in one or two columns on the screen. Menu selections are labelled [A], [B], [C], etc. When HEC-IFH displays a menu, one menu selection is always highlighted (displayed in reverse colors and surrounded by [square brackets]). The direction keys located on the numeric keypad of the PC keyboard may be used to highlight other menu selections. The [Home] and [End] keys move the highlight to the first and last menu selections, respectively.

Pressing the [Enter] key selects the highlighted menu selection. Menu selections may also be made by pressing the [A], [B], etc. key corresponding to the desired selection. Upper-case or lower-case letters may be used.

If Option [C] is selected from the HEC-IFH Main Menu, the Continuous Simulation Analysis Menu is displayed. Figure 2.5 illustrates this menu screen. The menu screen for Hypothetical Event Analysis is similar.

```
CSA 01.01.00                                                           MC
Study ID  RBENDZ    Continuous Simulation Analysis (CSA)

                     Select Option:

                       A. Define Interior Analysis Data
                       B. Perform Interior Analysis
                       C. Hydrologic Analysis Summaries
                       D. Comparison of Plans - Hydrologic Results

1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
            Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 2.5 HEC-IFH Continuous Simulation Analysis Menu

The Continuous Simulation Analysis menu selections provide the following operations:

A) **Define Interior Analysis Data**: allows input data to be entered or edited for a Continuous Simulation Analysis. Figure 2.6 illustrates the resulting menu screen.

B) **Perform Interior Analysis**: instructs the HEC-IFH program to perform the Continuous Simulation interior analysis computations after all input data have been defined. Chapter 10 describes Interior Analysis computations.

C) **Hydrologic Analysis Summaries**: displays or prints the results of a single interior analysis (See Chapter 11.)

D) **Comparison of Plans - Hydrologic Results**: displays or prints a comparison of the results of up to 7 different interior analyses. Chapter 12 describes these reports.

```
CSA 01.01.00                                                         MCA
Study ID  RBENDZ        Define Interior Analysis Data

                    Select Option:

                      A. Basin Average Precipitation (PRECIP)
                      B. Runoff Hydrograph Parameters (RUNOFF)
                      C. Interior Pond (POND)
                      D. Gravity Outlets (GRAVITY)
                      E. Pump Outlets (PUMP)
                      F. Exterior Stage (EXSTAGE)
                      G. Auxiliary Inflow/Outflow (AUXFLOW)

1Help   2PrtScr 3     4     5     6DOS    7     8     9     10Exit
          Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 2.6 HEC-IFH Data Entry Menu

2.4. HEC-IFH DATA ENTRY MODULES

Data entry ***modules*** store the input data used by the HEC-IFH program. Each of the 7 modules represents a group of related data. The HEC-IFH program provides data entry screens and computational procedures to develop the data for each module. The modules are:

1. **PRECIP Module**: Basin Average Precipitation. (See Chapter 3).
2. **RUNOFF Module**: Runoff Hydrograph Parameters. (See Chapter 4).
3. **POND Module**: Interior Pond Data. (See Chapter 5).
4. **GRAVITY Module**: Gravity Outlet Data. (See Chapter 6).
5. **PUMP Module**: Pump Outlet Data. (See Chapter 7).
6. **EXSTAGE Module**: Exterior Stage Data. (See Chapter 8).
7. **AUXFLOW Module**: Auxiliary Inflows and Outflows. (See Chapter 9).

Several sets of data may be entered and stored for each module, and specific module identifiers (***Module IDs***) describe each set. For example, you may enter two sets of PUMP module data: a set which includes two pumps and another set which includes three pumps. These sets of data are both PUMP module data, but they would have different Module IDs ("2PUMPS" and "3PUMPS", for example).

After entering and storing the data for each module, the desired ID for each module is specified. Continuing the example described above, you might specify a PUMP Module ID of "2PUMPS" for the first plan. A PUMP Module ID of "3PUMPS" might be specified in a later plan for comparison.

In addition to Module IDs, other IDs are used to identify individual data sets within the various data entry modules. For example, the data sets in the "2PUMPS" module might have ID's of "PUMP1" and "PUMP2" to represent performance data for a 100- and 200- cfs pump, respectively. The use of data set IDs to identify data items makes the HEC-IFH program more powerful and easier to use.

2.5. DATA ENTRY ROUTINES

Each data input screen of the HEC-IFH program includes a series of highlighted fields for entering and editing data values. When the HEC-IFH program displays a data entry screen, the cursor is always located initially at the first data entry field on the first line. Unless directed otherwise, HEC-IFH moves from left to right across each line. After the last data entry field on a particular line, HEC-IFH moves down to the first field on the next line.

The ***direction keys*** or ***arrow keys*** control the location of the cursor. These keys are located on the numeric keypad of the PC keyboard. Each direction key is labelled with an arrow.

The up-arrow key moves the cursor to the preceding field. The down-arrow key moves the cursor to the next field, if such a field exists. The [Enter] key moves the cursor to the next field on the screen, like the down-arrow key. The keys located on the numeric keypad labelled [Home] and [End] move the cursor to the first field of the screen and the last field of the screen, respectively.

The [Tab] and [Shift-Tab] keys move the cursor right and left, respectively, between groups of data entry fields on the screen. The following sections describe how to enter data in fields and tables on the screen, and how to select items from a list of choices.

2.5.1. Entering Values in Data Entry Fields

Data entry may be performed in ***insert mode*** or in ***typeover mode***. Pressing the [Ins] key changes from one mode to the other. Insert mode is the default. The size of the cursor indicates the current mode. The cursor is a large blinking square for insert mode and a blinking underline for typeover mode.

In insert mode, characters are inserted at the cursor, shifting any previous characters from the cursor one position to the right. The cursor advances one position as each character is inserted. If a field is filled, no number or character may be inserted in insert mode; the program sounds a bell if the sound effects option is enabled.

In typeover mode, the typed characters always replace the character at the cursor location and the cursor advances to the next location.

Deleting Characters: The [Del] (Delete) key deletes the character at the current cursor location. The [Backspace] key deletes the character to the left of the current cursor position. If the cursor is at the left-most position of the field, the [Backspace] key has no effect.

Moving Between Characters: The left and right arrow keys move within the field.

Replacing Existing Values: If the first keystroke in a data entry field is a data key (as opposed to a control key), the former value is erased and a new value begins with the entered character. This is true for both insert and typeover modes, making it easier to replace existing values.

2.5.2. Entering Data in Tables

Time-series data sets such as precipitation or stage may be represented as tables with thousands of values. The HEC-IFH program uses other tables, such as pond elevation versus surface area, with up to 20 values. In either case, however, the entire table is not displayed on the data entry screen. Instead, a "window" of about 14 values is visible. While entering values in this window, the [Page Up] and [Page Down] keys scroll the window up and down, respectively. When the cursor is on the first line of the window, the up-arrow key causes the window to scroll up one line. Similarly, the down-arrow key causes the window to scroll down one line when the cursor is on the last line of the window. Of course, the window cannot scroll up if it already displays the first value in the table, and it cannot scroll below the last value in the table.

While entering tabular data, HEC-IFH repeats the value directly above automatically when the ["] (double quote) key is pressed. The [*] (asterisk) key provides the same function, and may be more convenient for those using the numeric keypad for data entry.

2.5.3. Picking Values from Lists

A convenient way of entering data is to pick an item from a list. HEC-IFH sometimes lists the available items on a single line, with the current value bracketed. The left or right arrow keys change which item is highlighted. The space bar selects and brackets the highlighted item. Pressing up-arrow or down-arrow moves the cursor to the previous or next field, respectively.

If the items are each listed on a separate line, the up-arrow or down-arrow keys change the highlighted item. The space bar selects and brackets the highlighted item. Pressing up-arrow at the top of the list moves the cursor to the previous data entry field. Similarly, pressing down-arrow at the bottom of the list moves the cursor to the next data entry field.

2.5.4. Error Processing

HEC-IFH provides interactive data entry capabilities for all input data values. These interactive data entry routines can "screen" input data values to eliminate some common errors.

The program will not accept non-printable characters in any data entry field. The program will not accept invalid characters or spaces in numeric fields. The program uses a bell sound to emphasize an invalid entry if the bell sound option is enabled. (See Appendix B.)

The HEC-IFH program will accept upper-case or lower-case input for character fields. It automatically converts entries to a upper case for displaying variable names.

For HEC-IFH numeric data entry, valid ranges are defined by definite physical limits (e.g., value > 0) rather than "reasonable" ranges (e.g., 0 < value < 20.0). These physical limits are applicable to all values, except for elevation values.

2.5.4.1. Valid Range of Elevation Values

Many of the input data values required by HEC-IFH are elevations. Elevation values, when measured in feet NGVD, always fall within the range of -1,000 to +30,000 feet. The HEC-IFH program displays an error message whenever the user enters an elevation value outside this range.

2.5.4.2. *Zero-Based Tables*

Several of the input data tables required by HEC-IFH must begin with zero (0) as the first value for one or more columns. For example, the flow rate column of a channel rating table must begin with 0. Table 2.1 lists the data entry tables used in HEC-IFH which are required to begin with zero values in one or more columns.

TABLE 2.1 Zero-Based Data Entry Tables Used in HEC-IFH

Module	Screen ID	Variable
RUNOFF	RUNO10	Modified Puls Channel Routing Storage
RUNOFF	RUNO10	Modified Puls Channel Routing Outflow
POND	POND04	Interior Ditch Discharge Capacity
GRAVITY	GRAV03	Tailwater Depth
GRAVITY	GRAV03	Flow Capacity
PUMP	PUMP02	Pump Unit Head
EXSTAGE	EXST06	Exterior Channel Rating Curve Discharge
EXSTAGE	EXST10	Tributary Flow
AUXFLOW	AUXF04	Runoff + Auxiliary Inflow
AUXFLOW	AUXF04	Diverted Flow
AUXFLOW	AUXF06	Drainage Basin Overflow
AUXFLOW	AUXF07	Differential Head
AUXFLOW	AUXF07	Seepage Inflow

HEC-IFH displays each of these data entry screens with the first value in the table already set to zero. The program displays a message and changes the first entry to the default value of zero if the user enters any other value.

2.5.4.3. *Monotonically Increasing Independent Variables*

Some of the input data tables used in the HEC-IFH program must be "monotonically increasing". That is, the values of the independent variable should not decrease from one row of the table to the next. As the user completes a data entry screen for such a table, the program verifies that the table is monotonically increasing. If not, the program automatically truncates the table after the last value which increases or remains the same.

2.6. FUNCTION KEYS

While a menu screen, data entry screen, or report display screen is displayed, the first ten Function Keys perform several standard operations. The Function Keys are located either on the left side or along the top of the computer keyboard. All operations are not always available. The available function key operations are displayed at the bottom of each screen. The available operations may change depending on the screen being displayed or the cursor position on the screen. The following paragraphs describe each operation.

2.6.1. F1 Help Key: Displaying HEC-IFH Help Screens

The [F1] key opens a "Help Window" which provides instructions or information about the current data entry field. Figure 2.7 is an example. Pressing [F1] again displays a more general help window for the current screen. Pressing the [Esc] key removes the help message and resumes regular program operation.

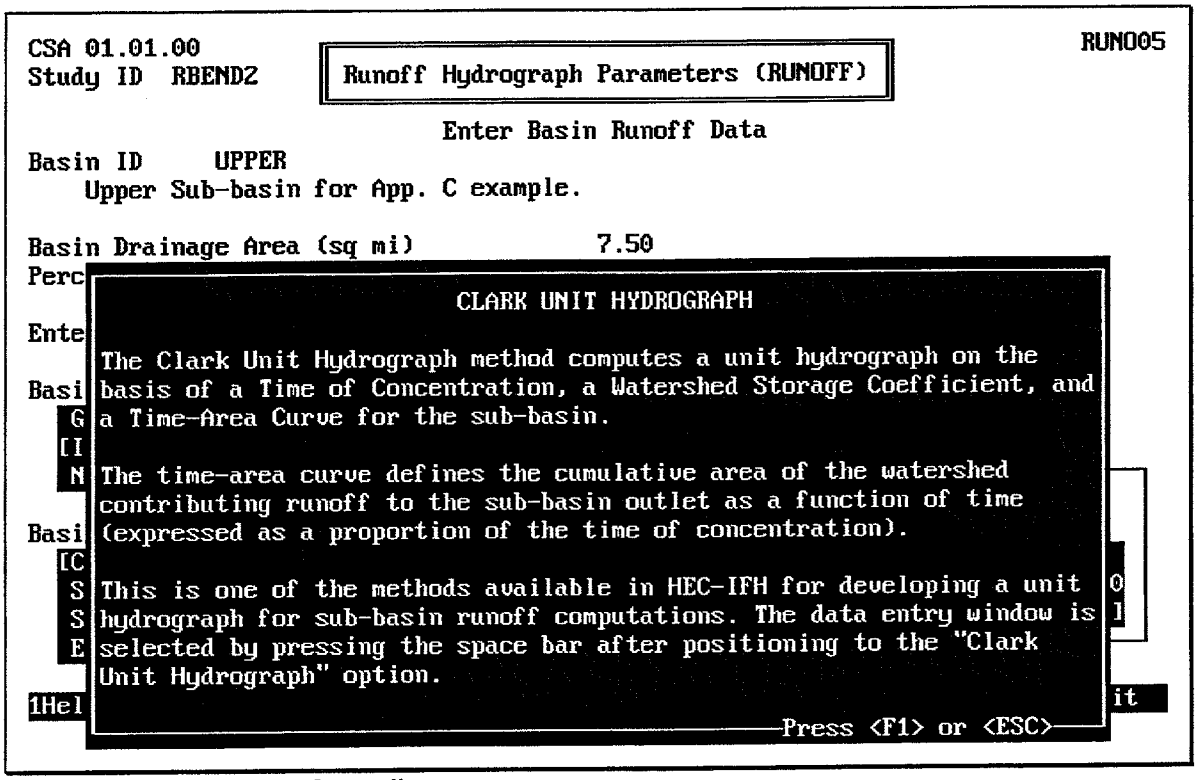


FIGURE 2.7 F1 Help Key Operation

2.6.2. F2 PrtScrn Key: Printing Current Computer Screen

The [F2] key copies the current text screen image or graphic plot to the printer. The [F2] PrtScrn function is always available, except when the computer is reading or writing disk files, or performing computations. The program displays an error message if a printer is not available. Pressing the [Esc] key removes the error message and resumes regular program operation.

The [Print Screen] key on the computer keyboard may also be used to print text or graphics screens on some printers. However, using the HEC-IFH [F2] key has several advantages. These advantages include the following:

- **Automatic Page Breaks**: HEC-IFH automatically inserts a page break after printing a graphics screen, and after printing each set of two text screens. Additional page breaks may be inserted at any time by pressing the [Ctrl] [L] key combination.

- **Automatic Character Conversions**: HEC-IFH can be configured to automatically convert screen box characters (which are used extensively in HEC-IFH screen displays) to corresponding characters for printers which do not support the screen box characters.

Plots may also be printed to a file on disk, which may then be stored for printing later, or transferred to another computer for printing. To print a plot to a file, press [Alt] [F2] instead of [F2]. The printer commands necessary to generate the plot will be stored in a file which is named "GRAPHXXX.EXT" where XXX is a number from 1 to 999. This number is incremented automatically by the HEC-IFH program, so that up to 999 plot files can be generated without duplicating file names. The file name extension "EXT" will vary according to the type of printer installed. Program configuration settings for printer characteristics are described in Appendix B.

2.6.3. F3 Index Key: Listing Available IDs

As described in Section 2.4 of this manual, HEC-IFH uses IDs (identifiers) when referring to groups of related data. For example, all of the precipitation data necessary for a particular plan analysis would be identified by a Precipitation (PRECIP) Module ID.

When the cursor is located on a ID data entry field, the [F3] key opens an "Index Window" displaying a list of available IDs which may be entered. The index is displayed in alphabetical order, with the associated descriptions and date/time stamps. You may highlight an item from the index using the cursor movement keys, and select the item using the [Enter] key. Pressing the [Esc] key removes the index window and resumes regular program operation without selecting an item. Figure 2.7 illustrates an index window.

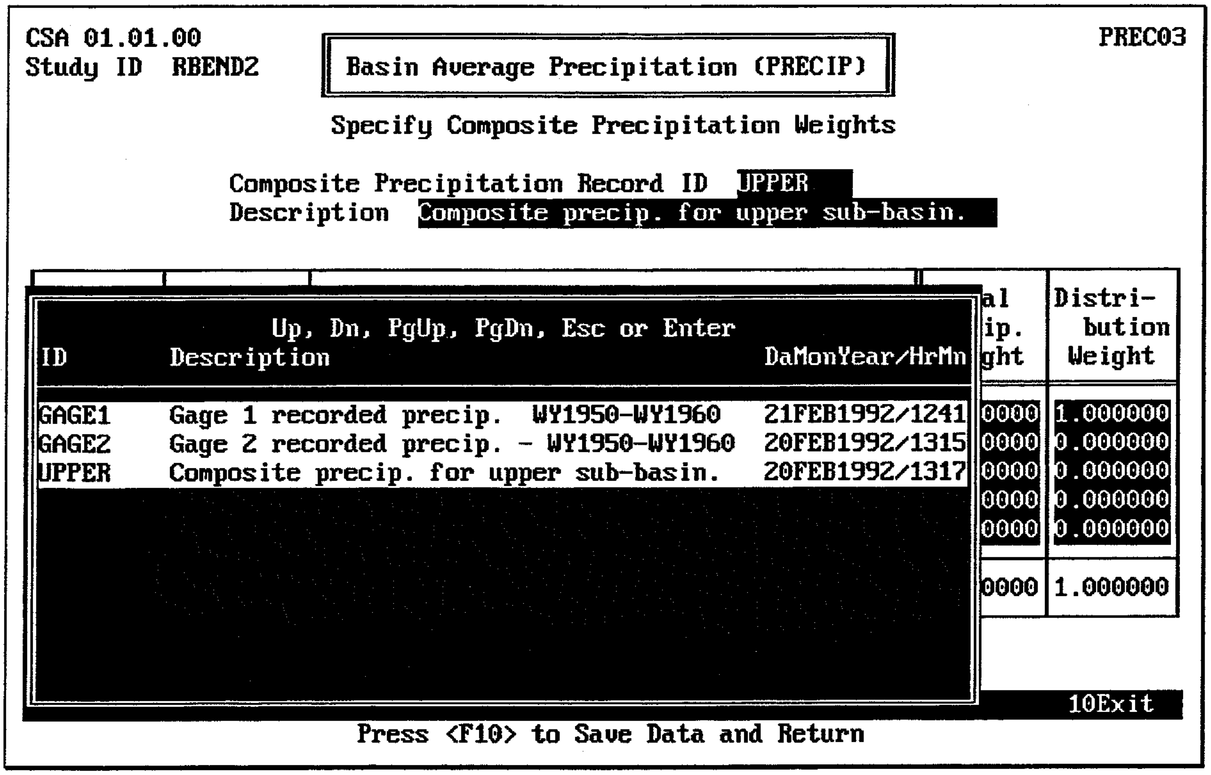


FIGURE 2.8 F3 Index Key Operation

2.6.4. F4 Goto Key: Movement to a Specified Date/Time Value

When viewing a lengthy set of time-series (chronological) data, the [F4] key allows immediate movement of the cursor to a specific date/time value within the data set. It can only be used when "4Goto" appears in the function key description bar at the bottom of the screen. This will always occur when the cursor is positioned within the time-series data window. If the selected value is not in the data set, the time-series data window will scroll to the closest date and time that exists in the data set. Pressing the [Esc] key exits this operation without change. Figure 2.9 illustrates the Goto option.

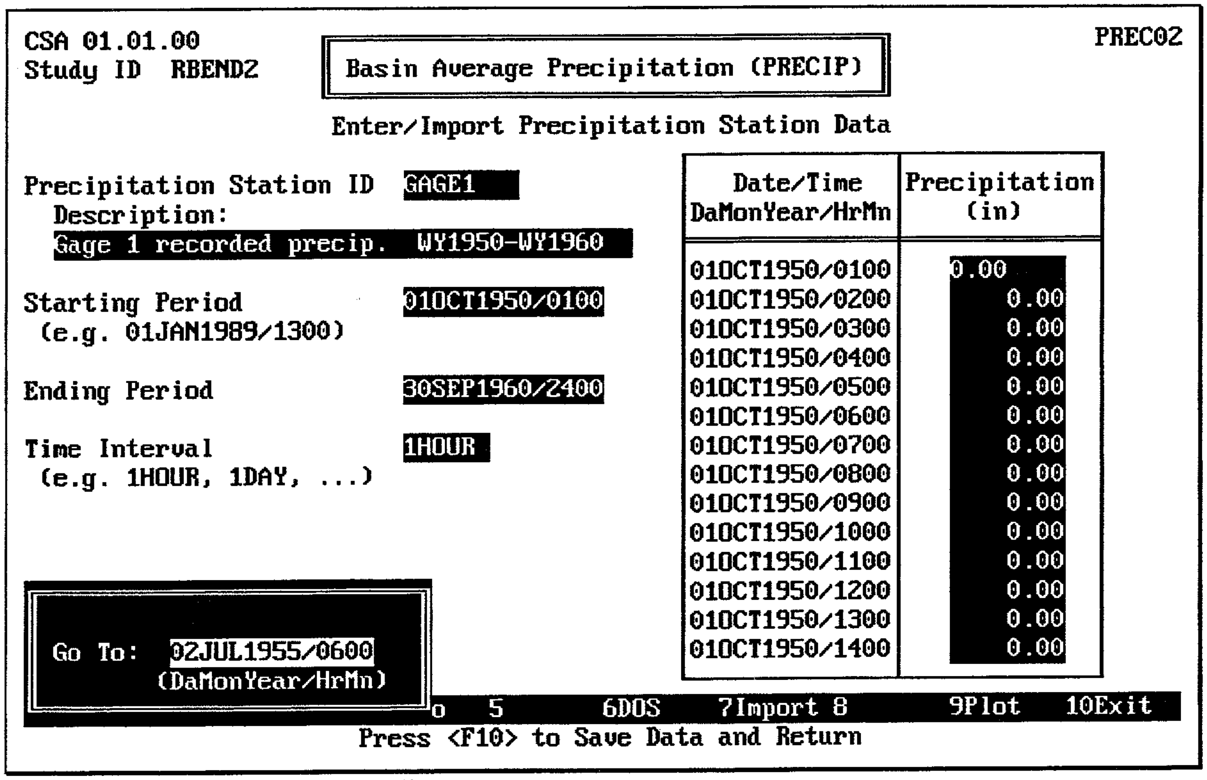


FIGURE 2.9 F4 Goto Key Operation

2.6.5. F5 Report Key: Producing Printed Reports

The HEC-IFH program can generate several reports of analysis results. When the program is displaying Hydrologic Analysis Summary screens or other report screens, the [F5] key allows any selected range of values to be printed in a formatted report. As illustrated in Figure 2.10, HEC-IFH prompts the user for the starting and ending date/time values for the report. The default starting and ending date/time is the beginning and ending periods of the time series displayed on the current report screen. Any range of date/time values which fall within these date/time values may be entered. The ending date/time value must be later than the starting date/time value.

The HEC-IFH program can deal with extremely long time series (up to 500,000 time periods or more) in a Continuous Simulation Analysis. Therefore, some printed reports can be extremely lengthy. As the starting and ending dates and time change, HEC-IFH computes and displays the number of pages required for the report. The number of pages depends upon the number of lines printed on each page. This can be adjusted using the program configuration options described in Appendix B.

Pressing the [Esc] key exits the operation without printing.

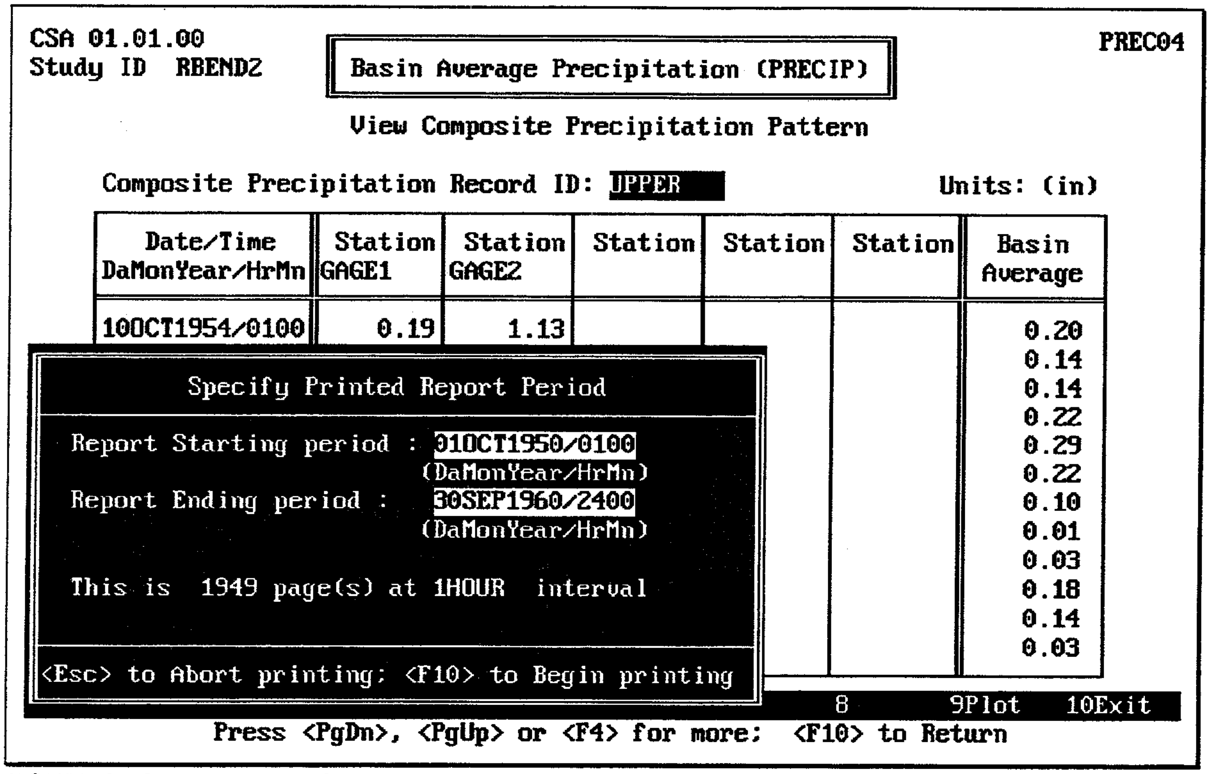


FIGURE 2.10 Report Key Operation

2.6.6. DOS Key

The F6 key suspends operation of the HEC-IFH program temporarily and returns control to the computer's operating system. Standard operations such as erasing or renaming files may then be performed. Other small programs may also be executed, although large programs may exceed available memory limitations. You should not install any memory-resident ("pop-up") program after pressing the F6 key, because this may interfere with memory controlled by the HEC-IFH program. The DOS EXIT command returns control to the HEC-IFH program.

2.6.7. Import Key

The F7 key instructs the HEC-IFH to import a time-series data set from an external HEC-DSS file. You may enter the HEC-DSS file name and path name (/A/B/C/D/E/F/) parts. The program displays default HEC-DSS file names and path part names for the import operation. The default names can be edited as required to specify the exact HEC-DSS file name and path name parts for data to be imported. Figure 2.11 illustrates the operation of the F7 key for Continuous Simulation Analysis (CSA). For Hypothetical Event Analysis (HEA), HEC-IFH allows the user to specify up to 8 different values for Part F of the HEC-DSS path name. These represent the different storm events which may be analyzed in a single HEA plan analysis. If one or more storm events will not be used in a particular plan analysis, the user may enter SKIP for the corresponding Part F. The time series for that storm event will not be imported. Appendix C contains more information about HEC-DSS and HEC-IFH data storage.

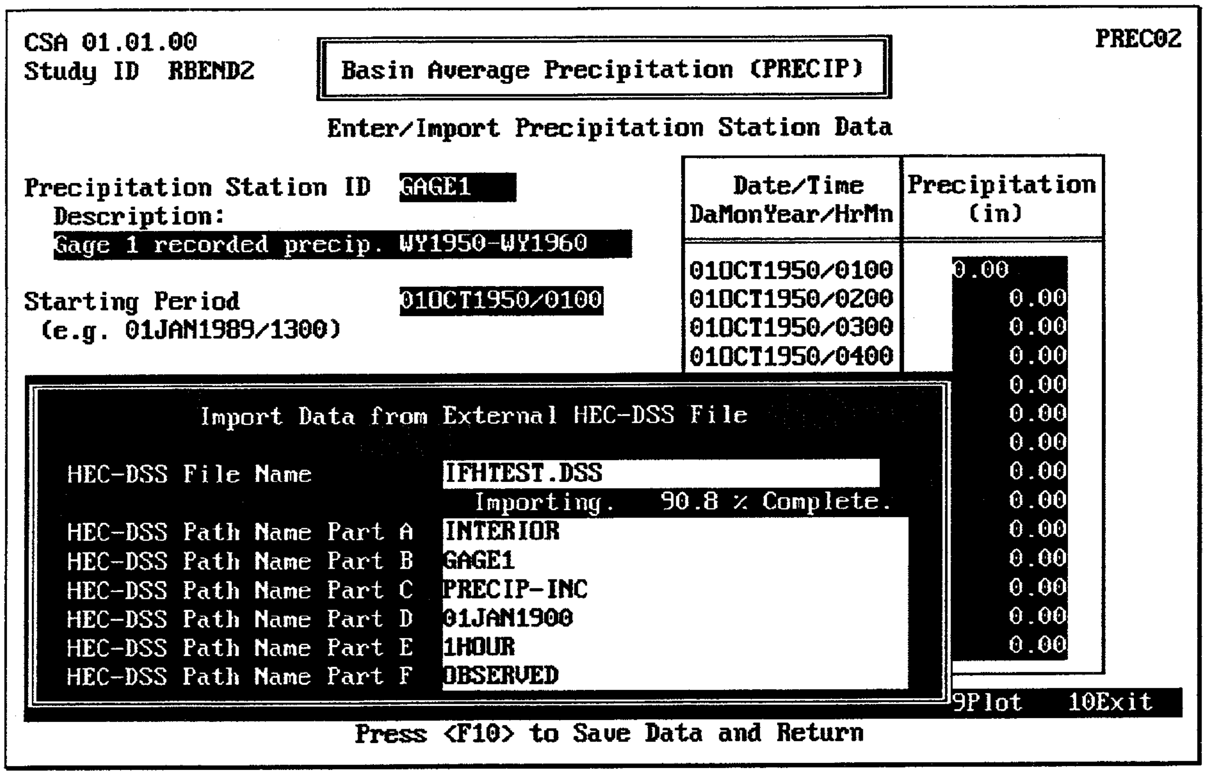


FIGURE 2.11 F7 Import Key Operation

2.6.8. F9 Plot Key: Displaying Plots

Screen plots are often available to illustrate tabular or time-series data sets used in the HEC-IFH program. The [F9] key causes HEC-IFH to display a plot of the current data set, or a list of available plots. After viewing the screen plot, press the [Esc] key or [F10] key to restore the previous screen. The [F2] key may be used to make a printed copy of the plot if a printer is on-line.

Several types of plots are available in the HEC-IFH program. Regardless of the type of graph used, however, all screen plots have the following common characteristics:

1. **Horizontal Time Scale**: HEC-IFH shows time values on the horizontal axis.
2. **Vertical Elevation Scale**: The program shows elevation values on the vertical axis.
3. **Engineering Scales**: HEC-IFH automatically scales numeric labels to reasonable "engineering" intervals (generally multiples of 2, 4, 5, or 10 units per interval).
4. **Multiple Colors**: If multiple data sets are displayed on multi-color graphics adapters (such as EGA or VGA), each data set is in a different color. The program displays a legend identifying each data set across the top of the plot, immediately above the data area.
5. **Multiple Line Types**: If a multi-color graphics adapters is not available, each data set is in a different line type. (See Appendix B for program configuration options.)
6. **Graph Title**: The program centers the title of the graph at the top of the screen.

7. **Descriptive Labels**: HEC-IFH shows the STUDYID at the upper left corner of the plot, above the legend line. The MODULEID or data set ID (for input data) or the PLANID (for output data) is shown on the same line at the upper right corner of the plot. Examples of data set IDs are STATIONID for Precipitation Station data, BASINID for Basin Runoff data, and STRUCTUREID for Gravity Outlet data.

Most of the plots produced by HEC-IFH are time-scaled graphics. Time-scaled regular line graphs may represent various "views" according to the total time span included on the plot. The program automatically selects the view which will display the entire data set with the greatest detail possible. The user may then switch from one view to another, if the view is consistent with the time interval and time span of the data set. The following views are possible for CSA time-series plots:

1. **Up to 100 annual values**: Annual values for each water year may represent annual totals, maxima, minima, or averages, as appropriate for each data set. This is the default view if the data set covers more than one water year. Figure 2.12 illustrates a plot of several years' data.
2. **Up to 366 Daily Values**: Daily values may represent daily totals, maxima, minima, or averages, as appropriate for each data set. This is the default view if the data set covers more than one calendar month but not more than one water year. Figure 2.13 illustrates a plot of one year's data.
3. **Up to One Month of Computation Interval Values**: This is the default view if the data set is contained within one calendar month. Figure 2.14 illustrates a plot of one month's data.
4. **Up to One Day of Computation Interval Values**: Figure 2.15 illustrates a plot of one day's data.

The plots described in items 3. and 4. listed above are available for HEA time-series plots.

Zooming: Users may zoom from one view of a time-scaled line graph to the next by pressing the up-arrow or down-arrow arrow keys. In zooming in to a more detailed view, the time period highlighted on the data entry or report screen will always be included in the plot. Assume, for example, that a user is browsing through a data set of 30 years of hourly runoff values, and that the runoff value for 6:00 a.m. July 2, 1955 is highlighted. If the user requests a plot of the data, the program would first display a plot of all 30 years of water year annual runoff values. Then, as the user repeatedly pressed the down-arrow key, the program would step through the following sequence of graphs:

1. 365 daily values for 1955.
2. 744 hourly values for July 1955.
3. 24 hourly values for July 2, 1955.

Pressing a number key followed by an up-arrow or down-arrow key causes the program to zoom up or down the corresponding number of "levels". For example, pressing 2 following by the down-arrow key would instruct the HEC-IFH program to go straight from the plot of 30 annual to the plot of 744 hourly values. This would skip the plot of 365 daily values altogether.

Repeatedly pressing the up-arrow several times would cause the program to step back through the sequence of graphs just listed. Optionally, pressing 2 following by up-arrow would instruct HEC-IFH to return directly to the plot of 30 annual values.

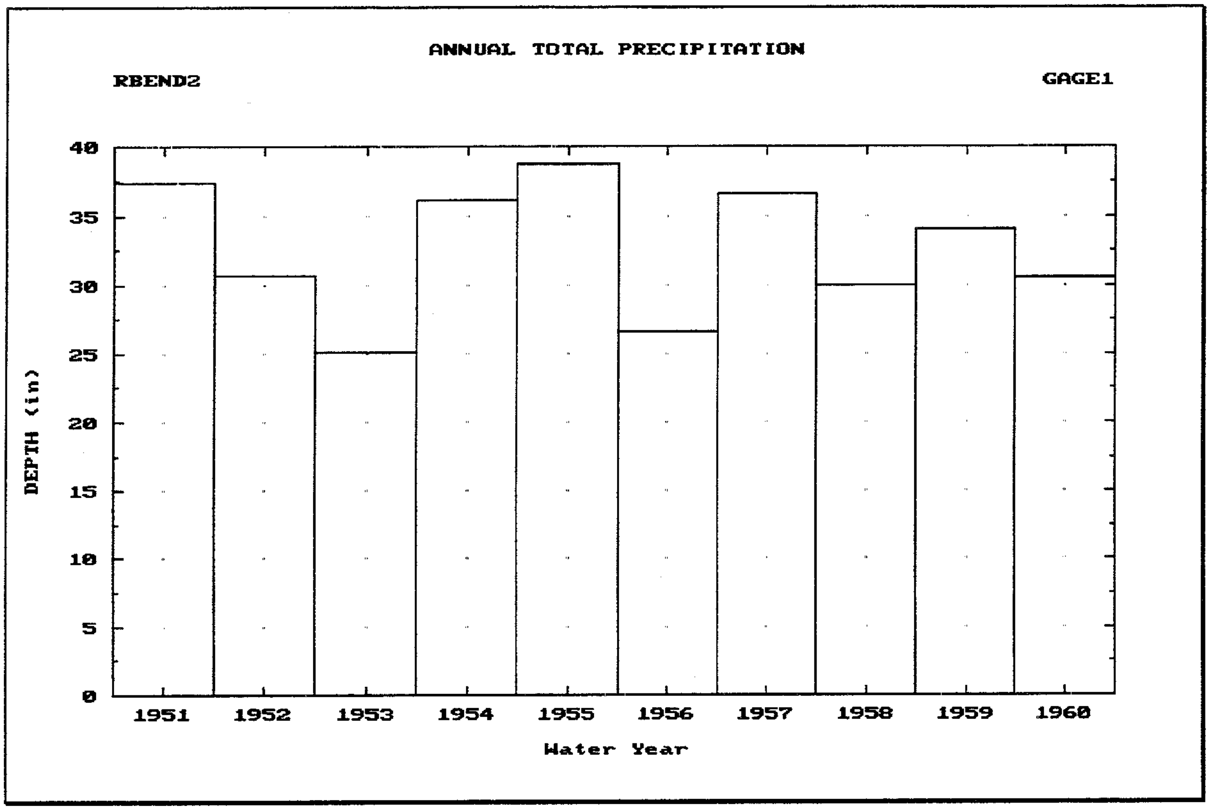


FIGURE 2.12 Example Multi-Year Plot of Annual Values

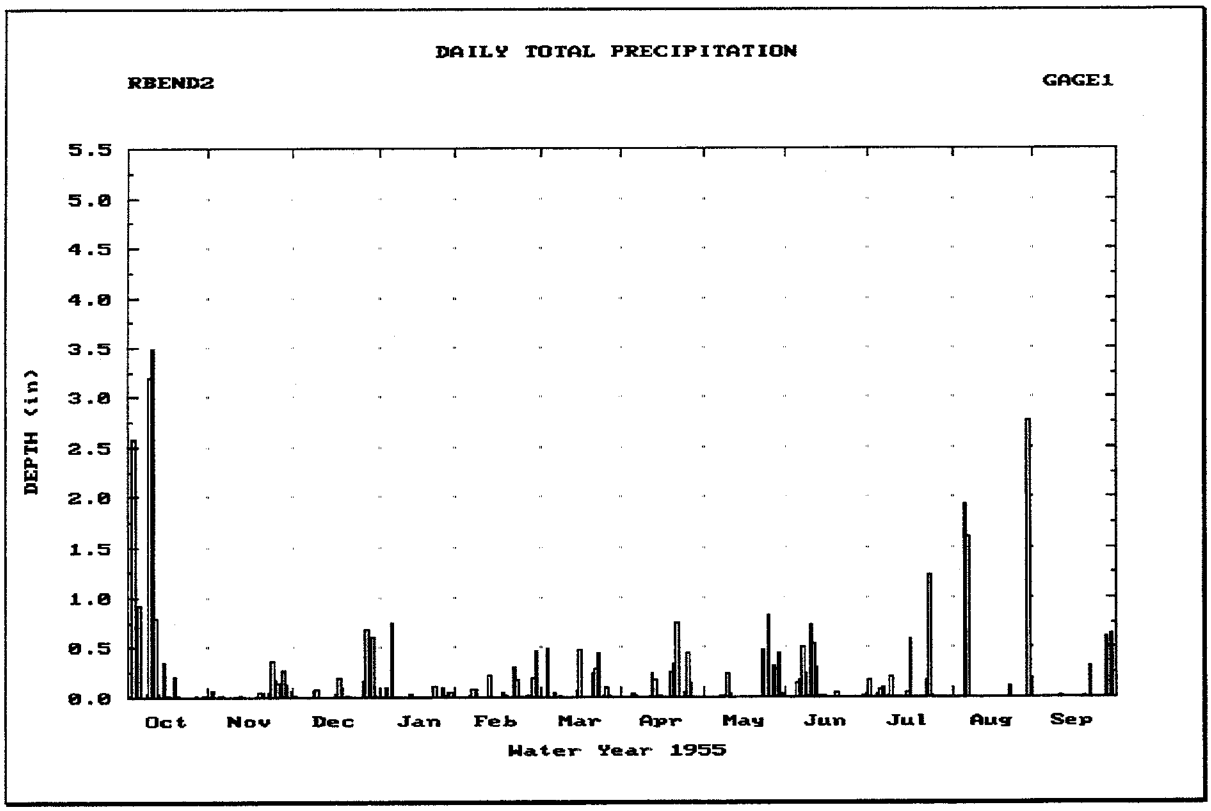


FIGURE 2.13 Example One-Year Plot of Daily Values

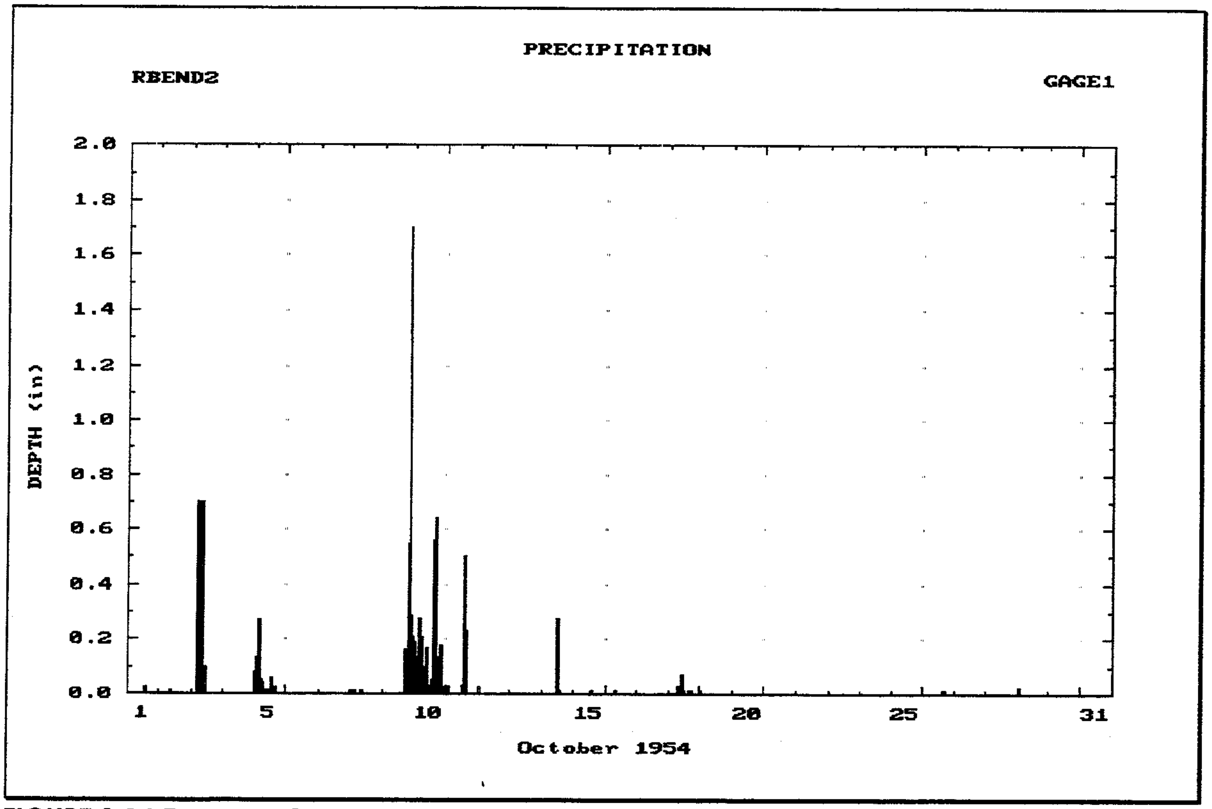


FIGURE 2.14 Example One-Month Plot of Computation Interval Values

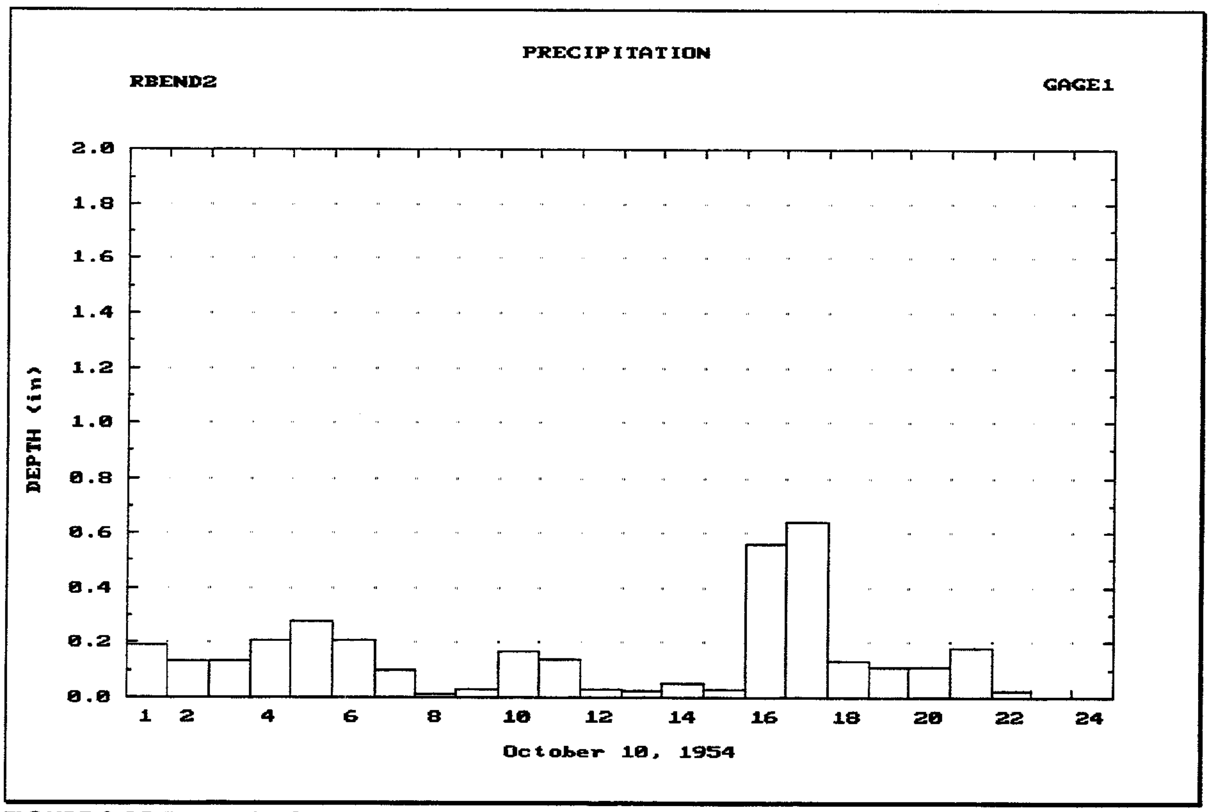


FIGURE 2.15 Example One-Day Plot of Computation Interval Values

Panning: Users may also pan from one time span to the next in the same view by pressing the right-arrow or left-arrow arrow keys. For example, if the 744 hourly values for July 1955 were displayed, pressing the right-arrow key would cause the program to display the 744 hourly values for August 1955. If the user then returned to the report screen, the cursor position would be advanced 744 hours to the runoff value for 6:00 a.m. August 2, 1955.

HEC-IFH also allows users to skip several intervening plot screens when panning. This is done by typing a number followed by a right-arrow or left-arrow key. HEC-IFH then immediately displays the plot which would be displayed by panning the specified number of times. For example, if a monthly plot of values for July 1955 is displayed and the user presses 3 followed by a right-arrow key, HEC-IFH displays the plot of values for October 1955. Up to 999 intervals may be skipped in this way.

2.6.9. F10 Exit Key: Exiting the Current Screen

The [F10] key causes the data that has been entered, edited, or imported to be saved and exits the present screen. If this occurs on a data entry or report screen, this may lead to a subsequent data entry or report screen. If there are no subsequent screens, it will lead back to the previous menu. From a menu screen, [F10] will call up the next higher level menu screen. From the main menu screen, it will call up the Study Selection screen, from which it will exit the program to return to DOS.

2.6.10. Abort Key: Terminating the Current Operation

The [Esc] key aborts the present operation. If data has been entered, imported, or edited, the program will ask the user whether the changes should be saved. Valid responses are (Y)es or (N)o, with the default being (N)o. If no data values have been changed, the program exits the current screen and displays the previous screen. For example, pressing the [Esc] key while entering a data value will end the data entry without changing the data value. The program will also exit the screen if no other values have been changed.

The [Alt] [F10] key combination is a "Super Abort" which immediately exits the HEC-IFH program.

Chapter 3. Basin Average Precipitation

3.1. INTRODUCTION

The HEC-IFH program uses a ***precipitation hyetograph*** as the input for all runoff calculations. Basin average precipitation is either input or computed using gaged data and transformed to runoff using the unit hydrograph technique. Any of the options used to specify precipitation produce a hyetograph similar to that shown in Figure 3.1. The hyetograph represents the total incremental precipitation depth for each computation interval during the analysis.

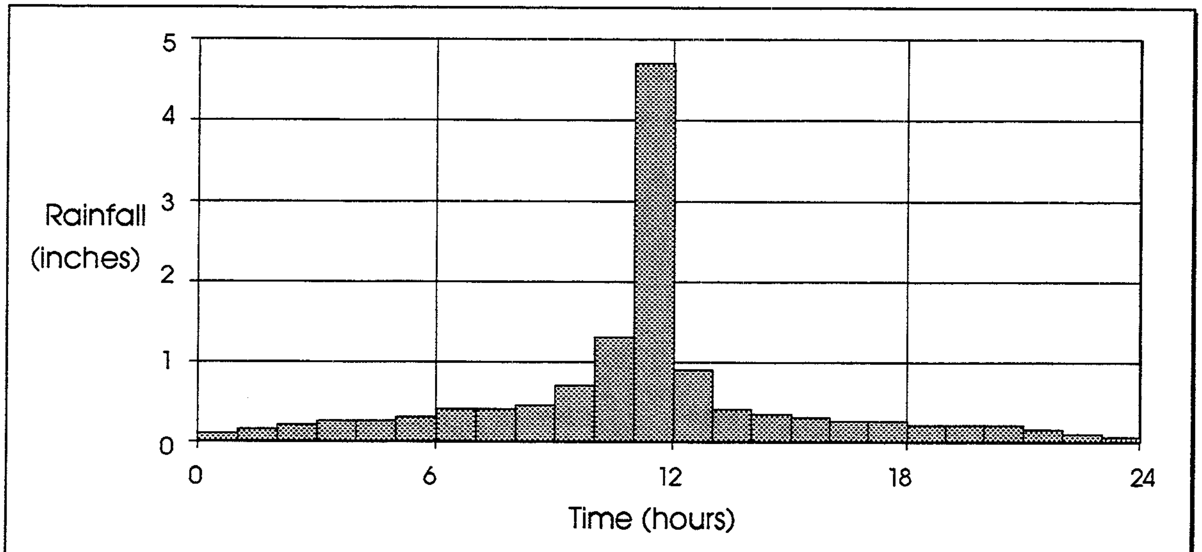


FIGURE 3.1 Precipitation Hyetograph

An HEC-IFH analysis can be based on historical rainfall data or a ***synthetic storm***. Continuous Simulation Analyses are based on historical or other long-term rainfall data. The precipitation hyetograph used in the analysis may be based on a single rainfall gage record that represents basin average precipitation, or a **composite rainfall record** computed from the weighted average of up to 5 gage records.

Hypothetical Event Analyses are always based on a standard group of synthetic storm events. These types of synthetic storms that can be used for Hypothetical Event Analyses are described below:

1. **Hypothetical Frequency Storms**, which may be entered by the user or computed by HEC-IFH, are balanced storm distributions with total rainfall amounts consistent with specific exceedance frequencies or recurrence intervals. Hypothetical Event Analyses can consider the 0.2% (500-year), 1% (100-year), 2% (50-year), 4% (25-year), 10% (10-year), 20% (5-year), and 50% (2-year) hypothetical frequency storms.
2. **Standard Project Storm**, which is applicable to basin areas from 10 to 1,000 square miles located east of 105 degrees longitude, and is determined according to the criteria discussed in EM 1110-2-1411 (CORPS OF ENGINEERS, 1952).

Table 3.1 lists the precipitation options available for each method of analysis.

TABLE 3.1 Computational Methods for Precipitation

Computational Method or Option	Continuous Simulation	Hypothetical Event Analysis
Enter/Import Precipitation Station Data	✔	–
Composite Precipitation Record Computations	✔	–
Hypothetical Frequency Storm Computation	–	✔
Standard Project Storm Computation	–	✔

3.2. CONTINUOUS SIMULATION ANALYSIS

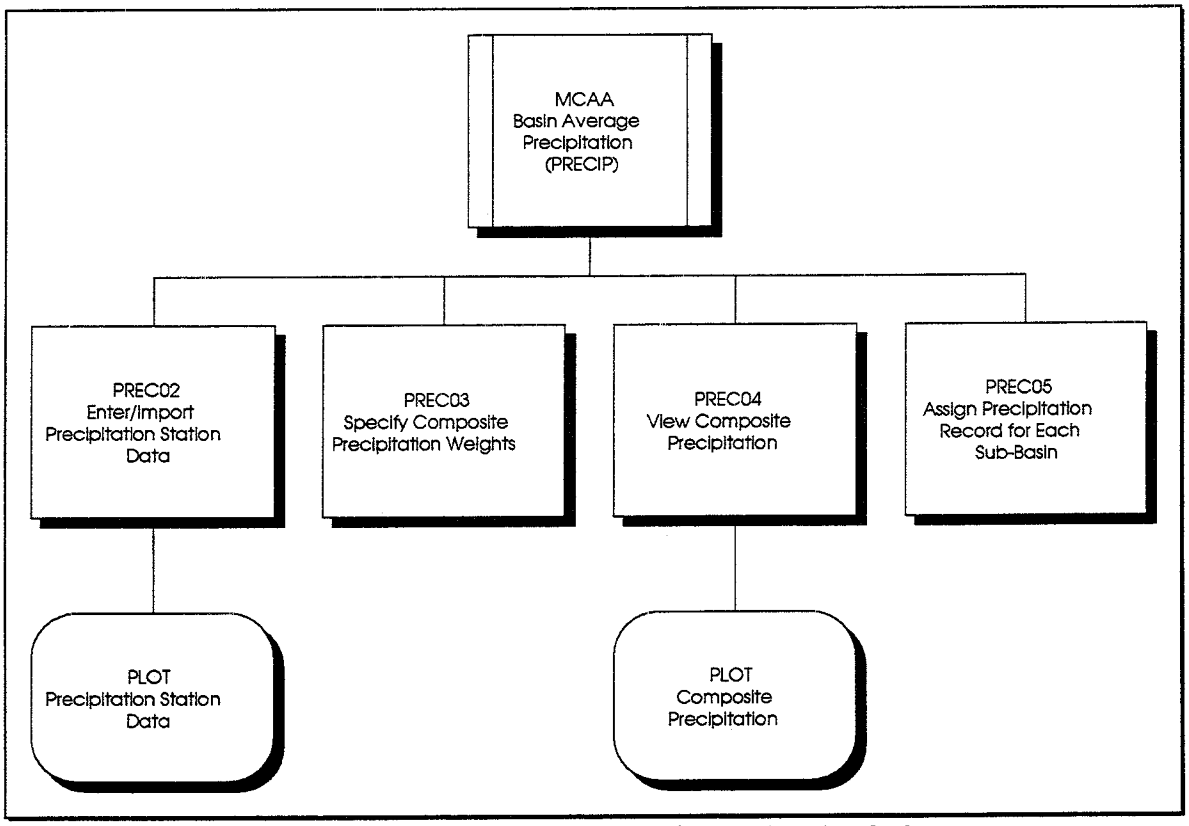


FIGURE 3.2 PRECIP Module Structure for Continuous Simulation Analysis

Figure 3.2 shows the structure of the HEC-IFH program user interface which deal with continuous simulation precipitation data entry, computations, and plotting. As this figure indicates, the various precipitation options are controlled from a single menu. Figure 3.3 shows the precipitation menu screen for Continuous Simulation Analysis. This menu provides the following options:

- Option A allows the rainfall gage data to be entered or imported, as described in Section 3.2.1. Precipitation Station Data beginning on page 31.
- Options B and C are for making composite rainfall computations, as described in Section 3.2.2. Composite Precipitation Records beginning on page 34.
- Option D specifies the rainfall record to use for each sub-basin. It is described in Section 3.2.3. Specifying Precipitation Data beginning on page 38.

```
CSA 01.01.00                                                          MCAA
Study ID  RBEND2      Basin Average Precipitation (PRECIP)



              Select Option:

                A. Enter/Import Precipitation Station Data
                B. Specify Composite Precipitation Weights
                C. View Composite Precipitation Patterns
                D. Assign Precipitation Record for Each Sub-Basin





1Help  2PrtScr 3      4       5       6DOS    7       8       9      10Exit
              Press Letter: or use Arrow Keys and <Enter> to Select
```

FIGURE 3.3 Precipitation Menu Screen - Continuous Simulation Analysis

3.2.1. Precipitation Station Data

As described previously, historical rainfall data generally consist of rainfall gage records. The HEC-IFH program allows these data values to be entered directly. To help avoid situations where long period precipitation time-series data would need to be entered manually, the HEC-IFH program has the capability to import data from the HEC Data Storage System (HEC-DSS).

Figure 3.4 illustrates the data entry screen used to enter rainfall gage data for a Continuous Simulation Analysis. Each gage record must be identified by a unique 8-character **Precipitation Station ID**. This ID is used to identify the gage record during subsequent steps. A 40-character **Description** may be used to provide further background information on the precipitation record.

Several rainfall gage record time series may be entered, each one identified by a different Precipitation Station ID. When the cursor is on the Precipitation Station ID field, the F3 key displays a list of previously entered precipitation station IDs. Any of these previous IDs may be selected, and the corresponding time series precipitation data will be read and displayed on the screen.

The **Starting Period** and **Ending Period** of the gage record must be entered using the standard HEC-DSS format for date and time. The starting period is the end of the first time interval, and the ending period is the end of the last time interval in the time series. For example, a record consisting of hourly values for the month of October 1990 would have a starting period of 01OCT1990/0100 and an ending period of 31OCT1990/2400. If the precipitation record for October 1990 consisted of daily instead of hourly values, the starting period would be 01OCT1990/2400 (the end of the first day), but the ending period would still be 31OCT1990/2400. The ending period must be later than the starting period.

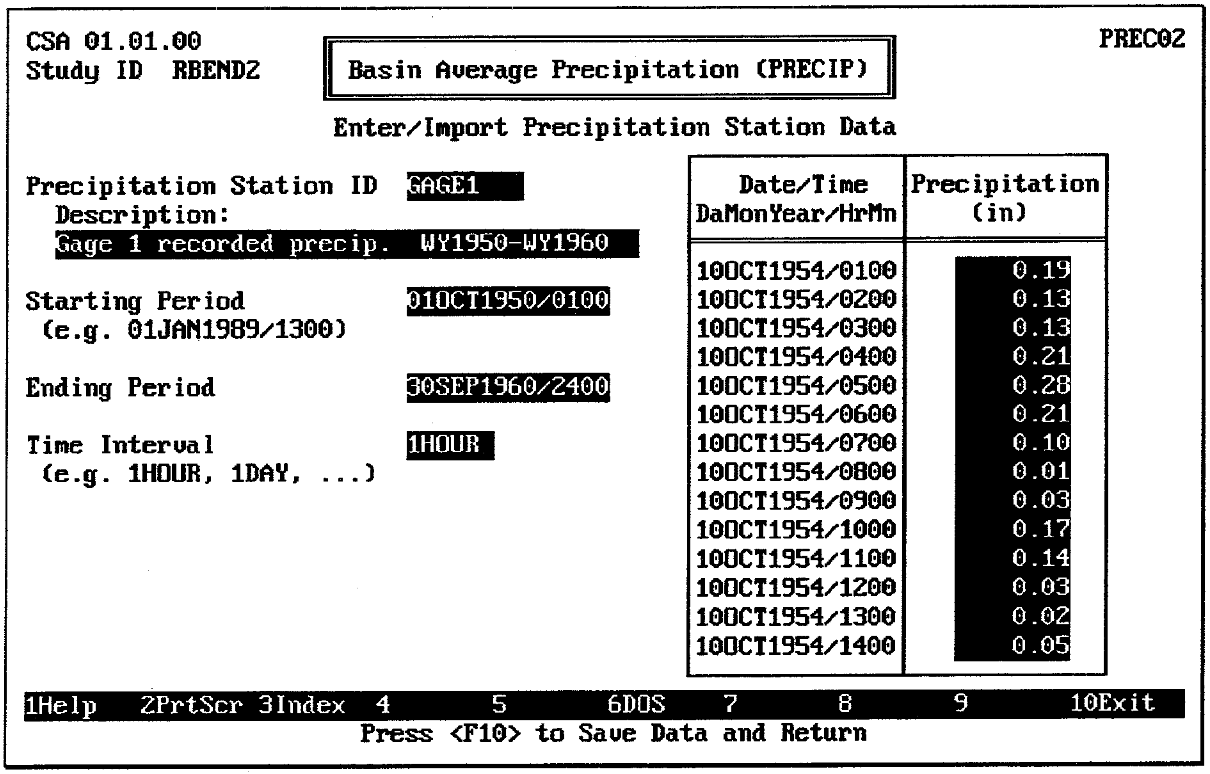


FIGURE 3.4 Precipitation Record Data Entry Screen

The **Time Increment** must be entered as a number combined with a unit of time. Time intervals must be standard HEC-DSS time intervals between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The time increment must be consistent with the starting and ending period. For example, a time increment of 2HOUR would not be consistent with a starting period of 01OCT1990/0100. A time increment of 1HOUR would be appropriate for this starting time.

After entering the starting and ending times and time interval, the HEC-IFH program is ready to receive incremental **Precipitation** values for each time period. The user may enter these values or import them from an external HEC-DSS file on disk. All incremental precipitation values must be equal to or greater than zero (0).

To import a rainfall gage record time series, press the F7 key after entering the time increment but before entering any precipitation values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated. It is best to deal appropriately with missing data values prior to importing precipitation data into HEC-IFH.

Pressing the F4 Goto key during data entry instructs HEC-IFH to move directly to any specified time interval in the time series. This program capability is discussed in Chapter 2.

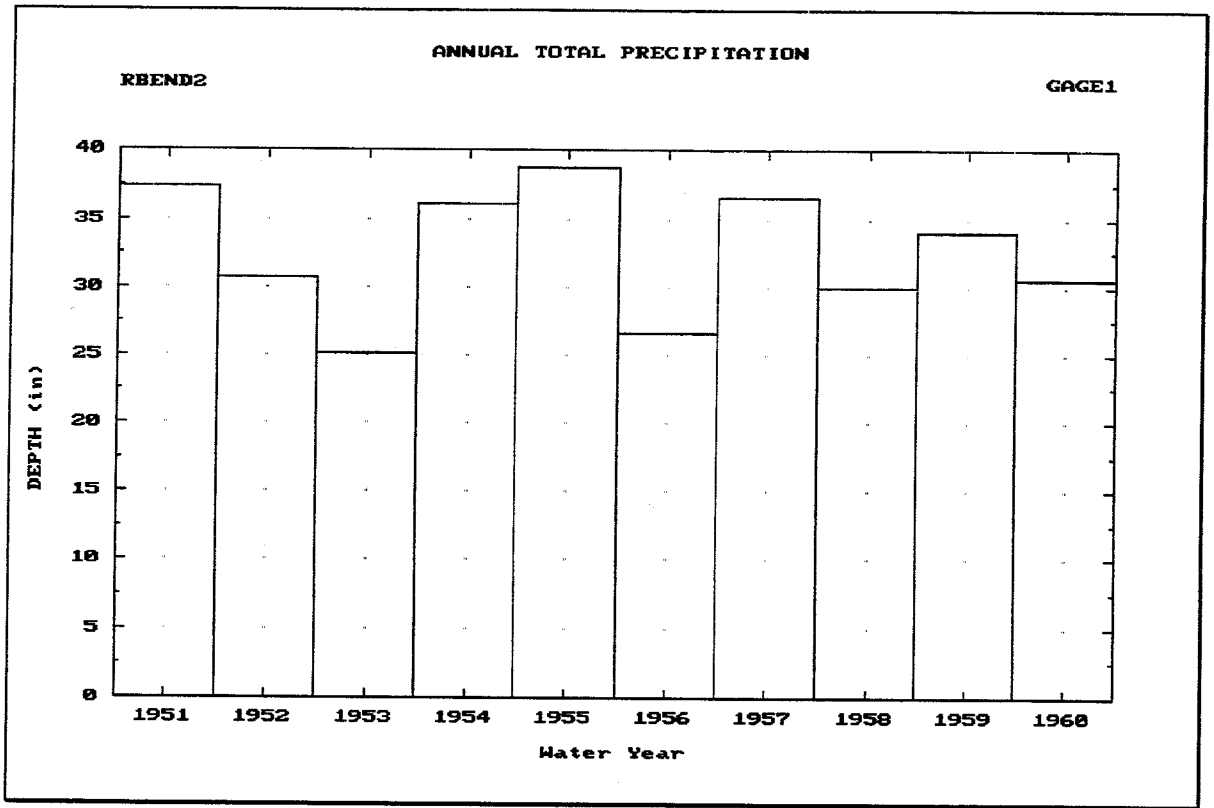


FIGURE 3.5 Multi-Year Plot of Annual Precipitation Totals

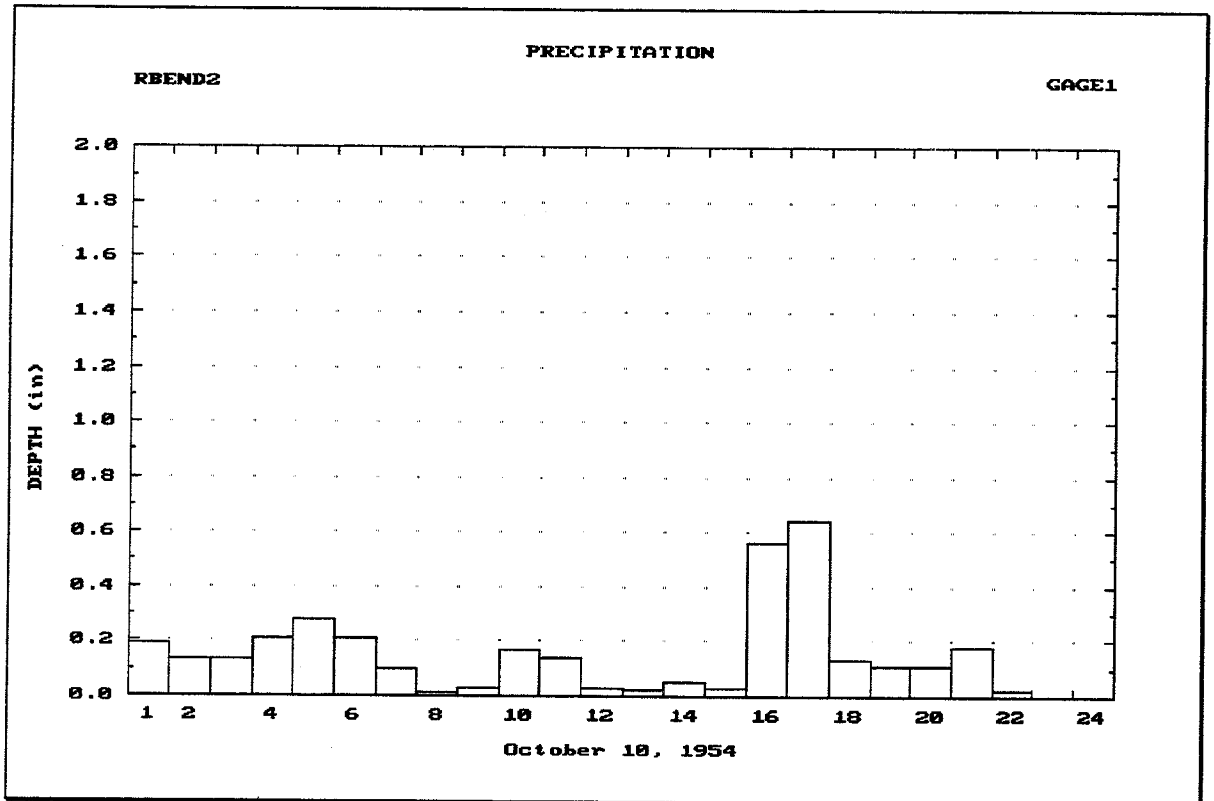


FIGURE 3.6 One-Day Plot of Periodic Precipitation Values

After entering or importing rainfall gage records, you may plot the precipitation hyetograph. Figure 3.5 illustrates a typical annual precipitation hyetograph. If you have entered enough data values, you may "zoom" to a one-year plot of monthly totals, a one-month plot of actual values, or a one-day plot of actual values (as shown in Figure 3.6). From the one-year, one-month, or one-day plots, you may "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

3.2.2. Composite Precipitation Records

Composite (weighted) rainfall values are determined when more than one rain gage is located within or near the watershed. Records from up to 5 rain gages may be used in the analysis. Before a composite precipitation record can be computed, the rainfall gage records to be used must already have been entered or imported as described in the previous section.

A typical situation is illustrated in Figure 3.7. Two rainfall gages are located within the interior area watershed, while a third is located outside the watershed. For the average precipitation for the upper portion of the watershed (sub-area A), gage number 2 would receive the largest weighting, followed by gage number 3 and then gage number 1. For sub-area B, gage number 1 would be assigned the largest weighting factor, while gage numbers 2 and 3 would receive approximately equal weightings. The weightings can be determined using the Thiessen polygon method.

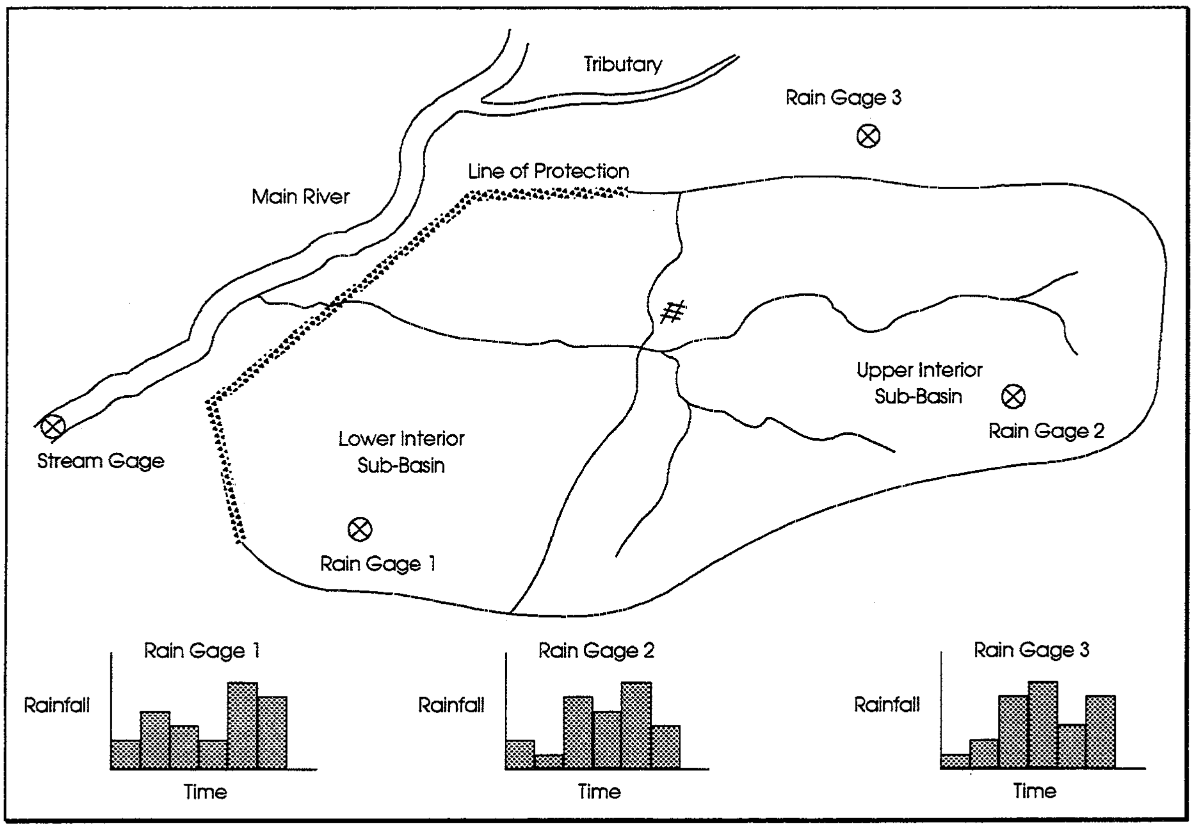


FIGURE 3.7 Illustration of Multiple Rain Gages for Computing Composite Precipitation

Weightings for both storm total rainfall and rainfall distribution can be specified. The rainfall total for a sub-basin may be computed as the weighted average of totals from several rainfall gages:

$$PRCPA = \frac{\sum_{J=1}^{n} PRCPN_J \times WTN_J}{\sum_{J=1}^{n} WTN_J} \qquad (3.1)$$

in which:

$PRCPA$ = the sub-basin average total precipitation

$PRCPN_J$ = the total precipitation for gage J

WTN_J = the relative weight for gage J

n = the number of gages

The rainfall distribution or temporal pattern, indicates how the total rainfall is distributed throughout the storm. The temporal rainfall distribution is computed as a weighted average of temporal patterns from recording stations:

$$PRCP_I = \frac{\sum_{J=1}^{n} PRCPR_{IJ} \times WTR_J}{\sum_{J=1}^{n} WTR_J} \qquad (3.2)$$

in which:

$PRCP_I$ = the basin-average precipitation for time interval I

$PRCPR_{IJ}$ = the recording station precipitation for time interval I and gage J

WTR_J = the relative weight for gage J

Caution should be used when averaging temporal distributions because the maximum storm rainfall intensity may be sharply reduced.

The composite basin average rainfall hyetograph is computed using the computed rainfall distribution, *PRCP*, to distribute the computed total rainfall, *PRCPA*.

3.2.2.1. Specifying Composite Precipitation Weights

Figure 3.8 shows the data entry screen used to specify the data necessary to compute a composite rainfall record for a Continuous Simulation Analysis. Like all rainfall records, the composite rainfall record must be identified by a unique 8-character **Precipitation Record ID**. This ID is used later when specifying which gage record will be used for each computation. The 40-character **Description** may be used to provide additional descriptive information.

After the record ID and description are entered, up to 5 precipitation stations may be selected for the composite computation. Previously defined precipitation station IDs are entered or selected from the list of available precipitation station IDs presented when the [F3] Index key is pressed. As each station ID is entered, the HEC-IFH program automatically lists the time increment and 40-character description of the rainfall gage record. This information helps ensure that the correct gages are specified.

The **Total Precipitation Weight** and **Distribution Weight** for each gage must be entered. These weights may be entered in any convenient units. Although the total weights are listed for each column, the totals are not required to equal any certain number such as

1.00 or 100%. The actual weight used for each gage will be computed as the gage weight divided by the total of all gage weights. All values must be greater than or equal to zero (0).

```
CSA 01.01.00                                                        PREC03
Study ID  RBEND2      Basin Average Precipitation (PRECIP)

                  Specify Composite Precipitation Weights

             Composite Precipitation Record ID  UPPER
             Description  Composite precip. for upper sub-basin.

 Precip.   Time                                          Total     Distri-
 Station   Interval                                      Precip.    bution
   ID                Description                         Weight    Weight

 GAGE1     1HOUR     Gage 1 recorded precip.  WY1950-WY1960  0.600000  1.000000
 GAGE2     1HOUR     Gage 2 recorded precip. - WY1950-WY1960 0.400000  0.000000
                                                         0.000000  0.000000
                                                         0.000000  0.000000
                                                         0.000000  0.000000

                                                 Total:  1.000000  1.000000

1Help  2PrtScr 3Index  4      5       6DOS    7      8      9       10Exit
                  Press <F10> to Save Data and Return
```

FIGURE 3.8 Composite Basin Average Precipitation Data Entry Screen

After the composite precipitation weights are specified on this screen, the resulting composite precipitation pattern may be viewed as described in the next section.

3.2.2.2. Viewing Composite Precipitation Patterns

Figure 3.9 shows the screen used to view a computed composite precipitation pattern for Continuous Simulation Analysis. A similar screen is available for a Hypothetical Event Analysis. The screen provides a place to enter the **Composite Record ID** at the top of the screen. This composite record must have already been specified as described in the previous section. If the composite precipitation has not been previously computed, some time delay may result while the program computes the entire composite precipitation pattern.

After the composite precipitation pattern is computed, the screen displays the computed basin average rainfall value for each time interval. The corresponding rainfall values for each gage used in the computation are also listed. The starting time of the composite precipitation record equals the latest starting time of any of the gages used in the composite computation. Similarly, the ending time equals the earliest ending time of any of the gages. The shortest time interval of the various gage records is used as the time interval of the composite record.

The [F4] Goto key is available for this table, and a printed report is available by pressing the [F5] Report key as described in Chapter 2.

After entering or importing rainfall gage records, you may plot the composite precipitation pattern and the individual gage records. Figure 3.10 illustrates a typical annual composite precipitation hyetograph. On a color computer monitor, the composite precipitation and each of the individual gage records would be plotted in a different color.

CSA 01.01.00 PREC04
Study ID RBEND2

Basin Average Precipitation (PRECIP)

View Composite Precipitation Pattern

Composite Precipitation Record ID: UPPER Units: (in)

Date/Time DaMonYear/HrMn	Station GAGE1	Station GAGE2	Station	Station	Station	Basin Average
10OCT1954/0100	0.19	1.13				0.20
10OCT1954/0200	0.13	0.38				0.14
10OCT1954/0300	0.13	0.28				0.14
10OCT1954/0400	0.21	0.12				0.22
10OCT1954/0500	0.28	0.23				0.29
10OCT1954/0600	0.21	0.17				0.22
10OCT1954/0700	0.10	0.22				0.10
10OCT1954/0800	0.01	0.02				0.01
10OCT1954/0900	0.03	0.02				0.03
10OCT1954/1000	0.17	0.06				0.18
10OCT1954/1100	0.14	0.05				0.14
10OCT1954/1200	0.03	0.00				0.03

1Help 2PrtScr 3Index 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Press <PgDn>, <PgUp> or <F4> for more; <F10> to Return

FIGURE 3.9 Composite Storm Table

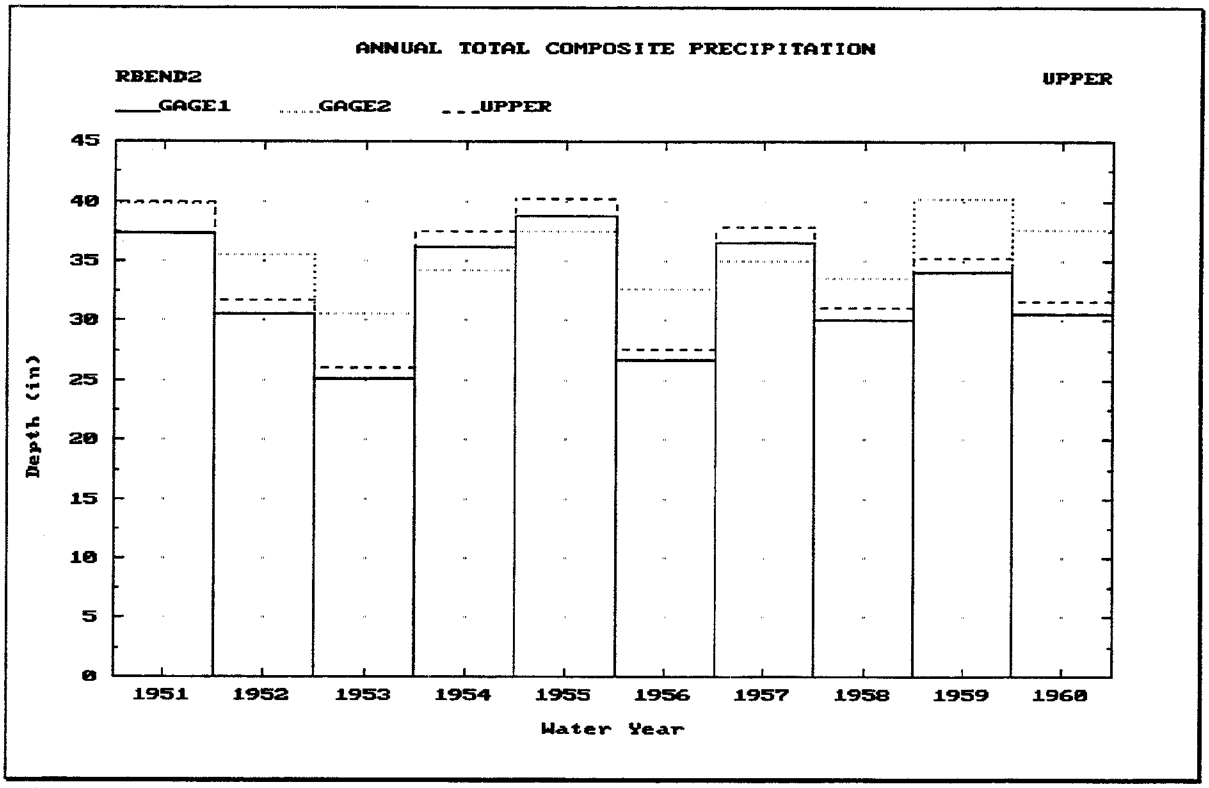


FIGURE 3.10 Multi-Year Plot of Composite Precipitation Annual Totals

If you have entered enough data values, you may "zoom" to a one-year plot of daily totals or a one-month or one-day plot of actual values (as shown in Figure 3.11). From the one-year, one-month, or one-day plots, you may "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

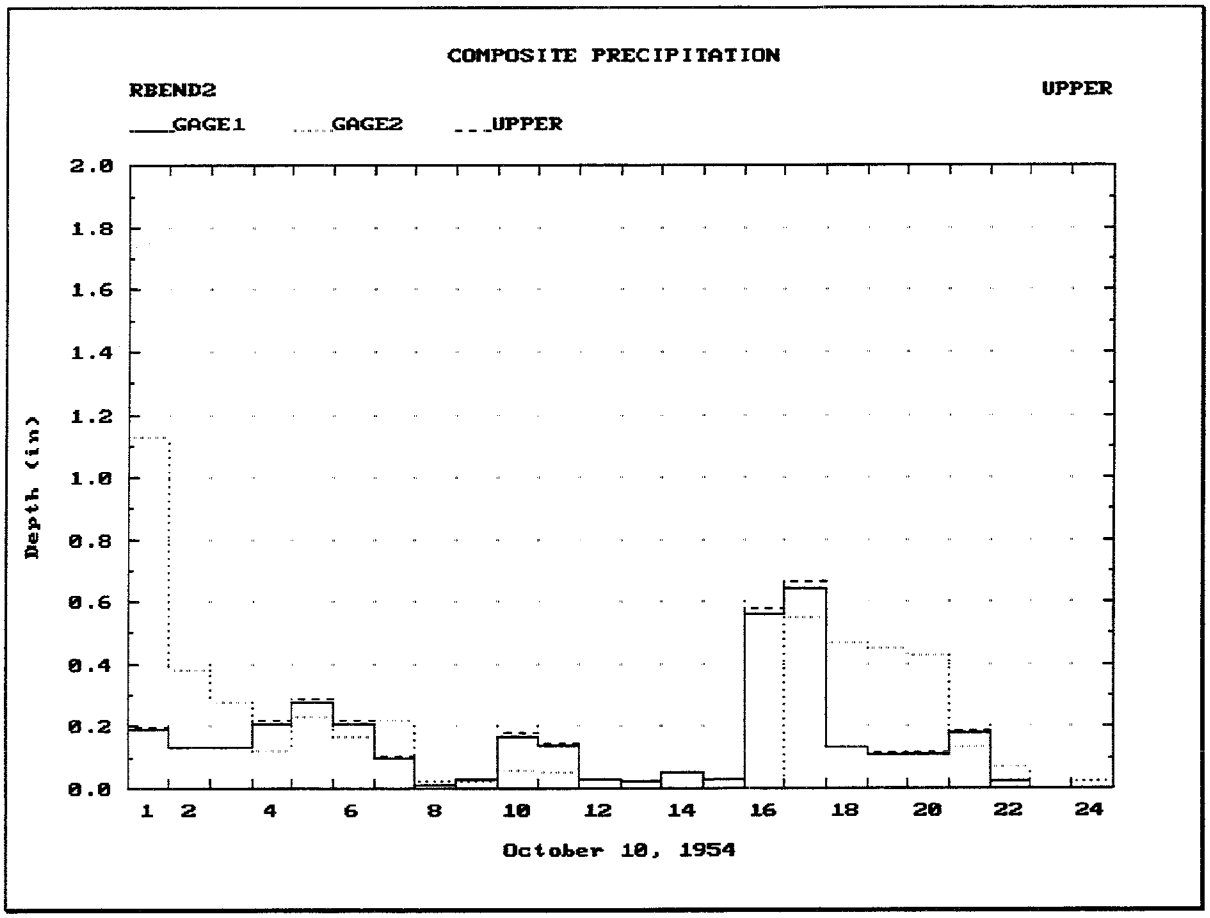


FIGURE 3.11 One-Day Plot of Composite Precipitation

3.2.3. Specifying Precipitation Data

Rainfall data may be required for up to two sub-basins for the interior analysis. Therefore, the user must specify which precipitation gage or composite precipitation station will be used for basin average precipitation for each sub-basin. These sub-basins include:

1. **The Lower Sub-Basin**: An interior sub-basin which directly contributes to flow behind the line-of-protection.
2. **The Upper Sub-Basin**: An optional interior sub-basin producing runoff may be routed through a channel segment to the line-of-protection.

Figure 3.12 illustrates the lower and upper interior sub-basins. Figure 3.13 illustrates the screen used to specify the precipitation data which will be used to determine runoff during Continuous Simulation for each interior sub-basin.

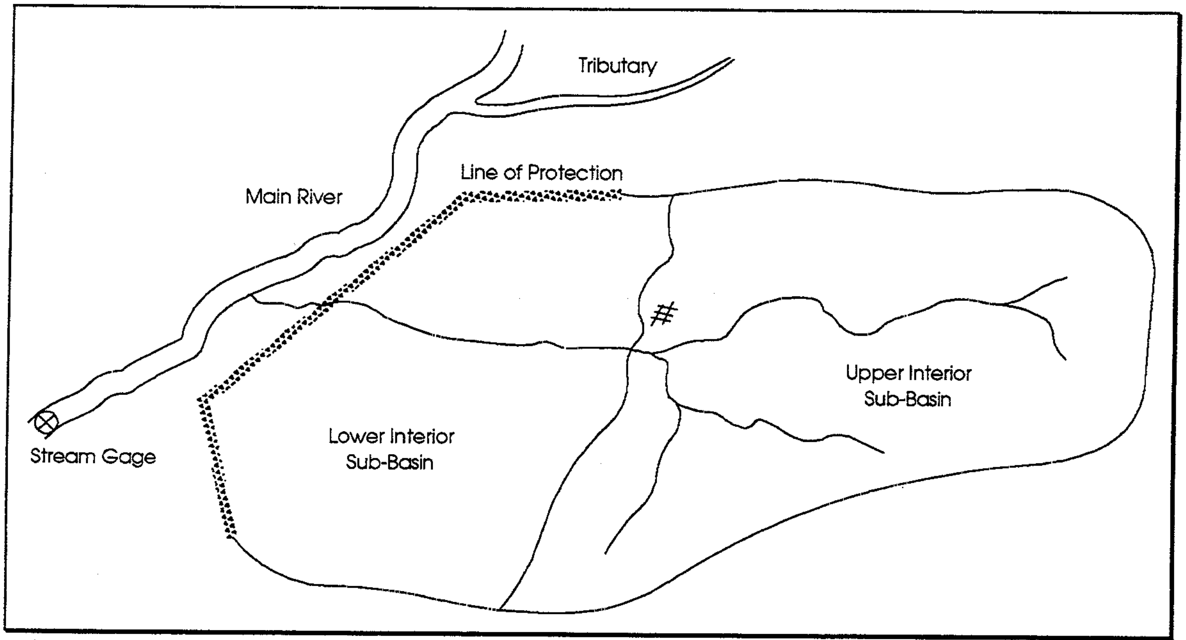


FIGURE 3.12 Lower and Upper Interior Sub-Basins

CSA 01.01.00
Study ID RBEND2

Basin Average Precipitation (PRECIP)

PREC05

Assign Precipitation Record for Each Sub-Basin

Module ID PRECIP1
Description Precip. data for App. C.

Sub-Basin	Precipitation Station ID	Description
Lower Interior	GAGE2	Gage 2 recorded precip. - WY1950-WY1960
Upper Interior	UPPER	Composite precip. for upper sub-basin.

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE 3.13 Continuous Simulation Precipitation Data Specification Screen

Like other HEC-IFH data entry modules, the PRECIP module data is defined using a **Module ID**. Several PRECIP module data sets may be defined using different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously defined IDs. Any of these previously defined IDs may be selected, and the corresponding data will be displayed on the screen and may be edited. The 40-character **Description** provides documentation for each PRECIP Module data set.

The Continuous Simulation PRECIP module data includes up to two **Precipitation Station IDs** (one for the optional upper interior sub-basin and the other for the lower interior sub-basin). These Station IDs may represent actual rainfall gage records, or a composite precipitation record. When the cursor is on each ID field, the [F3] key displays a list of previously defined Precipitation Station IDs. Any of these previously defined IDs may be selected. As each ID is entered, the HEC-IFH program displays the 40-character description for that ID. This helps the user to verify that the program is using the correct data.

The user may reenter the PRECIP module later in order to change the ID for each Precipitation Station. Additional rainfall gage records may also be entered or computed using new IDs.

3.3. HYPOTHETICAL EVENT ANALYSES

As noted earlier in this chapter, HEC-IFH provides 2 options for computing rainfall data for Hypothetical Event Analyses. These ***synthetic*** storm methods include the hypothetical frequency storm distribution and the Corps of Engineers Standard Project Storm, which are similar to the synthetic storms implemented in the HEC-1 computer program (HEC, 1990).

Figure 3.14 illustrates the main data entry screen for the Hypothetical Event Analysis PRECIP module. The Hypothetical Event Analysis precipitation data is stored under a **Module ID**. Several PRECIP module data sets may be stored under different IDs. When the cursor is on the Module ID field, the [F3] key displays a list of previously defined IDs. Any of these previous IDs may be selected, and the corresponding data will be loaded for editing. The 40-character **Description** provides documentation for each PRECIP Module data set.

The **Storm Area** is the total area over which the storm occurs. It must be greater than zero, and it may exceed the drainage area of the sub-basin.

The rainfall depths which are provided to HEC-IFH are "point" rainfall depths – they are directly applicable for storm areas of less than 10 square miles. For larger storm areas, HEC-IFH automatically adjusts the point precipitation values to the basin average for the actual area of the storm using the following equation [HERSHFIELD, 1961, FIG. 15].

$$FACTOR = 1 - BV \times (1 - EXP(-0.015 \times AREA)) \quad (3.3)$$

in which:

FACTOR is the coefficient used to adjust point rainfall.

BV is the maximum reduction of point rainfall (from Table 3.2).

AREA is the storm area in square miles. A value greater than zero (0) must be entered.

TABLE 3.2 Point-to-Area Rainfall Conversion Factors

Duration (hours)	0.5	1	3	6	24	48	96	168	240
BV	0.48	0.35	0.22	0.17	0.09	0.068	0.055	0.049	0.044

Source: Table 3.4 of the HEC-1 Users Manual [HEC, 1990]

```
HEA 01.01.00                                                         MDAA+
Study ID  SILVERCR    Basin Average Precipitation (PRECIP)


                 Module Id    STORM1

                 Description  Precip. depth-duration data.

                 Storm Area (sq mi)                    15.00

                 Type of Series *                  [Annual] Partial

                 Time Interval (e.g., 1HOUR, 1DAY)  1HOUR


       * NOTE:  ANNUAL  - Convert Rainfall from Partial to Annual
                PARTIAL - No Conversion

1Help  2PrtScr 3Index  4      5      6DOS   7      8      9      10Exit
                     Press <F10> to Proceed to the Menu
```

FIGURE 3.14 Hypothetical Event Analysis Data Entry Screen

Computed precipitation depths may be based on two **Types of Series** or frequency analyses: **Annual** series and **Partial**-duration series. An annual series frequency analysis is based on the largest rainfall event for each year. A partial-duration series frequency analysis includes all independent rainfall events above a base value and may include more than one event per year. Hypothetical frequency storms may be either partial or annual series based on the intended application of resulting discharge frequency relationships. However, precipitation depths obtained from TP-40 [HERSHFIELD, 1961] and TP-49 [MILLER, 1964] are based on partial-duration analyses. If the "annual" type of series is selected, HEC-IFH automatically converts precipitation depths from partial-duration series to annual series using the factors given in Table 3.3. When "partial" series is selected, the adjustments in Table 3.3 are not applied.

TABLE 3.3 Partial-Duration to Equivalent Annual Series Conversion Factors

Storm Recurrence Interval	Storm Frequency	Conversion Factor
2 years	50%	0.88
5 years	20%	0.96
10 years	10%	0.99

Source: [Hershfield, 1961, Table 2]

The **Time Increment** is the interval between each successive ordinate of the computed storm distribution. It must be entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. For best results, the time increment specified should be equal to or less than the computation interval of the analysis.

Figure 3.15 illustrates the menu screen which controls the data entry and display options for Hypothetical Event Analysis precipitation data. Option A on this menu allows the user to enter the data necessary to compute hypothetical frequency and Standard Project Storm distributions. Option B allows the user to enter or import hypothetical (or historical) storm data for the analysis. Option C displays the computed or entered storm distributions.

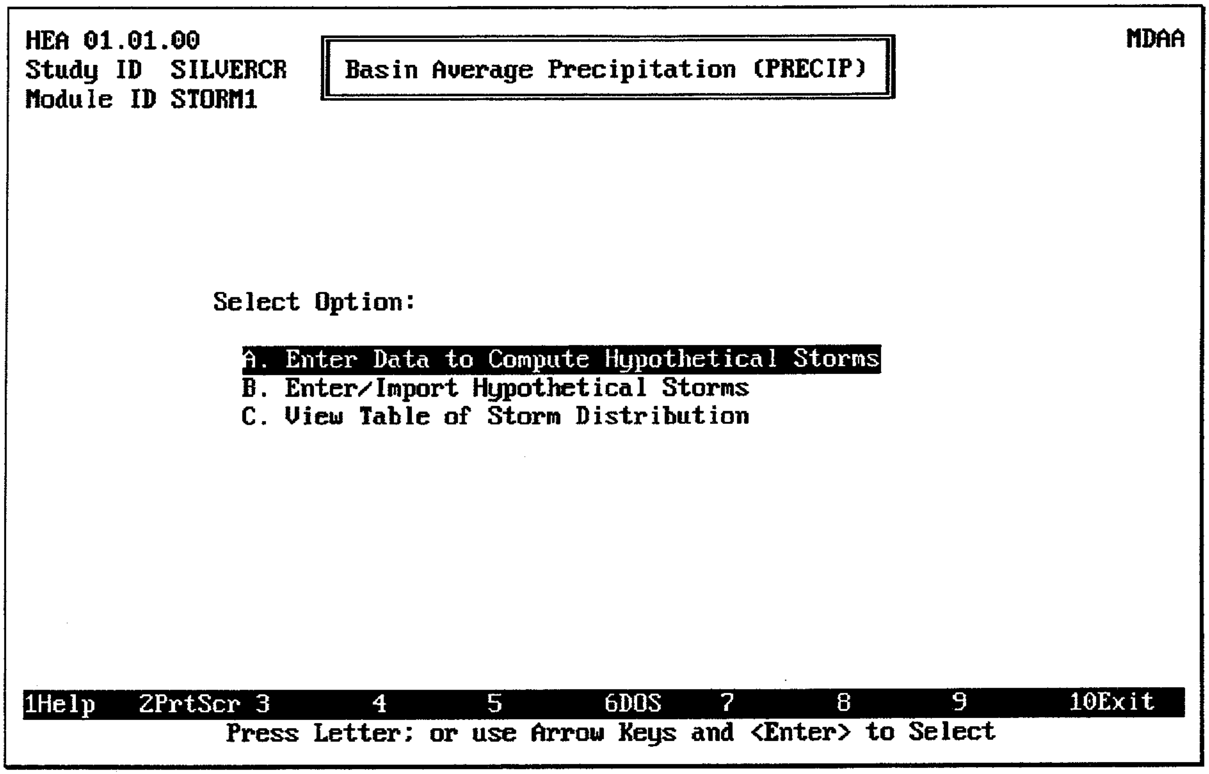


FIGURE 3.15 Hypothetical Event Analysis Precipitation Menu Screen

3.3.1. Computing Hypothetical Storms

Hypothetical frequency or Standard Project storms may be computed by the HEC-IFH Hypothetical Event Analysis method. The hypothetical frequency storm computation used in the HEC-IFH program is very similar to that used in the HEC-1 computer program [HEC, 1990]. There is one difference, however: the HEC-IFH program does not utilize the depth-area reduction procedure of generating index hydrographs and interpolating the runoff hydrograph at combination points within the stream system. Such a procedure is not necessary for the simple stream systems considered when using HEC-IFH.

3.3.1.1. Computing Hypothetical Frequency Storms

A synthetic storm of any valid duration from 5 minutes to 10 days can be generated. The following storm durations are valid: 5 or 15 minutes; 1, 2, 3, 6, 12, or 24 hours; and 2, 4, 7, or 10 days. Figure 3.14 shows the data entry screen used to provide hypothetical frequency storm depth-duration-frequency data for an HEC-IFH Hypothetical Event Analysis. Since HEC-IFH can compute rainfall distributions for several storms ranging from 50% to 0.2% frequency, the rainfall depths for any or all of these storm frequencies may be entered. The advantage to this is that an interior elevation-frequency relationship can be determined directly during a single HEC-IFH analysis.

To compute a synthetic storm distribution, HEC-IFH requires the **Rainfall Depth** for each of the **Durations** listed, beginning at the specified time increment and continuing through the total storm duration. For example, to generate a hypothetical storm with a duration of 24 hours and a time interval of 1 hour, the precipitation depths for durations of 1, 2 , 3, 6, 12, and 24 hours must be entered.

HEA 01.01.00 PREC06
Study ID SILVERCR
Module ID STORM1

Basin Average Precipitation (PRECIP)

Enter Partial-Duration Rainfall Depth-Duration-Frequency Data

Duration	Rainfall Depth (in) for each Hypothetical Event						
	50%	20%	10%	4%	2%	1%	0.2%
5 minutes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 minutes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 hour	1.50	1.65	1.95	2.30	2.50	2.75	3.20
2 hours	1.80	2.00	2.30	2.70	2.90	3.25	3.60
3 hours	2.20	2.40	2.60	2.90	3.25	3.60	4.00
6 hours	2.40	2.60	3.00	3.50	3.80	4.25	4.70
12 hours	2.60	3.00	3.50	4.00	4.50	5.00	5.60
24 hours	2.80	3.50	4.00	4.60	5.20	5.70	6.20
2 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Save Data and Continue

FIGURE 3.16 Hypothetical Frequency Storm Depth-Duration-Frequency Data Entry Screen

The rainfall depths for a storm event of a particular frequency and duration vary according to the climate of the area. The National Weather Service (NWS) has compiled statistical data on historical rainfall amounts for most of the United States. This information is available in the following documents:

1. ***U.S. Weather Bureau Technical Paper No. 40 (TP-40)*** presents standard precipitation-frequency information for rainfall events with durations of 30 minutes to 24 hours and return periods of 1 year to 100 years. The data is presented in a series of 49 isopluvial maps, each of which illustrates rainfall depth contours for a particular storm frequency and duration. While TP-40 provides rainfall data for the entire coterminous United States, it has been shown to be inadequate for areas west of 105 degrees longitude (about the location of Denver) because it does not address the effects of topography on rainfall events. However, TP-40 is still considered to be valid for the central and eastern United States.

2. ***National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35*** lists rainfall depths for storm durations of 5 minutes to 60 minutes and storm recurrence intervals of 2 years to 100 years. The isopluvial maps presented in HYDRO-35 cover only the central and eastern portions of the United States, the same areas for which TP-40 is considered to be valid. HYDRO-35 also contains equations for computing rainfall depths for intermediate frequencies and durations. HYDRO-35 supersedes TP-40 for durations of 60 minutes or less.

3. ***Weather Bureau Technical Paper No. 49 (TP-49)***, which lists rainfall depths for storm durations of 2 days to 10 days.

4. ***NOAA Atlas 2, "Precipitation-Frequency Atlas of the Western United States,"*** was published in 1973 to provide refined rainfall data for the 11 states west of

about 103 degrees longitude. Each volume of this atlas contains 6-hour and 24-hour precipitation depths for return periods of from 2 years to 100 years. Also included are methods and nomograms for estimating rainfall depths for durations other than 6 hours and 24 hours. This publication differs from TP-40 in that it accounts for the effects of topography on precipitation-frequency values.

Table 3.4 summarizes the available sources of rainfall data in the eastern United States. Local drainage authorities may specify the rainfall amounts which should be used in their area.

TABLE 3.4 References for Required Rainfall Data

Storm Duration	Reference
5 minutes	NWS Hydro-Meteorological Report No. 35, Figures 6 and 7
15 minutes	NWS Hydro-Meteorological Report No. 35, Figures 8 and 9
60 minutes	NWS Hydro-Meteorological Report No. 35, Figures 4 and 5
2 hours	Weather Bureau Technical Paper No. 40, Charts 15-21
3 hours	Weather Bureau Technical Paper No. 40, Charts 22-28
6 hours	Weather Bureau Technical Paper No. 40, Charts 29-35
12 hours	Weather Bureau Technical Paper No. 40, Charts 36-42
24 hours	Weather Bureau Technical Paper No. 40, Charts 43-49
48 hours (2 days)	Weather Bureau Technical Paper No. 49, Figures 12-17
4 days	Weather Bureau Technical Paper No. 49, Figures 18-23
7 days	Weather Bureau Technical Paper No. 49, Figures 24-29
10 days	Weather Bureau Technical Paper No. 49, Figures 30-35

Note: This table apply only for areas of the United States east of the 105th meridian (which passes through Denver, CO). West of this longitude, NOAA Atlas 2 should be used.

The standard Corps of Engineers hypothetical storm distribution is called a "balanced" distribution because the maximum rainfall depths for all time intervals less than or equal to the total storm duration have a consistent exceedance frequency or return period.

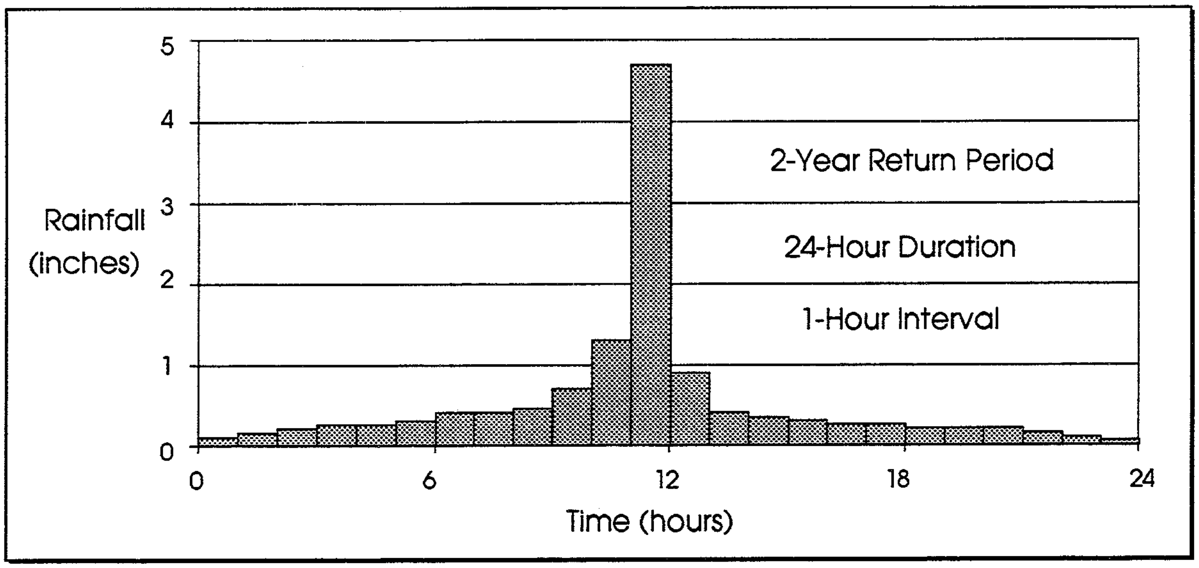


FIGURE 3.17 Hypothetical Frequency Storm

Cumulative precipitation for each time interval is computed by log-log interpolation of depths from the depth-duration data. Incremental precipitation is then computed and rearranged so that the largest value occurs during the time interval immediately following the midpoint of the storm duration. The second largest value precedes the largest value, the third largest value follows the largest value, the fourth largest precedes the second largest, etc. Figure 3.17 illustrates such a pattern.

3.3.1.2. Computing Standard Project Storms

The HEC-IFH program allows the user to compute an SPS using the same Standard Project Storm computation method utilized in the HEC-1 computer program [HEC, 1990]. The procedure for computing SPS utilized in HEC-IFH is applicable to basins with drainage areas of 10 to 1,000 square miles located east of 105 degrees longitude (which passes through Denver, CO). Figure 3.18 illustrates the data entry screen used to enter Standard Project Storm data.

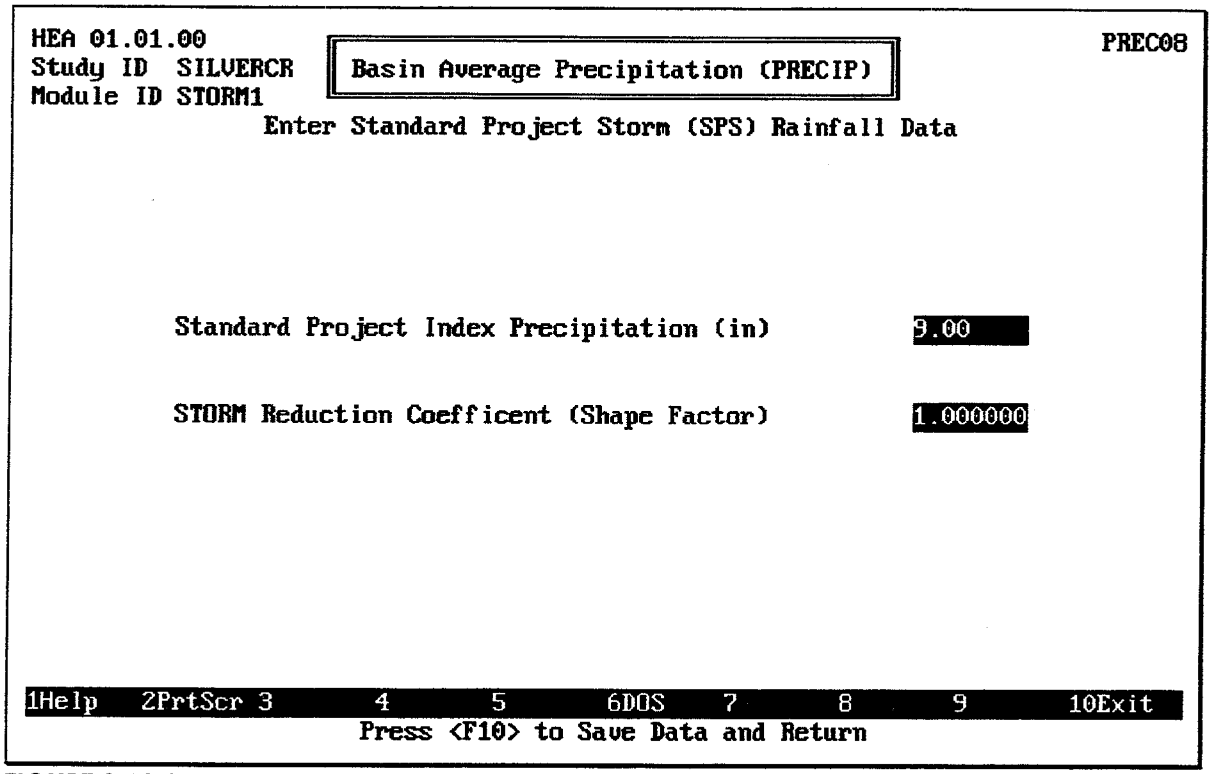


FIGURE 3.18 Standard Project Storm Data Entry Screen

The **Standard Project Index Precipitation**, *SPFE*, and the **STORM Reduction Coefficient** or **Shape Factor**, *TRSPC*, are both determined by referring to manual EM-1110-2-1411 [Corps of Engineers, 1952]. *SPFE* must be greater than or equal to 6, while *TRSPC* must be greater than 0.

The HEC-IFH program uses the input data to determine a total storm depth. This depth is distributed over a 96-hour duration based on the following formulas which were derived from design charts in manual EM-1110-2-1411 [Corps of Engineers, 1952]:

$$R24HR(1) = 3.5 \tag{3.4a}$$

$$R24HR(2) = 15.5 \tag{3.4b}$$

$$R24HR(3) = 182.15 - 14.3537 \times \ln(TRSDA + 80) \tag{3.4c}$$

$$R24HR(4) = 6.0 \tag{3.4d}$$

where $R24HR(I)$ is the percent of the index precipitation occurring during the Ith 24-hour period. Figure 3.19 illustrates the four 24-hour precipitation periods for SPS computations.

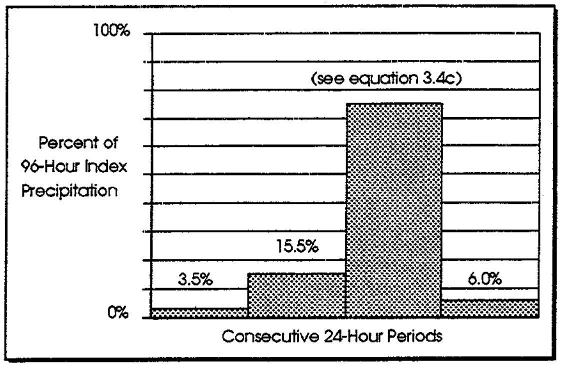


FIGURE 3.19 SPS 24-Hour Rainfall as a Percentage of Index Precipitation

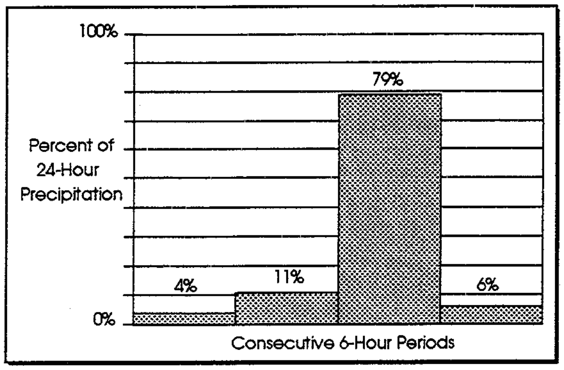


FIGURE 3.20 SPS 6-Hour Rainfall as a Percentage of 24-Hour Rainfall (for SPFE = 10 in)

The program also divides each 24-hour period into four 6-hour periods. The ratio of the 24-hour precipitation occurring during each 6-hour period is calculated as

$$R6HR(2) = 0.055(SPFE - 6.0)^{0.51} \quad 3.5a$$

$$R6HR(3) = 13.42(SPFE + 11.0)^{-0.93} \quad 3.5b$$

$$R6HR(4) = 0.5[1 - R6HR(3) - R6HR(2)] + 0.0165 \quad 3.5c$$

$$R6HR(1) = \mathrm{R6HR}(4) - 0.033 \quad 3.5d$$

where *R6HR(I)* is the ratio of 24-hour precipitation occurring during the *I*th 6-hour period and *SPFE* is the index precipitation in inches. Figure 3.20 illustrates the distribution of 6-hour rainfall amounts within 24-hour periods. For values of *SPFE* greater than 41.3 inches, the second 24-hour period contains the largest precipitation depth.

HEC-IFH computes the precipitation for each time interval, except during the peak 6-hour period, as:

$$PRCP = 0.01 \times R24HR \times R6HR \times SPFE \times (TRHR/6) \quad 3.6$$

where *TRHR* is the computation time interval in hours. This concept is illustrated in Figure 3.21.

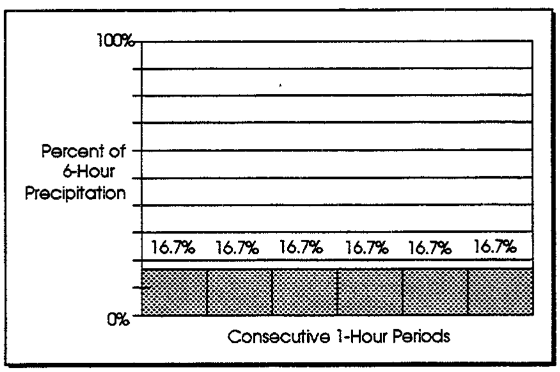


FIGURE 3.21 SPS 1-Hour Rainfall in Non-Peak 6-Hour Periods

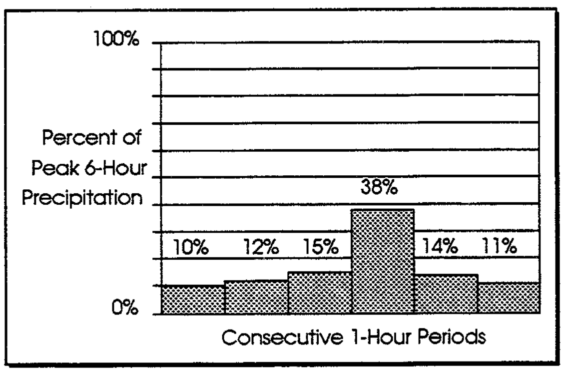


FIGURE 3.22 SPS 1-Hour Rainfall in Peak 6-Hour Periods

The program distributes the peak 6-hour precipitation of each day according to the percentages listed in Table 3.5 and illustrated in Figure 3.22. When the time interval is larger than 1 hour, the percentage for the peak time interval is the sum of the highest percentages. For example, the values for a 2-hour time interval are (14+12)%, (38+15)%, and (11+10)%. Acceptable computation timer intervals greater than or equal to 1 hour are 1, 2, 3, 4, 6, and 24 hours.

TABLE 3.5 Distribution of Maximum 6-Hour SPS in Percent of 6-Hour Amount

Duration (Hours)	EM 1110-2-1411 Criteria (Default)
1	10%
2	12%
3	15%
4	38%
5	14%
6	11%

If time intervals less than one hour are used, the peak 1-hour precipitation is distributed according to the percentages in Table 3.6. Acceptable computation time intervals less than 1 hour are 5, 10, 15, and 30 minutes.

TABLE 3.6 Distribution of Maximum 1-Hour SPS

Duration (minutes)	Percent of Maximum 1-hour Precipitation in Each Time Interval	Accumulated Percent of Precipitation
5	3%	3%
10	4%	7%
15	5%	12%
20	6%	18%
25	9%	27%
30	17%	44%
35	25%	69%
40	11%	80%
45	8%	88%
50	5%	93%
55	4%	97%
60	3%	100%

Note: This distribution is based on the distribution of 100-yr precipitation at St. Louis, MO. from NOAA Technical Memorandum NWS Hydro-35.

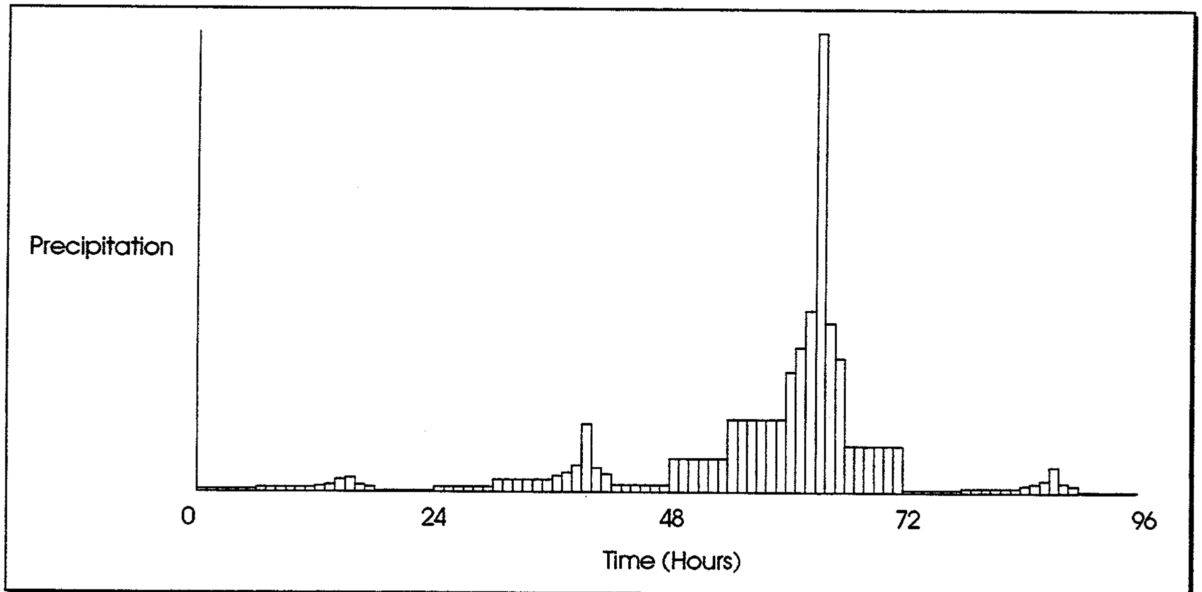


FIGURE 3.23 Typical SPS Precipitation Distribution

For all intervals, the interval with the largest percentage is preceded by the second largest and followed by the third largest. The second largest percentage is preceded by the fourth largest, the third largest percentage is followed by the fifth largest, etc. Figure 3.23 illustrates a typical precipitation hyetograph for an entire 96-hour Standard Project Storm event, assuming a one-hour computation time interval.

3.3.2. Entering or Importing Hypothetical Storms

The HEC-IFH program allows the user to enter hypothetical frequency and/or Standard Project storms if temporal distributions other than the standard Corps of Engineers distributions are desired. After selecting option B: "Enter/Import Hypothetical Storms", the data entry screen illustrated in Figure 3.24 appears. This screen allows incremental precipitation depths to be entered for each time interval for the full storm duration, for all desired hypothetical storms. Hypothetical storm incremental rainfall can also be imported from an external HEC-DSS file. If hypothetical storm depth-duration-frequency data and/or Standard Project storm data have previously been specified, the computed storm depth values will be displayed, and may be manually edited by the user.

Incremental precipitation values for an historical storm can also be entered or imported in the SPS column, if desired. However, if this is done, the user should be aware that this storm and associated runoff will be labeled "SPS" or "SPF" in tables and on plots.

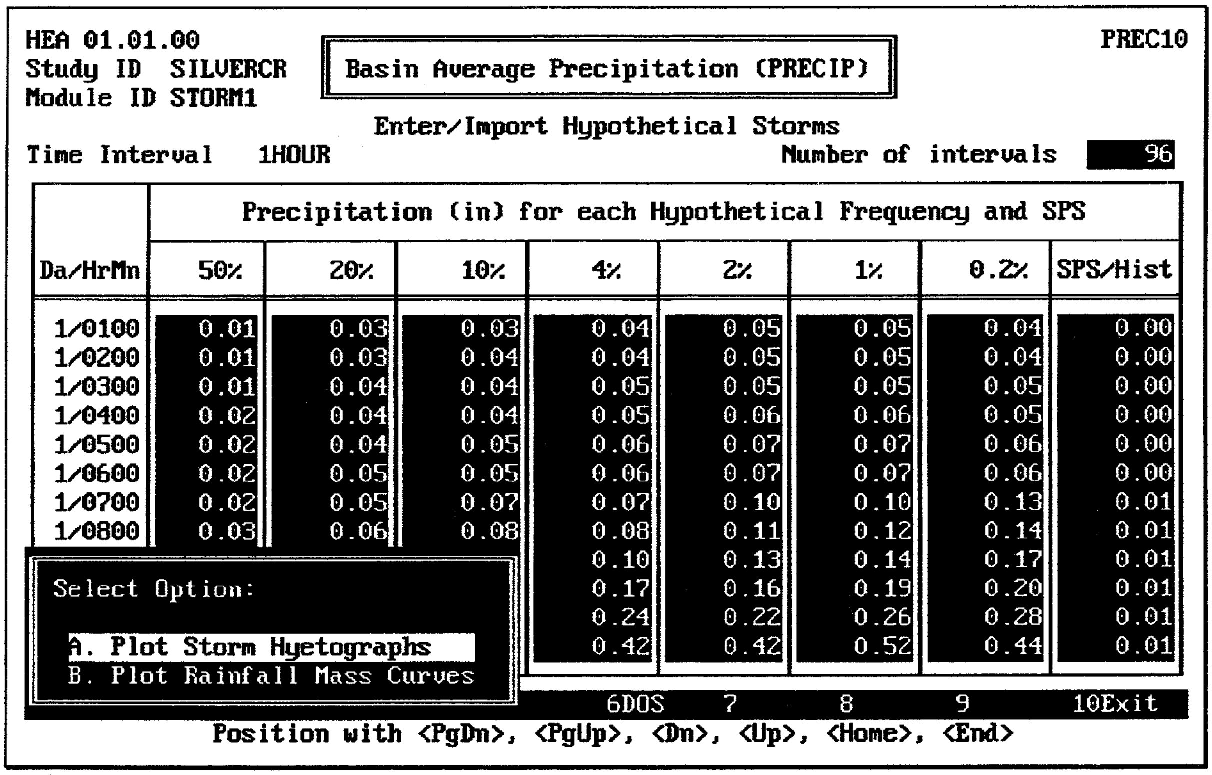


FIGURE 3.24 Hypothetical Frequency Storm Values Data Entry Screen

The [F4] Goto key is available for this data entry screen, and a printed report is available by pressing the [F5] Report key as described in Chapter 2. You may plot the hypothetical precipitation patterns by pressing the [F9] Plot key and selecting one of the following from a menu:

A) **Plot Storm Hydrographs**

B) **Plot Mass Rainfall Curves**

For both of these types of plots, any or all of the available storm events may be plotted. Figure 3.25 illustrates the window which controls which storm events will appear on the plot. To plot a particular hypothetical storm event, enter "Y" in the corresponding box on this window.

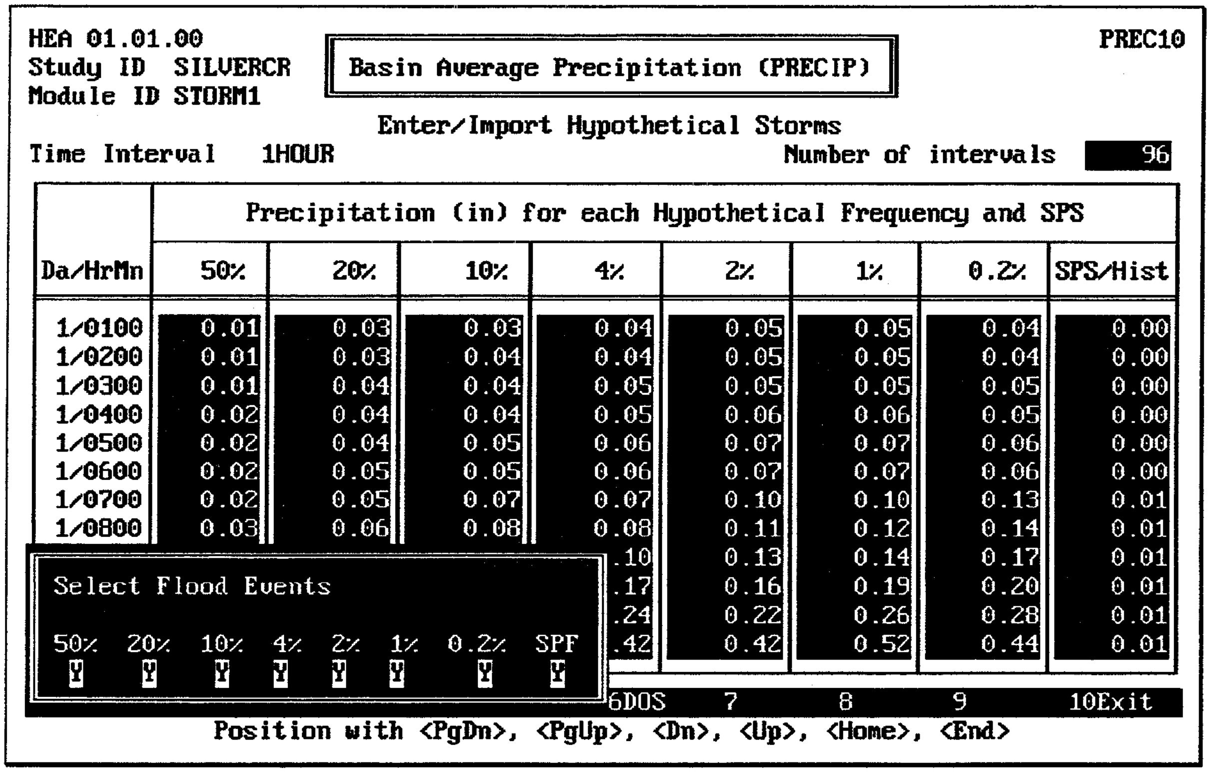


FIGURE 3.25 Storm Events Plot Menu

Storm Hydrographs are plots of the incremental precipitation depths for the storm. The initial storm hydrograph plot (Figure 3.26) shows the entire storm event, which may extend over several days. On a color computer monitor, each storm event would be plotted using a different color. If you have entered enough data values, you may "zoom" to a one-day plot of periodic totals (Figure 3.27). From the one-day plot, you may "pan" to plots of different days, if available. The zoom and pan plot options are described in Chapter 2.

Mass Rainfall Curves are plots of the cumulative precipitation depths for the storm. The initial mass rainfall curve, which is illustrated in Figure 3.28 shows the entire storm event. You may also "zoom" to a one-day mass rainfall curve, which is illustrated in Figure 3.29, and "pan" between adjacent one-day plots using the methods described in Chapter 2. On a color computer monitor, each storm event would be plotted using a different color.

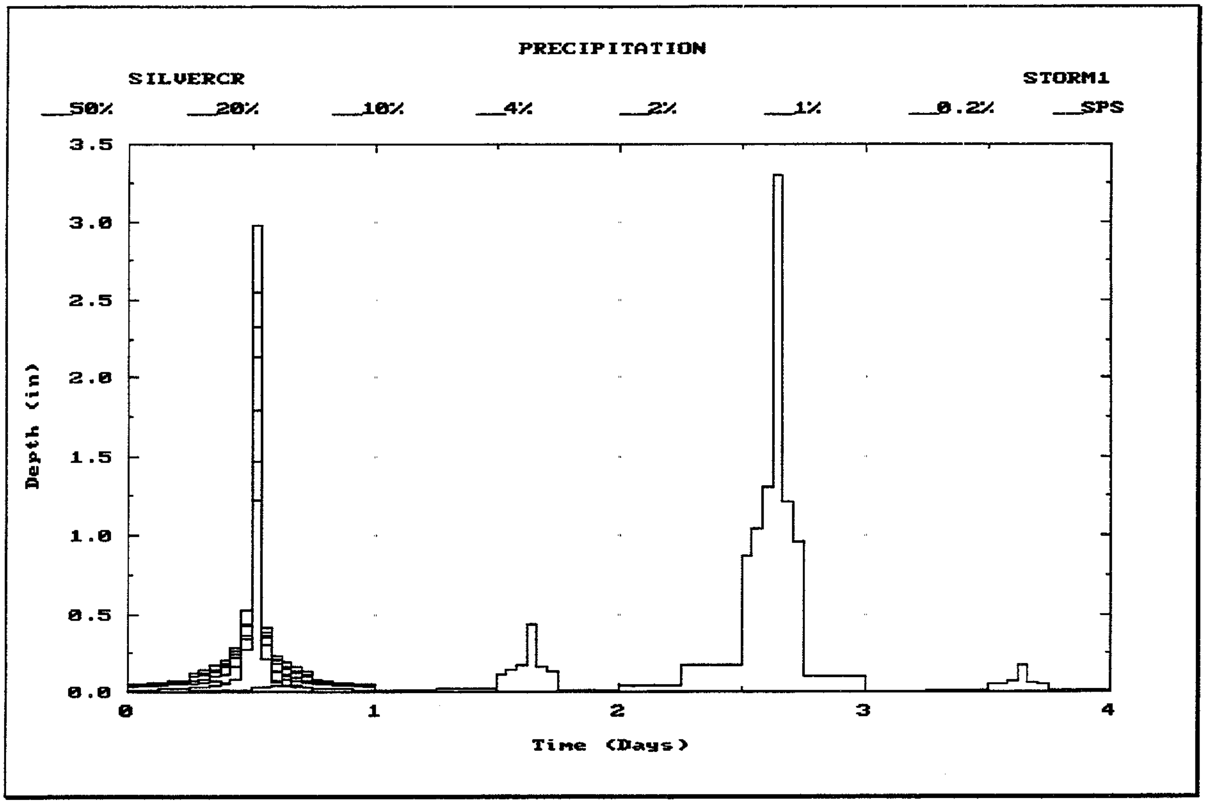


FIGURE 3.26 Plot of Entire Storm Hydrographs

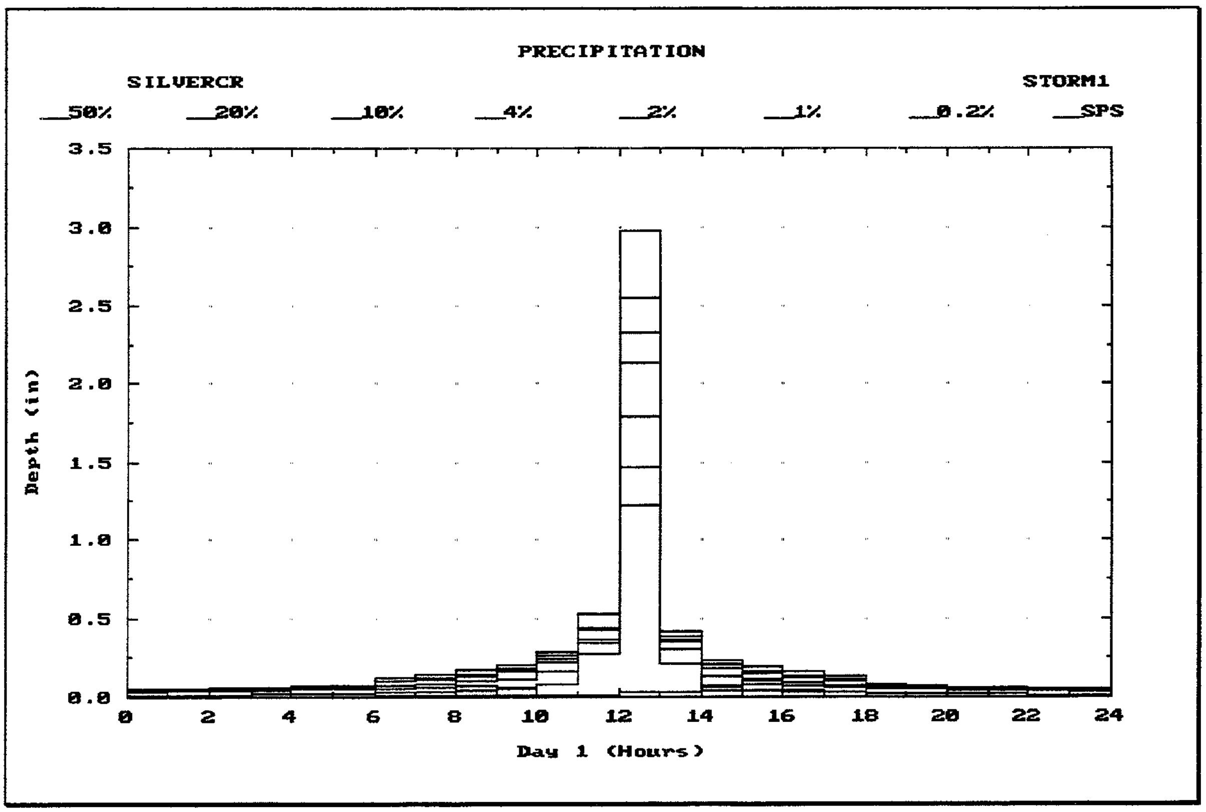


FIGURE 3.27 Plot of Daily Storm Hydrographs

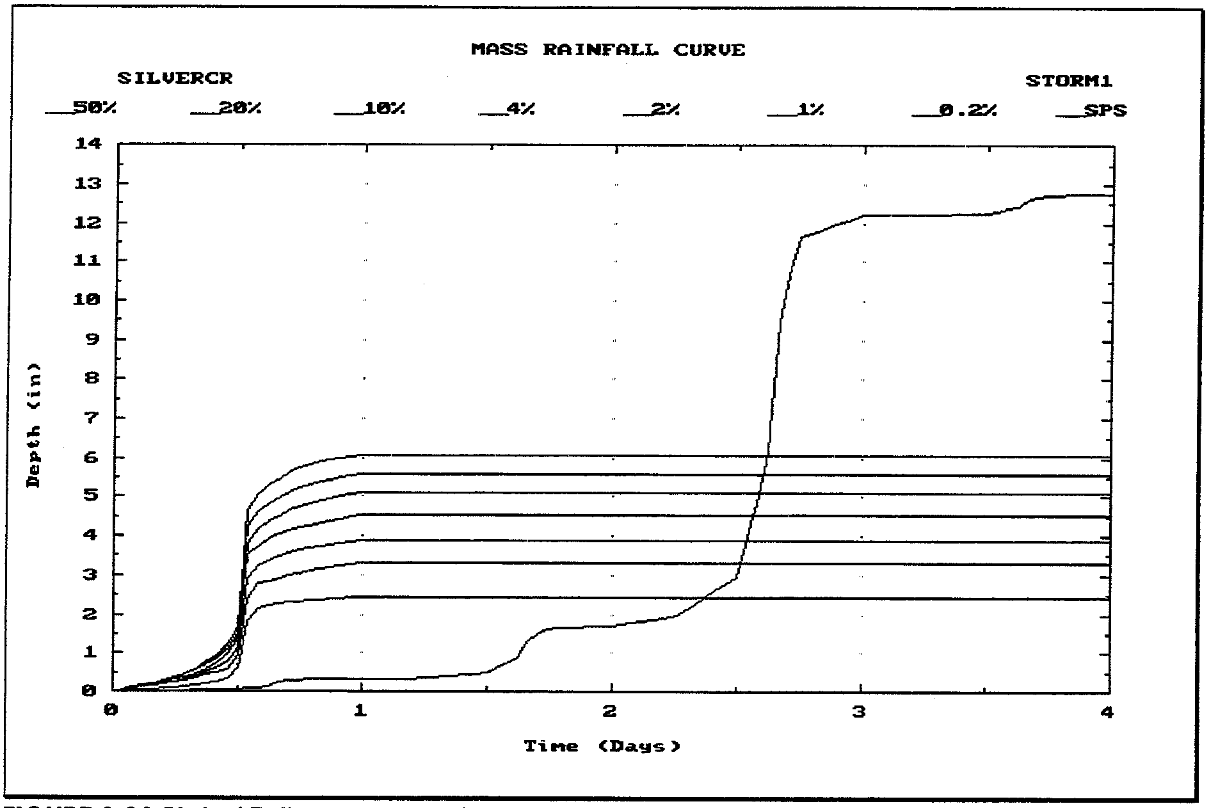


FIGURE 3.28 Plot of Entire Mass Rainfall Curves

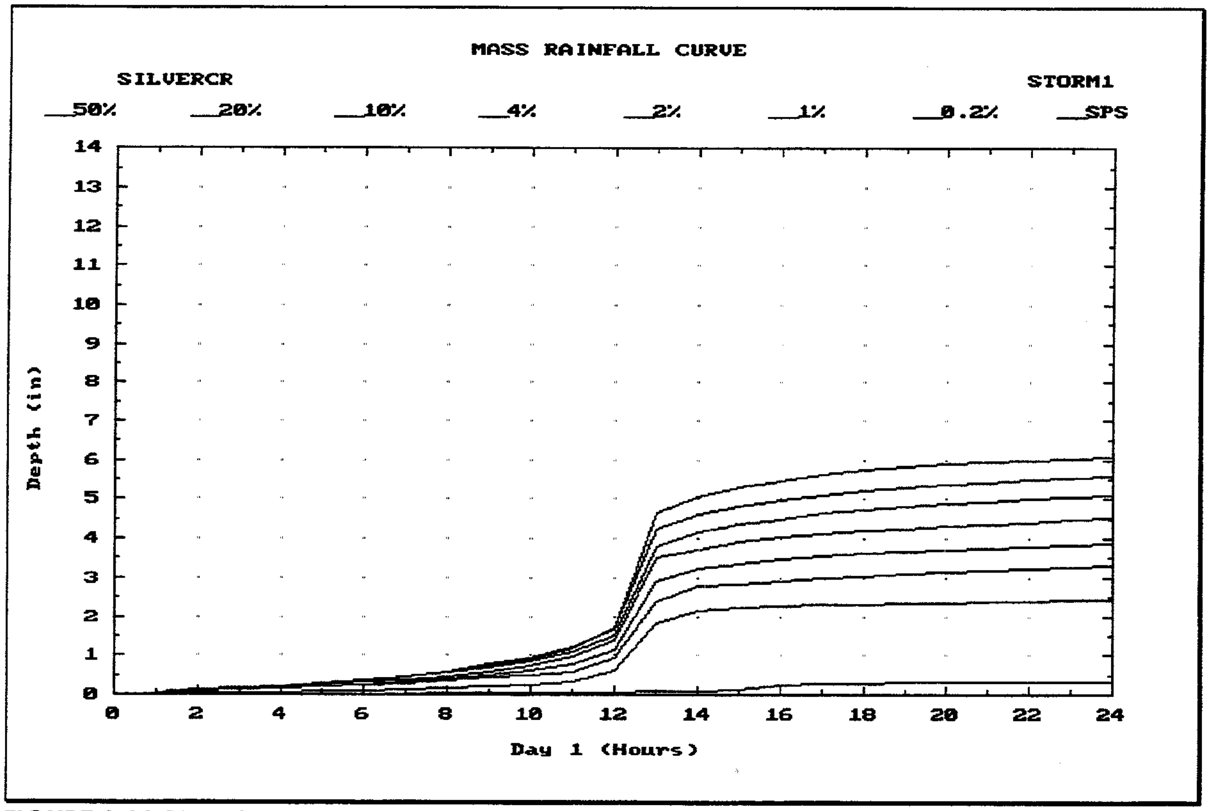
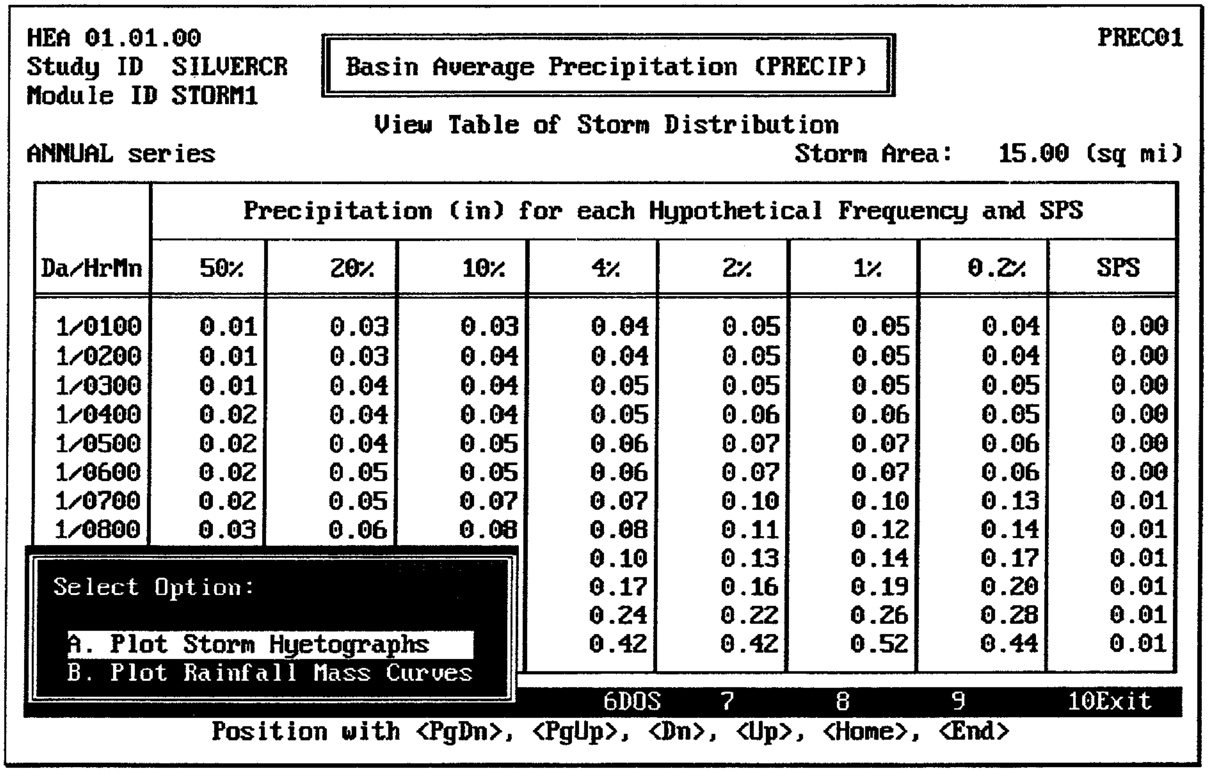


FIGURE 3.29 Plot of Daily Mass Rainfall Curves

3.3.3. Viewing Storm Distributions

Figure 3.30 shows the screen used in the HEC-IFH program to display the entered or computed hypothetical frequency storm distributions for a Hypothetical Event Analysis.



HEA 01.01.00
Study ID SILVERCR
Module ID STORM1

Basin Average Precipitation (PRECIP)

PREC01

View Table of Storm Distribution

ANNUAL series Storm Area: 15.00 (sq mi)

Da/HrMn	Precipitation (in) for each Hypothetical Frequency and SPS							
	50%	20%	10%	4%	2%	1%	0.2%	SPS
1/0100	0.01	0.03	0.03	0.04	0.05	0.05	0.04	0.00
1/0200	0.01	0.03	0.04	0.04	0.05	0.05	0.04	0.00
1/0300	0.01	0.04	0.04	0.05	0.05	0.05	0.05	0.00
1/0400	0.02	0.04	0.04	0.05	0.06	0.06	0.05	0.00
1/0500	0.02	0.04	0.05	0.06	0.07	0.07	0.06	0.00
1/0600	0.02	0.05	0.05	0.06	0.07	0.07	0.06	0.00
1/0700	0.02	0.05	0.07	0.07	0.10	0.10	0.13	0.01
1/0800	0.03	0.06	0.08	0.08	0.11	0.12	0.14	0.01
				0.10	0.13	0.14	0.17	0.01
				0.17	0.16	0.19	0.20	0.01
				0.24	0.22	0.26	0.28	0.01
				0.42	0.42	0.52	0.44	0.01

Select Option:

A. Plot Storm Hyetographs
B. Plot Rainfall Mass Curves

6DOS 7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 3.30 Computed Hypothetical Storm Distributions

After the hypothetical storm patterns are computed, the screen displays the computed basin average rainfall value for each time interval. The F4 Goto key is available for this table, and a printed report is available by pressing the F5 Report key as described in Chapter 2. You may plot the hypothetical precipitation patterns by pressing the F9 Plot key and selecting one of the following from a menu. The plot options operate exactly as described in the previous section.

CHAPTER 4.
Runoff Hydrographs

4.1. INTRODUCTION

HEC-IFH can use specified loss rates, unit hydrographs, and channel routing methods to compute runoff hydrographs for interior and exterior sub-basins.

A maximum of two interior sub-basins may be analyzed in a single plan analysis. These sub-basins are the upper and lower portions of the interior watershed. A single channel routing reach through the lower portion of the interior watershed is allowed. Rainfall-runoff ca also be analyzed for the exterior basin, which is the watershed of the stream receiving the discharge of the interior area. Figure 4.1 illustrates a typical interior system with upper interior and lower interior sub-basins.

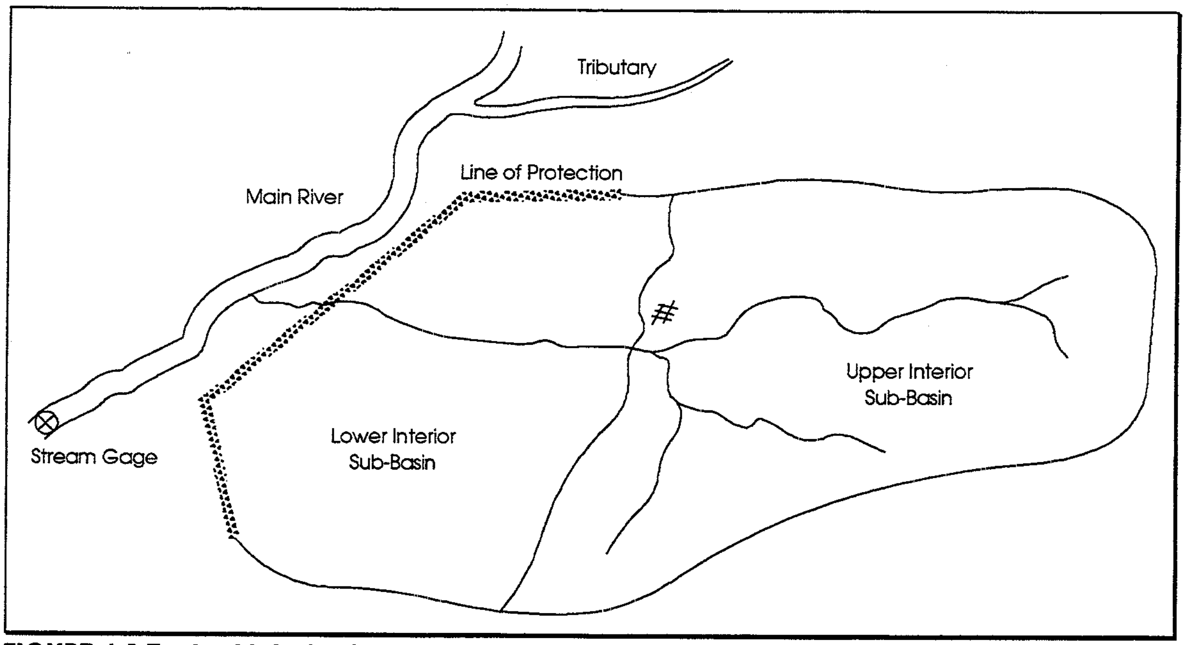


FIGURE 4.1 Typical Interior System

The runoff characteristics for both interior and exterior areas are defined in the same manner using the following elements:

1. The drainage area of each sub-basin.
2. The base flow and recession parameters for each sub-basin.
3. The infiltration loss parameters for each sub-basin, including percentage of impervious area.
4. The unit hydrograph for each sub-basin.
5. The channel routing parameters for the upper interior sub-basin runoff hydrograph.

Runoff parameters and channel routing parameters are entered by the user. Figure 4.2 illustrates the main menu screen for runoff data entry. Option A of this menu is used to enter sub-basin runoff parameters, as described in the section entitled "BASIN RUNOFF DATA" beginning on page 54. Option B allows you to enter channel routing data, as described beginning in the section entitled "CHANNEL ROUTING DATA FOR UPPER SUB-BASIN" on page 75.

After entering all of the required basin runoff parameters for each sub-basin, and the channel routing parameters for the upper interior sub-basin, Option C of this menu is used to select which set of parameters will be used for each sub-basin in the interior analysis. This option is described in the section entitled "SPECIFYING RUNOFF DATA" beginning on page 87.

```
CSA 01.01.00                                                          MCAB
Study ID  RBEND2     Runoff Hydrograph Parameters (RUNOFF)



             Select Option:

               A. Enter Basin Runoff Data
               B. Enter Channel Routing Data for Upper Sub-Basin
               C. Assign Basin Runoff Data Set for Each Sub-Basin



1Help  2PrtScr 3     4     5     6DOS   7     8     9      10Exit
              Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 4.2 Runoff Data Entry Options

4.2. BASIN RUNOFF DATA

Figure 4.3 illustrates the data entry screen used to enter interior area sub-basin and exterior basin runoff parameters for Continuous Simulation Analysis. Figure 4.4 shows the corresponding screen for Hypothetical Event Analysis. Each set of basin runoff data must be identified by a unique 8-character **Basin ID**. This ID is used later when specifying which data will be used for each computation. A 40-character **Description** provides further background information on the basin.

When the cursor is on the Basin ID field, the F3 Index key displays a list of Basin IDs which have been previously defined. By selecting any of these existing Basin IDs, the user may load the corresponding runoff parameters for review or modification. The HEC-IFH program displays the 40-character description for each record to help ensure that the correct records are selected.

The **Basin Drainage Area** must be entered for each basin. It must be greater than zero (0). The **Percent (%) of Drainage Area Impervious** may also be specified. No infiltration losses are assumed to occur for this portion of the drainage area. Any value from 0 through 100 may be entered.

```
CSA 01.01.00                                                        RUN001
Study ID  RBEND2      Runoff Hydrograph Parameters (RUNOFF)

                            Enter Basin Runoff Data
Basin ID       UPPER
    Upper Sub-basin for App. C example.

Basin Drainage Area (sq mi)                  7.50
Percent of Drainage Area Impervious          15.0

Enter Monthly Base Flow Rates              Yes [No]

Basin Infiltration Loss Data
   Generalized Runoff Coefficients
  [Initial-Uniform-Recovery Method]
   No Losses Computed

Basin Unit Hydrograph Data
   Clark's Unit Hydrograph
   Snyder's Unit Hydrograph
  [SCS Dimensionless Unit Graph]
   Enter Unit Hydrograph

1Help  2PrtScr 3Index  4    5    6DOS   7    8    9    10Exit
                  Press <F10> to Save Data and Return
```

FIGURE 4.3 Continuous Simulation Runoff Data Entry Screen

```
HEA 01.01.00                                                        RUN018
Study ID  SILVERCR     Runoff Hydrograph Parameters (RUNOFF)

                            Enter Basin Runoff Data
Basin ID      SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                       15.00
Percent of Drainage Area Impervious          10.0

Enter Base Flow Data and Recession       [Yes] No

Infiltration Loss Data               Unit Hydrograph Data
   SCS Curve Number Method              Clark's Unit Hydrograph
   Holtan Method                        Snyder's Unit Hydrograph
   Green-Ampt Method                   [SCS Dimensionless Unit Graph]
  [Initial-Uniform Method ]             Enter Unit Hydrograph
   No Losses Computed

1Help  2PrtScr 3Index  4    5    6DOS   7    8    9    10Exit
                  Press <F10> to Save Data and Return
```

FIGURE 4.4 Hypothetical Event Runoff Data Entry Screen

4.2.1. Base Flow Rates

Base flow is a steady or slowly-changing discharge from a drainage basin, resulting from groundwater return flow, interflow, wastewater effluent, or other sources not directly related to current rainfall events. HEC-IFH provides a simple "Yes-No" menu on the runoff data entry screen to determine if base flow is to be considered for a particular basin. To specify base flow data, move the cursor to "Yes" and press the space bar. A base flow data entry window will appear.

For Continuous Simulation Analysis, the HEC-IFH program can apply a different constant base flow rate for each calendar month. Figure 4.5 illustrates the data entry window for **Monthly Base Flow Rates**. Each value must be greater than or equal to zero. No recession computations are performed for Continuous Simulation Analysis. The base flow rate is assumed to be constant during each month as specified.

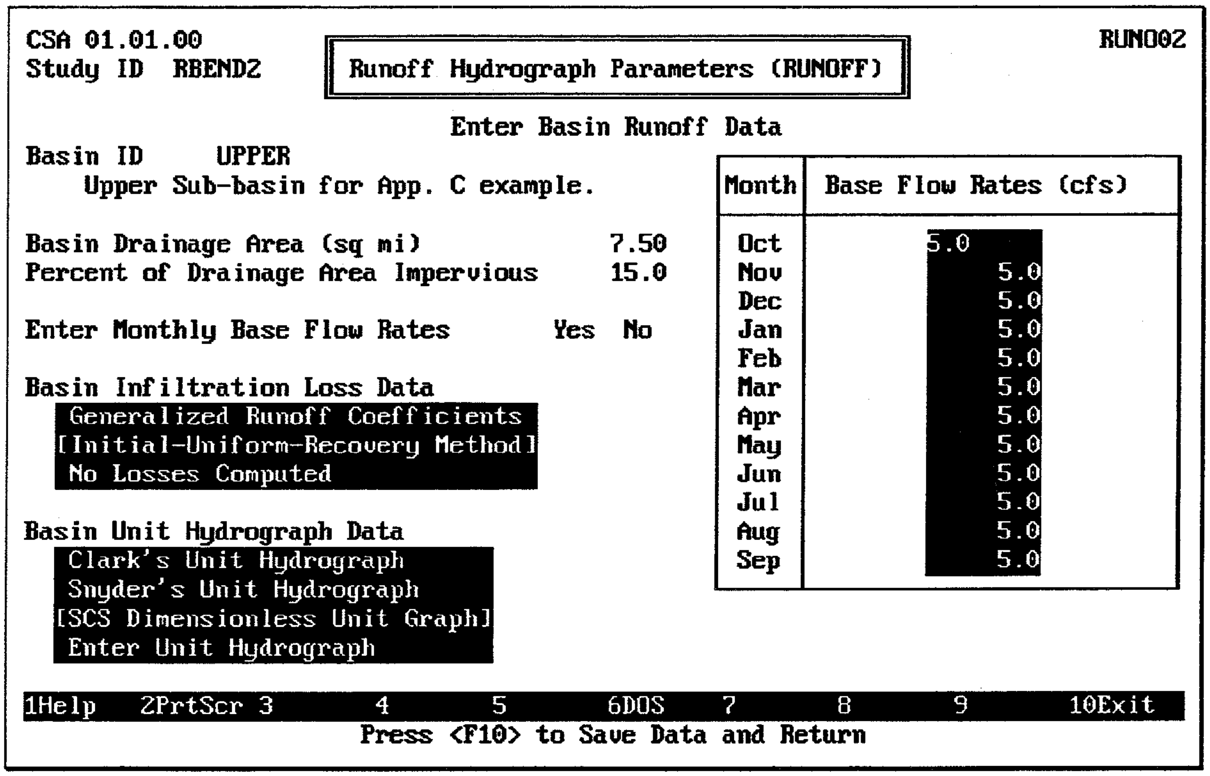


FIGURE 4.5 Continuous Simulation Base Flow Data Entry Window

The HEC-IFH Hypothetical Event Analysis method can provide more sophisticated base flow and recession computations. Figure 4.6 illustrates the data entry window for base flow and recession parameters for a Hypothetical Event analysis. The **Flow at Start of Storm** must be greater than or equal to zero (0). It represents the base flow rate resulting entirely from previous events and conditions in the basin just prior to the current event.

The **Flow Below Which Base Flow Starts** and the **Ratio to Peak** provide alternate methods for determining the beginning of recession computations. Only one of these values may be entered. The other value must be zero (0). Negative values cannot be entered, and the Ratio to Peak value, if used, cannot exceed one (1).

If the Ratio to Peak value is specified, then the HEC-IFH program multiplies this value by the peak flow rate of the runoff hydrograph to determine the Flow Below Which Base Flow Starts. As the rate of runoff falls below this flow rate, further runoff rates are not determined using unit hydrograph computations. Instead, the runoff rate at each succeeding hour is computed by dividing the previous hour's runoff rate by the **Ratio of Recession Flow 1 Hour Later**. This recession ratio must be one (1) or greater, so that base flow always recedes and cannot increase.

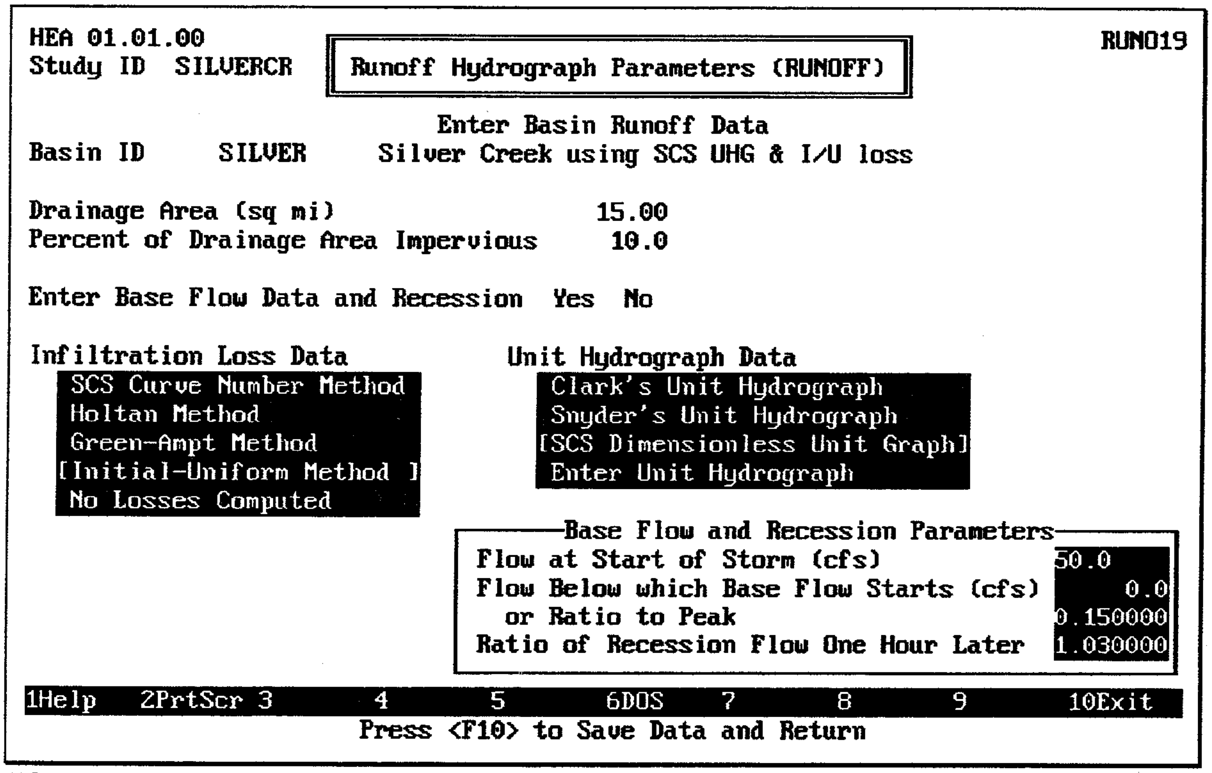


FIGURE 4.6 Hypothetical Event Base Flow Data Entry Screen

4.2.2. Basin Infiltration Loss Data

There are several methods in the HEC-IFH program that can be used to calculate precipitation losses. Using any of these methods, an average precipitation loss is determined for a computation interval and subtracted from the rainfall hyetograph. The resulting precipitation excess is used to compute an outflow hydrograph for a sub-basin. The precipitation loss is considered to be a sub-basin average (uniformly distributed over an entire sub-basin).

HEC-IFH provides a simple menu on the runoff data entry screen to select the method of computing infiltration losses for a particular basin. To make a selection, move the cursor to the desired method and press the space bar. A data entry window will appear for the selected method.

For the Hypothetical Event Analysis method, HEC-IFH provides most of the same infiltration loss rate computations which are available in the HEC-1 computer program. However, Continuous Simulation Analyses require special methods for estimating rainfall losses because the simulation extends over much longer periods of time. During the time periods between flood events, the soil may recover substantial infiltration capacity which is available for the next storm event. Table 4.1 lists the infiltration loss rate methods available for each condition.

No matter which infiltration loss rate method is selected, no infiltration losses are computed for the impervious portion of the basin. The **Percent (%) of Drainage Area Impervious** controls this computation.

TABLE 4.1 Computational Methods for Infiltration Losses

Computational Method or Option	Continuous Simulation Analysis	Hypothetical Event Analysis
Generalized Runoff Coefficients	✔	–
Initial & Uniform With Recovery	✔	–
SCS Curve Number	–	✔
Green-Ampt	–	✔
Holtan	–	✔
Initial & Uniform, No Recovery	–	✔
No Losses	✔	✔

4.2.2.1. *Generalized Runoff Coefficient Loss Computation*

Monthly Generalized Runoff Coefficients specify the fraction of precipitation which becomes rainfall excess (surface runoff) during a Continuous Simulation Analysis. The coefficients are entered as decimals (50% is input as 0.50). A different runoff coefficient may be specified for each month of the water year. Each coefficient must equal or exceed zero (0), but cannot exceed one (1). Runoff is assumed to be 100% for the proportion of the drainage area that is impervious. Figure 4.7 illustrates the data entry window for this method.

```
CSA 01.01.00                                                                RUN003
Study ID  RBEND2      Runoff Hydrograph Parameters (RUNOFF)

                                 Enter Basin Runoff Data
Basin ID     UPPER                                     Month  Gen. Runoff Coefficient
    Upper Sub-basin for App. C example.
                                                       Oct          0.800000
Basin Drainage Area (sq mi)               7.50         Nov          0.800000
Percent of Drainage Area Impervious       15.0         Dec          0.800000
                                                       Jan          0.800000
Enter Monthly Base Flow Rates         Yes  No          Feb          0.800000
                                                       Mar          0.800000
Basin Infiltration Loss Data                           Apr          0.800000
  [Generalized Runoff Coefficients]                    May          0.800000
   Initial-Uniform-Recovery Method                     Jun          0.800000
   No Losses Computed                                  Jul          0.800000
                                                       Aug          0.800000
Basin Unit Hydrograph Data                             Sep          0.800000
   Clark's Unit Hydrograph
   Snyder's Unit Hydrograph
  [SCS Dimensionless Unit Graph]
   Enter Unit Hydrograph

1Help   2PrtScr 3     4     5     6DOS    7     8     9     10Exit
                    Press <F10> to Save Data and Return
```

FIGURE 4.7 Generalized Runoff Coefficient Data Entry Window

4.2.2.2. *Initial-Uniform and Initial-Uniform-Recovery Loss Computation*

Infiltration losses can be computed using an **Initial Loss** in inches and a **Uniform Loss** rate in inches per hour. Both values must equal or exceed zero (0). All rainfall is lost until the volume of initial loss is satisfied. After the initial loss is satisfied, rainfall is lost at the uniform rate. Runoff is assumed to be 100% for the proportion of the area that is impervious.

For Hypothetical Event Analyses, an Initial-Uniform loss computation is available in HEC-IFH. This computation is identical to the Initial-Uniform computation implemented in the HEC-1 computer program [HEC, 1990].

For Continuous Simulation Analysis only, an **Initial Loss Recovery** rate may also be specified. This value may be zero (0) or greater. During periods of no precipitation, the initial precipitation loss recovers at this rate until the specified initial loss capacity is reached. A different value of the recovery rate may be specified for each month of the year. Figure 4.8 illustrates the data entry window for the Initial-Uniform-Recovery loss method. The same data entry window is used for specifying Initial-Uniform loss without recovery, by simply not entering Recovery values.

```
CSA 01.01.00                                                          RUN004
Study ID  RBEND2         Runoff Hydrograph Parameters (RUNOFF)

                                 Enter Basin Runoff Data
Basin ID      UPPER
    Upper Sub-basin for App. C example.          Month   Initial Loss Recovery

Basin Drainage Area (sq mi)             7.50     Oct        0.10      (in/day)
Percent of Drainage Area Impervious     15.0     Nov        0.10
                                                 Dec        0.10
Enter Monthly Base Flow Rates        Yes  No     Jan        0.10
                                                 Feb        0.10
Basin Infiltration Loss Data                     Mar        0.10
  Generalized Runoff Coefficients                Apr        0.10
 [Initial-Uniform-Recovery Method]               May        0.10
  No Losses Computed                             Jun        0.10
                                                 Jul        0.10
Basin Unit Hydrograph Data                       Aug        0.10
  Clark's Unit Hydrograph                        Sep        0.10
  Snyder's Unit Hydrograph
 [SCS Dimensionless Unit Graph]                  Initial Loss (in)        0.50
  Enter Unit Hydrograph                          Uniform Loss (in/hr)     0.02

1Help  2PrtScr 3    4    5    6DOS    7    8    9    10Exit
                   Press <F10> to Save Data and Return
```

FIGURE 4.8 Initial-Uniform-Recovery Data Entry Window

4.2.2.3. *SCS Curve Number Loss Computation*

The SCS Curve Number loss computation is available for Hypothetical Event Analyses. This is identical to the SCS Curve Number loss method implemented in the HEC-1 computer program [HEC, 1990]. Figure 4.9 illustrates the data entry window for this method.

The SCS Curve Number method is based on a soil classification system instituted by the Soil Conservation Service (SCS), U.S. Department of Agriculture, for use in soil survey maps across the country. Based on experimentation and experience, the SCS has been able to relate the drainage characteristics of soil groups to an **SCS Curve Number**, *CN* (SCS, 1972 AND 1975). The SCS provides information on relating soil group type to the curve number as a function of soil cover, land use type and antecedent moisture conditions.

```
HEA 01.01.00                                                      RUN020
Study ID  SILVERCR   Runoff Hydrograph Parameters (RUNOFF)

                              Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & SCS Curve

Drainage Area (sq mi)                     15.00
Percent of Drainage Area Impervious        10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data            Unit Hydrograph Data
  [SCS Curve Number Method]          Clark's Unit Hydrograph
   Holtan Method                     Snyder's Unit Hydrograph
   Green-Ampt Method                [SCS Dimensionless Unit Graph]
   Initial-Uniform Method            Enter Unit Hydrograph
   No Losses Computed
                                ─────────SCS Curve Number Method─────────
                                 Initial Rainfall Abstraction (in)   0.5000
                                 (If blank, computed as 0.2*(1000 - 10*CN)/CN)

                                 SCS Curve Number (CN)               80

1Help  2PrtScr 3     4      5      6DOS   7      8      9      10Exit
                      Press <F10> to Save Data and Return
```

FIGURE 4.9 SCS Curve Number Data Entry Window

For the SCS Curve Number method, precipitation loss is calculated based on supplied values of **SCS Initial Rainfall Abstraction** and SCS Curve Number. The initial rainfall abstraction is the surface moisture storage capacity at the beginning of the storm event. The curve number and initial abstraction are related to a total runoff depth for a storm by the following relationships:

$$ACEXS = \frac{(ACRAN - IA)^2}{ACRAN - IA + S} \qquad 4.1$$

$$S = \frac{1000 - 10CN}{CN} \qquad 4.2$$

in which:

CN is the SCS curve number

IA is the initial abstraction

ACEXS is the accumulated excess in inches

ACRAN is the accumulated rainfall depth in inches

S is the currently available soil moisture storage deficit in inches.

The **SCS Curve Number** must always be greater than zero (0), because a value of 0 would cause an error in Equation 4.2. The maximum value for the Curve Number is 100, because a Curve Number of 100 results in an *S* value of zero (0) and no losses.

The **Initial Rainfall Abstraction** may be a value of 0 or greater. If a value of 0 is entered for *IA*, a default value is computed as

$$IA = 0.2S \qquad 4.3$$

This relation is based on empirical evidence established by the Soil Conservation Service.

Since the SCS method gives total excess for a storm, the incremental excess (the difference between rainfall and precipitation loss) for a time period is computed as the difference between the accumulated excess at the end of the current period and the accumulated excess at the end of the previous period.

The SCS soil classification system uses four groups, as follows:

A: deep sand, deep loess, aggregated silts

B: shallow loess, sandy loam

C: clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay.

D: soils that swell significantly when wet, heavy plastic clays, and certain saline soils.

All other factors being equal, Group A soils have the lowest runoff potential and Group D soils have the highest runoff potential.

Usually, the best source of information for determining the SCS soil group for a particular drainage area is the county soil survey. The SCS National Engineering Handbook, Section 4 [SCS, 1972], also contains useful information. However, the SCS soil group can also be determined using field observations of soil characteristics or the results of infiltration tests. The following infiltration values can be used to judge the results of infiltration tests:

Group A soils: 0.30 to 0.45 inches per hour minimum infiltration

Group B soils: 0.15 to 0.30 inches per hour minimum infiltration

Group C soils: 0.05 to 0.15 inches per hour minimum infiltration

Group D soils: 0.00 to 0.05 inches per hour minimum infiltration

Tables 4.2 and 4.3 list appropriate values for the SCS Curve Number for each of the four SCS soil groups. These tables are also divided according to the SCS cover complex, which consists of three factors: land use, land treatment or practice, and hydrologic condition. For example, the land use for a particular area may be "Row crops". If the land treatment or practice were "Straight row" and the hydrologic condition were "Good", then the SCS Curve Numbers would range from 67 to 89, depending on the soil group.

Note: this program uses an optional "Percent of Drainage Area Impervious" value to adjust runoff volume for development. If this value is used, the SCS Curve Number should not be "adjusted" for urban development. If an "adjusted" Curve Number is used, the "Percent of Drainage Area Impervious" value should be zero (0), in order to avoid over-estimating the effects of development.

TABLE 4.2 Values of SCS Curve Number for Rural Areas

	Hydrologic Soil Group:			
Land Use Description	**A**	**B**	**C**	**D**
Fallow:				
Straight Row	77	86	91	94
Row Crops:				
Straight Row, Poor Condition	72	81	88	91
Straight Row, Good Condition	67	78	85	89
Contoured, Poor Condition	70	79	84	88
Contoured, Good Condition	65	75	82	86
Contoured and Terraced, Poor Condition	66	74	80	82
Contoured and Terraced, Good Condition	62	71	78	81
Small Grain:				
Straight Row, Poor Condition	65	76	84	88
Straight Row, Good Condition	63	75	83	87
Contoured, Poor Condition	63	74	82	85
Contoured, Good Condition	61	73	81	84
Contoured and Terraced, Poor Condition	61	72	79	82
Contoured and Terraced, Good Condition	59	70	78	81
Close-Seeded Legumes or Rotation Meadow:				
Straight Row, Poor Condition	66	77	85	89
Straight Row, Good Condition	58	72	81	85
Contoured, Poor Condition	64	75	83	85
Contoured, Good Condition	55	69	78	83
Contoured and Terraced, Poor Condition	63	73	80	83
Contoured and Terraced, Good Condition	51	67	76	80
Pasture or Range:				
Poor Condition	68	79	86	89
Fair Condition	49	69	79	84
Good Condition	39	61	74	80
Contoured, Poor Condition	47	67	81	88
Contoured, Fair Condition	25	59	75	83
Contoured, Good Condition	6	35	70	79
Meadow, Good Condition:	30	58	71	78
Woods or Forest Land:				
Poor Condition	45	66	77	83
Fair Condition	36	60	73	79
Good Condition	25	55	70	77
Farmsteads:	59	74	82	86

Source: [McCuen, 1982]

TABLE 4.3 Values of SCS Curve Number for Urban and Suburban Areas

	Hydrologic Soil Group			
Land Use Description	**A**	**B**	**C**	**D**
Residential:				
1/8 acre or less average lots (65% impervious)	77	85	90	92
1/4 acre average lots (38% impervious)	61	75	83	87
1/3 acre average lots (35% impervious)	57	72	81	86
1/2 acre average lots (25% impervious)	54	70	80	85
1 acre average lots (20% impervious)	51	68	79	84
Paved parking lots, roofs, driveways, etc.:	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89
Commercial & Business Areas (85% Impervious):	89	92	94	95
Industrial Districts (72% Impervious):	81	88	91	93
Open Spaces, Lawns, Parks, Golf Courses, Cemeteries, etc.:				
good condition: grass cover on 75% or more	39	61	74	80
fair condition: grass cover on 50% to 75%	49	69	79	84

Source: [McCuen, 1982]

4.2.2.4. Holtan Loss Computation

The Holtan Loss Computation computes loss rate based on the infiltration capacity given by the formula [Holtan et al, 1975]:

$$f = GIA \times SA^{BEXP} + FC \qquad 4.4$$

in which:

f is the infiltration capacity in inches per hour.

GI is a "growth index" representing the relative maturity of the ground cover.

A is the infiltration capacity in inches per hour (inch$^{1.4}$ of available storage).

SA is the equivalent depth in inches of pore space in the surface layer of the soil which is available for storage of infiltrated water.

FC is the constant rate of percolation of water through the soil profile below the surface layer. (See Table 4.4).

BEXP is an empirical exponent, typically taken equal to 1.4.

Figure 4.10 shows the data entry window for the Holtan Method. All of the input data items for this method must be zero (0) or greater. The Holtan Method implemented in HEC-IFH is identical to the implementation used in the HEC-1 computer program (HEC, 1990).

Estimates of *FC* can be based on the hydrologic soil group given in the SCS National Engineering Handbook [SCS, 1972 and 1975], as listed in Table 4.4.

TABLE 4.4 Values of *FC* for SCS Hydrologic Soil Groups

Hydrologic Soil Group	**A**	**B**	**C**	**D**
FC (inches per hour)	0.45 to 0.30	0.30 to 0.15	0.15 to 0.05	0.05 or less

Source: [Musgrave, 1955]

The available storage, *SA*, is decreased by the amount of infiltrated water and increased at the percolation rate, *FC*. Note, by calculating *SA* in this manner, soil moisture recovery occurs at the deep percolation rate. The amount of infiltrated water during a time interval is computed as the smaller of 1) the amount of available water, i.e., rain, or 2) the average infiltration capacity times the length of the time interval.

```
HEA 01.01.00                                                       RUN021
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                                Enter Basin Runoff Data
Basin ID      SILVER     Silver Creek using SCS UHG & Holtan loss

Drainage Area (sq mi)                    15.00
Percent of Drainage Area Impervious      10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data              Unit Hydrograph Data
  SCS Curve Number Method             Clark's Unit Hydrograph
 [Holtan Method             ]         Snyder's Unit Hydrograph
  Green-Ampt Method                  [SCS Dimensionless Unit Graph]
  Initial-Uniform Method              Enter Unit Hydrograph
  No Losses Computed
                           -----------Holtan Method------------------
                           Holtan Deep Percolation Rate (in/hr)       0.080
                           Infiltration Rate (in/hr)                  0.900
                           Depth of Available Soil Moisture Storage (in)  0.750
                           Exponent of Available Soil Moisture Storage    1.400

1Help   2PrtScr 3       4      5      6DOS    7      8      9      10Exit
                        Press <F10> to Save Data and Return
```

FIGURE 4.10 Holtan Method Data Entry Window

The HEC-IFH and HEC-1 computer programs use the following infiltration equation:

$$F = \frac{F_1 + F_2}{2} TRHR \qquad 4.5$$

in which F_1 and F_2 and SA_1 and SA_2 are the infiltration rates and available storage, respectively, at the beginning and end of the time interval *TRHR*, and

$$F_1 = GIA \times SA_1^{BEXP} + FC \qquad 4.6$$

$$F_2 = GIA \times SA_2^{BEXP} + FC \qquad 4.7$$

$$SA_2 = SA_1 - F + FC \times TRHR \qquad 4.8$$

4.2.2.5. Green-Ampt Loss Computation

For the Green-Ampt Loss Computation, the Green-Ampt infiltration function [Mein and Larson, 1973] is combined with an initial abstraction to compute rainfall losses. The initial abstraction is satisfied prior to rainfall infiltration as follows:

$$r(t) = 0 \text{ for } P(t) \leq IA \qquad t > 0 \qquad 4.9$$

$$r(t) = r_0(t) \text{ for } P(t) > IA \qquad t > 0 \qquad 4.10$$

in which:

P(t) is the cumulative precipitation over the watershed *r(t)* is the rainfall intensity adjusted for surface losses

t is the time since the start of rainfall, $r_0(t)$

IA is the initial abstraction in inches

The Green and Ampt infiltration is applied to the remaining rainfall by applying the following equation:

$$F(t) = \frac{PSIF \times DTHETA}{f(t) \,/\, XKSAT - 1} \qquad f(t) > XKSAT \qquad 4.11$$

$$F(t) = r(t) \qquad f(t) \leq XKSAT \qquad 4.12$$

in which:

F(t) is the cumulative infiltration

$f(t) = dF(t)/dt$ is the infiltration rate

PSIF = the wetting front suction in inches

DTHETA = the volumetric moisture deficit

XKSAT = the hydraulic conductivity at natural saturation in inches per hour.

Figure 4.11 shows the data entry window for the Green-Ampt method. All four of the input values for this method must be zero (0) or greater.

The application of the Green-Ampt equation is complicated by the fact that it is only applicable to a rainfall rate greater than the infiltration rate. The difficulty is overcome by calculating a time to ponding [Mein and Larson, 1973] [Morel-Seytoux, 1980]. Time to ponding (the time at which the ground surface is saturated) is calculated by applying Equation 4.11 over the computation interval Δt:

$$\Delta F = F_j - F_{j-1} = \frac{PSIF - DTHETA}{\left(\frac{r_j}{XKSAT}\right) - 1} \sum_{i=1}^{j-1} r_i \Delta t \qquad r(j) \geq XKSAT \qquad 4.13$$

where it is recognized that at ponding the infiltration and rainfall rates are equal ($i(t) = r(t)$)

r_j is the average rainfall rate during period *j*

F_j and F_{j-1} are the cumulative infiltration rates at the end of periods *j* and *j*-1

ΔF is the incremental infiltration over period *f*.

Ponding occurs if the following condition is satisfied:

$$\Delta F < r_i \Delta t \qquad 4.14$$

otherwise the rainfall over the period will be completely infiltrated. Once ponding has occurred, the infiltration and rainfall rates are independent and Equation 4.11 an be easily integrated to calculate the infiltration over the computation interval. The ponded surface condition might not be maintained during the entire storm. This occurs when the rainfall rate falls below the ponding infiltration rate. In this case a new ponding time is calculated and infiltration calculation is applied as previously described. Although a time to ponding is used, no surface sotrage is modelled; i.e., there is no carry-over of surface water from one time step to the next.

```
HEA 01.01.00                                                          RUN022
Study ID  SILVERCR     Runoff Hydrograph Parameters (RUNOFF)

                              Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & Green-Ampt

Drainage Area (sq mi)                        15.00
Percent of Drainage Area Impervious          10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data              Unit Hydrograph Data
  SCS Curve Number Method             Clark's Unit Hydrograph
  Holtan Method                       Snyder's Unit Hydrograph
 [Green-Ampt Method            ]     [SCS Dimensionless Unit Graph]
  Initial-Uniform Method              Enter Unit Hydrograph
  No Losses Computed
                   ----------Green-Ampt Method----------
                   Initial Loss (in)                                  0.750
                   Volumetric Moisture Deficit                        0.390
                   Wetting Front Suction (in)                        12.500
                   Hydraulic Conductivity at Natural Saturation (in/hr) 0.000

1Help   2PrtScr 3      4       5      6DOS    7      8      9      10Exit
                    Press <F10> to Save Data and Return
```

FIGURE 4.11 Green-Ampt Data Entry Window

4.2.3. Basin Unit Hydrograph Data

A 1-hour ***unit hydrograph*** is defined as the sub-basin surface outflow due to a unit (1 inch) rainfall excess applied uniformly over a sub-basin in a period of one hour. Unit hydrograph durations other than one hour are common. The HEC-IFH program automatically sets the ***unit hydrograph duration*** equal to the computation interval selected for watershed simulation.

The rainfall excess hyetograph is transformed to a sub-basin outflow hydrograph by utilizing the general equation:

$$Q(i) = \sum_{j=1}^{1} U(j) P_e(i - j + 1) \qquad 4.15$$

in which:

$Q(i)$ is the sub-basin outflow at the end of computation interval i

$U(j)$ is the jth ordinate of the unit hydrograph

$P_e(i)$ is the average rainfall excess for computation interval i

This process of computing the runoff hydrograph is called ***convolution***. The equation is based on two important assumptions:

1. The unit hydrograph is characteristic for a sub-basin and is not storm dependent.
2. The runoff due to excess from different periods of rainfall excess can be linearly superposed.

The largest computed flow rate within the hydrograph is the ***peak flow rate***. The time of computed peak rate of runoff is simply the time at which the peak flow rate is computed.

Three empirical methods for developing unit hydrographs are available within the HEC-IFH program. These are the Clark, Snyder, and SCS methods. In addition, unit hydrograph ordinates may be entered directly. If a unit hydrograph is entered directly, the computation interval specified for the interior analysis (described in Chapter 10) must be equal to the durction of the input unit hydrograph.

The Continuous Simulation and Hypothetical Event Analysis approaches both use the same unit hydrograph methods and data.

4.2.3.1. Clark Unit Hydrograph Computation

The Clark method (1945) requires three parameters to calculate a unit hydrograph: *TC*, the time of concentration for the basin, *R*, a storage coefficient, and a time-area curve. A time-area curve defines the cumulative area of the watershed contributing runoff to the sub-basin outlet as a function of time (expressed as a proportion of *TC*). The HEC-IFH program utilizes a dimensionless time-area curve defined as follows:

$$AI = 1.414T^{1.5} \qquad 0.0 \leq T < 0.5 \qquad 4.16$$

$$1 - AI = 1.414(1 - T)^{1.5} \qquad 0.5 \leq T \leq 1.0 \qquad 4.17$$

in which:

AI = the cumulative area as a fraction of total sub-basin area

T = the fraction of the time of concentration

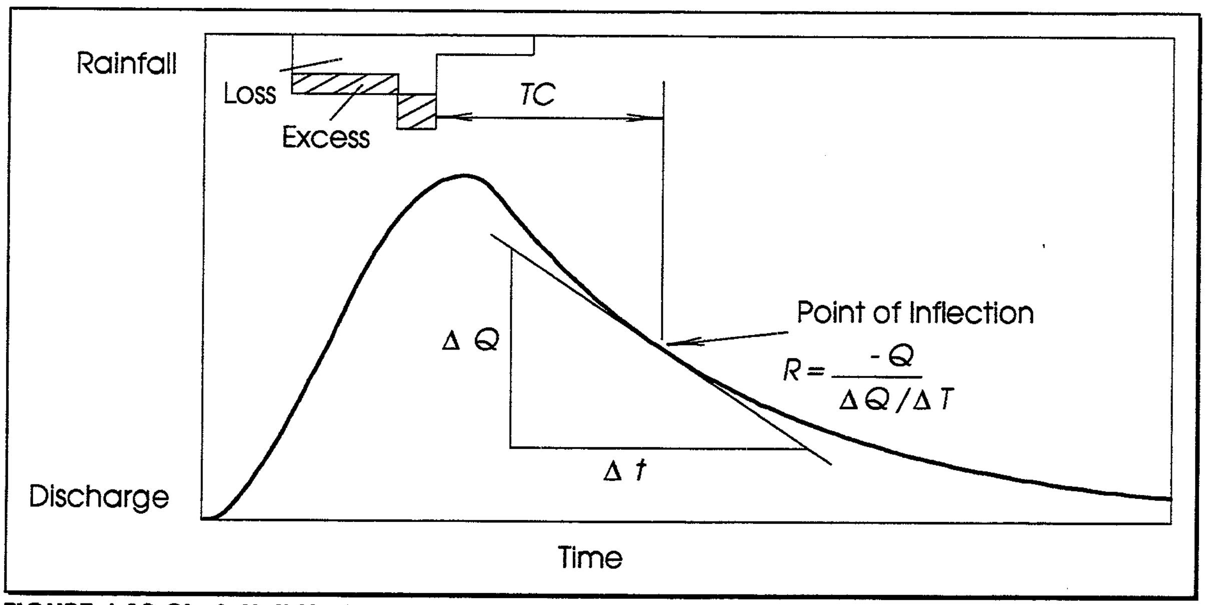


FIGURE 4.12 Clark Unit Hydrograph Method

The ordinates of the time-area curve are converted to volume of runoff per second for unit excess and interpolated to the given time interval. The resulting translation hydrograph is then routed through a linear reservoir to simulate the storage effects of the watershed. The resulting unit hydrograph for instantaneous excess is averaged to produce the hydrograph for unit excess occurring in the given time interval. Figure 4.12 illustrates the general concepts of the Clark unit hydrograph method.

The linear reservoir routing is accomplished using the general equation:

$$Q_2 = (CA \times I) + (CB \times Q_1) \qquad 4.18$$

The routing coefficients *CA* and *CB* are calculated from:

$$CA = \frac{\Delta t}{R + 0.5\Delta t} \qquad 4.19$$

$$CB = 1 - CA \qquad 4.20$$

$$QUNGR = \frac{Q_1 + Q_2}{2} \qquad 4.21$$

in which:

Q_2 = the instantaneous flow at the end of the period

Q_1 = the instantaneous flow at the beginning of the period

I = the ordinate of the translation hydrograph

Δt = the computation time interval in hours (also duration of unit excess)

R = the basin storage factor in hours.

$QUNGR$ = the unit hydrograph ordinate at the end of the computation interval

The computation of unit hydrograph ordinates is terminated when the runoff volume exceeds 0.995 inch or 150 ordinates are computed, whichever occurs first.

Figure 4.13 shows the data entry window for the Clark Unit Hydrograph Method for Hypothetical Event Analysis. A similar screen is available for Continuous Simulation Analysis. The **Time of Concentration** and **Watershed Storage** must both be greater than zero (0).

Note that a short "Yes No" menu is also presented in the Clark Unit Hydrograph data entry window for **Display (Tabulate) U. Hyd.?**. After the unit hydrograph parameters are entered, this menu can be used to compute and display the unit hydrograph ordinates. The Unit Hydrograph Tabulation window is illustrated in Figure 4.14. As indicated, the **Unit Hydrograph Duration** must be provided in order for the unit hydrograph ordinates to be tabulated. Several unit hydrographs with different durations can be specified, viewed, and plotted in this manner. The duration entered in this window is used to compute the unit hydrograph for display only, and has no effect on runoff computations. The unit hydrograph ordinates used in actual runoff computations are based on a unit hydrograph duration equal to the computation interval of the interior analysis, as described in Chapter 10.

The Unit Hydrograph Duration is entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY.

```
HEA 01.01.00                                                          RUN026
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                             Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using Clarks UHG & I/U loss

Drainage Area (sq mi)                      15.00
Percent of Drainage Area Impervious         10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data           Unit Hydrograph Data
  SCS Curve Number Method         [Clark's Unit Hydrograph        ]
  Holtan Method                    Snyder's Unit Hydrograph
  Green-Ampt Method                SCS Dimensionless Unit Graph
 [Initial-Uniform Method ]         Enter Unit Hydrograph
  No Losses Computed

                                  ----------Clark's Unit Hydrograph---------
                                  Time of Concentration TC (hr)      3.000
                                  Storage Coefficient R (hr)         4.500
                                  Display (Tabulate) U. Hyd.?     yes [no]

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
Press SPACE to select; Press <F10> to Save Data and Return
```

FIGURE 4.13 Clark Unit Hydrograph Data Entry Window

```
HEA 01.01.00                                                          RUN029
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                             Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                      15.00   Unit Hydro. Duration 1HOUR
Percent of Drainage Area Impervious         10.0
                                                       Time    Unit Hydrograph
Enter Base Flow Data and Recession  Yes  No           (HOUR)   Ordinates (cfs)

Infiltration Loss Data           Unit Hydrograph         1          114.9
  SCS Curve Number Method           Clark's Unit         2          350.7
  Holtan Method                     Snyder's Unit        3          732.6
  Green-Ampt Method                 SCS Dimension        4         1119.2
 [Initial-Uniform Method ]          Enter Unit Hy        5         1304.7
  No Losses Computed                                     6         1304.7
                                                         7         1157.5
                                                         8          955.2
                                                         9          689.5
                                                        10          499.2
                                                        11          368.7

1Help  2PrtScr 3      4      5      6DOS   7      8      9Plot  10Exit
                  Press <F10> to Save Data and Return
```

FIGURE 4.14 Unit Hydrograph Tabulation Window

The unit hydrograph tabulation can be an effective way to check computation of the unit hydrograph ordinates for the expected compuation interval of the interior analysis. The tabulated unit hydrograph should include at least 3 or 4 ordinates defined prior to the peak. This would be applicable if peak flow definition is important to the analysis. An example is a situation in which peak flow definition would be important is when very little ponding area storage is available and runoff hydrograph attenuation would be insignificant. When significant ponding storage is available, peak flow definition is not a major concern.

After the unit hydrograph is tabulated, the standard HEC-IFH cursor movement keys may be used to move through the unit hydrograph ordinates. The F9 plot key may be used to display a plot of the unit hydrograph. An example unit hydrograph plot is illustrated in Figure 4.15.

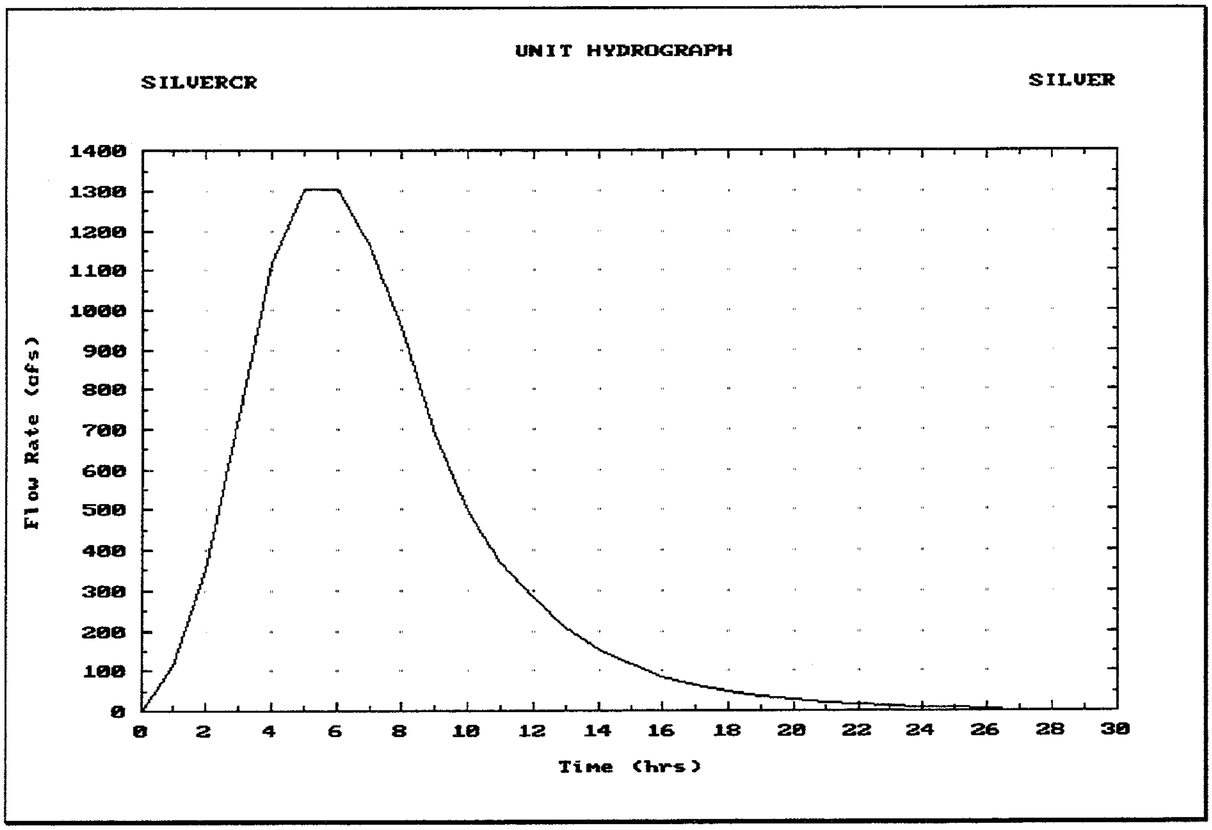


FIGURE 4.15 Unit Hydrograph Plot

4.2.3.2. Snyder Unit Hydrograph Computation

Snyder (1938) proposed two equations to be used in constructing synthetic unit hydrographs. The first equation defines the ***lag time*** of the watershed, or the time from the centroid of rainfall excess to the peak of the unit hydrograph.

$$T_P = C_t(L \times L_{ca})^{0.3} \qquad 4.22$$

in which:

T_P = watershed lag in hours

L = the length of the watershed along the main channel from the point of reference to the upstream boundary of the watershed, in miles

L_{ca} = the distance along the main channel from the point of reference to a point opposite the centroid of the watershed, in miles

C_t = a coefficient representing variations in watershed slopes and storage

The second equation gives the **peak discharge** of the unit hydrograph.

$$q_P = \frac{640C_P}{T_P} \qquad 4.23$$

in which:

q_p = peak discharge in cubic feet per second per square mile

T_P = watershed lag in hours

C_P = a coefficient accounting for flood wave and storage conditions.

The Snyder method determines the unit hydrograph peak discharge and time to peak only. The widths of the unit hydrograph at 50% and 75% of the peak discharge (W_{50} and W_{75}, respectively) are generally determined by regional regression analyses of basin characteristics. Figure 4.16 illustrates these aspects of the Snyder unit hydrograph method.

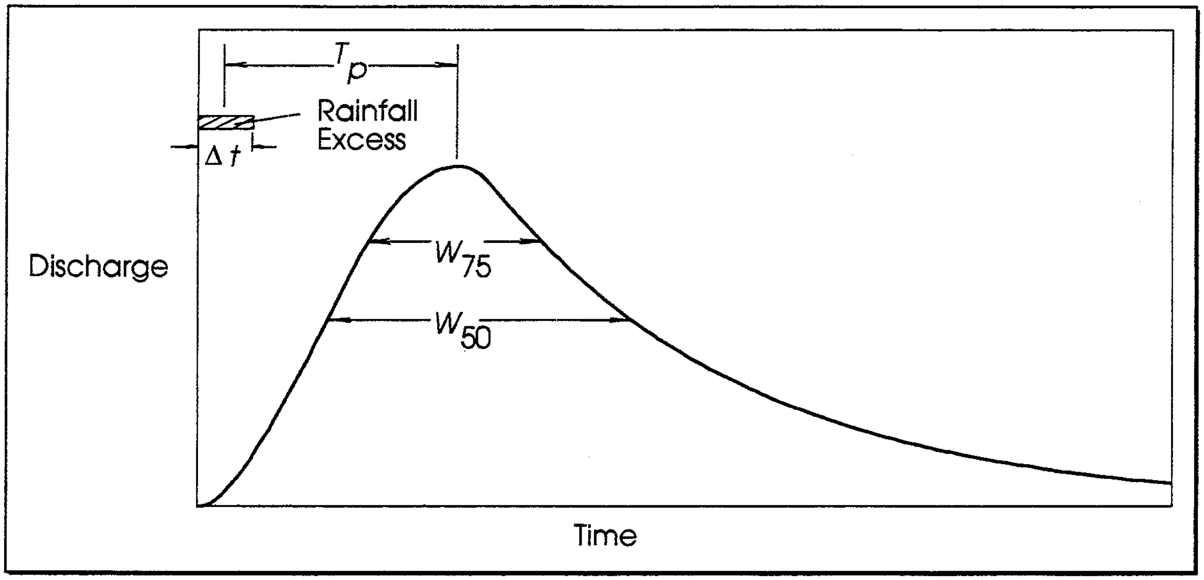


FIGURE 4.16 Snyder Unit Hydrograph Method

Since the Snyder method does not produce the complete unit hydrograph required by the HEC-IFH program, the HEC-IFH program uses the Clark method to determine the shape of a Snyder unit hydrograph. The initial Clark parameters are estimated from the given Snyder's parameters, *Tp* and *Cp*. A unit hydrograph is computed using Clark's method and Snyder parameters are computed from the resulting unit hydrograph by the following equations:

$$CP_{TMP} = Q_{MAX}\frac{T_{PEAK} - 0.5\Delta t}{C \times A} \qquad 4.24$$

$$ALAG = 1.048(T_{PEAK} - 0.75\Delta t) \qquad 4.25$$

in which:

CP_{TMP} = Snyder's C_P for the computed unit hydrograph

Q_{MAX} = the maximum ordinate of the unit hydrograph

T_{PEAK} = the time when Q_{MAX} occurs, in hours

Δt = the duration of excess, in hours

A = the sub-basin area, in square miles

C = a conversion factor for units of measurement

ALAG = Snyder's standard lag, T_p, for the computed unit hydrograph.

Snyder's standard lag is for a unit hydrograph which has a duration of excess equal to $T_p/5.5$. The coefficient 1.048 in Equation 4.25 results from converting the duration of excess to the given time interval.

Clark's *TC* and *R* are adjusted to compensate for differences between values of T_p and C_p calculated by the equations above and the given values. A new unit hydrograph is computed using these adjusted values. This procedure continues through 20 iterations or until the differences between computed and given values of T_p and C_p are less than one percent of the given values. A message is written to the warning/error message file during runoff computations if the program is unable to converge on suitable *TC* and *R* values within 20 iterations. (See Appendix E.)

Figure 4.17 illustrates the data entry window used for the Snyder Unit Hydrograph method for Continuous Simulation Analyses. A similar data entry window is used for Hypothetical Event Analyses.

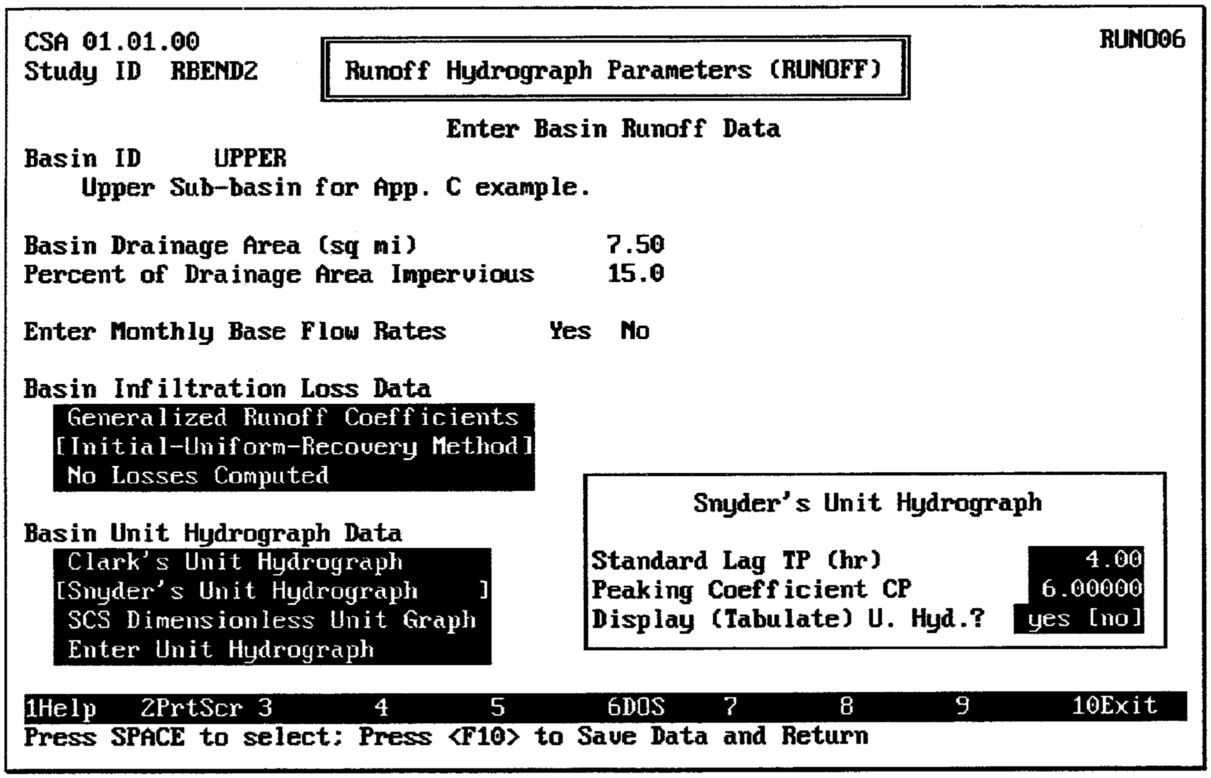


FIGURE 4.17 Snyder Unit Hydrograph Data Entry Window

The **Standard Lag** and **Peaking Coefficient** values entered in this window must both be greater than zero (0). After these values are entered, the unit hydrograph may be computed for tabulation or plotting, in the same way described for the Clark Unit Hydrograph method in the previous section.

4.2.3.3. SCS Dimensionless Unitgraph Computation

Input data for the Soil Conservation Service (SCS) dimensionless unitgraph method (1972) consists of a single parameter, T_{LAG}, which is equal to the lag time (hours) between the center of mass of rainfall excess and the peak of the unit hydrograph. The time to peak of the unitgraph is computed using the following equation:

$$T_{PEAK} = \frac{\Delta t}{2} + T_{LAG} \qquad 4.26$$

in which:

T_{PEAK} = the time to peak of the unitgraph, in hours

Δt = the computation time interval, in hours

T_{LAG} = the watershed lag value, in hours

The peak flow rate of the unitgraph is computed using the following equation:

$$Q_{PEAK} = \frac{484\ AREA}{T_{PEAK}} \qquad 4.27$$

in which:

Q_{PEAK} = the peak flow rate of the unitgraph

$AREA$ = the watershed area in square miles

T_{PEAK} = the time to peak as computed using the previous equation.

The constant in this equation (484) is valid only for terrain with moderate slopes. The constant would change to about 600 for steep terrain or to about 300 for flat, swampy terrain [SCS, 1972]. The shape of the dimensionless unitgraph would change accordingly.

The unit hydrograph is interpolated for the specified computation interval and computed peak flow rate from the dimensionless unitgraph shown in Figure 4.18. The dimensionless unitgraph ratios are listed in Table 4.5.

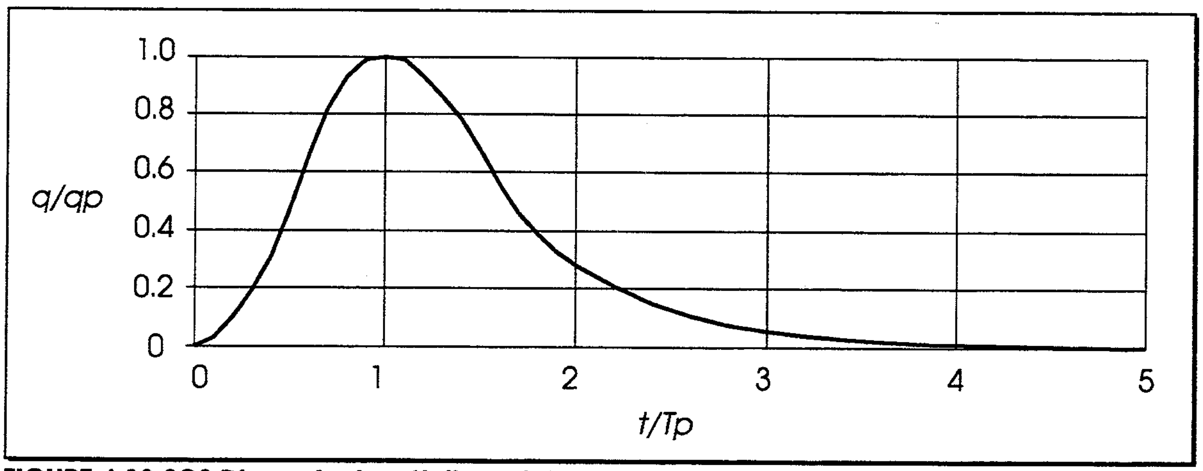


FIGURE 4.18 SCS Dimensionless Unitgraph Method

Since the program computation interval is used in the computation of T_{PEAK} and Q_{PEAK} for the unit hydrograph, changing the computation interval will affect the computed unit hydrograph. In order to meet the assumptions made in formulating the SCS Dimensionless Unitgraph method, the computation interval Δt should be less than or equal to 0.29 x T_{LAG}.

TABLE 4.5 SCS Dimensionless Unitgraph Discharge Ratios

Time Ratios (t/T_p)	Discharge Ratios (q/q_p)	Time Ratios (t/T_p)	Discharge Ratios (q/q_p)
0.0	0.000	1.7	0.460
0.1	0.030	1.8	0.390
0.2	0.100	1.9	0.330
0.3	0.190	2.0	0.280
0.4	0.310	2.2	0.207
0.5	0.470	2.4	0.147
0.6	0.660	2.6	0.107
0.7	0.820	2.8	0.077
0.8	0.930	3.0	0.055
0.9	0.990	3.2	0.040
1.0	1.000	3.4	0.029
1.1	0.990	3.6	0.021
1.2	0.930	3.8	0.015
1.3	0.860	4.0	0.011
1.4	0.780	4.5	0.005
1.5	0.680	5.0	0.000
1.6	0.560		

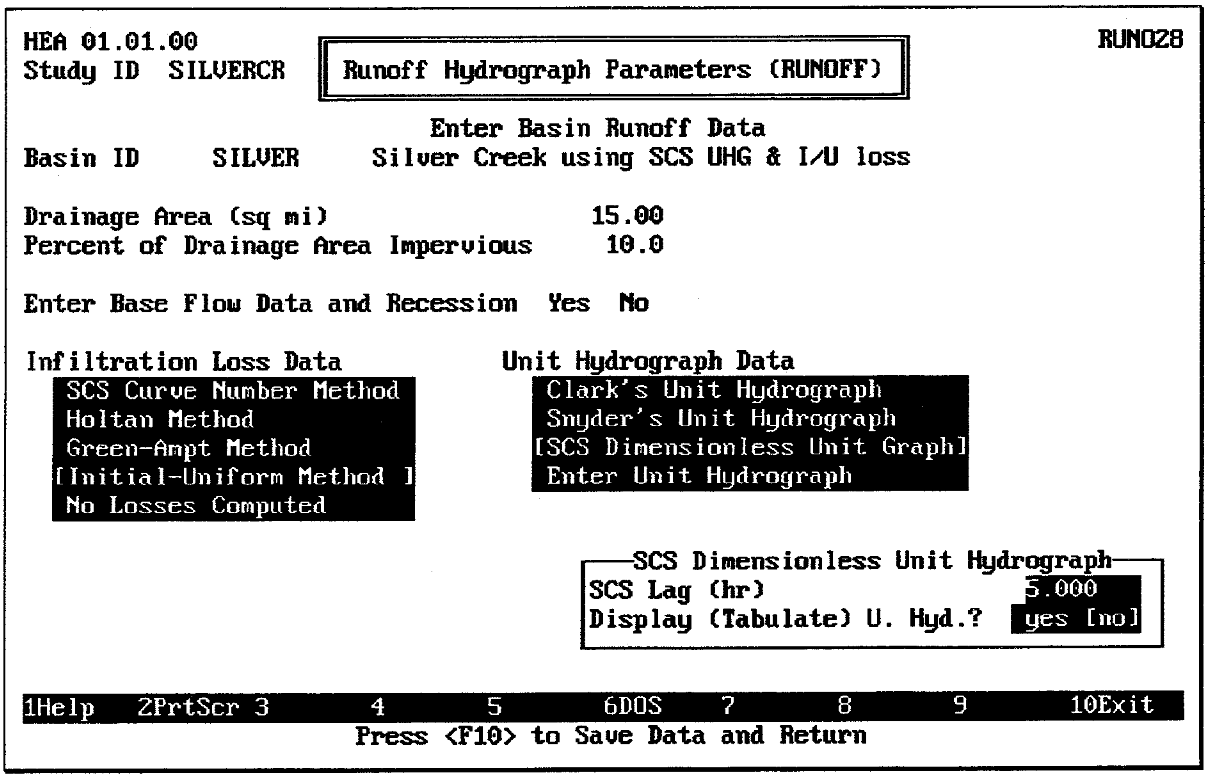


FIGURE 4.19 SCS Dimensionless Unit Hydrograph Data Entry Window

Figure 4.19 shows the data entry window for the SCS Dimensionless Unit Hydrograph Method for Hypothetical Event Analyses. A similar data entry window is available for

Continuous Simulation Analyses. The **SCS Lag** value must be greater than zero (0). After the lag value is entered, the unit hydrograph may be computed for tabulation or plotting, in the same way described for the Clark Unit Hydrograph method in a previous section.

4.2.3.4. Entering a Unit Hydrograph

A unit hydrograph may also be entered directly by the user. Figure 4.20 shows the data entry window for the this option. Each **Unit Hydrograph Ordinate** may be any value of zero (0) or greater.

The **Unit Hydrograph Tabulation Interval** is entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The entered unit hydrograph must have the same duration as the computation interval of the interior analysis which uses this unit hydrograph for runoff computations. (See Chapter 10).

After the unit hydrograph is entered, the standard HEC-IFH cursor movement keys may be used to move through the unit hydrograph ordinates. The F9 plot key may be used to display a plot of the unit hydrograph, similar to the example illustrated in Figure 4.15.

```
CSA 01.01.00                                                              RUN008
Study ID  RBEND2        Runoff Hydrograph Parameters (RUNOFF)

                              Enter Basin Runoff Data
Basin ID     UPPER
   Upper Sub-basin for App. C example.             Unit Hydro. Duration 1HOUR

Basin Drainage Area (sq mi)            7.50          Time     Unit Hydrograph
Percent of Drainage Area Impervious   15.0          (HOUR)    Ordinates (cfs)

Enter Monthly Base Flow Rates      Yes  No             1           86.0
                                                       2          270.7
Basin Infiltration Loss Data                           3          556.6
  Generalized Runoff Coefficients                      4          741.3
 [Initial-Uniform-Recovery Method]                     5          766.7
  No Losses Computed                                   6          676.2
                                                       7          532.9
Basin Unit Hydrograph Data                             8          353.8
  Clark's Unit Hydrograph                              9          248.9
  Snyder's Unit Hydrograph                            10          180.1
  SCS Dimensionless Unit Graph                        11          127.2
 [Enter Unit Hydrograph        ]                      12           89.8

1Help  2PrtScr 3     4     5     6DOS   7     8     9     10Exit
                   Press <F10> to Save Data and Return
```

FIGURE 4.20 Unit Hydrograph Data Entry Screen

4.3. CHANNEL ROUTING DATA FOR UPPER SUB-BASIN

Four streamflow routing techniques may be applied in the HEC-IFH program. They include the Modified Puls, Muskingum, and Muskingum-Cunge methods, as well as a simple lag method with no attenuation of flows.

Figure 4.21 illustrates the channel routing menu screen for the Hypothetical Event Analysis approach. A similar menu screen is used for the Continuous Simulation Analysis approach. However, the Muskingum-Cunge method is implemented for Hypothetical analysis only. It is not practical for Continuous Simulations because of the lengthy computations necessary.

```
HEA 01.01.00                                                          RUN031
Study ID  SILVERCR     Runoff Hydrograph Parameters (RUNOFF)

                      Channel Routing Data for Upper Sub-Basin

          Channel Routing ID  MODPULS
          Description         Modified Puls channel routing

          Computation method
            [Modified Puls Channel Routing  ]
             Muskingum Channel Routing
             Muskingum-Cunge Channel Routing
             Lag Channel Routing
             No Channel Routing

1Help   2PrtScr 3Index  4       5       6DOS    7       8       9       10Exit
                        Press <F10> to Save Data and Return
```

FIGURE 4.21 Channel Routing Menu Screen

4.3.1. Modified Puls Routing Computation

The Modified Puls routing method [CHOW, 1964] is a variation of the storage routing method described by [HENDERSON, 1966]. It is applicable to both channel and reservoir routing. Caution must be used when applying this method to channel routing. The degree of attenuation introduced in the routed flood wave varies depending on the river reach lengths chosen, or alternatively, on the number of routing steps specified for a single reach. The number of routing steps is a calibration parameter for the Modified Puls storage routing method; it can be varied to produce desired routed hydrographs. A storage indication function is computed from given storage and outflow data:

$$STRI_i = C \times \frac{STOR_i}{\Delta t} + \frac{OUTFL_i}{2} \qquad 4.28$$

in which:

$STRI$ = the storage indication

$STOR$ = the storage in the routing reach for a given outflow

$OUTFL$ = the outflow from the routing reach in cfs

C = a conversion factor for units

Δt = is the time interval in hours

i = a subscript indicating corresponding values of storage and outflow.

Storage indication at the end of each time interval is given by

$$STRI_2 = STRI_1 + Q_I - Q_O \qquad 4.29$$

in which:

Q_I is the average inflow in cfs

Q_O is the outflow in cfs

Subscripts 1 and 2 indicate the beginning and end of the current time interval, respectively.

The outflow at the end of the time interval is interpolated from a table of storage indication (*STRI*) versus outflow (*OUTFL*). Storage (*STR*) is then computed from:

$$STR = \left(STRI - \frac{Q}{2}\right) \times \frac{\Delta t}{C} \qquad 4.30$$

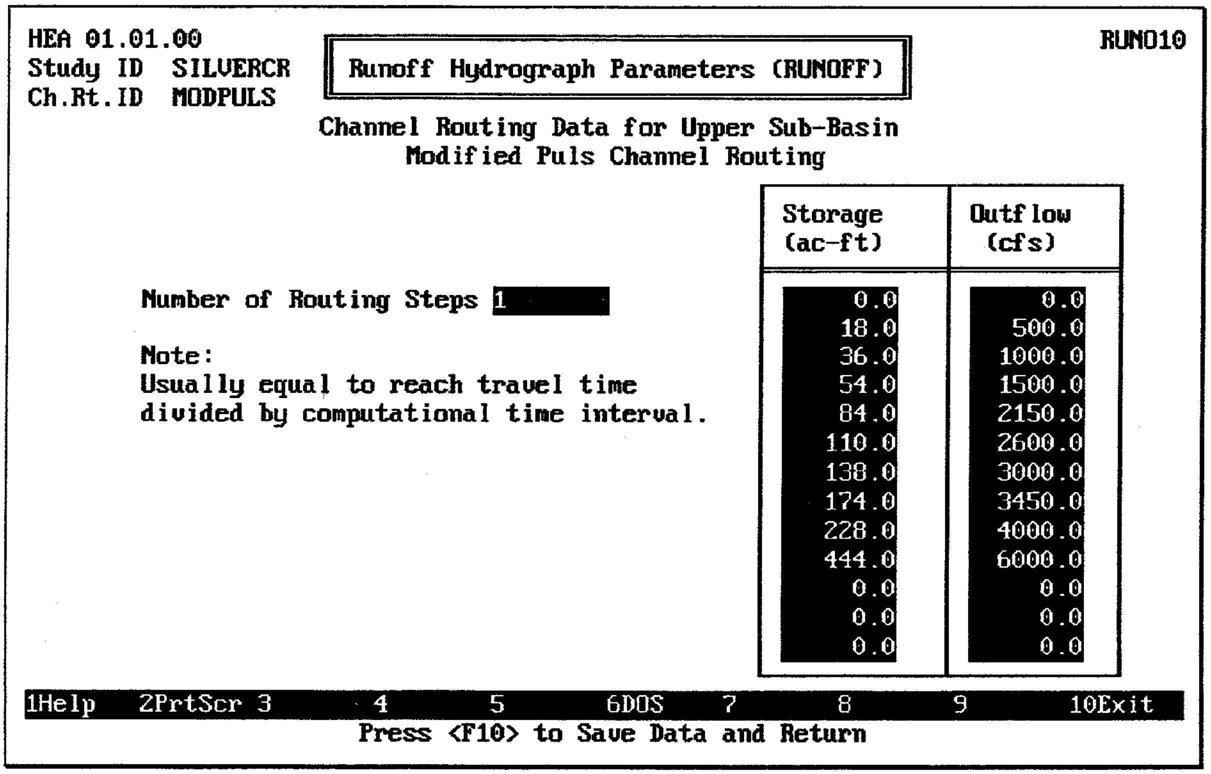


FIGURE 4.22 Modified Puls Routing Data Entry Screen

Modified Puls routing is accomplished by providing a storage versus outflow relationship as direct input to the HEC-IFH program. Such a relationship can be derived from water surface profile studies or other hydraulic analyses of rivers or reservoirs. Figure 4.22 illustrates the data entry screen for the Modified Puls routing data. Modified Puls channel routing is available for Continuous Simulation and Hypothetical Event analyses.

The **Number of Routing Steps** represents the number of routing reaches into which the channel should be divided. Any integer value greater than zero (0) may be entered. The first **Storage** and **Outflow** values should be zero (0). All subsequent values of storage and outflow should increase. Up to 20 values may be entered in each column.

After the storage versus outflow relationship has been specified, press the F9 plot key to generate a plot of the relationship, as shown in Figure 4.23.

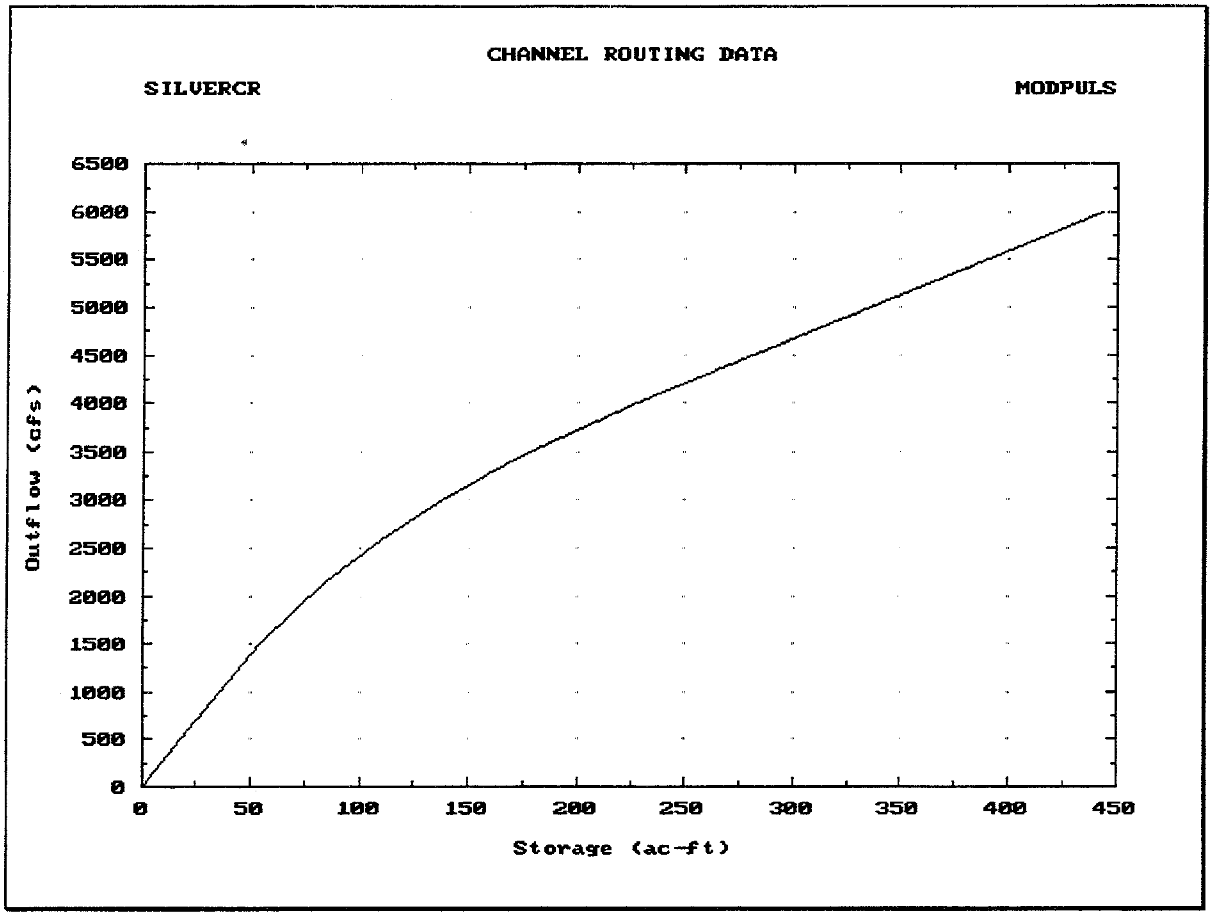


FIGURE 4.23 Modified Puls Storage-Outflow Plot

4.3.2. Muskingum Routing Computation

Muskingum channel routing is available for Continuous Simulation and Hypothetical Event analyses. The Muskingum method [Corps of Engineers, 1960] computes outflow from a reach using the following equations:

$$Q_{O2} = (CA - CB) \times Q_{I1} + (1 - CA) \times Q_{O1} + CB \times Q_{I2} \quad 4.31$$

in which:

$$CA = \frac{2\Delta t}{2K(1 - x) + \Delta t} \quad 4.32$$

$$CB = \frac{\Delta t - (2Kx)}{2K(1 - x) + \Delta t} \quad 4.33$$

Q_I = the inflow to the routing reach

Q_O = the outflow from the routing reach

K = the travel time through the reach in hours

x = the Muskingum weighting factor

The routing procedure may be repeated for several sub-reaches or routing steps (*NSTPS*) so the total travel time through the reach is *K*. To insure the method's computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that:

$$\frac{1}{2(1-x)} \leq \frac{K}{NSTPS \times \Delta t} \leq \frac{1}{2x} \qquad 4.34$$

```
HEA 01.01.00                                                            RUN011
Study ID   SILVERCR    | Runoff Hydrograph Parameters (RUNOFF) |
Ch.Rt.ID   MUSK1
                       Channel Routing Data for Upper Sub-Basin
                              Muskingum Channel Routing

                       Number of Routing Steps          5

                       Muskingum K Coefficient (hr)     5.00000

                       Muskingum x Coefficient          0.400000

           Note Limits for K and x:

              1                         K                             1
           ------  <  ---------------------------------------  <  ---
           2(1-x)     (comp. interval in hrs)(num. of steps)        2x


1Help  2PrtScr 3    4     5     6DOS    7     8     9       10Exit
                   Press <F10> to Save Data and Return
```

FIGURE 4.24 Muskingum Routing Data Entry Screen

Figure 4.24 shows the data entry screen for the Muskingum routing parameters. The **Number of Routing Steps** represents the number of routing reaches into which the channel should be divided. Any integer value greater than zero (0) may be entered. The **Muskingum K Coefficient** is the travel time through the routing reach. This value must also be greater than 0. The **Muskingum x Coefficient** may be any value from 0 through 0.5. A low value (near 0) would be entered for unimproved channels, because such a value would result in greater hydrograph attenuation (reduction in peak flow rate) during routing computations. A higher value (near 0.5) would be entered for improved channels. A value of 0.5 for the *x* coefficient results in the hydrograph being translated (lagged) during routing, but with no attenuation. In this case, the lag routing computation described in the following section should be used to avoid spurious instability warnings during routing computations.

4.3.3. Lag Routing Computation

The Lag Only routing method simply lags each hydrograph ordinate by a specified amount of time. The peak of the hydrograph is not attenuated (reduced). Figure 4.25 illustrates the data entry screen for the lag routing computation. Only one input value is required: the **Number of Hours to Lag Hydrograph**. This value must be zero (0) or greater. Lag routing computations are available for Continuous Simulation and Hypothetical Event Analyses.

```
HEA 01.01.00                                                    RUN016
Study ID  SILVERCR   Runoff Hydrograph Parameters (RUNOFF)
Ch.Rt.ID  LAG1
                     Channel Routing Data for Upper Sub-Basin
                                Lag Channel Routing


                     Number of Hours to Lag Hydrograph  2.50







1Help  2PrtScr 3     4     5     6DOS   7     8     9Plot  10Exit
                     Press <F10> to Save Data and Return
```

FIGURE 4.25 Lag Routing Data Entry Screen

To perform routing computations, the HEC-IFH program transforms the lag value into an integer number of computation intervals. For example, the user may specify that the inflow hydrograph will be lagged 1.5 hours. If a 1-hour computation interval is used for the interior analysis (see Chapter 10), then the lag value will be adjusted to 1 interval. If a 30-minute computation interval is specified, then the lag value will be 3 intervals.

4.3.4. Muskingum-Cunge Routing Computation

The Muskingum-Cunge channel routing technique is a non-linear coefficient method that accounts for hydrograph diffusion based on physical channel properties and the inflowing hydrograph.

The advantages of this method over other hydrologic techniques are:

1. **Physically-Based Parameters**: the parameters of the model are based primarily on the physical shape and condition of the stream channel.
2. **Good Performance**: the method has been shown to compare well against the full unsteady flow equations over a wide range of flow situations [PONCE, 1983][BRUNNER, 1989];
3. **Computation Interval**: the solution is independent of the user-specified computation interval.

The major limitations of the Muskingum-Cunge application in HEC-IFH are that:

1. **No Backwater**: it can not account for backwater effects.
2. **Low Slopes**: the method begins to diverge from the full unsteady flow solution when very rapidly rising hydrographs are routed through very flat slopes (i.e. channel slopes less than 1 ft./mile).

The Modified Puls and Muskingum channel routing implementations in HEC-IFH are identical to the implementations in the HEC-1 computer program. The Muskingum-Cunge Routing implementation is almost identical, differing only in the maximum number of hydrograph ordinates which can be routed. HEC-1 limits the number of hydrograph ordinates to only 300 or 2,000, depending on which version of the program is selected. HEC-IFH, however, allows hydrographs of up to 10,000 ordinates to be routed. This is sufficient for a hydrograph of about 34 days using a 5-minute computation interval. The Muskingum-Cunge channel routing is not implemented for Continuous Simulation Analysis because of the lengthy computations which are required for the method.

The basic formulation of the equations is derived from the continuity equation and the diffusion form of the momentum equation:

$$\frac{\delta A}{\delta t} + \frac{\delta Q}{\delta x} = q_L \qquad \text{(continuity)} \qquad 4.35$$

$$S_f = S_o - \frac{\delta Y}{\delta x} \qquad \text{(diffusion form of Momentum equation)} \qquad 4.36$$

By combining Equation 4.35 and 4.36 and linearizing, the following convective diffusion equation is formulated [MILLER AND CUNGE, 1975]:

$$\frac{\delta Q}{\delta t} + c\frac{\delta Q}{\delta x} = \mu \frac{\delta^2 Q}{\delta x^2} + c q_L \qquad 4.37$$

in which:

Q = Discharge

A = Flow area

t = Time in seconds

x = Distance along the channel

Y = Depth of flow

q_L = Lateral inflow per unit of channel length

S_f = Friction slope

S_o = Bed Slope

c = The wave celerity in the x direction as in Equation 4.38.

$$c = \frac{\delta Q}{\delta A}\Big|_x \qquad 4.38$$

The hydraulic diffusivity (μ) is expressed as follows:

$$\mu = \frac{Q}{2BS_o} \qquad 4.39$$

where B is the width of the water surface.

Following a Muskingum-type formulation, with lateral inflow, the continuity Equation 4.35 is discretized on the x-t plane to yield:

$$Q_{j+1}^{n+1} = C_1 Q_j^{n} + C_2{}_j^{n+1} + C_3{}_{j+1}^{n} + C_4 Q_L \qquad 4.40$$

where:

$$C_1 = \frac{\frac{\Delta t}{K} + 2X}{\frac{\Delta t}{K} + 2(1-X)} \qquad 4.41$$

$$C_2 = \frac{\frac{\Delta t}{K} - 2X}{\frac{\Delta t}{K} + 2(1-X)} \qquad 4.42$$

$$C_3 = \frac{2(1-X) - \frac{\Delta t}{K}}{\frac{\Delta t}{K} + 2(1-X)} \qquad 4.43$$

$$C_4 = \frac{2\left(\frac{\Delta t}{K}\right)}{\frac{\Delta t}{K} + 2(1-X)} \qquad 4.44$$

$$Q_L = q_L \Delta x \qquad 4.45$$

It is assumed that the storage in the reach is expressed as the classical Muskingum storage:

$$S = K\,[XI + (1-X)O] \qquad 4.46$$

where:

S = channel storage

K = cell travel time (seconds)

x = weighting factor

I = inflow

O = outflow

In the Muskingum equation the amount of diffusion is based on the value of x, which varies between 0.0 and 0.5. The Muskingum x parameter is not directly related to physical channel properties. The diffusion obtained with the Muskingum technique is a function of how the equation is solved, and is therefore considered numerical diffusion rather than physical. In the Muskingum-Cunge formulation, the amount of diffusion is controlled by forcing the numerical diffusion to match the physical diffusion (μ) from Equation 4.37 and Equation 4.39. The Muskingum-Cunge equation is therefore considered an approximation of the convective diffusion equation (Equation 4.37). As a result, the parameters K and x are expressed as follows [CUNGE, 1969], [PONCE, 1981]:

$$K = \frac{\Delta x}{c} \qquad 4.47$$

$$X = \frac{1}{2}\left(1 - \frac{Q}{BS_o c \Delta x}\right) \qquad 4.48$$

Then the Courant (C) and cell Reynolds (D) numbers can be defined as :

$$C = c\frac{\Delta t}{\Delta x} \quad 4.49$$

and

$$D = \frac{Q}{BS_o c\Delta x} \quad 4.50$$

The routing coefficients for the non-linear diffusion method (Muskingum-Cunge) are then expressed as follows:

$$C_1 = \frac{1 + C - D}{1 + C + D} \quad 4.51$$

$$C_2 = \frac{-1 + C + D}{1 + C + D} \quad 4.52$$

$$C_3 = \frac{1 - C + D}{1 + C + D} \quad 4.53$$

$$C_4 = \frac{2C}{1 + C + D} \quad 4.54$$

in which the dimensionless numbers C and D are expressed in terms of physical quantities (Q, B, S_o, and c) and the grid dimensions (Δx and Δt).

The method is non-linear in that the flow hydraulics (Q, B, c), and therefore the routing coefficients (C_1, C_2, C_3, and C_4) are re-calculated for every Δx distance step and Δt time step. An iterative four-point averaging scheme is used to solve for c, B and Q. This process has been described in detail [PONCE, 1986].

Values for Δt and Δx are chosen internally by the model for accuracy and stability. First, Δt is evaluated by looking at the following three criteria and selecting the smallest value:

1. The user defined computation interval, NMIN.
2. The time of rise of the inflow hydrograph divided by 20 ($T_r/20$).
3. The travel time of the channel reach.

Once Δt is chosen, Δx is evaluated as follows:

$$\Delta x = c\Delta t \quad 4.55$$

but Δx must also meet the following criteria to preserve consistency in the method [PONCE, 1983]:

$$\Delta x < \frac{1}{2}\left(c\Delta t + \frac{Q_o}{BS_o C}\right) \quad 4.56$$

where Q_O is the reference flow determined from Equation 4.57:

$$Q_o = Q_B + 0.50(Q_{peak} - Q_B) \quad 4.57$$

where Q_B is the base flow taken from the inflow hydrograph. Δx is chosen as the smaller value from the two criteria. Before the hydrograph is used in subsequent operations, it is converted back to the user-specified computation interval.

Figure 4.26 illustrates the main data entry screen for the Muskingum-Cunge method. As shown, a **Channel Length** must be entered for the routing reach. This channel reach length may be any value above zero (0). A positive value is also required for the **Channel Invert Slope**, or Bed Slope, S_O. The **Channel Roughness Coefficient** is the Manning roughness coefficient (*n*-value) for the channel portion of the cross-section. Any value greater than 0 but less than 1 is acceptable for the *n*-value.

```
HEA 01.01.00                                                         RUN012
Study ID  SILVERCR   Runoff Hydrograph Parameters (RUNOFF)
Ch.Rt.ID  MCUNGE1
                     Channel Routing Data for Upper Sub-Basin
                          Muskingum-Cunge Channel Routing

                     Channel Length (ft)              24000.0
                     Channel Invert Slope (ft/ft)      0.00080
                     Channel Roughness Coefficient    0.015000

                     Channel Shape
                       Trapezoidal Channel
                       Circular Channel
                      [Eight-Point Cross-Section]






1Help  2PrtScr 3     4     5     6DOS   7     8     9Plot  10Exit
                       Press <F10> to Save Data and Return
```

FIGURE 4.26 Muskingum-Cunge Routing Data Entry Screen

The Muskingum-Cunge method can be used with a simple trapezoidal or circular cross-section, or a more detailed 8-point cross-section. A menu is provided, as shown in Figure 4.26, to select the channel cross-section shape. The appropriate shape is selected by using the up-arrow and down-arrow cursor movement keys to highlight the desired shape, the pressing the space bar to complete the selection. A data entry screen will appear for the selected shape.

Figure 4.27 shows the data entry screen for a trapezoidal channel. Only two data values are required to describe a trapezoidal channel. These are the **Trapezoidal Channel Bottom Width** and the **Trapezoidal Channel Side Slope**. These values may be zero (0) or greater, as long as both values are not zero. The Channel Bottom Width is zero for a triangular channel, and the Channel Side Slope is zero for a rectangular channel.

Figure 4.28 shows the data entry screen for a circular channel. The **Circular Channel Diameter** must be greater than zero.

```
HEA 01.01.00                                                          RUN013
Study ID   SILVERCR     Runoff Hydrograph Parameters (RUNOFF)
Ch.Rt.ID   MCUNGE1
                       Channel Routing Data for Upper Sub-Basin
                          Muskingum-Cunge Channel Routing

                       Channel Length (ft)               24000.0
                       Channel Invert Slope (ft/ft)      0.00080
                       Channel Roughness Coefficient    0.015000

                       Channel Shape
                         [Trapezoidal Channel        ]
                          Circular Channel
                          Eight-Point Cross-Section

                      ------------ Trapezoidal Channel ----------

                       Channel Bottom Width (ft)        25.00
                       Channel Side Slope (ft/ft)        1.00000

1Help   2PrtScr 3       4       5       6DOS    7       8       9Plot   10Exit
                       Press <F10> to Save Data and Return
```

FIGURE 4.27 Muskingum-Cunge Trapezoidal Channel Data Entry Screen

```
HEA 01.01.00                                                          RUN014
Study ID   SILVERCR     Runoff Hydrograph Parameters (RUNOFF)
Ch.Rt.ID   MCUNGE1
                       Channel Routing Data for Upper Sub-Basin
                          Muskingum-Cunge Channel Routing

                       Channel Length (ft)               24000.0
                       Channel Invert Slope (ft/ft)      0.00080
                       Channel Roughness Coefficient    0.015000

                       Channel Shape
                          Trapezoidal Channel
                         [Circular Channel           ]
                          Eight-Point Cross-Section

                      ------------ Circular Channel ------------

                       Channel Diameter (ft)            100.00

1Help   2PrtScr 3       4       5       6DOS    7       8       9Plot   10Exit
                       Press <F10> to Save Data and Return
```

FIGURE 4.28 Muskingum-Cunge Circular Channel Data Entry Screen

Figure 4.29 shows the data entry screen for an Eight-Point Cross-Section. This data entry screen allows a more complex cross-sectional shape to be represented as a set of exactly eight (8) pairs of offset-elevation coordinates. Two of these coordinate pairs must be in the left overbank portion of the cross-section (outside the left channel bank). Two others must be in the right overbank portion of the cross-section (outside the right channel bank).

HEA 01.01.00
Study ID SILVERCR
Ch.Rt.ID MCUNGE1

Runoff Hydrograph Parameters (RUNOFF)

RUN015

Channel Routing Data for Upper Sub-Basin
Muskingum-Cunge Channel Routing

Eight-Point Cross-Section

Length 24000.0 Slope 0.00080 Roughness 0.015000

Location	Distance (ft)	Elevation (ft)
Left Overbank	0.00	35.00
Left Overbank	50.00	25.00
Left Bank	225.00	20.00
Channel	250.00	5.00
Channel	270.00	4.00
Right Bank	300.00	15.00
Right Overbank	450.00	25.00
Right Overbank	525.00	40.00

Roughness Coefficients (Manning's n-values)	
Left Overbank	0.060000
Right Overbank	0.050000

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE 4.29 Muskingum-Cunge 8-Point Channel Data Entry Screen

The left and right channel bank locations must be represented by two of the coordinates. The remaining two coordinate pairs are used within the channel itself, usually representing the toe of the channel bank slope on each side.

Each **Distance** (offset) value may be zero (0) or greater. Each distance value must be greater than the previous value. The **Elevation** values must fall within the valid range of elevations specified in Chapter 2.

Since the eight-point cross-section has overbank portions, additional n-values are required to specify the **Roughness Coefficients** of the overbanks. These may be given any value greater than 0 but less than 1.

To verify the shape of the eight-point cross-section, the cross-section may be plotted by pressing the F9 key. Figure 4.30 illustrates such a cross-section plot.

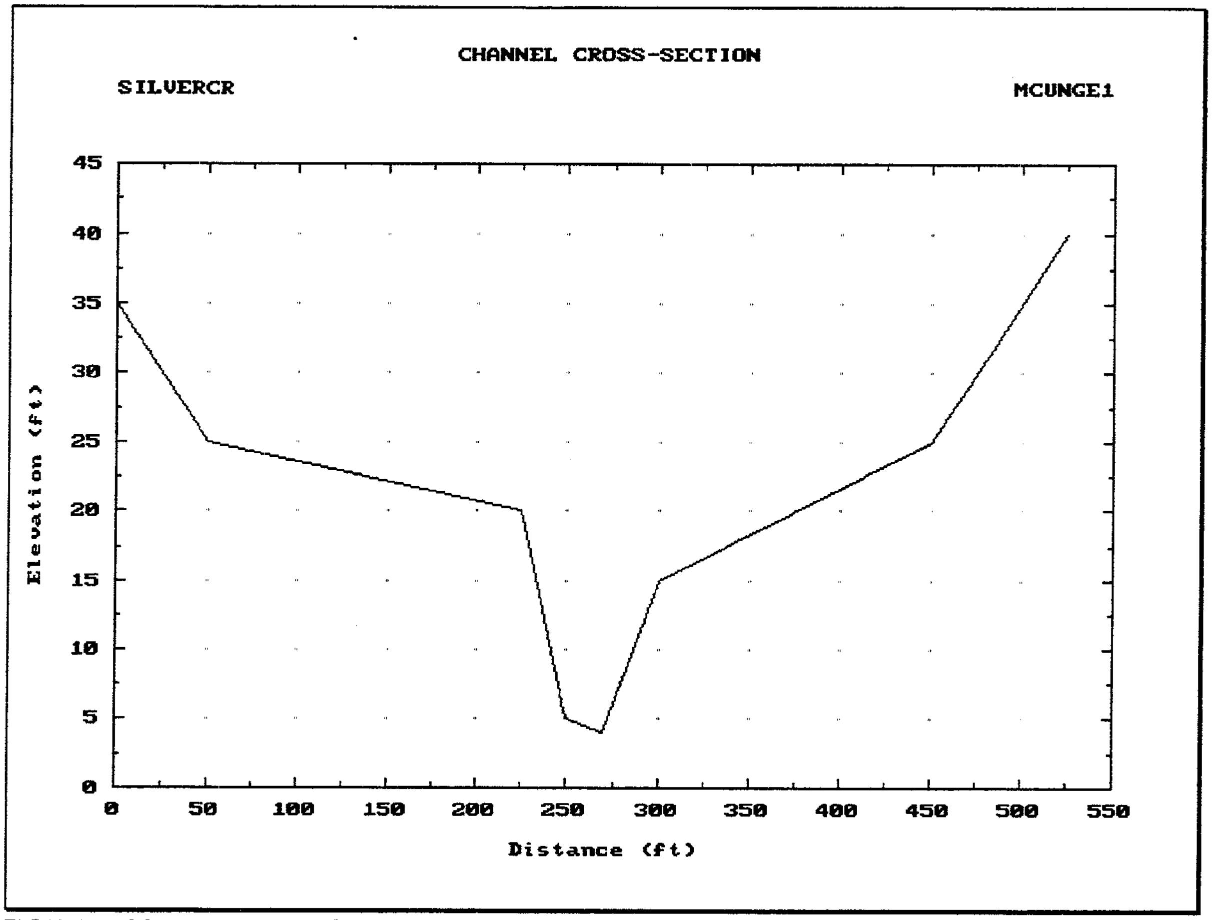


FIGURE 4.30 Muskingum-Cunge 8-Point Channel Plot

4.4. SPECIFYING RUNOFF DATA

The screen used for specifying Runoff Module data is illustrated in Figure 4.31. Like other HEC-IFH data entry modules, the RUNOFF module data is stored under a **Module ID**. Several RUNOFF module data sets may be stored under different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding data will be loaded for editing.

The 40-character **Description** is used to provide documentation for each RUNOFF Module data set.

The RUNOFF module data may consist of a **Channel Routing ID** for the upper sub-basin and a **Basin ID** for each interior basin. Any Channel Routing ID or Basin ID already defined for the present STUDYID may be selected. When the cursor is on each ID field, the F3 key displays a list of previously-defined IDs. Any of these previous IDs may be selected.

Any of the IDs may be omitted. Here are several examples:

- If the interior area consists of a Lower Interior sub-basin only, then the Upper Interior Basin ID and the Channel Routing ID should be omitted.
- If the interior area includes Lower and Upper Interior sub-basins, but you prefer not to use the HEC-IFH runoff computation routines for the upper sub-basin, then the Upper Interior Basin ID should be omitted. In this case, Auxiliary Inflows are

generally included for the upper sub-basin (see Chapter 9). A Channel Routing ID must be included if it is required to route these flows downstream to the interior ponding area.

- If the interior area consists of an Upper Interior sub-basin only (not likely), then the Lower Interior Basin ID should be omitted.
- If you prefer not to use the HEC-IFH runoff computation routines to model the runoff of the lower sub-basin, then the Lower Interior Basin ID may be omitted. In this case, Auxiliary Inflows are generally included for the lower sub-basin (see Chapter 9).

You may re-enter this data entry screen later to change the IDs for the sub-basins or the Channel Routing, or to enter additional basin data or channel routing data under new IDs.

```
CSA 01.01.00                                                          RUN017
Study ID  RBEND2     Runoff Hydrograph Parameters (RUNOFF)

                  Assign Basin Runoff Data Set for Each Sub-Basin

                Module ID     RUNOFF1

                Description   Runoff data for App. C. example.

                                                               Drainage Area
  Sub-Basin       Basin ID   Description                          (sq mi)

Lower Interior   LOWER     Lower sub-basin for App. C example.      5.00
Upper Interior   UPPER     Upper Sub-basin for App. C example.      7.50


  Upper Sub-Basin Channel Routing ID   ROUTE1
                                       Channel routing data for App. C example.

1Help   2PrtScr 3Index  4      5      6DOS    7      8      9      10Exit
                    Press <F10> to Save Data and Return
```

FIGURE 4.31 Runoff Module Data Specification Screen

See Chapter 8. Exterior Stage, for specifying the runoff data set to be used to compute exterior basin runoff hydrograph, if required.

CHAPTER 5.
Interior Pond

5.1. INTRODUCTION

One important element of most interior flooding studies is the analysis or design of an interior ponding area. Such an area provides temporary storage of floodwaters during storm events. The HEC-IFH computer program is limited to the consideration of a single ponding area. Multiple ponding areas may be considered only if they are hydraulically linked such that the water surfaces in all ponding areas rise and fall together.

The interior ponding area characteristics **must** be specified and are described using a table of pond water surface elevations versus pond surface area values. The HEC-IFH program uses this data to compute the pond storage volume during flood routing computations.

HEC-IFH uses the water surface elevation in the interior ponding area to compute the headwater elevation for all gravity outlets and pumps. Since the program considers only one interior ponding area, all outlets are influenced by the same interior water surface elevation. A varying tailwater condition can be specified for up to five locations as described in Chapter 8.

The discharge rate of gravity outlets and pumps may be limited by the flow capacity of a discharge channel which conveys flow from the interior ponding area to the outlets. If such a condition is to be simulated, a table of pond water surface elevations versus channel discharge rate can be specified to define the channel capacity. The HEC-IFH program assumes that all gravity outlets and pumps are served by the same discharge channel.

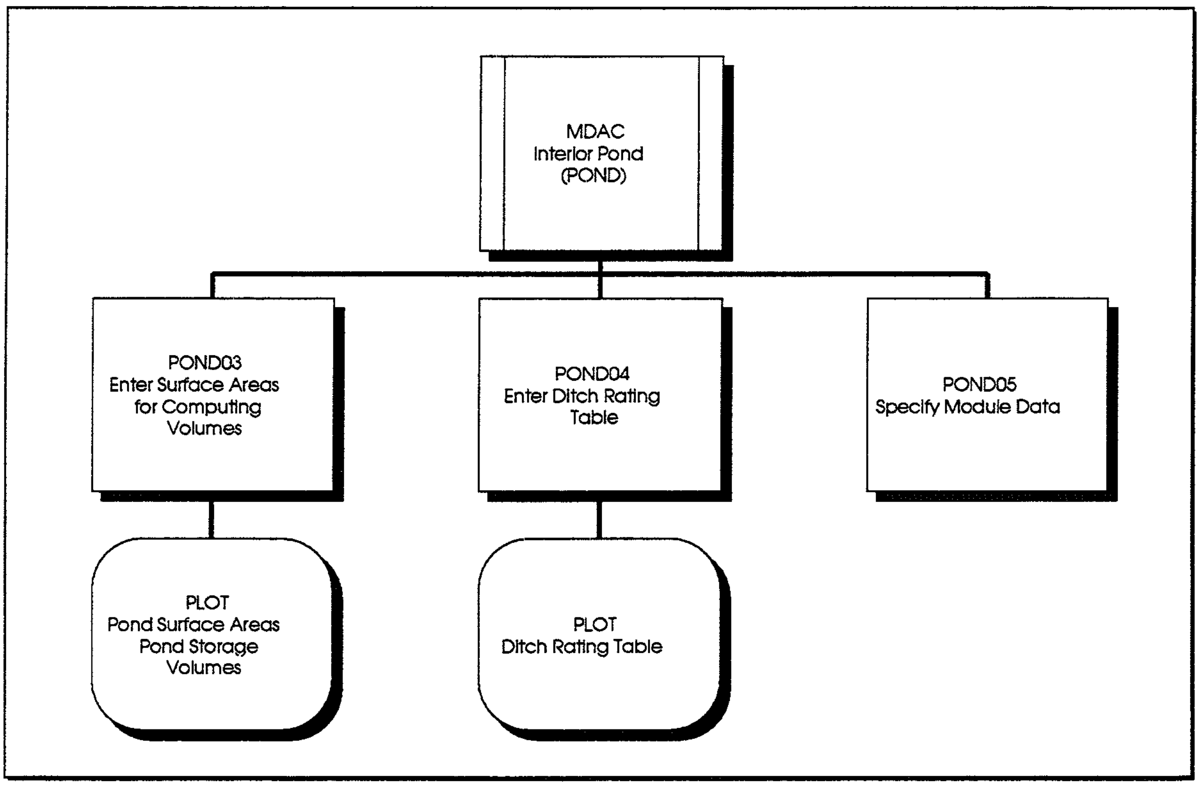


FIGURE 5.1 POND Module Structure

Figure 5.1 shows the structure of the HEC-IFH program screens which deal with data entry and plotting for the interior pond and ditch. As shown, HEC-IFH provides two data entry screens and two plots for pond data. These are available through the POND Module Menu Screen, which is illustrated in Figure 5.2. Pond module data entry is handled identically in both the Continuous Simulation and Hypothetical Event analysis approaches.

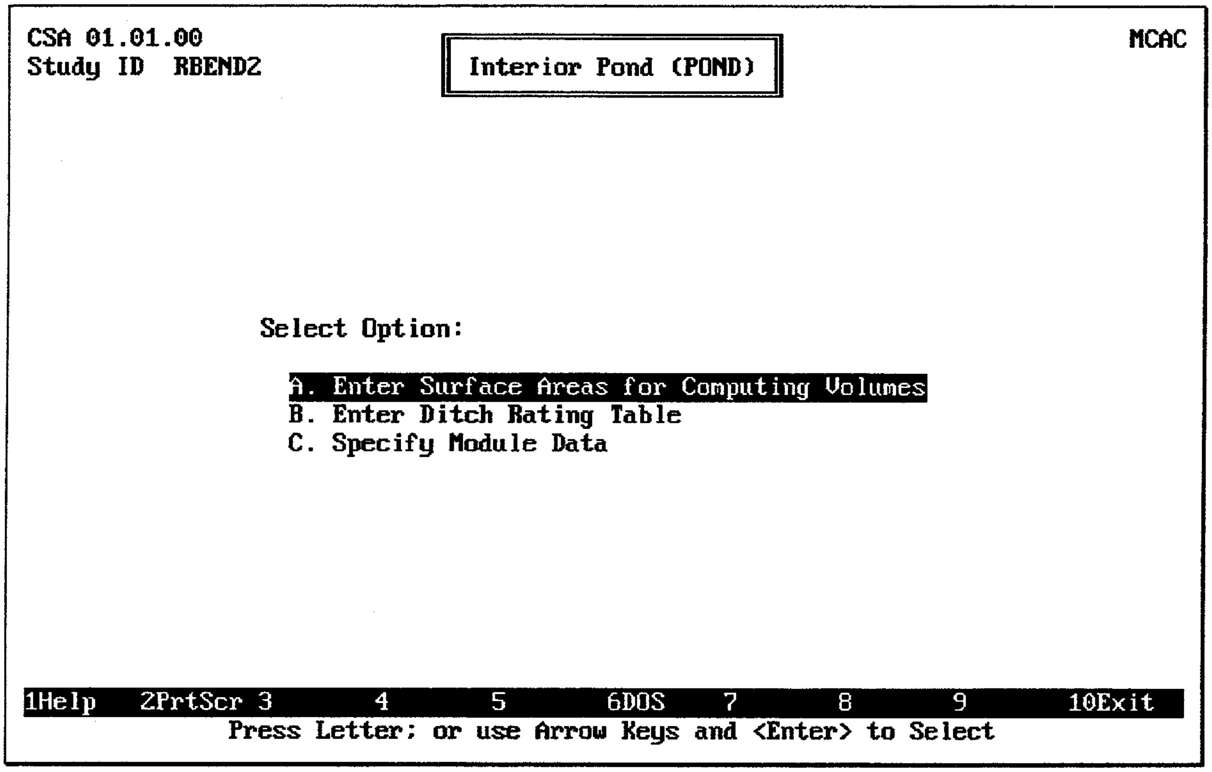


FIGURE 5.2 POND Module Menu Screen

5.2. POND ELEVATION VERSUS SURFACE AREA TABLE

The data entry screen shown in Figure 5.3 is used to enter the elevation versus pond surface area table. Up to 20 values may be used. The pond storage volume at each elevation is automatically computed using an average end-area method. The program displays the computed volumes on the screen during data entry.

It is important to enter an appropriate elevation-area relationship in the table. A sufficient number of data points must be entered to describe the curvilinear relationship. The program uses ***linear*** interpolation between entered points for area, and average end-area for volume. The final (highest) elevation entered should equal or exceed the highest interior stage expected during the analysis. The program will not extrapolate beyond this last point. This highest elevation is also used for setting limits on gravity outlet rating tables used internally by the program (see Chapter 6). For this reason, an unrealistically high elevation should not be used.

Several pond surface area tables may be entered, with each one stored under a different **Storage Table ID**. When the cursor is on the Storage Table ID field, the F3 key displays a list of previously-defined IDs. When any previous ID is selected, the corresponding table is displayed for editing.

CSA 01.01.00 POND03
Study ID RBEND2

Interior Pond (POND)

Enter Surface Areas for Computing Volumes

Storage Table ID POND1

Description
Interior pond for App. C example.

Pond Elevation (ft)	Surface Area (ac)	Storage Volume (ac-ft)
591.00	0.0	0.0
592.00	4.0	2.0
593.00	10.0	9.0
594.00	15.0	21.5
595.00	75.0	66.5
596.00	130.0	169.0
597.00	200.0	334.0
598.00	275.0	571.5
599.00	400.0	909.0
600.00	525.0	1371.5
601.00	700.0	1984.0
605.00	2000.0	7384.0
0.00	0.0	0.0

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE 5.3 Pond Surface Area Data Entry Screen

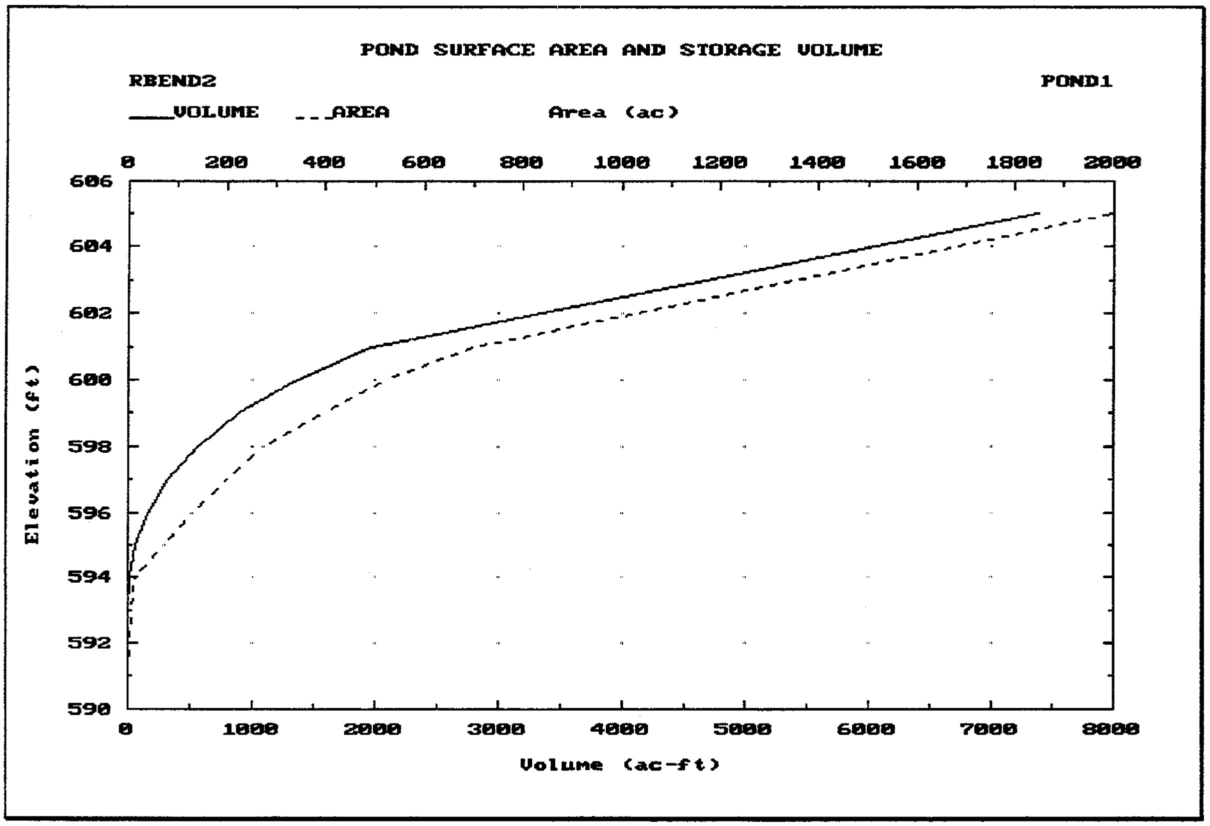


FIGURE 5.4 Pond Surface Area and Storage Volume Plot

All **Elevation** values must fall within the allowable minimum and maximum values described in Chapter 2. **Surface Area** values must be zero (0) or greater. Each elevation value should also equal or exceed the previously-entered value. Pressing the F9 key causes the elevation versus surface area and computed pond storage volume tables to be plotted on the computer screen. Figure 5.4 illustrates this plot.

5.3. INTERIOR DITCH RATING TABLE

Sometimes gravity and pump outlets are separated from the interior ponding area by a channel or ditch. The capacity of this ditch limits the total outlet capacity of the interior system. When the capacity of the ditch is less than the combined outlet capacity of the gravity and pump outlets, flow is apportioned to the gravity outlet(s) and then to the pump outlet(s).

For evaluating new facilities, the ditch capacity should be sufficient to convey flow to the gravity outlets and pumping stations without restricting the combined outlet capacity of these facilities.

An interior ditch rating table is used to describe the capacity of the outlet ditch at various interior ponding elevations. The ditch table is input directly to the HEC-IFH program in the form of a table of water surface elevations and corresponding channel discharges. Up to 20 data points may be used. Figure 5.5 illustrates the appearance of the data entry screen for the ditch rating table.

```
CSA 01.01.00                                                   POND04
Study ID  RBEND2            Interior Pond (POND)

                          Enter Ditch Rating Table

Ditch Table ID  DITCH1                          Pond       Discharge
                                                Elevation  Capacity
Description                                     (ft)       (cfs)
  Interior Ditch (Pond to Outlets)
                                                  591.00        0.0
                                                  592.00       40.0
                                                  593.00      100.0
                                                  594.00      150.0
Note: If discharge capacity is left blank,        595.00      750.0
      capacity is assumed to be unlimited.        596.00     1300.0
                                                  597.00     2000.0
                                                  598.00     2750.0
                                                  599.00     4000.0
                                                  600.00     5251.0
                                                  601.00     7000.0
                                                  605.00    20000.0
                                                    0.00        0.0
1Help  2PrtScr 3Index  4      5      6DOS    7      8      9Plot   10Exit
                   Press <F10> to Save Data and Return
```

FIGURE 5.5 Data Entry Screen for Ditch Table

Several ditch rating tables may be entered, with each one stored under a different Ditch Table ID. When the cursor is on the **Ditch Table ID** field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding table will be loaded for editing.

The 40-character **Description** is used to provide documentation for each ditch table.

The **Discharge Capacity** always begins with a value of zero (0) corresponding to the first **Elevation** value. The range of elevations specified for the ditch rating table should correspond to the range of elevations specified for the pond elevation-surface area relationship. All elevation values must fall within the allowable minimum and maximum values described in Chapter 2. Each discharge capacity and elevation value should equal or exceed the previously entered value.

Pressing the F9 key causes the ditch rating table to be plotted on the computer screen. Figure 5.6 illustrates the plot.

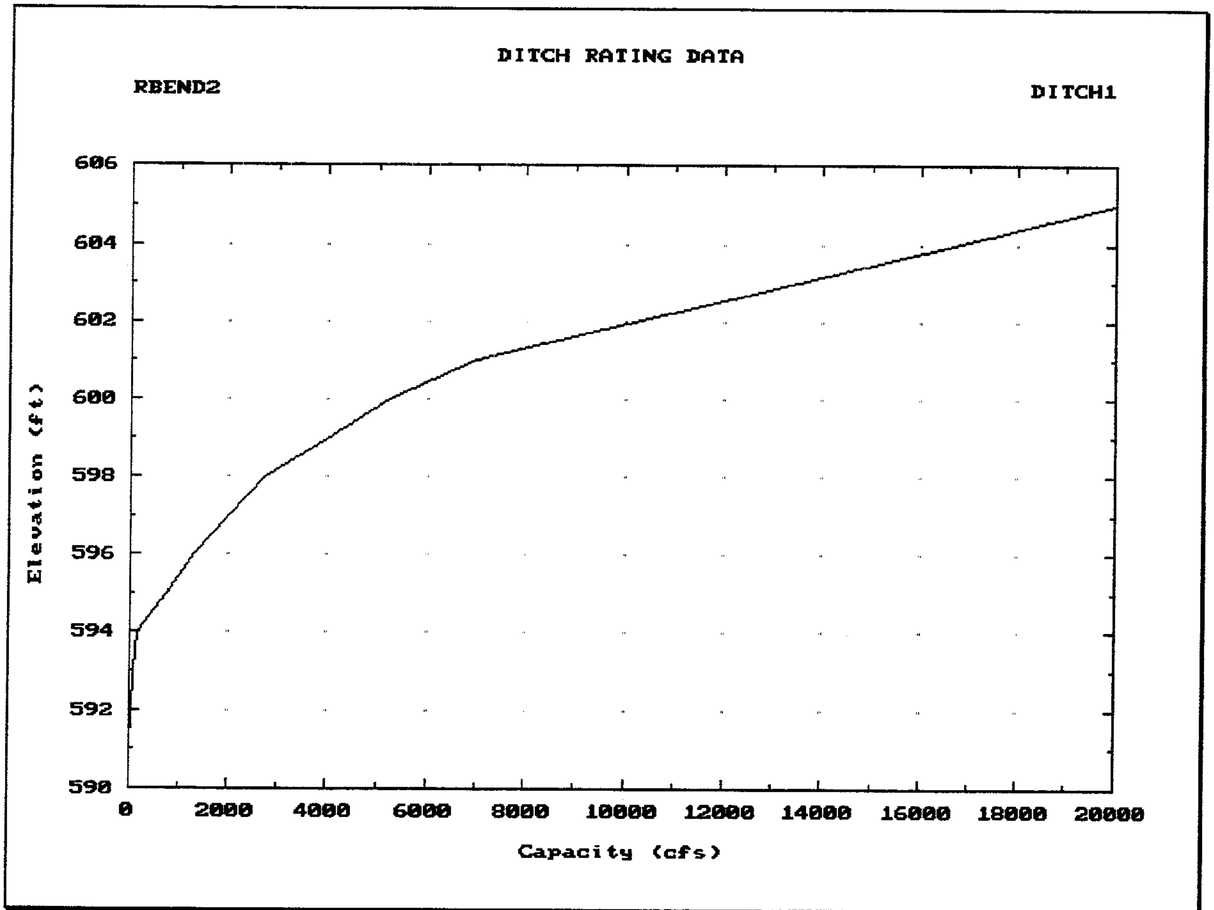


FIGURE 5.6 Interior Ditch Table Plot

5.4. SPECIFYING POND DATA

Figure 5.7 illustrates the screen used to specify data for the POND module. Like other HEC-IFH data entry modules, the POND module data is stored under a **Module ID**. You may store several POND module data sets under different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously-stored IDs. You may select any of these previous IDs, and the corresponding data will be loaded for editing. The 40-character **Description** is used to provide documentation for each POND Module data set.

```
CSA 01.01.00                                                     POND05
Study ID  RBEND2            Interior Pond (POND)

                            Specify Module Data

     Module ID         INTPOND1

     Description       Interior pond module data for App. C.

     Storage Table ID  POND1      Interior pond for App. C example.
     Ditch Table ID

1Help  2PrtScr 3      4       5       6DOS    7       8       9      10Exit
                      Press <F10> to Save Data and Return
```

FIGURE 5.7 Pond Data Specification Screen

The POND module data consists of a pond Storage Table ID and a Ditch Table ID. Any Storage Table ID or Ditch Table ID already entered for the present STUDYID may be selected. When the cursor is on each ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected.

If the interior ponding area is connected directly to the gravity and pump outlets with no ditch, the Ditch Table ID may be omitted. If a Ditch Table ID is specified, the flowline elevation of the ditch must be at or above the minimum elevation of interior pond. If not, the interior pond routing computations may be unstable. The HEC-IFH program compares these two values and issues a warning message if necessary.

You may re-enter the POND module later in order to change the ID for the Storage Table or the Ditch Table, or to enter additional Storage Tables or Ditch Tables under new IDs.

CHAPTER 6. Gravity Outlets

6.1. INTRODUCTION

Culverts are the most common types of gravity outlets for interior areas. A ***culvert*** is a relatively short length of closed conduit which connects two open channel segments or bodies of water. Two types of culverts are commonly used: ***circular or pipe culverts***, which have a round cross-section, and ***box culverts***, which are rectangular in cross-section. Figures 6.1 and 6.2 illustrate circular culverts and box culverts, respectively.

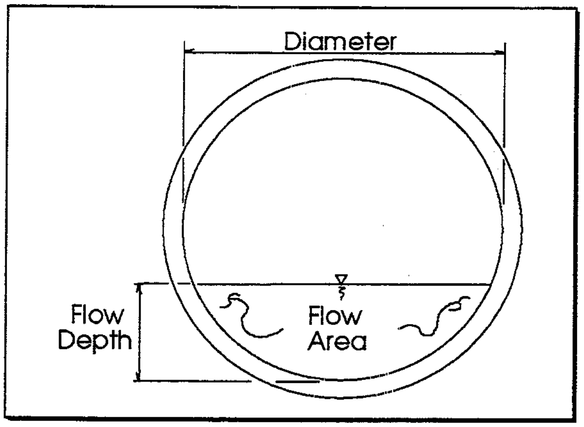


FIGURE 6.1 Cross-Section of a Circular Culvert

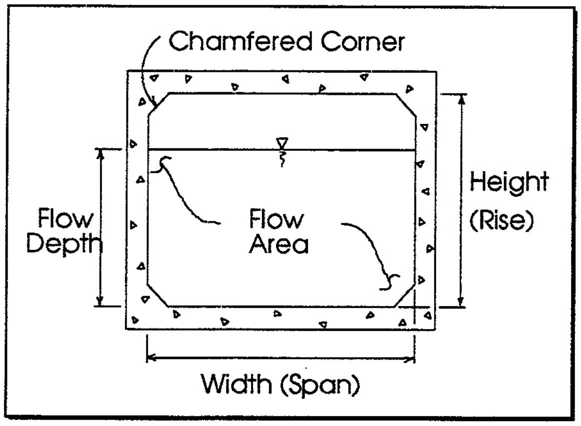


FIGURE 6.2 Cross-Section of a Box Culvert

Culverts are made up of an ***entrance*** where water flows into the culvert, and a ***barrel***, which is the closed conduit portion of the culvert. The total flow capacity of a culvert depends upon the characteristics of the entrance as well as the culvert barrel.

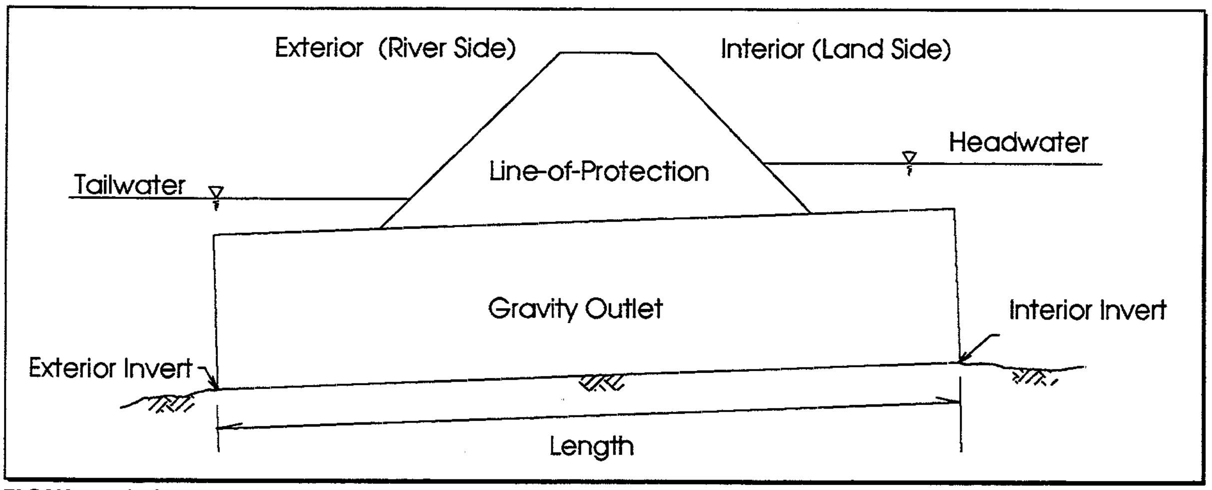


FIGURE 6.3 Gravity Outlet Structure

The ***tailwater*** at a culvert is the depth of water on the discharge or downstream side of the culvert, as measured from the downstream flow-line of the culvert. The ***flow-line*** is the lowest point on the inside of the culvert at a particular cross-section. It is sometimes called the ***invert***. The tailwater depth depends on the flow rate and hydraulic conditions downstream of the culvert. In HEC-IFH, the tailwater depth is computed using the exterior stage values.

The ***headwater*** at a culvert is the depth of water on the entrance or upstream side of the culvert, as measured from the upstream flow-line of the culvert. The headwater is related to the tailwater as follows:

	Tailwater
+	Energy Loss Through Culvert
-	Drop in Flow-Line Elevation Through Culvert
=	Headwater

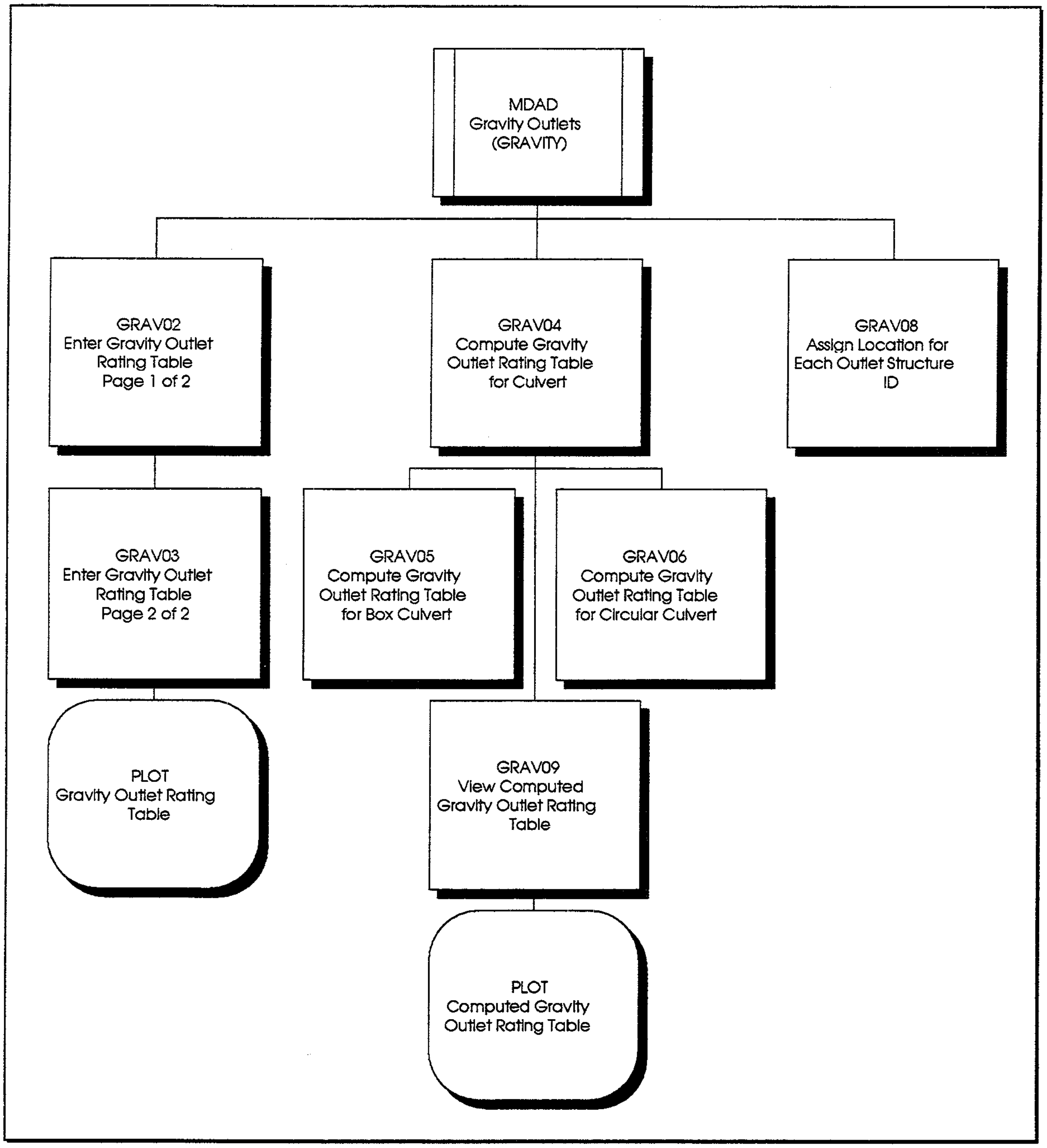


FIGURE 6.4 GRAVITY Module Structure

The HEC-IFH program can use up to twenty-five (25) gravity outlets in each interior analysis. These gravity outlets discharge water from the interior ponding area. The gravity outlets and pumps may be separated from the interior ponding area by an interior ditch, as described in Chapter 5, which may limit the total outflow capacity of the interior system. For interior analyses, the culvert headwater is the interior ponding elevation and the culvert tailwater is the exterior stage. Two items of information are required for each gravity outlet:

- A **gravity outlet rating table** which lists the headwater depth required for a range of outlet flow rates and tailwater depths. During the interior analysis, the discharge rate of each gravity outlet is computed using this table. This table may be entered by the user, or computed by the HEC-IFH program for circular or box culverts.
- The **gravity outlet location**. This allows HEC-IFH to adjust the exterior stage or tailwater condition to match the actual location of each gravity outlet.

Figure 6.4 shows the structure of the HEC-IFH program screens which deal with data entry and plotting for gravity outlets. As this figure indicates, HEC-IFH provides the capability of computing as well as entering a gravity outlet rating table. Rating tables may be computed for box culverts as well as pipe culverts. After the rating tables are computed, the location of each outlet must be specified.

The Continuous Simulation and Hypothetical Event analysis approaches both use the same gravity outlet data entry screens. Figure 6.5 illustrates the main menu screen of the GRAVITY module.

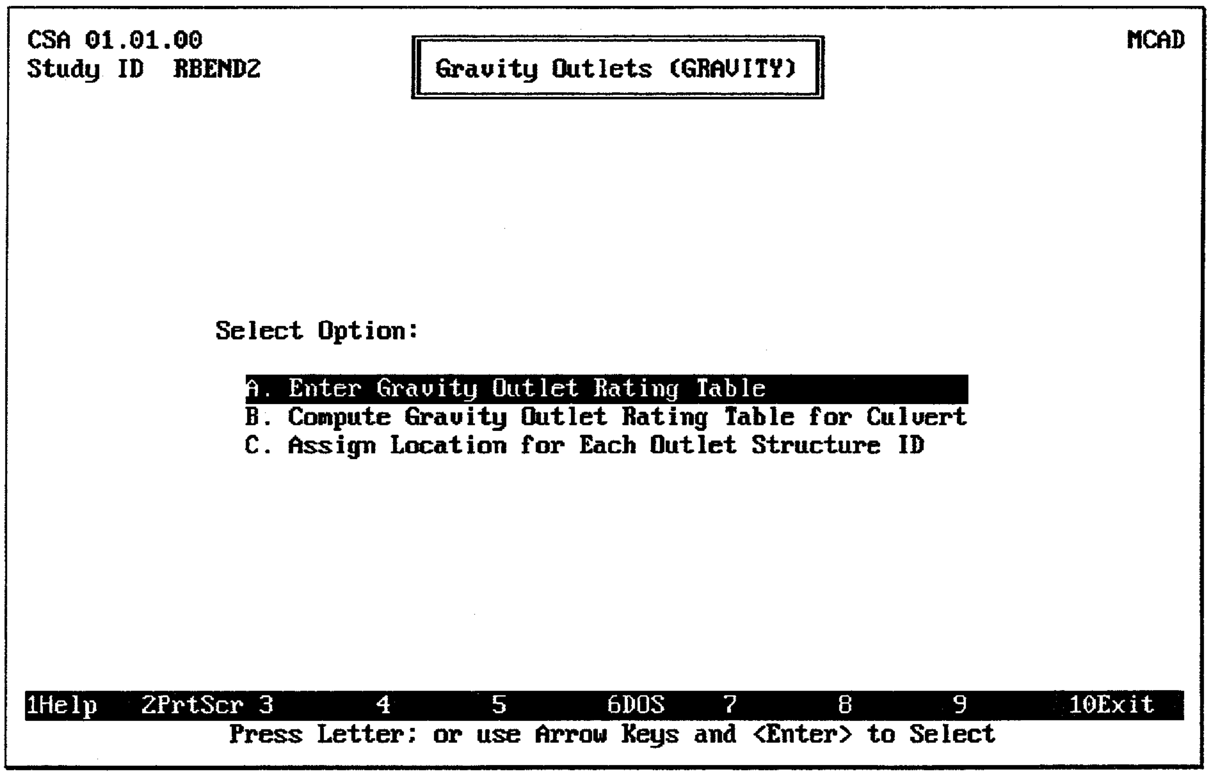


FIGURE 6.5 GRAVITY Module Menu Screen

6.2. ENTERING GRAVITY OUTLET RATING TABLE

A user-defined outlet rating curve may be directly input to the HEC-IFH program. This allows the external preparation of rating data to determine head losses through outlet structures.

Some preliminary information about the gravity outlet is required before the actual rating table is entered. The preliminary information is entered on Gravity Outlet Rating Table Data Entry Screen 1, which is illustrated in Figure 6.6.

The **Outlet Structure ID** is a string of alphanumeric characters used to assign a unique identity to the structure. Up to 8 characters may be used. Several gravity outlet rating tables may be entered, with each one stored under a different Outlet Structure ID. When the cursor is on the Outlet Structure ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding rating table will be loaded for review or revision.

The 40-character **Description** is used to provide documentation for each gravity outlet rating table.

The gravity outlet rating table may represent a number of identical outlets. If the **Number of Identical Outlets** is greater than 1, the total discharge from the outlet installation is computed as the discharge capacity of each outlet times the number of outlets. This feature eliminates the need to enter the same gravity outlet rating table several times to represent identical outlets. Any integer number of one (1) or more may be specified.

The **Exterior Invert Elevation** and the **Interior Invert Elevation** define the minimum elevations of the outlet at its exterior (riverside) and interior (landside) ends, respectively. No flow can occur through the gravity outlet until the interior ponding elevation exceeds the interior invert elevation for the outlet. Figure 6.3 illustrates these elevations. Both elevation values must fall within the range of valid elevations described in Chapter 2.

The optional **Exterior Elevation for Gate Closure** is the exterior stage elevation at which gravity flows through the line of protection are assumed to cease. In other words, whenever the exterior stage exceeds the Exterior Elevation for Gate Closure, the HEC-IFH program sets the gravity outlet discharge equal to zero. This models the operation of interior systems in which gates on the gravity outlets are automatically or manually closed when the exterior stage reaches a critically high value.

If a value for gate closure is not entered or is zero, the gravity outlet will be open whenever the interior elevation exceeds some minimum value. This is the **Minimum Head for Gravity Outlet Operation**, which is specified during the Perform Interior Analysis data input as described in Chapter 10. The gravity outlet will be closed for all other conditions. In other words, no backflow through the outlet will occur when exterior elevation exceeds interior elevation.

The **Cross-Sectional Area of Each Outlet** must also be entered. This value is not used in any computations, but is listed in various summary reports for comparison with other outlets. A value greater than zero (0) must be entered.

After entering the preliminary information on Gravity Outlet Rating Table Data Entry Screen 1, the actual rating table values are entered on Gravity Outlet Rating Table Data Entry Screen 2, which is illustrated in Figure 6.7. The table represents a matrix of headwater values for combinations of up to 7 **Tailwater** values (across the top of the screen) and up to 20 **Flow Capacity** values (down the left side of the screen).

CSA 01.01.00 GRAV02
Study ID RBEND2

Gravity Outlets (GRAVITY)

Enter Gravity Outlet Rating Table - Page 1 of 2

Outlet Structure ID 4X4BOX2
Description Example of 4x4 Box Culvert Outlet

Number of Identical Outlets 1

Exterior Invert Elevation (ft) 589.00

Interior Invert Elevation (ft) 591.00

Exterior Elevation for Gate Closure (ft) 605.00
(optional)

Cross-sectional Area, Each Outlet (sqft) 16.00

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Press <F10> for Next Screen

FIGURE 6.6 Gravity Outlet Rating Table Data Entry Screen 1

CSA 01.01.00 GRAV03
Study ID RBEND2
Struc.ID 4X4BOX2

Gravity Outlets (GRAVITY)

Enter Gravity Outlet Rating Table - Page 2 of 2

Flow Capacity (cfs)	Headwater Elevation (ft)						
	No TailWater	TailWater Elev. 1 593.00	TailWater Elev. 2 597.00	TailWater Elev. 3 601.00	TailWater Elev. 4 605.00	TailWater Elev. 5 609.00	TailWater Elev. 6 613.00
0.0	591.00	593.00	597.00	601.00	605.00	609.00	613.00
20.0	592.56	593.05	597.05	601.05	605.05	609.05	613.05
40.0	593.30	593.30	597.22	601.22	605.22	609.22	613.22
60.0	594.04	594.04	597.49	601.49	605.49	609.49	613.49
80.0	594.71	594.71	597.87	601.87	605.87	609.87	613.87
100.0	595.34	595.34	598.36	602.36	606.36	610.36	614.36
120.0	596.29	596.29	598.96	602.96	606.96	610.96	614.96
140.0	597.17	597.17	599.66	603.66	607.66	611.66	615.66
160.0	598.07	598.07	600.48	604.48	608.48	612.48	616.48
180.0	599.09	599.09	601.40	605.40	609.40	613.40	617.40
200.0	600.24	600.24	602.44	606.44	610.44	614.44	618.44

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE 6.7 Gravity Outlet Rating Table Data Entry Screen 2

The first flow capacity and tailwater values are always zero (0). Each succeeding flow capacity and tailwater value should equal or exceed the previous value. If you enter a decreasing value in either series of the table, the program will accept the decreasing value and display it on the data entry screen. However, when you press the F10 key to end data entry, HEC-IFH checks the values which have been entered. If any values decrease, the program increases them to match the next larger value in the table. All tailwater elevations must fall within the valid range of elevations described in Chapter 2.

Pressing the F9 key displays a plot of headwater versus flow rate, as illustrated in Figure 6.8. Each line on the plot represents a different tailwater depth.

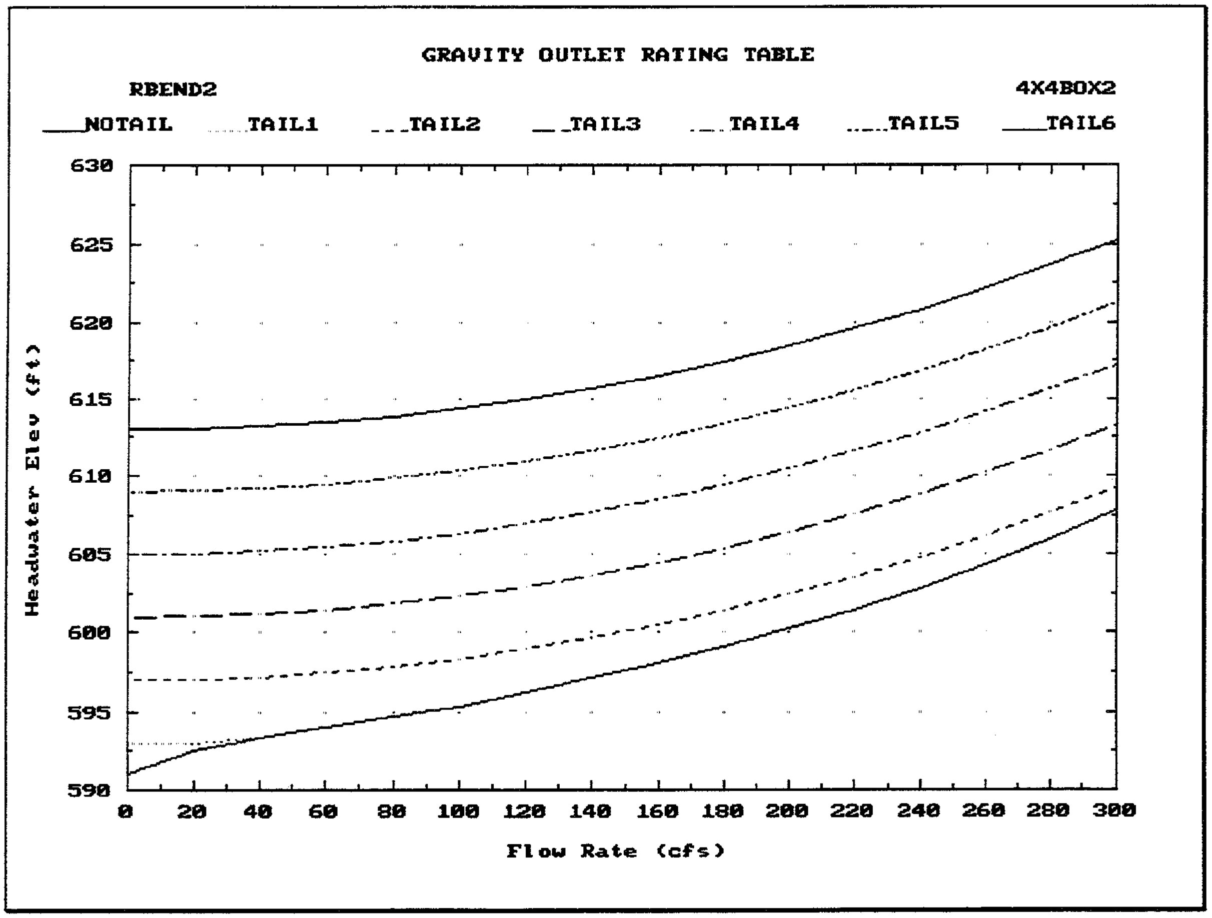


FIGURE 6.8 Gravity Outlet Rating Table Plot

6.3. COMPUTING GRAVITY OUTLET RATING TABLE FOR CULVERTS

The HEC-IFH program will also compute outlet rating tables for circular or box culverts. Some preliminary information about the gravity outlet is required before the rating table can be computed. The preliminary information is entered on the screen illustrated in Figure 6.9.

```
CSA 01.01.00                                                    GRAV04
Study ID  RBEND2          Gravity Outlets (GRAVITY)

              Compute Gravity Outlet Rating Table for Culvert

              Outlet Structure ID  4X4BOX
              Description          Single 4x4 Box culvert.

              Culvert Type:                         [Box] Circular

              Number of Identical Outlets                  1
              Length (ft)                             200.00
              Manning's n                           0.012000
              Entrance Loss Coefficient             0.400000

            * Tailwater Tabulation Interval (ft)        4.00
           ** Flow Capacity Tabulation Interval (cfs)   20.0

              Exterior Outlet Invert Elevation (ft)   589.00
              Interior Outlet Invert Elevation (ft)   591.00
              Exterior Elevation for Gate Closure (ft) 605.00

* 1/7th the expected elevation range      ** 1/20th the expected flow range
1Help  2PrtScr 3Index  4    5    6DOS   7    8    9    10Exit
                  Press <F10> to Save Data and Return
```

FIGURE 6.9 Data Entry Screen for Culvert Computations

The **Outlet Structure ID** is a string of alphanumeric characters used to assign a unique identity to the structure. Up to 8 characters may be used. Several gravity outlet rating tables may be computed, with each one stored under a different Outlet Structure ID. When the cursor is on the Outlet Structure ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding culvert data will be loaded for editing.

The 40-character **Description** is used to provide documentation for each computed gravity outlet rating table.

The culvert data may represent a number of identical culverts. If the **Number of Identical Outlets** is greater than 1, the total discharge from the outlet installation is computed as the discharge capacity of each culvert times the number of culverts. The number of identical culverts may be any integer number greater than zero (0).

The **Manning 'n' Value** and the **Entrance Loss Coefficient** are described in the following sections. The **Culvert Length** is illustrated in Figure 6.10. It must be greater than zero (0).

The **Tailwater Tabulation Interval** is the tailwater (exterior stage) elevation increment at which HEC-IFH computes rating table values. The computed rating table begins with a tailwater of zero, and each succeeding tailwater value is incremented by the tailwater tabulation interval. A value greater than zero (0) must be entered.

The **Flow Capacity Tabulation Interval** is the flow rate increment used by HEC-IFH to compute rating table values. The computed rating table begins with a flow capacity of zero, and each succeeding flow capacity value is incremented by the flow capacity tabulation interval. This tabulation interval must also be greater than zero (0). Together, the tailwater and flow capacity tabulation intervals form a matrix for computing and displaying a rating table. Internally, the HEC-IFH program uses a 50 by 50 computed rating table during pond routing computations.

The **Exterior Invert Elevation** and the **Interior Invert Elevation** define the minimum elevations of the outlet at its exterior (riverside) and interior (landside) ends, respectively. No flow can occur through the culvert until the interior ponding elevation exceeds the interior invert elevation. Figure 6.10 illustrates these invert elevations. Both of these elevations must fall within the range of valid elevation values described in Chapter 2. In addition, the Interior Invert Elevation must be greater than or equal to the Exterior Invert Elevation. In other words, the culvert barrel must have a positive slope or be horizontal. An adverse slope is not allowed.

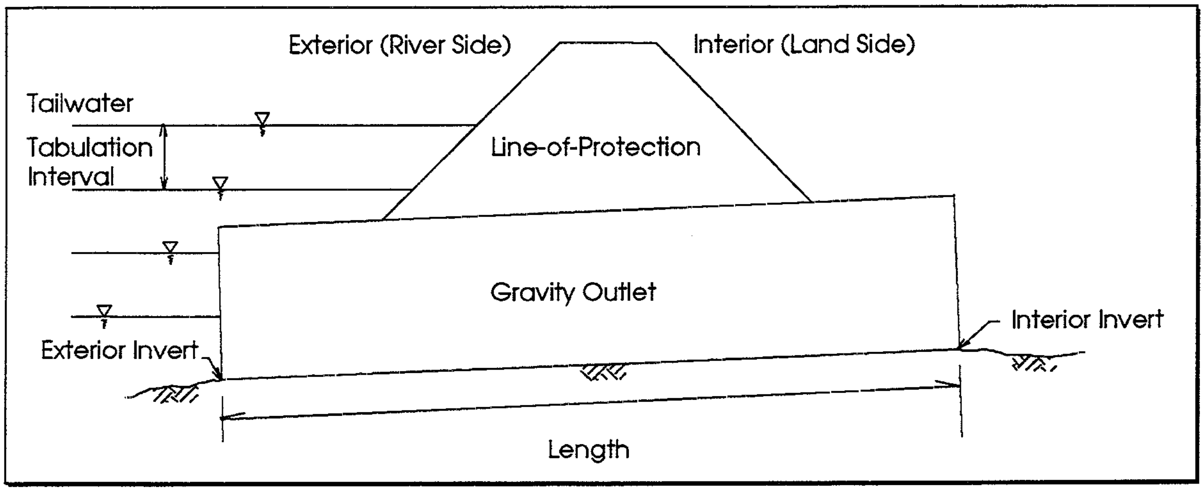


FIGURE 6.10 Gravity Outlet Structure

The optional **Exterior Elevation for Gate Closure** is the exterior stage elevation at which gravity flows through the line of protection are assumed to cease. In other words, whenever the exterior stage exceeds the Exterior Elevation for Gate Closure, the HEC-IFH program sets the gravity outlet discharge equal to zero. This models the operation of interior systems in which sluice gates on the gravity outlets are automatically or manually closed when the exterior stage reaches a critically high value. If this value is not entered, the gravity outlet is assumed to remain open under all conditions. However, no backflow is ever assumed to occur through the gravity outlets.

The exterior elevation for gate closure, if entered, must fall within the valid range of elevation values described in Chapter 2. In addition, the gate closure elevation must equal or exceed the exterior invert elevation for the gravity outlet.

6.3.1. Manning 'n' Value

The Manning "n" Value is used by the program to compute friction losses for flows through the outlet structure. Any value greater than zero but less than one may be entered. Tables 6.1 and 6.2 list Manning roughness coefficients for a wide variety of culvert materials.

TABLE 6.1 Manning 'n' for Closed Metal Conduits Flowing Partly Full

Type of Metal and Description	Minimum	Normal	Maximum
Smooth Brass	0.009	0.010	0.013
Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
Iron:			
Coated Cast Iron	0.010	0.013	0.014
Uncoated Cast Iron	0.011	0.014	0.016
Black Wrought iron	0.012	0.014	0.015
Galvanized Wrought iron	0.013	0.016	0.017
Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Storm drain	0.021	0.024	0.030

Source: [CHOW, 1959, TABLE 5-6]

TABLE 6.2 Manning 'n' for Closed Non-Metal Conduits Flowing Partly Full

Type of Material and Description	Minimum	Normal	Maximum
Lucite:	0.008	0.009	0.010
Glass:	0.009	0.010	0.013
Cement:			
Neat, surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
Concrete:			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Straight sewer with manholes, inlets, etc.	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.020
Wood:			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified subdrain with open joint	0.014	0.016	0.018
Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections:	0.012	0.013	0.016
Paved invert, sewer, smooth bottom:	0.016	0.019	0.020
Rubble masonry, cemented:	0.018	0.025	0.030

Source: [CHOW, 1959, TABLE 5-6]

TABLE 6.3 Manning 'n' for Corrugated Metal Pipe

Type of Pipe and Diameter	Unpaved	25% Paved	Fully Paved
Annular Corrugations			
2.67 x 1/2 in. (all diameters)	0.024	0.021	0.012
3 x 1 in. (all diameters below 48 inch)	0.027	0.023	0.012
1.50 x 1/4 inch Helical Corrugations			
8 inch diameter	0.012	—	—
10 inch diameter	0.014	—	—
2.67 x 1/2 inch Helical Corrugations			
12 inch diameter	0.011	—	—
18 inch diameter	0.014	—	—
24 inch diameter	0.016	0.015	0.012
36 inch diameter	0.019	0.017	0.012
48 inch diameter	0.020	0.020	0.012
60 inch & larger	0.021	0.019	0.012
3 x 1 inch Helical Corrugations			
48 inch diameter	0.023	0.020	0.012
54 inch diameter	0.023	0.020	0.012
60 inch diameter	0.024	0.021	0.012
66 inch diameter	0.025	0.022	0.012
72 inch diameter	0.026	0.022	0.012
78 inch & larger	0.027	0.023	0.012
6 x 2 inch Corrugations			
60 inch diameter	0.033	0.028	—
72 inch diameter	0.032	0.027	—
120 inch diameter	0.030	0.026	—
180 inch diameter	0.028	0.024	—

Source: American Iron and Steel Institute's "Modern Sewer Design".

6.3.2. Entrance Loss Coefficient

Entrance and exit loss coefficients are used to compute so-called *minor losses*, or *form losses*, due to the contraction and expansion of flow at the upstream and downstream ends of a gravity outlet. Tables 6.4 and 6.5 contain appropriate values of entrance loss coefficients for various outlet shapes and headwall configurations. Any value of zero (0) or more may be used for the entrance loss coefficient. The exit loss coefficient is set equal to 1.0.

TABLE 6.4 Entrance Loss Coefficient for Box Culverts

Type of Structure and Design of Entrance	Coefficient
Headwall parallel to embankment (no wingwalls):	
Square edge of three edges	0.50
3 edges rounded to radius of 1/12 barrel dimension	0.20
Wingwalls at 15 to 45 degrees to barrel:	
Square-edge top corner	0.40
Top corner rounded to radius of 1/12 barrel dimension	0.20

SOURCE: "Street and Highway Drainage", Institute of Transportation and Traffic Engineering, University of California at Berkeley, 1969.

TABLE 6.5 Entrance Loss Coefficient for Circular Culverts

Type of Structure and Design of Entrance	Coefficient
Concrete Pipe Projecting from Fill (no headwall):	
Socket end of pipe	0.20
Square cut end of pipe	0.50
Concrete Pipe with Headwall or headwall and wingwalls:	
Socket end of pipe	0.10
Square cut end of pipe	0.50
Rounded entrance, with rounding radius = 1/12 of diameter	0.10
Corrugated Metal Pipe:	
Projecting from fill (no headwall)	0.80
With Headwall or headwall and wingwalls, square edge	0.50

6.3.3. Box Culvert Data

If a box culvert is specified, a special data entry screen is used to enter specific data about the box culvert. Figure 6.11 illustrates the box culvert data entry screen.

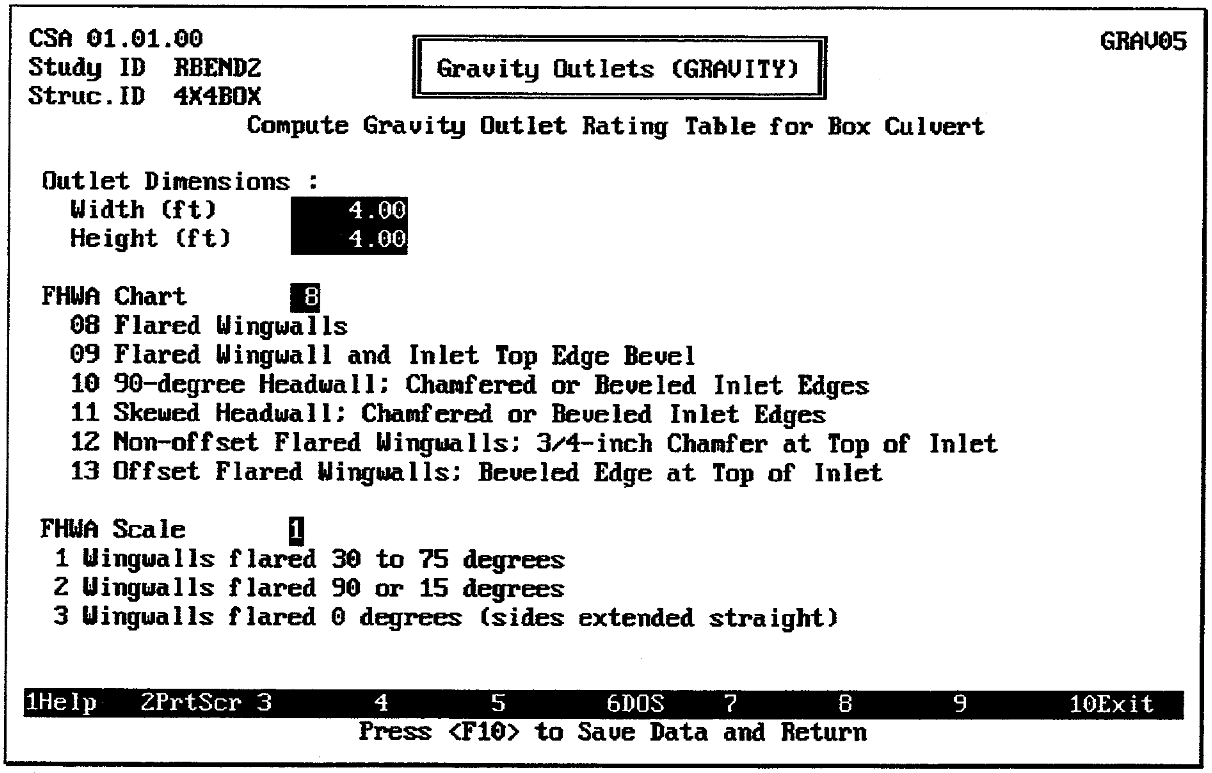


FIGURE 6.11 Box Culvert Data Entry Screen

The **Width** (span) and **Height** (rise) of the box culvert opening must be entered. Figure 6.2 on page 6-95 illustrates these dimensions. Both values must be greater than zero (0).

The **FHWA Chart Number** and **FHWA Scale Number** refer to a series of nomographs published by the Bureau of Public Roads (now the Federal Highway Administration) in 1965 [BPR, 1965], which allowed the inlet control headwater to be computed for different types of culverts operating under a wide range of flow conditions. These nomographs and others constructed using the original methods were republished in 1985 [FHWA, 1985].

Each of the FHWA charts has from two to four separate scales representing different culvert entrance designs. The appropriate FHWA Chart Number and Scale Number should be chosen according to the type of culvert and culvert entrance. Chart Numbers 8, 9, 10, 11, 12, and 13 apply only to box culverts. HEC-IFH automatically displays the available Scale Numbers for each FHWA Chart Number on the data entry screen. The program also checks the value of the Scale Number to assure that it is available for the given Chart Number. For example, a Scale Number of 4 would be available for Chart 11, but not for Chart 12.

Table 6.6 lists the FHWA Chart and Scale Number for Box Culverts. Figures 6.12 through 6.17 illustrate the culvert inlets corresponding to various box culvert charts.

TABLE 6.6 FHWA Chart and Scale Numbers for Box Culverts

Chart	Scale	Description
8		Box Culvert with Flared Wingwalls (see Figure 6.12)
	1	Wingwalls flared 30 to 75 degrees
	2	Wingwalls flared 90 or 15 degrees
	3	Wingwalls flared 0 degrees (sides extended straight)
9		Box Culvert with Flared Wingwall and Inlet Top Edge Bevel (see Figure 6.13)
	1	Wingwall flared 45 degrees; Inlet top edge bevel = 0.043D
	2	Wingwall flared 18 to 33.7 degrees; Inlet top edge bevel = 0.083D
10		Box Culvert; 90-degree Headwall; Chamfered or Beveled Inlet Edges (see Figure 6.14)
	1	Inlet edges chamfered 3/4-inch
	2	Inlet edges beveled 1/2-in/ft at 45 degrees (1:1)
	3	Inlet edges beveled 1-in/ft at 33.7 degrees (1:1.5)
11		Box Culvert; Skewed Headwall; Chamfered or Beveled Inlet Edges (see Figure 6.15)
	1	Headwall skewed 45 degrees; Inlet edges chamfered 3/4-inch
	2	Headwall skewed 30 degrees; Inlet edges chamfered 3/4-inch
	3	Headwall skewed 15 degrees; Inlet edges chamfered 3/4-inch
	4	Headwall skewed 10 to 45 degrees; Inlet edges beveled
12		Box Culvert; Non-Offset Flared Wingwalls; 3/4-inch Chamfer at Top of Inlet (see Figure 6.16)
	1	Wingwalls flared 45 degrees (1:1); Inlet not skewed
	2	Wingwalls flared 18.4 degrees (3:1); Inlet not skewed
	3	Wingwalls flared 18.4 degrees (3:1); Inlet skewed 30 degrees
13		Box Culvert; Offset Flared Wingwalls; Beveled Edge at Top of Inlet (see Figure 6.17)
	1	Wingwalls flared 45 degrees (1:1); Inlet top edge bevel = 0.042D
	2	Wingwalls flared 33.7 degrees (1.5:1); Inlet top edge bevel = 0.083D
	3	Wingwalls flared 18.4 degrees (3:1); Inlet top edge bevel = 0.083D

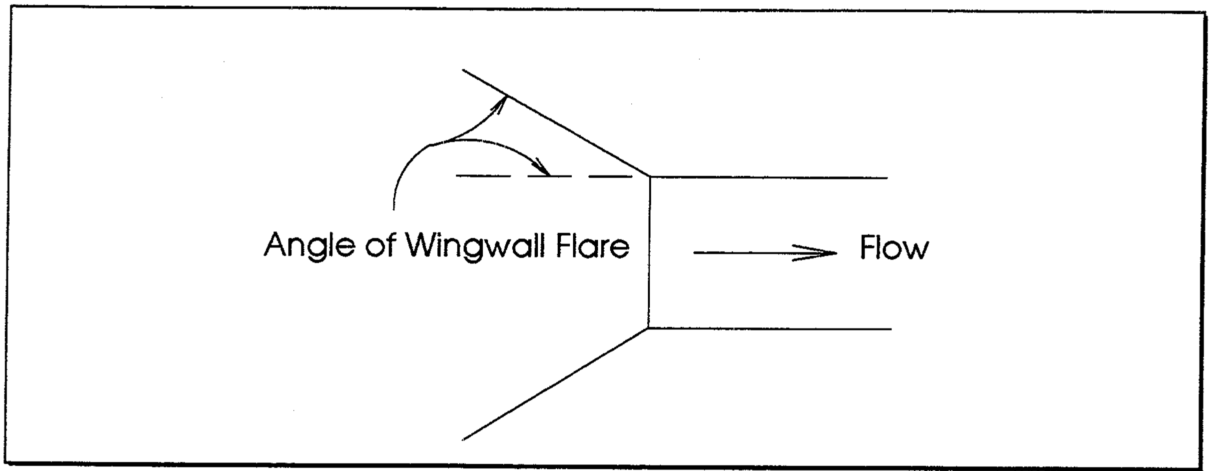


FIGURE 6.12 Flared Wingwalls (Chart 8)

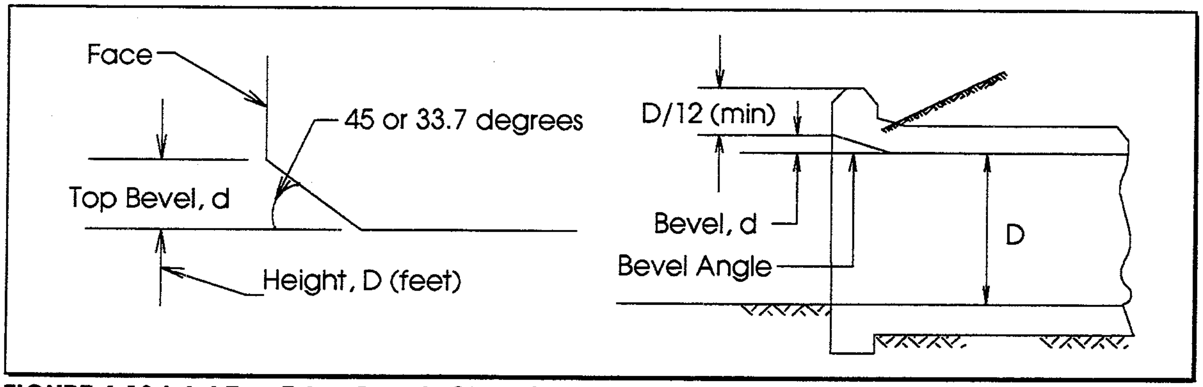


FIGURE 6.13 Inlet Top Edge Bevel (Chart 9)

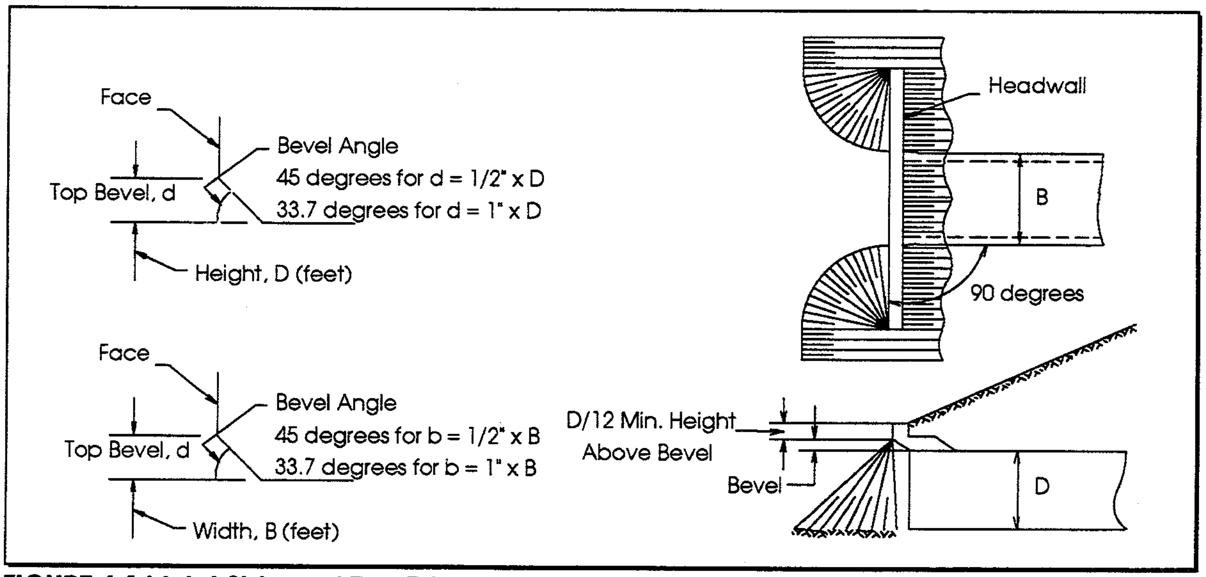


FIGURE 6.14 Inlet Side and Top Edge Bevel with 90-degree Headwall (Chart 10)

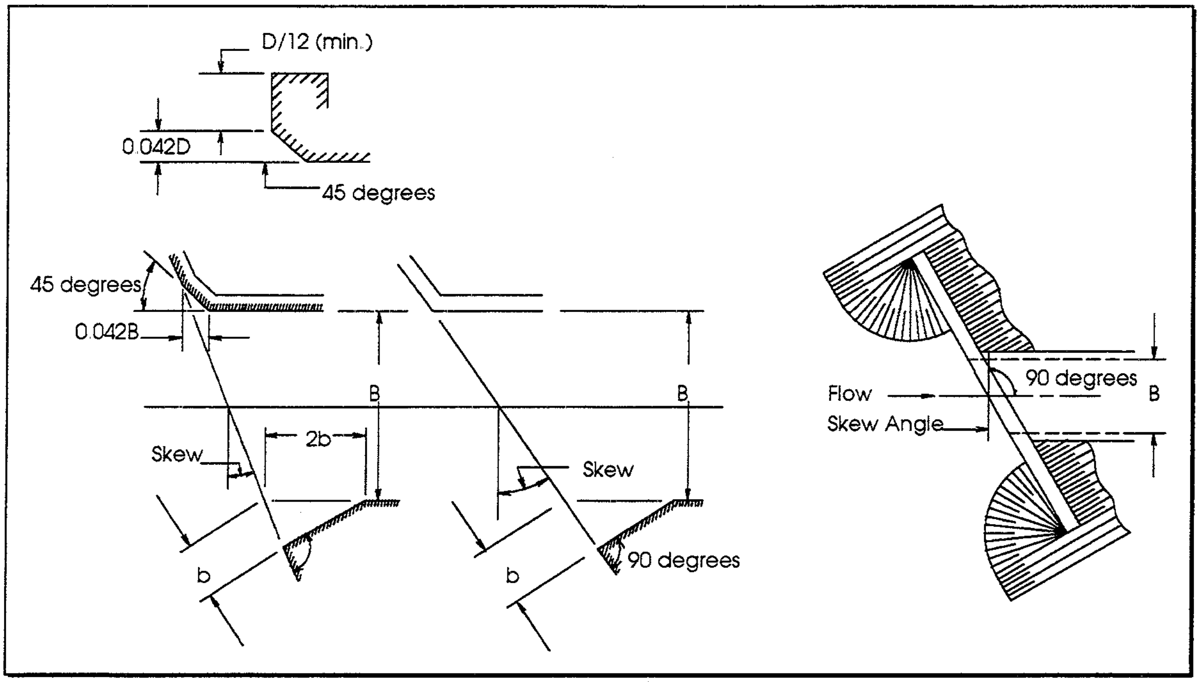


FIGURE 6.15 Inlet Side and Top Edge Bevel with Skewed Headwall (Chart 11)

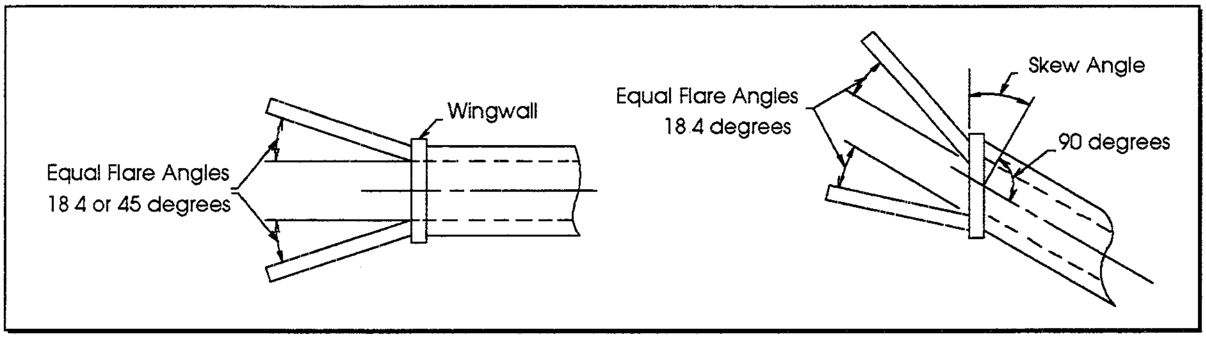


FIGURE 6.16 Non-Offset Flared Wingwalls (Chart 12)

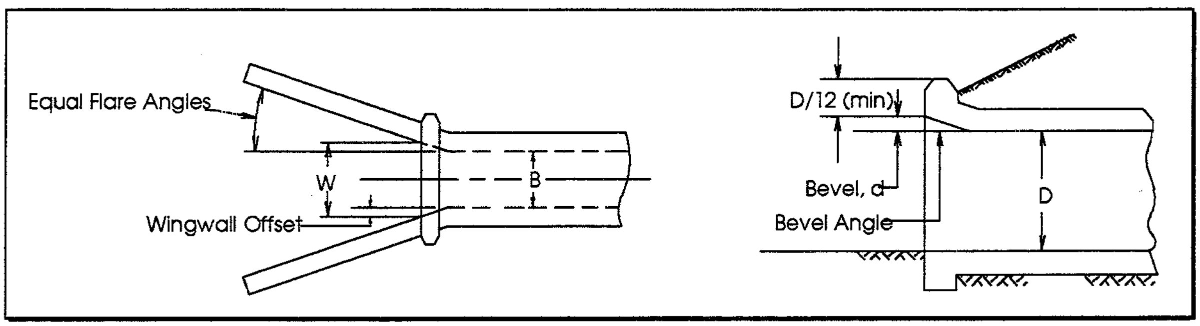


FIGURE 6.17 Offset Flared Wingwalls (Chart 13)

6.3.4. Circular Culvert Data

If a circular culvert is specified, a special data entry screen is used to enter specific data about the circular culvert. Figure 6.18 illustrates the circular culvert data entry screen.

```
CSA 01.01.00                                                              GRAV06
Study ID  RBEND2          | Gravity Outlets (GRAVITY) |
Struc.ID  4X4BOX
              Compute Gravity Outlet Rating Table for Circular Culvert


 Outlet Dimensions :
   Diameter (in)     48.00

 FHWA Chart        1
   1 Concrete
   2 Corrugated Metal
   3 Concrete: Beveled Ring Entrance

 FHWA Scale        1
  1 Square edge Entrance with headwall
  2 Groove end Entrance with headwall
  3 Groove end Entrance, pipe projecting from fill



1Help  2PrtScr 3      4       5       6DOS    7       8       9       10Exit
                        Press <F10> to Save Data and Return
```

FIGURE 6.18 Circular Culvert Data Entry Screen

The **Diameter** of the circular culvert opening must be entered. A value greater than zero (0) must be used. Figure 6.1 illustrates the culvert diameter.

TABLE 6.7 FHWA Chart and Scale Numbers for Circular Culverts

Chart	Scale	Description
1		Concrete Pipe Culvert
	1	Square edge Entrance with headwall (see Figure 6.19)
	2	Groove end Entrance with headwall (see Figure 6.19)
	3	Groove end Entrance, pipe projecting from fill (see Figure 6.21)
2		Corrugated Metal Pipe Culvert
	1	Headwall (see Figure 6.19)
	2	Mitered to conform to slope (see Figure 6.20)
	3	Pipe projecting from fill (see Figure 6.21)
3		Concrete Pipe Culvert; Beveled Ring Entrance (see Figure 6.22)
	1(A)	Small bevel: b/D = 0.042; a/D = 0.063; c/D = 0.042; d/D = 0.083
	2(B)	Large bevel: b/D = 0.083; a/D = 0.125; c/D = 0.042; d/D = 0.125

Note: For Chart 3, enter Scale Number 1 for Scale A and Scale Number 2 for Scale B.

The **FHWA Chart Number** and **FHWA Scale Number** are described in the section entitled "Box Culvert Data" beginning on page 105. Chart Numbers 1, 2, and 3 apply only to pipe culverts. Table 6.7 and Figures 6.19 through 6.22 can be used for guidance in determining which Chart and Scale Numbers to select for various types of culvert inlets. HEC-IFH automatically displays the available Scale Numbers for each FHWA Chart Number on the data entry screen.

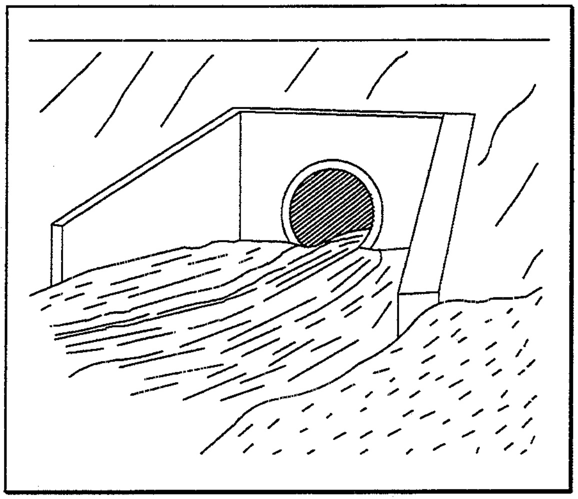


FIGURE 6.19 Inlet with Headwall and Wingwalls

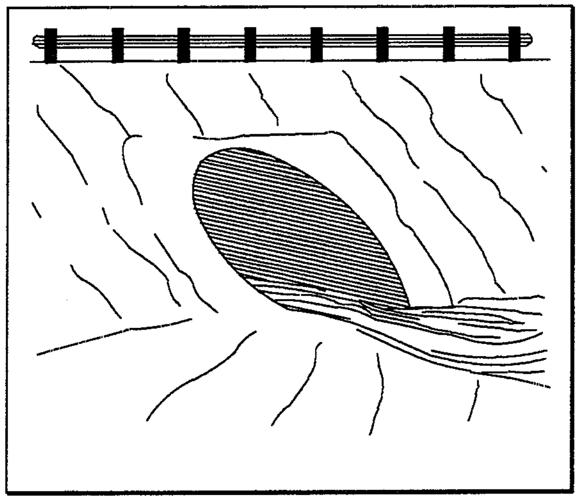


FIGURE 6.20 Inlet Mitered to Conform to Slope

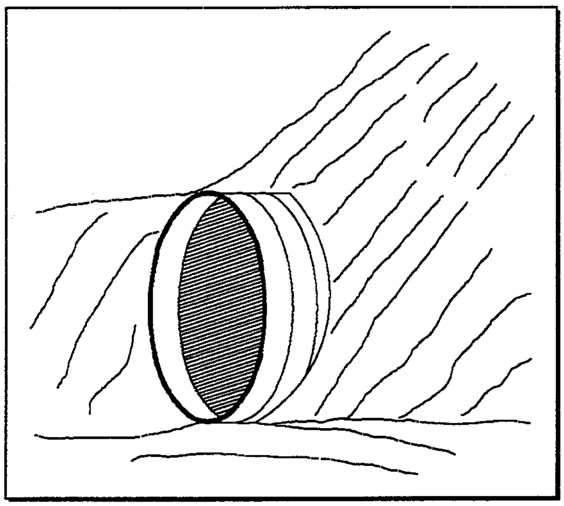


FIGURE 6.21 Culvert Inlet Projecting from Fill

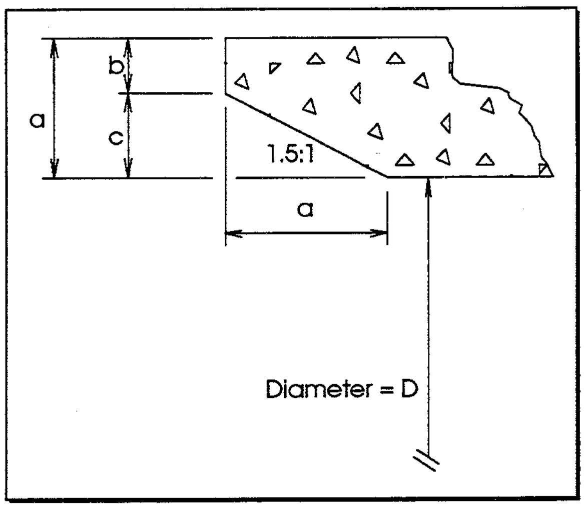


FIGURE 6.22 Inlet with Beveled Ring Entrance

6.4. VIEWING COMPUTED GRAVITY OUTLET RATING TABLE

The analysis of flow in culverts is quite complicated. It is common to use the concepts of "Inlet Control" and "Outlet Control" to simplify the analysis. ***Inlet Control*** flow occurs when the flow capacity of the culvert entrance is less than the flow capacity of the culvert barrel. ***Outlet Control*** flow occurs when the culvert capacity is limited by downstream conditions or by the flow capacity of the culvert barrel. HEC-IFH computes the headwater required to produce a given flow rate through the culvert for Inlet Control conditions and for Outlet Control conditions. The higher headwater "controls" and determines the type of flow in the culvert for a given flow rate and tailwater condition. On the computed gravity outlet rating table, inlet control headwater values are indicated by asterisks (*). Figure 6.23 illustrates a computed gravity outlet rating table.

CSA 01.01.00 GRAV09
Study ID RBEND2
Struc.ID 4X4BOX

Gravity Outlets (GRAVITY)

View Computed Gravity Outlet Rating Table

Flow Capacity (cfs)	Headwater Elevation (ft)						
	No TailWater	TailWater Elev. 1 593.00	TailWater Elev. 2 597.00	TailWater Elev. 3 601.00	TailWater Elev. 4 605.00	TailWater Elev. 5 609.00	TailWater Elev. 6 613.00
0.0	591.00	593.00	597.00	601.00	605.00	609.00	613.00
20.0	* 592.42	593.05	597.05	601.05	605.05	609.05	613.05
40.0	* 593.30	* 593.30	597.22	601.22	605.22	609.22	613.22
60.0	* 594.04	* 594.04	597.49	601.49	605.49	609.49	613.49
80.0	* 594.71	* 594.71	597.87	601.87	605.87	609.87	613.87
100.0	* 595.34	* 595.34	598.36	602.36	606.36	610.36	614.36
120.0	* 596.29	* 596.29	598.96	602.96	606.96	610.96	614.96
140.0	* 597.17	* 597.17	599.66	603.66	607.66	611.66	615.66
160.0	* 598.07	* 598.07	600.48	604.48	608.48	612.48	616.48
180.0	* 599.09	* 599.09	601.40	605.40	609.40	613.40	617.40
200.0	* 600.24	* 600.24	602.44	606.44	610.44	614.44	618.44

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

* Inlet Control Press <PgDn>, <PgUp> or <F10>

FIGURE 6.23 Computed Gravity Outlet Rating Table

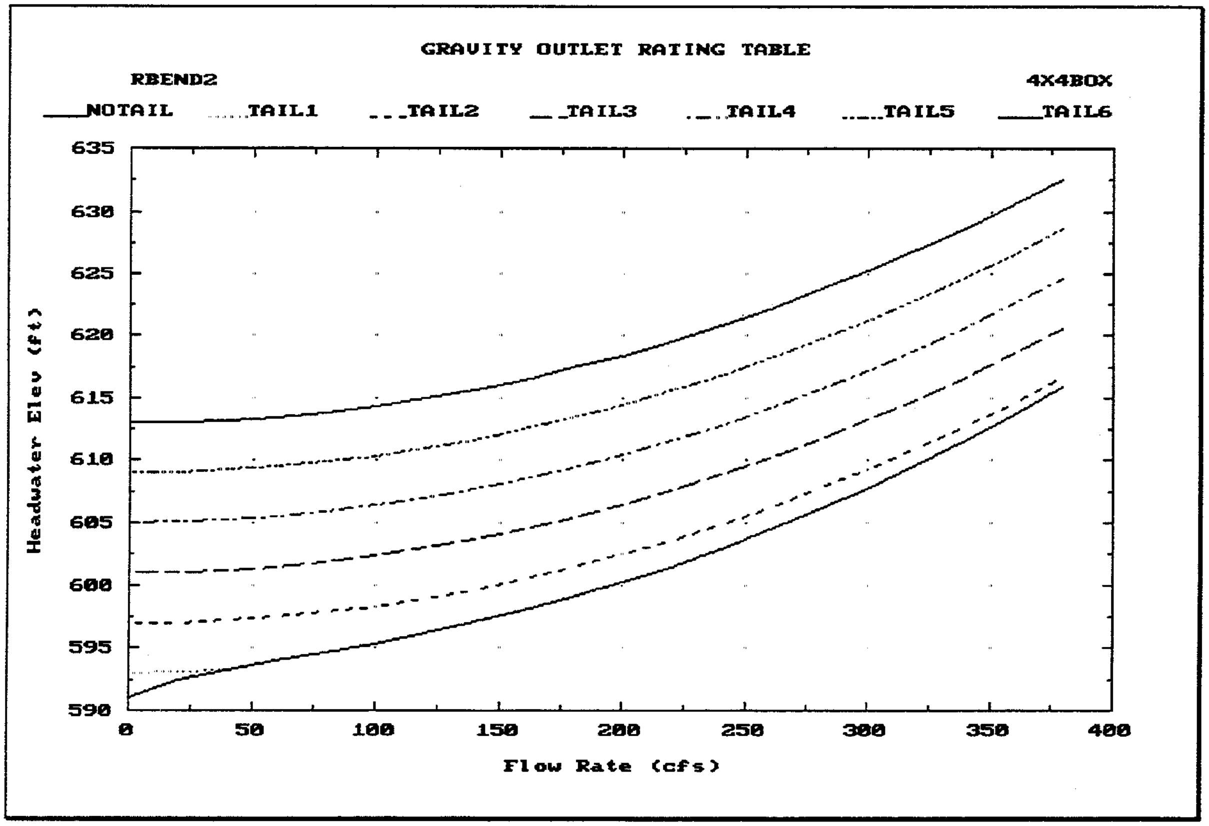


FIGURE 6.24 Computed Gravity Outlet Rating Table Plot

For Inlet Control, the required headwater is computed by assuming that the culvert inlet acts as an orifice or as a weir. Therefore, the Inlet Control capacity depends primarily on the geometry of the culvert entrance. The inlet control headwater for a circular or box culvert is computed using the methods applied in the HEC-2 computer program. These methods were developed by Dodson & Associates, Inc. based on equations developed by the Federal Highway Administration.

For Outlet Control, the required headwater is computed by taking the depth of flow at the culvert outlet, adding all head losses, and subtracting the change in flow-line elevation of the culvert from the upstream to downstream end. HEC-IFH considers the entrance losses, the friction loss in the culvert barrel, and the loss of velocity head at the outlet in computing the outlet control headwater of the culvert. The outlet control headwater is computed using the same methods used in the HEC-2 computer program. These methods are described later in this section.

Pressing the F9 key displays a plot of headwater versus flow rate, as illustrated in Figure 6.24. Each line on the plot represents a different tailwater depth.

6.4.1. Internally Computed Gravity Outlet Rating Table

The program uses an expanded and "inverted" rating table to determine gravity outlet discharge for any headwater and tailwater elevation. The inverted rating table has discharge rather than headwater elevation as the internal element. A 50 by 50 matrix of headwater and tailwater elevation versus discharge is constructed. Headwater elevations used in the table range from the elevation of the bottom of the pond to the maximum interior elevation specified for the pond surface area-elevation table. Tailwater elevations used in the table range from the gravity outlet invert elevation to the maximum interior elevation specified for the pond surface area-elevation table. This arrangement simplifies the interpolation of culvert discharge during interior analyses and allows for a more accurate determination of discharge than the data presented on the screen in Figure 6.23.

6.4.2. Computing Inlet Control Headwater

For inlet control conditions, the capacity of the culvert is limited by the capacity of the culvert opening, rather than by conditions farther downstream. Extensive laboratory tests by the National Bureau of Standards, the Bureau of Public Roads, and other entities resulted in a series of equations which describe the inlet control headwater under various conditions. These equations form the basis of the FHWA Inlet Control nomographs. [FHWA, 1985].

The FHWA inlet control equations are used by HEC-IFH in computing the inlet control headwater.

The FHWA nomographs are considered to be accurate to within about 10% in determining the required inlet control headwater [FHWA, 1985, P. 154]. The nomographs were computed assuming a culvert slope of 0.02 feet per foot (2%). For different culvert slopes, the nomographs are less accurate because inlet control headwater changes with slope. However, HEC-IFH considers the slope in computing the inlet control headwater. Therefore, the inlet control computations used in HEC-IFH should be more accurate than the FHWA nomographs, for slopes other than 0.02 feet per foot.

6.4.3. Computing Outlet Control Headwater

For outlet control flow, the required headwater must be computed considering several conditions within the culvert and downstream of the culvert. Figure 6.25 illustrates the logic of the outlet control computations.

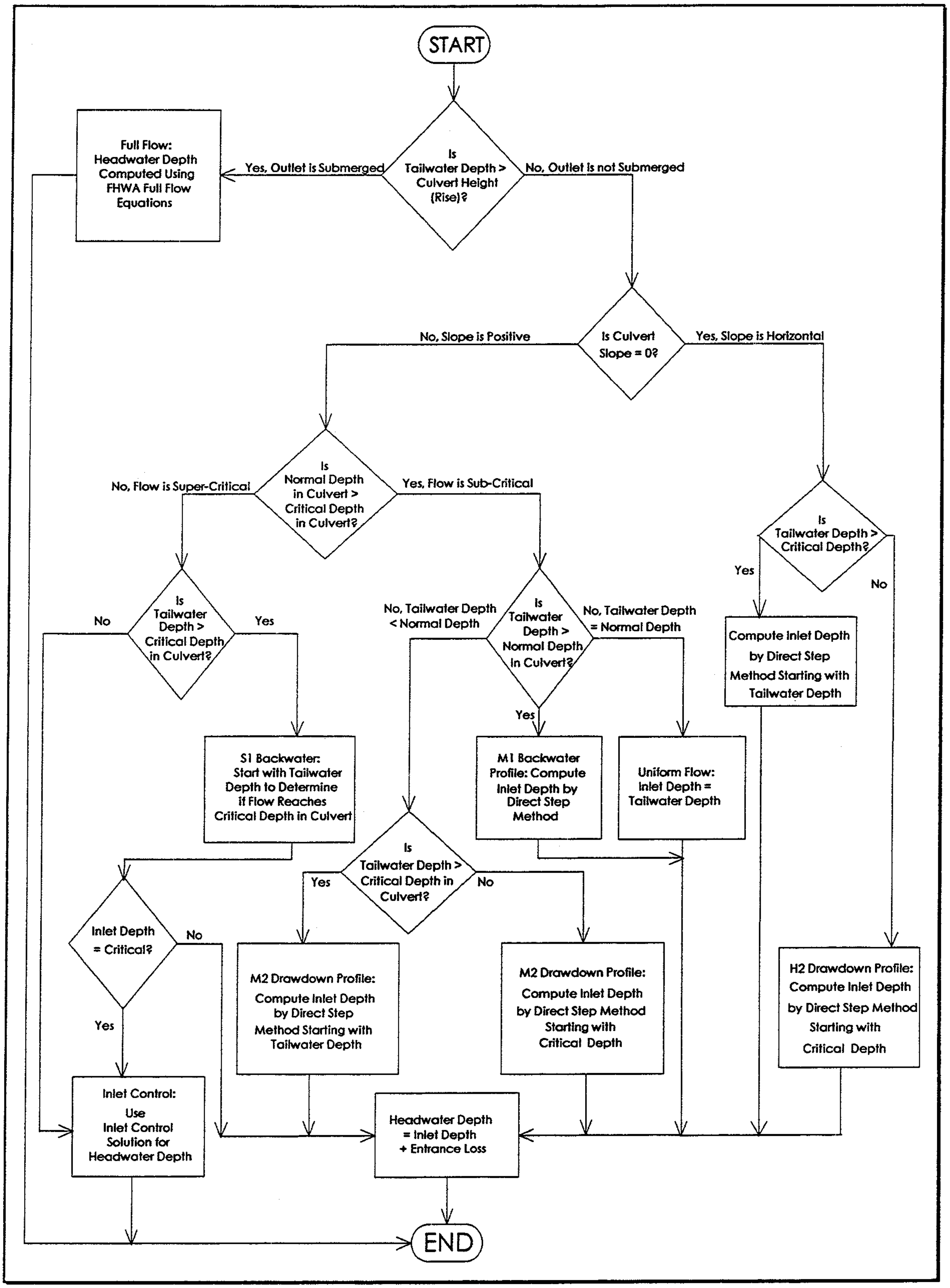


FIGURE 6.25 Flow Chart for Outlet Control Computations

6.4.3.1. FHWA Full Flow Equations

For culverts flowing full, the total ***Head Loss***, or energy loss, through the culvert is measured in feet. The head loss, L_H, is computed using the following formula:

$$L_H = L_E + L_F + L_X \tag{6.1}$$

in which:

L_F = Friction Loss (feet)

L_E = Entrance Loss (feet)

L_X = Exit Loss (feet)

The friction loss in the culvert is computed using Manning's formula, which is expressed as follows:

$$L_F = L\left(\frac{Qn}{1.486AR^{(2/3)}}\right)^2 \tag{6.2}$$

in which:

L_F = Friction Loss (feet)

L = Culvert Length (feet)

Q = Flow Rate in the culvert (cfs)

n = Manning's Roughness Coefficient

A = Area of Flow (square feet)

R = Hydraulic Radius (feet) = (Flow Area)/(Wetted Perimeter)

The entrance loss is computed as described in the section on "Entrance Loss Coefficient" on page 104 of this manual. The exit loss is assumed to equal the velocity head in the culvert.

6.4.3.2. Direct Step Water Surface Profile Computations

For culverts flowing partially full, the water surface profile in the culvert is computed using the Direct Step Method. This method is very efficient, because no iterations are required to determine the flow depth for each step. The water surface profile is computed for small increments of depth (usually between 0.01 and 0.05 feet). If the flow depth equals the height of the culvert before the profile reaches the upstream end of the culvert, the friction loss through the remainder of the culvert is computed assuming full flow.

The Direct Step Method computes the flow depth in the culvert at the inlet. The entrance loss is added to the computed flow depth in the culvert to compute the outlet control headwater.

6.4.3.3. Normal Depth of Flow in the Culvert

Normal Depth is the depth at which uniform flow will occur in an open channel. In other words, for a uniform channel of infinite length, carrying a constant flow rate, flow in the channel would be at a constant depth at all points along the channel, and this would be the Normal Depth.

Normal Depth often represents a good approximation of the actual depth of flow within a channel segment. For Inlet Control conditions, the depth of flow within the culvert is assumed to be equal to Normal Depth. This assumption is only valid if the culvert barrel is sufficiently long to allow the flow depth to stabilize at Normal Depth.

For both box culverts and circular culverts, the program computes Normal Depth using an iterative approach to arrive at a value which satisfies Manning's Equation:

$$Q = \frac{1.486}{n} AR^{(2/3)} \sqrt{S} \qquad 6.3$$

in which:

Q = Flow Rate in the culvert (cfs)

n = Manning's Roughness Coefficient

A = Area of Flow (square feet)

R = Hydraulic Radius (feet) = (Flow Area)/(Wetted Perimeter)

S = Slope of Energy Grade Line = Slope of Culvert Barrel (feet per foot)

6.4.3.4. *Critical Depth of Flow in the Culvert*

Critical depth occurs when the flow in a channel has minimum specific energy. ***Specific energy*** refers to the sum of the depth of flow and the velocity head. At critical depth, the velocity head is equal to one-half the average depth of flow. Critical depth depends only on the channel shape and flow rate. The depth of flow at the culvert outlet is assumed to be equal to critical depth for culverts operating under outlet control with low tailwater. Critical depth may also influence the inlet control headwater for unsubmerged conditions. HEC-IFH computes the critical depth in a pipe culvert by an iterative procedure, which arrives at a value satisfying the following equation:

$$\frac{Q^2}{g} = \frac{A^3}{T} \qquad 6.4$$

in which:

Q = Flow Rate in the culvert (cfs)

g = Acceleration due to gravity (32.2 ft/sec/sec)

A = Cross-sectional area of flow (square feet)

T = Top width of flow (feet)

Critical depth for box culverts is computed by the following equation [AISI, 1980]:

$$y_c = \sqrt[3]{\frac{q^2}{g}} \qquad 6.5$$

in which:

y_c = critical depth (ft)

q = discharge per linear foot of width (cfs/ft)

g = Acceleration due to gravity (32.2 ft/sec/sec)

6.4.3.5. *Horizontal Culvert Slope*

HEC-IFH allows horizontal culverts. As shown in Figure 6.25, the headwater depth for a horizontal culvert is computed using different methods depending on whether sub-critical or super-critical conditions are present in the culvert.

6.5. ASSIGNING LOCATIONS FOR EACH GRAVITY OUTLET STRUCTURE

Like other HEC-IFH data entry modules, the GRAVITY module data is stored under a **Module ID**. Several GRAVITY module data sets may be stored under different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding data will be loaded for editing. The 40-character **Description** is used to provide documentation for each GRAVITY Module data set.

The GRAVITY module data consists of a list of up to 25 different gravity outlets. Each gravity outlet is identified by its Outlet Structure ID. Any **Outlet Structure ID** already entered for the present STUDYID may be selected. When the cursor is on a Structure ID field, the F3 key displays a list of previously-stored IDs. Any of these IDs may be selected.

Each gravity outlet must be located at one of five standard locations: the **Primary**, **Secondary 1**, **Secondary 2**, **Secondary 3**, and **Secondary 4**. Each of these represents an actual physical location along the line of protection. The location is important because the data in the EXSTAGE module (described in Chapter 8) allows the HEC-IFH program to compute different exterior water surface elevations at each location. Up to five outlets may be at each location, or there may be no outlets at a particular location.

The **River/Levee Station** gives the relative location of each outlet structure with respect to distance along the receiving stream or line or protection. This station is used only as a reference for those using HEC-IFH or viewing HEC-IFH results. The River/Levee Station values are not used by the HEC-IFH program for any computations.

CSA 01.01.00 | Gravity Outlets (GRAVITY) | GRAV08

Study ID RBEND2

Assign Location for Each Outlet Structure ID

Module ID OUTLET1

Description 1 - 4x4 box at the primary location.

	Primary Location	Secondary 1 Location	Secondary 2 Location	Secondary 3 Location	Secondary 4 Location
Structure ID	4X4BOX				
Structure ID					
Structure ID					
Structure ID					
Structure ID					
River/Levee Station (mi)	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to Save Data and Return

FIGURE 6.26 Screen to Specify GRAVITY Module Data

You may re-enter the GRAVITY module later in order to change the ID for any outlet, or to enter additional outlets under new Outlet Structure IDs.

CHAPTER 7. Pump Outlets

7.1. INTRODUCTION

The HEC-IFH program can use up to ten pumping units in each interior analysis. These pumping units discharge water from the interior ponding area. The pumps may be separated from the interior ponding area by an interior ditch, as described in Chapter 5. All pumping units are assumed to be located at the primary gravity outlet location. Therefore, the HEC-IFH program assumes that they are all affected by the same exterior stages as the primary gravity outlet.

Figure 7.1 shows the structure of the HEC-IFH program screens which deal with data entry and plotting for pumps. As shown, HEC-IFH provides two data entry screens and two plots for pump data. These are available through the PUMP Module Menu Screen, which is illustrated in Figure 7.2. The Continuous Simulation and Hypothetical Event analysis approaches use almost the same pump outlet data; one minor difference between the two approaches is described later in this chapter.

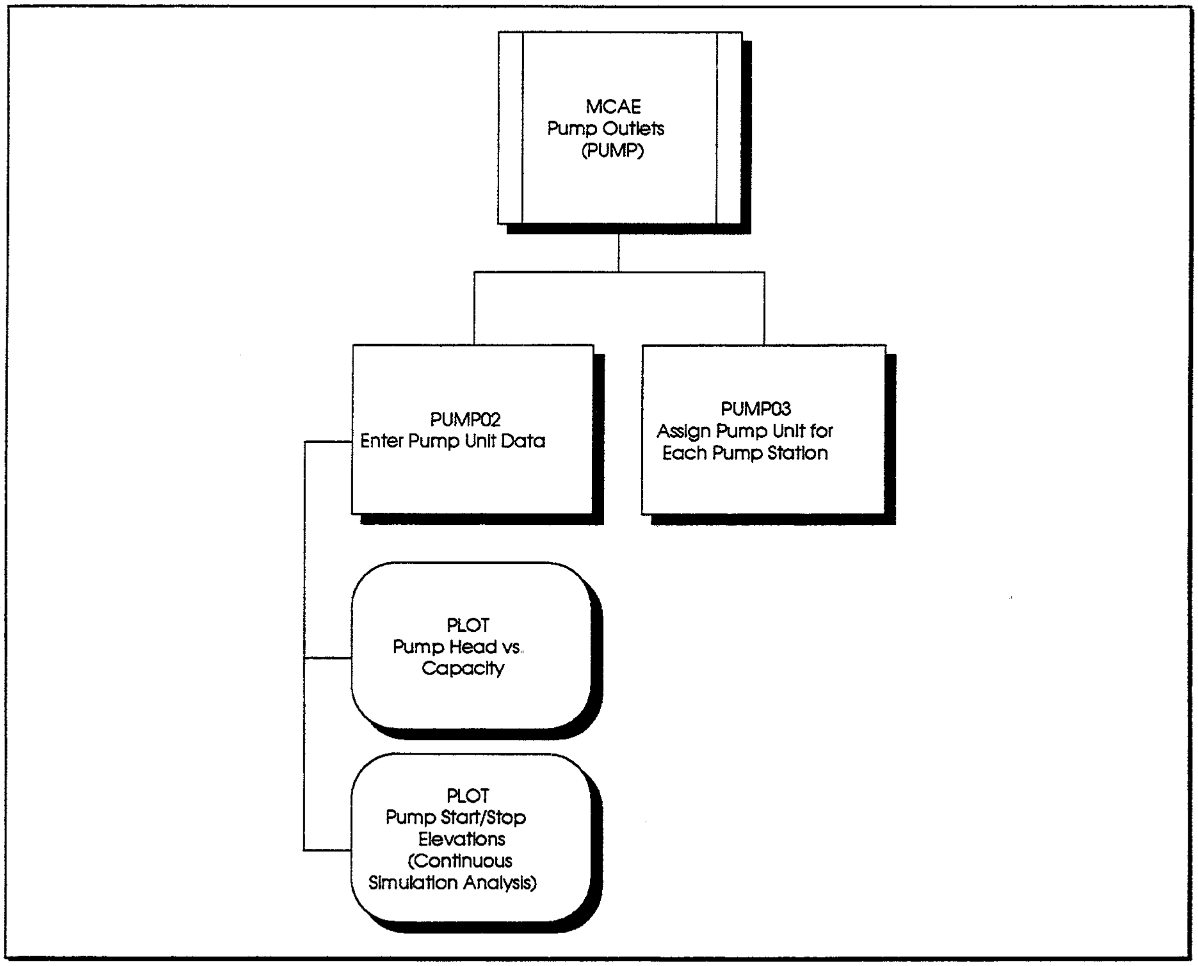


FIGURE 7.1 PUMP Module Structure

```
CSA 01.01.00                                                      MCAE
Study ID  RBEND2           Pump Outlets (PUMP)



                 Select Option:

                   A. Enter Pump Unit Data
                   B. Assign Pump Unit for Each Pump Station



1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
          Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 7.2 PUMP Module Menu Screen

7.2. ENTERING PUMP UNIT DATA

The operating data for each pump unit may be entered by the user. The pump unit data entry screen for Continuous Event Analyses is shown in Figure 7.3. Several pump unit data sets may be entered, with each one stored under a different **Pump Unit ID**. Up to eight characters may be used in the ID. A 40-character **Description** may be used to further document each pumping unit.

When the cursor is on the Pump Unit ID field, the [F3] key displays a list of previously-defined IDs. Any of these IDs may be selected, and the corresponding pump data will be displayed for editing.

The **Estimated Head Loss** is the lump sum of all the various head losses for the pump unit. These include friction loss, pipe bend losses, etc. The estimated head loss must be greater than or equal to 0.10 and less than 10.00. The defult value is 1.00.

The **Total Head** values represent the operating head of the pumping unit at various flow capacities. During the interior analysis, the total head on the pumping unit is computed as the sum of the Estimated Head Loss and the Static Head. The static head is the exterior water surface elevation minus the interior water surface elevation. Static head is assumed to be zero (0) when the interior pond elevation exceeds the exterior elevation. The Total Head will equal the Estimated Head Loss under this condition.

The final (highest) value in the Total Head column is the **Maximum Total Head**. It is the maximum head against which the pump can discharge water from the interior ponding area. When the total head exceeds this value during the interior analysis, the pump unit is assumed to shut off (have zero capacity). Each total head value should equal or exceed the previously entered value.

The pump **Capacity** is used to compute the pump discharge rate during the interior analysis. All capacity values should be greater than or equal to zero (0). The pump **Efficiency** values allow HEC-IFH to compute the total energy required for pumping operations. All efficiency values must be greater than or equal to zero (0), but less than 100%. Efficiency values are entered as percentages, not decimal fractions. For example, an efficiency value of 85% would be entered as 85, not 0.85. As Figure 7.3 indicates, the HEC-IFH program combines the pump capacity and efficiency tables for convenience in data entry. Up to 20 data points may be used.

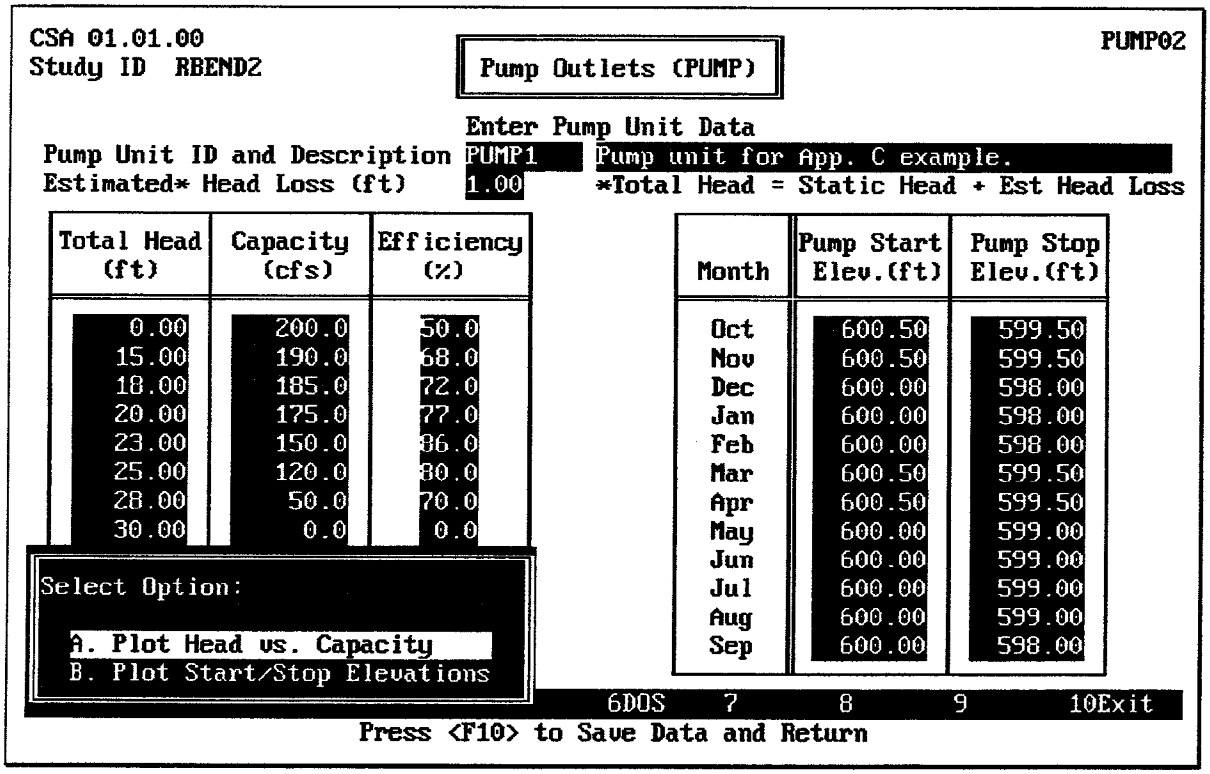


FIGURE 7.3 Pump Unit Data Entry Screen for Continuous Simulation Analyses

For Continuous Simulations, different values of **Pump Start Elevation** and **Pump Stop Elevation** may be defined for each calendar month of the year, as shown in Figure 7.3. For Hypothetical Event Analyses, a single pump start elevation and a single pump stop elevation are defined for use during the entire analysis. The data entry screen for Hypothetical Event Analyses is illustrated in Figure 7.4.

The Pump Start and Stop Elevations are used during the interior analysis to determine whether the pumping unit is operating at each time interval. The pump is assumed to begin operation when the interior ponding elevation exceeds the Pump Start Elevation. The pump continues to operate until the interior ponding elevation falls below the Pump Stop Elevation. To avoid "cycling" the pumping unit excessively during the interior analysis, each pump start elevation must exceed the corresponding pump stop elevation.

For Continuous Simulations, pressing the F9 key displays a menu which allows the selection of plots:

- A plot of operating head versus pump capacity and efficiency (Figure 7.5).
- A plot of pump start and stop elevations for each calendar month (Figure 7.6). This plot is not applicable to Hypothetical Event Analyses.

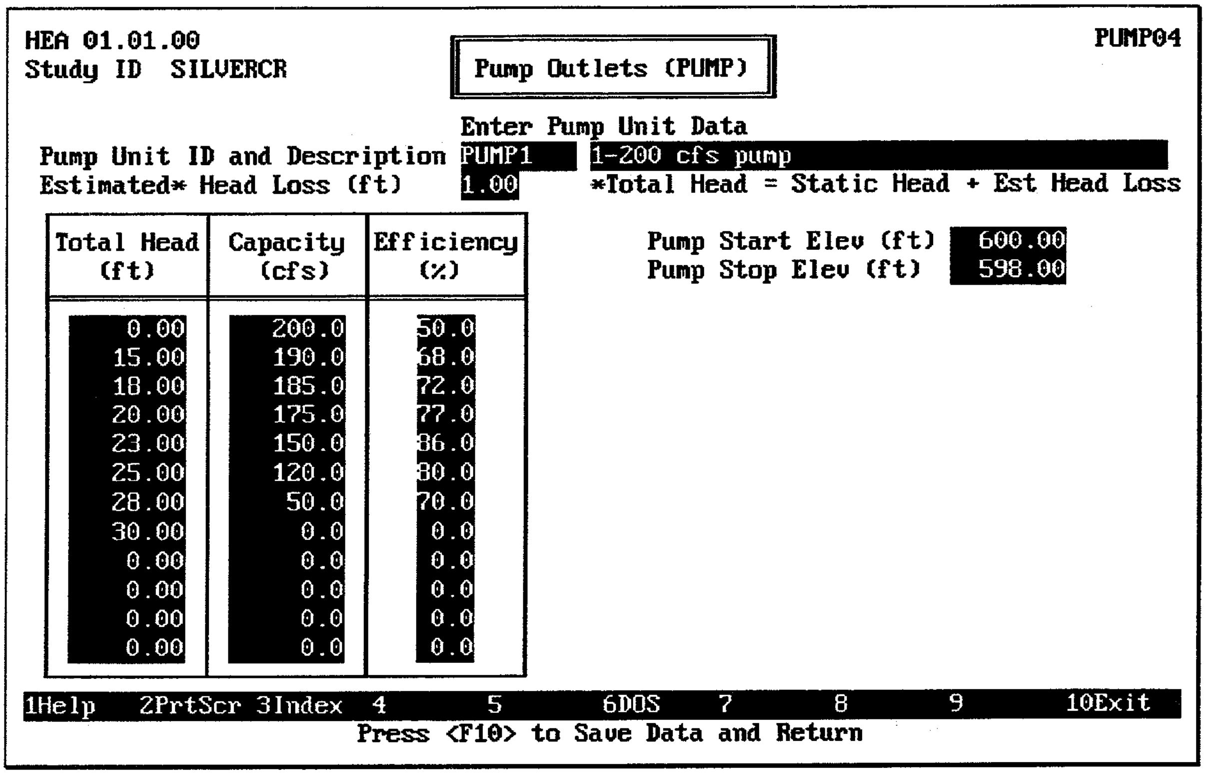


FIGURE 7.4 Pump Unit Data Entry Screen for Hypothetical Frequency Analyses

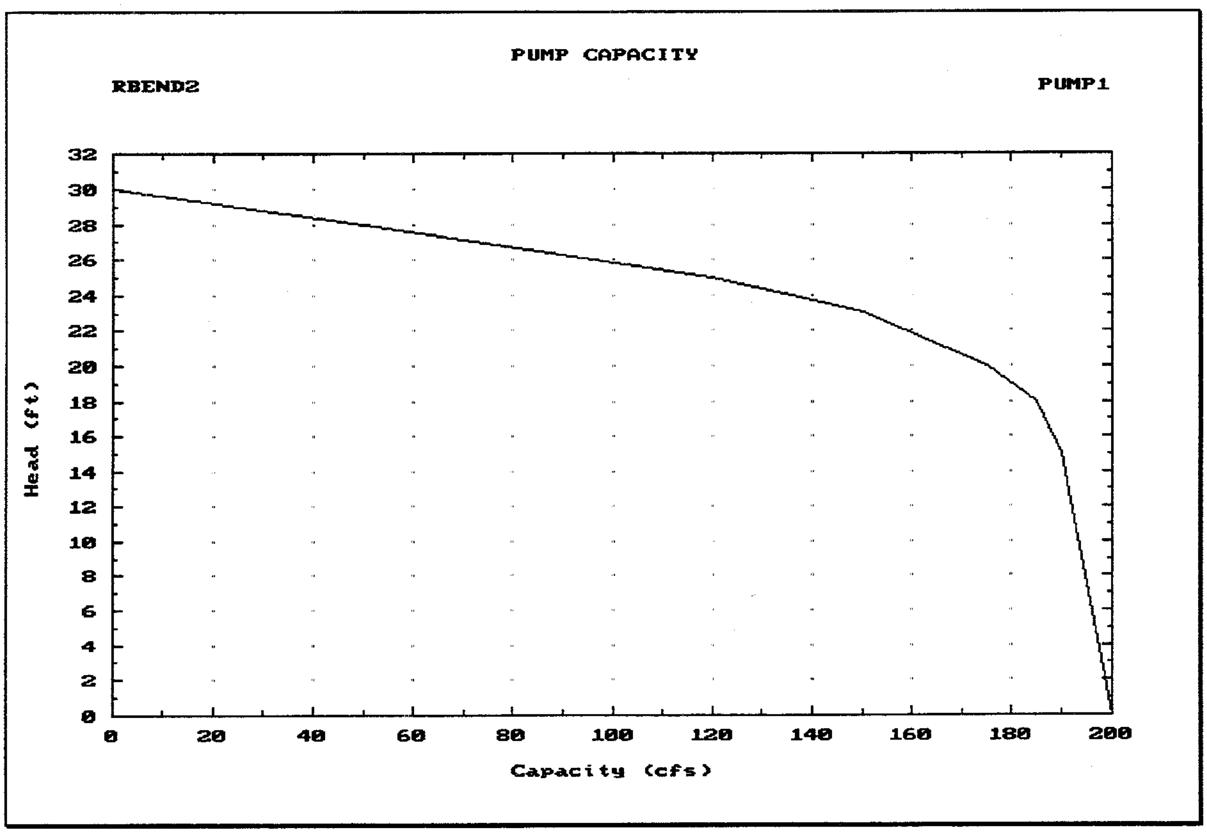


FIGURE 7.5 Plot of Pump Capacity Versus Head and Efficiency

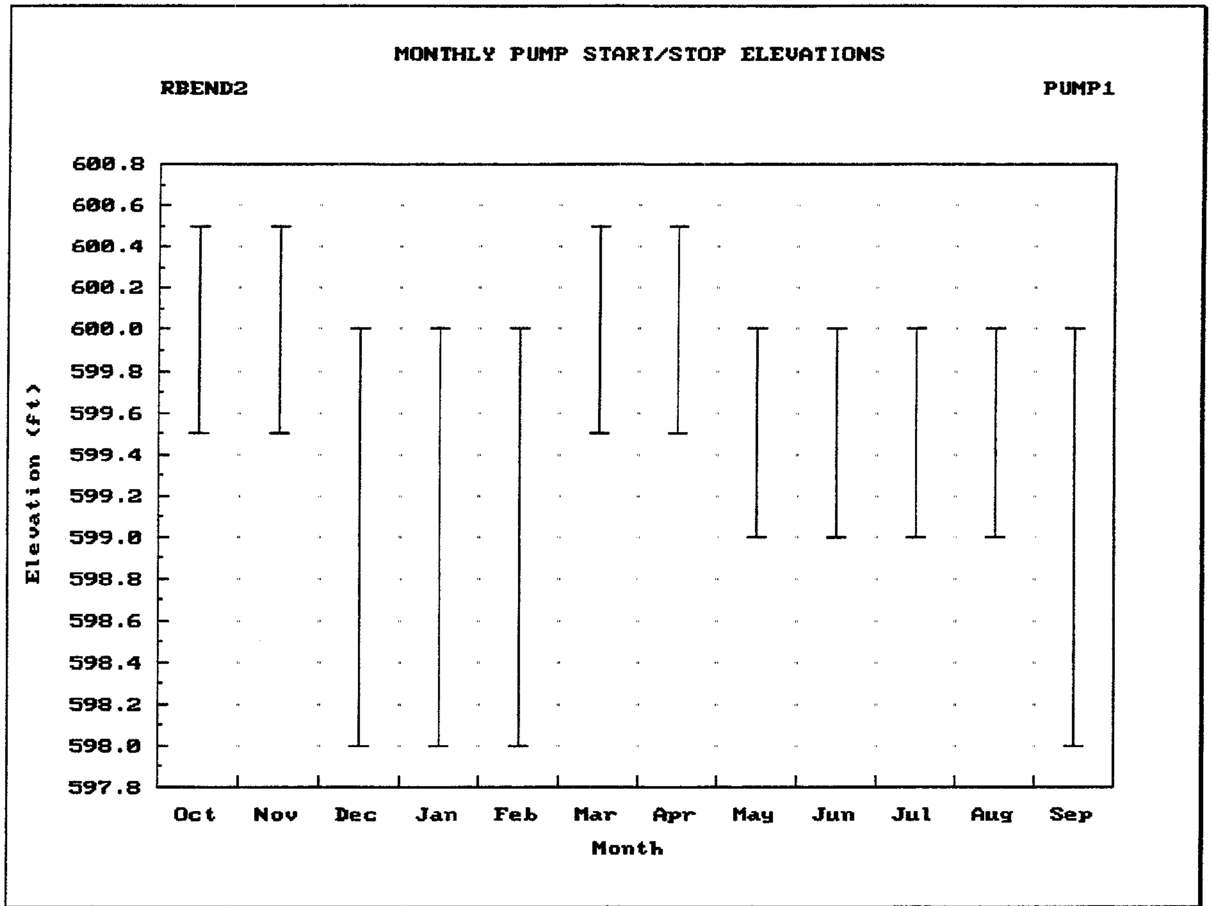


FIGURE 7.6 Plot of Monthly Pump Start/Stop Elevations for Continuous Simulations

7.3. SPECIFYING PUMP DATA

Figure 7.7 illustrates the screen used to specify PUMP module data. Like other HEC-IFH data entry modules, the PUMP module data is stored under a module ID. Several PUMP module data sets may be stored under different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously-defined IDs. Any of these IDs may be selected, and the corresponding data will be displayed for editing.

The 40-character description is used to provide documentation for each PUMP Module data set.

The PUMP module data consists of a list of up to ten different pumping units that make up a pumping station. Each pumping unit is identified by its Pump Unit ID. Any Pump Unit ID already entered for the present STUDYID may be selected. When the cursor is on each ID field, the F3 key displays a list of previously-defined IDs. Any of these IDs may be selected. As each ID is entered, the corresponding 40-character description is displayed.

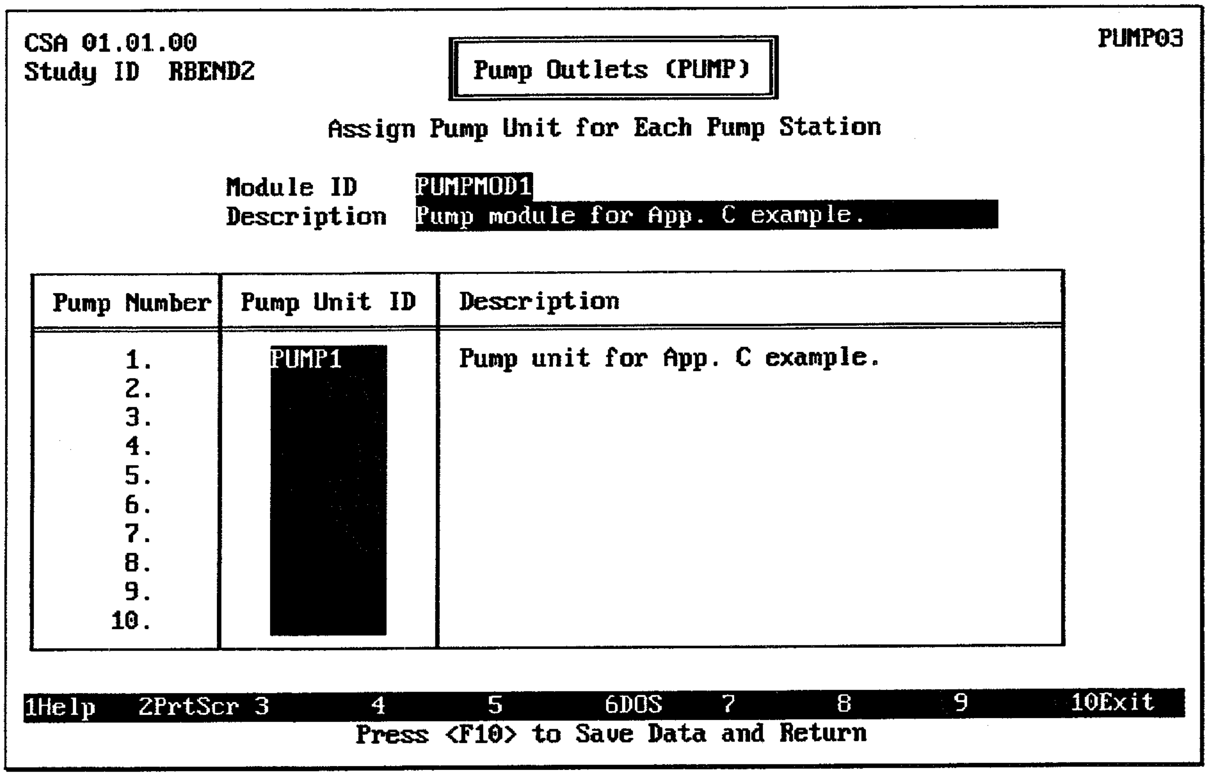


FIGURE 7.7 Screen to Specify PUMP Module Data

CHAPTER 8.
Exterior Stage

8.1. INTRODUCTION

The data in the EXSTAGE (exterior stage) module describe the water surface elevation values in the channel exterior to the line-of-protection. The exterior stage values are the tailwater values which affect the gravity or pump outlets of the interior drainage system. The exterior stages also affect the seepage computations. Gravity outlet computations are described in Chapter 6 of this manual. Pump outlets are discussed in Chapter 7. Chapter 9 describes auxiliary flow computations, including seepage.

For Continuous Simulations a single exterior stage hydrograph must be available. For Hypothetical Event Analyses exterior stage hydrographs must be available for each storm frequency analyzed. The HEC-IFH program provides three options for supplying stage hydrographs:

1. **Data Entry**: The exterior stage hydrograph or hydrographs may be entered directly.
2. **Import**: The exterior stage hydrograph or hydrographs may be imported from an external HEC-DSS data file.
3. **Computation**: The exterior stage hydrograph or hydrographs may be computed from a discharge hydrograph and a rating table for the exterior channel.

If exterior discharge hydrographs are used to compute the exterior stage hydrographs, HEC-IFH also provides three options for supplying these discharge hydrographs:

1. **Data Entry**: The exterior discharge hydrograph or hydrographs may be entered directly.
2. **Import**: The exterior discharge hydrograph or hydrographs may be imported from an external HEC-DSS data file.
3. **Computation**: The exterior discharge hydrograph or hydrographs may be computed from precipitation and sub-basin runoff data. Chapter 3 describes the specification of precipitation data and Chapter 4 describes the specification of basin runoff data for the exterior basin.

The HEC-IFH program can use **transfer relations** to transfer exterior stage values from one location along the exterior channel to another. For example, if the exterior stage values were recorded at a stream flow gaging station some distance from the gravity outlets, a transfer relation could be used to adjust the recorded exterior stages to reflect the appropriate values at each outlet location.

Figure 8.1 shows the structure of the HEC-IFH program screens which deal with data entry and plotting for exterior stage data for a Continuous Simulation Analysis. As indicated, a number of menu screens, data entry screens, report screens, and plots are provided.

Figure 8.2 illustrates the first data entry and menu screen of the EXSTAGE module for Continuous Simulation Analysis. The corresponding Hypothetical Event Analysis screen is identical.

Like other HEC-IFH data entry modules, the EXSTAGE module data is stored under a **Module ID**. Several EXSTAGE module data sets may be stored under different IDs. When the cursor is on the Module ID field, the [F3] key displays a list of previously-identified IDs.

Any of these previous IDs may be selected, and the corresponding data will be displayed for editing. The 40-character **Description** provides documentation for each EXSTAGE Module data set.

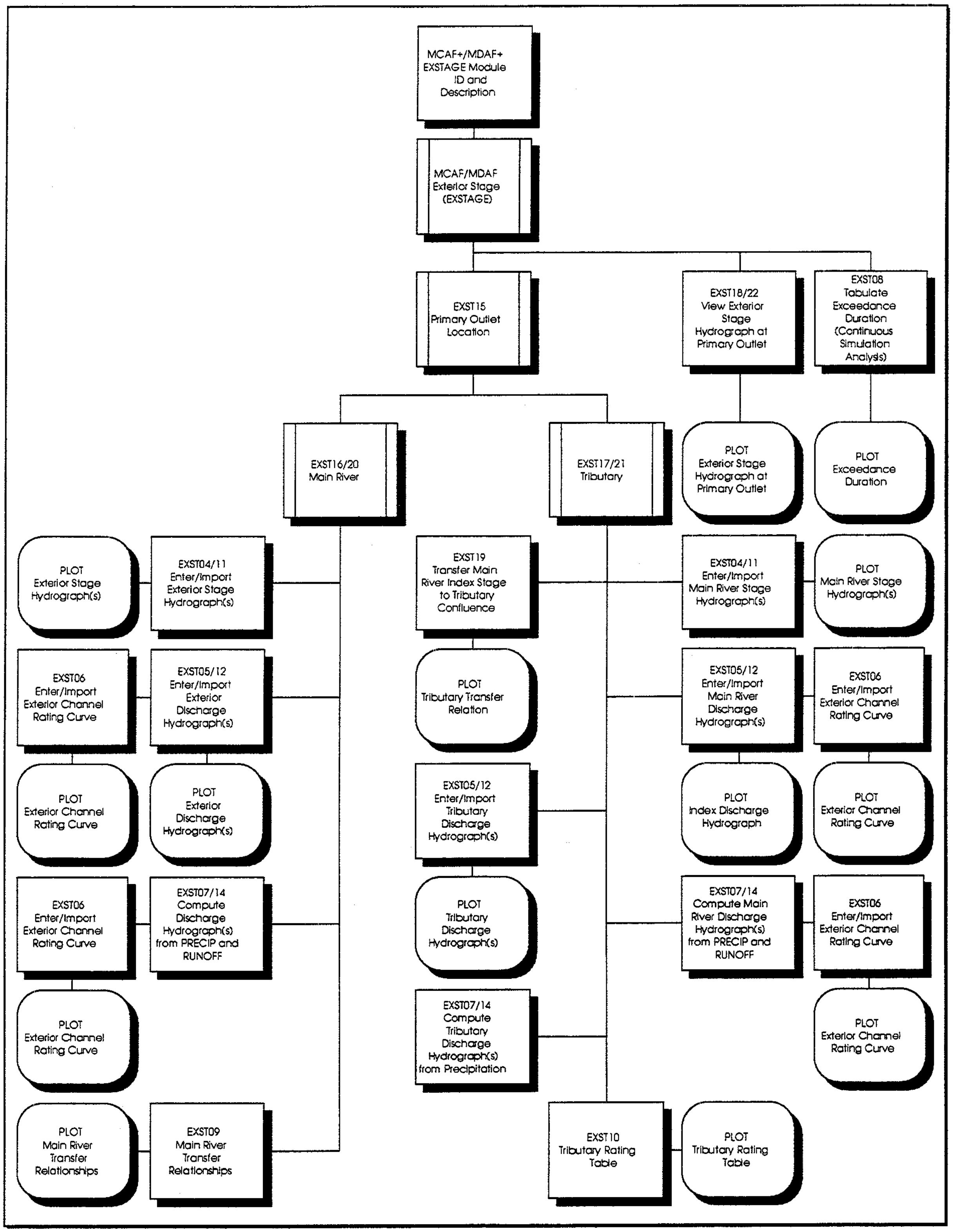


FIGURE 8.1 EXSTAGE Module Structure

```
CSA 01.01.00                 Exterior Stage (EXSTAGE)                 MCAF+
Study ID  RBEND2

              Module ID    EXSTAGE

              Description  Exterior stage data for App. C example.

1Help   2PrtScr 3      4       5       6DOS    7       8       9       10Exit
                        Press <F10> to Proceed to the Menu
```

FIGURE 8.2 Exterior Stage ID Screen

```
CSA 01.01.00                 Exterior Stage (EXSTAGE)                 MCAF
Study ID  RBEND2
Module ID EXSTAGE

        Select Option:

          A. Specify Exterior Stage
          B. View Exterior Stage Hydrograph at Primary Outlet
          C. Tabulate Primary Outlet Exterior Stage Exceedance Duration

1Help   2PrtScr 3      4       5       6DOS    7       8       9       10Exit
              Press Letter: or use Arrow Keys and <Enter> to Select
```

FIGURE 8.3 Exterior Stage Hydrograph Options

8.2. SPECIFYING EXTERIOR STAGE

A **Stage Hydrograph** is a relationship between time and water surface elevation. Exterior stage hydrographs are used by the HEC-IFH program to determine the exterior water surface elevation at each time increment during the storm event or period of time being analyzed. **Index Stage Hydrographs** are generally measured at stream gage stations. They represent a recorded or computed stage hydrograph at the gage location. The Index Stage Hydrograph must generally be "transferred" or adjusted to the location of each outlet.

The options available for specifying exterior stage hydrographs differ according to the location of the primary outlet. Two different primary outlet locations are considered:

- **The Main River**: The primary exterior stream affecting the levee system.
- **The Tributary**: A stream flowing into the Main River a short distance downstream of the primary outlet, so that water surface elevations at the primary outlet are affected by backwater from the main river.

The menu screen illustrated in Figure 8.4 allows the location of the Primary Outlet to be specified. The left and right arrow keys are used to move from one option to the other. Pressing the space bar selects the highlighted option and displays the next data entry screen for the selected option.

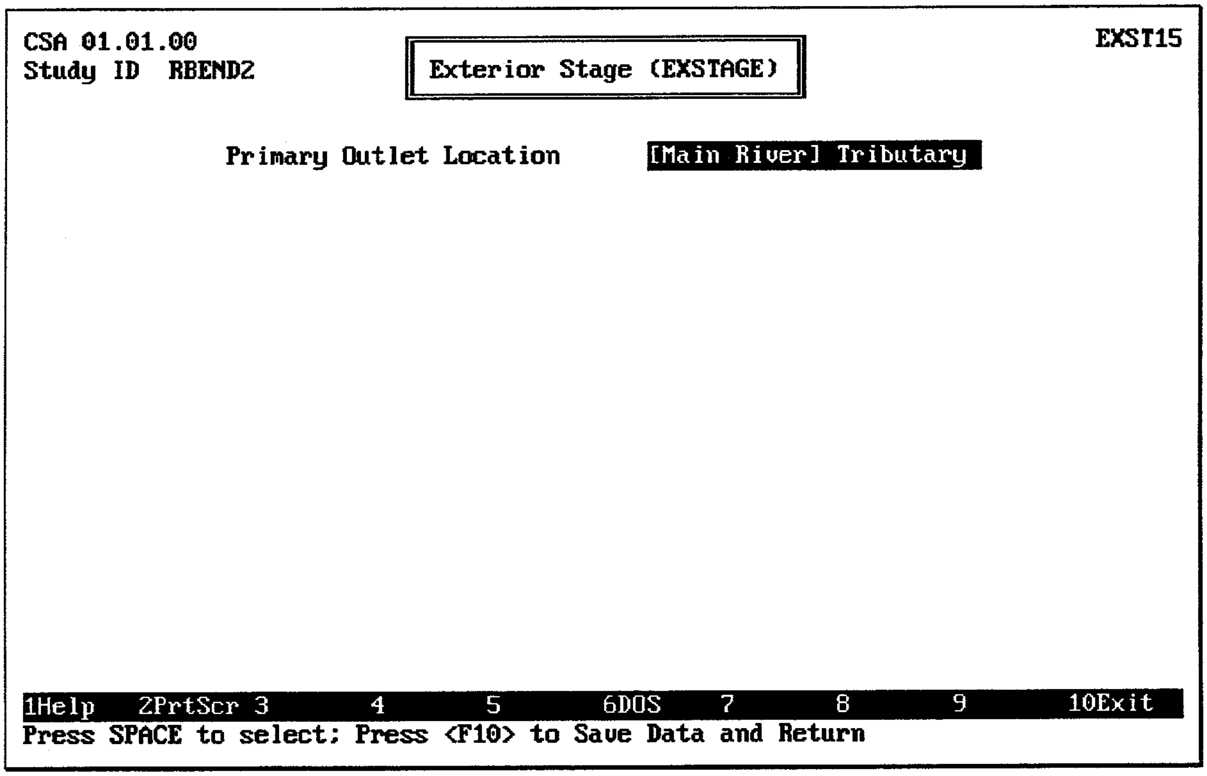


FIGURE 8.4 Primary Outlet Location Menu

8.2.1. Primary Outlet Locations on Main River

Figure 8.5 illustrates the HEC-IFH program menu screen which controls the various options when the primary outlet is on the main river. The menu screen illustrated in the figure is used for Continuous Simulation Analysis. An identical menu screen is used for Hypothetical Event Analysis, except that it refers to Index Stage Hydrographs (plural) rather than Index Stage Hydrograph (singular). This reflects the fact that the Hypothetical

Event Analysis method requires a separate Index Stage Hydrograph for each storm event which is to be analyzed.

The menu screen illustrated in Figure 8.5 is used to select two types of options:

- **Transfer Relation**: Options which control the computations which may be used to transfer the index stage hydrograph or hydrographs from the index location to the primary and secondary outlet locations.
- **Index Stage Hydrograph(s)**: Options which control the source of the Index Stage Hydrograph or Hydrographs.

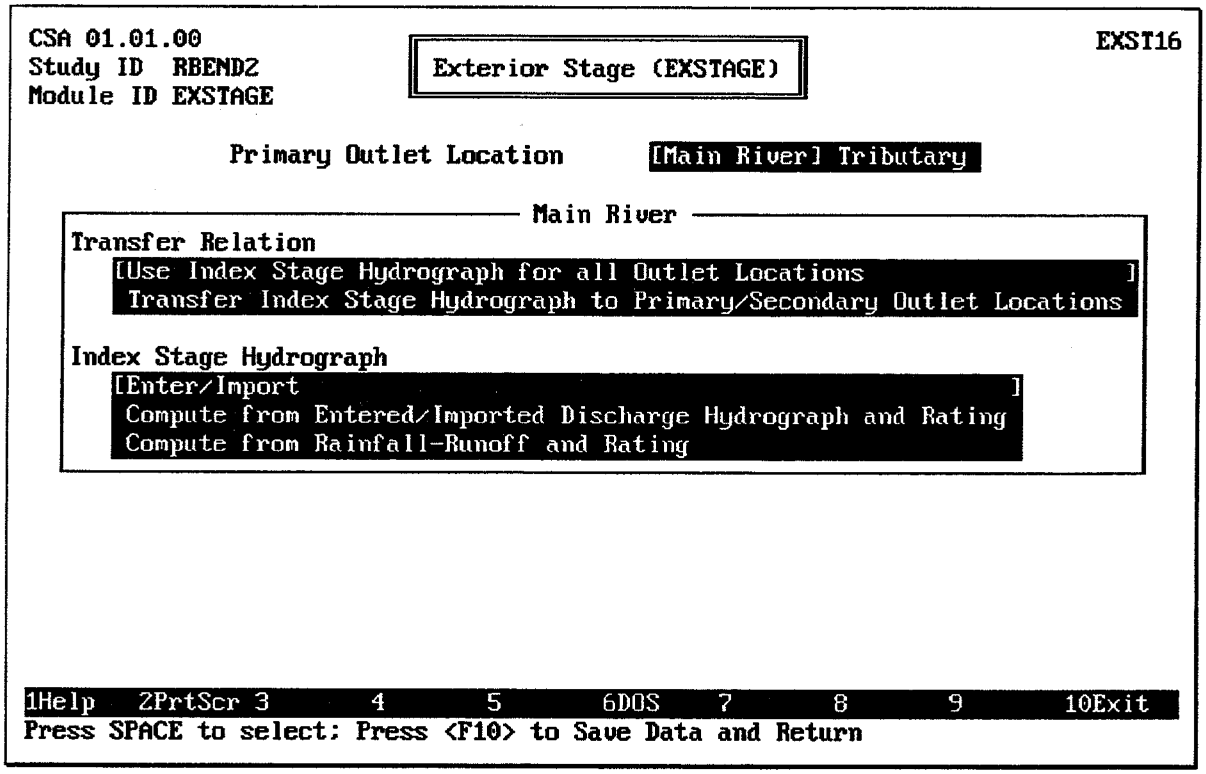


FIGURE 8.5 Menu Screen for Primary Outlet Location on Main River

8.2.1.1. Transfer Relation Options

As illustrated on Figure 8.5, two transfer relation options are available when the primary outlet is located on the main river:

- **Use Index Stage Hydrograph(s) for all Outlet Locations**: The index stage hydrograph or hydrographs are assumed to represent the conditions at the primary outlet location and all secondary outlet locations without any adjustment. After the index stage hydrograph or hydrographs are specified, no further actions are necessary.
- **Transfer Index Stage Hydrograph(s) to Primary/Secondary Outlet Locations**: The index stage hydrograph or hydrographs represent the conditions at a point along the main river which is significantly different from the primary outlet location or the secondary outlet locations. Main River Transfer Relations are specified and used to adjust the index stage hydrograph or hydrographs to the locations of the primary and secondary outlets.

Main River Transfer Relations are used to account for slope in the water surface profile of a river between a remote gaging station and an outlet location. For each of a series of main river index elevations, the corresponding exterior water surface elevation at the primary outlet location and each of the secondary outlet locations may be specified.

Figures 8.6 and 8.7 illustrate a typical situation in which a main river transfer relationship would be used. As indicated, the exterior stage values are available at the **index location**. This is often a stream gaging station. The index location may be upstream or downstream of the outlet locations. (In fact, the index location may be upstream of some outlets and downstream of others.) Because of the slope in the water surface elevation along the river, the stages will generally be different at the index location and at each of the various outlet locations. Since the slope in water surface varies according to the flow rate in the river, the adjustment between the index location and the outlet locations is not a fixed value for all flow rates.

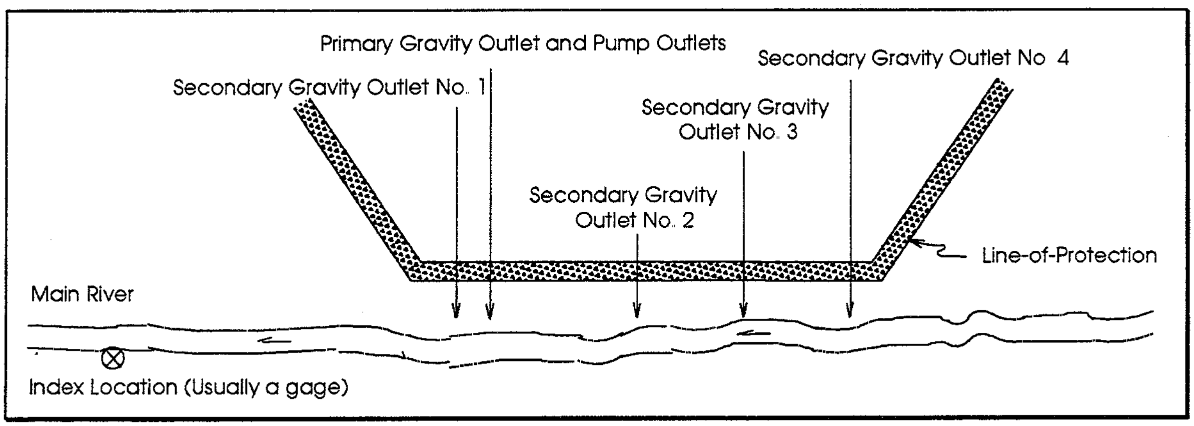


FIGURE 8.6 Main River Transfer Relation Concepts: Plan View

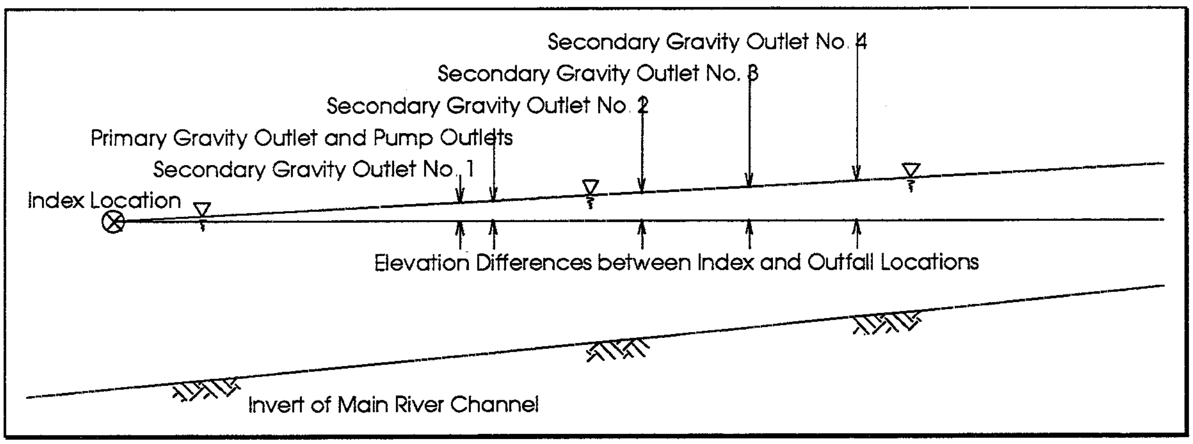


FIGURE 8.7 Main River Transfer Relation Concepts: Profile View

Figure 8.8 illustrates the main river transfer relationship data entry screen. As indicated, the transfer relationship consists of a table with up to 20 rows. Each row includes a single **Index Elevation** and up to 5 **Transferred Elevations**. All elevation values must be within the valid range of elevations described in Chapter 2. Each index elevation value should exceed the previous value.

CSA 01.01.00
Study ID RBEND2
Module ID EXSTAGE

Exterior Stage (EXSTAGE)

EXST09

Main River Transfer Relationships

Index Elev. (ft)	Transferred Elevation (ft)				
	Primary Outlet	Secondary Gravity 1	Secondary Gravity 2	Secondary Gravity 3	Secondary Gravity 4
589.00	590.00	591.00	592.00	593.00	594.00
590.00	591.00	592.00	593.00	594.00	595.00
595.00	596.00	597.00	598.00	599.00	600.00
600.00	601.00	602.00	603.00	604.00	605.00
605.00	606.00	607.00	608.00	609.00	610.00
610.00	611.00	612.00	613.00	614.00	615.00
615.00	616.00	617.00	618.00	619.00	620.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Save Data and Exit

FIGURE 8.8 Main River Transfer Relationship Data Entry Screen

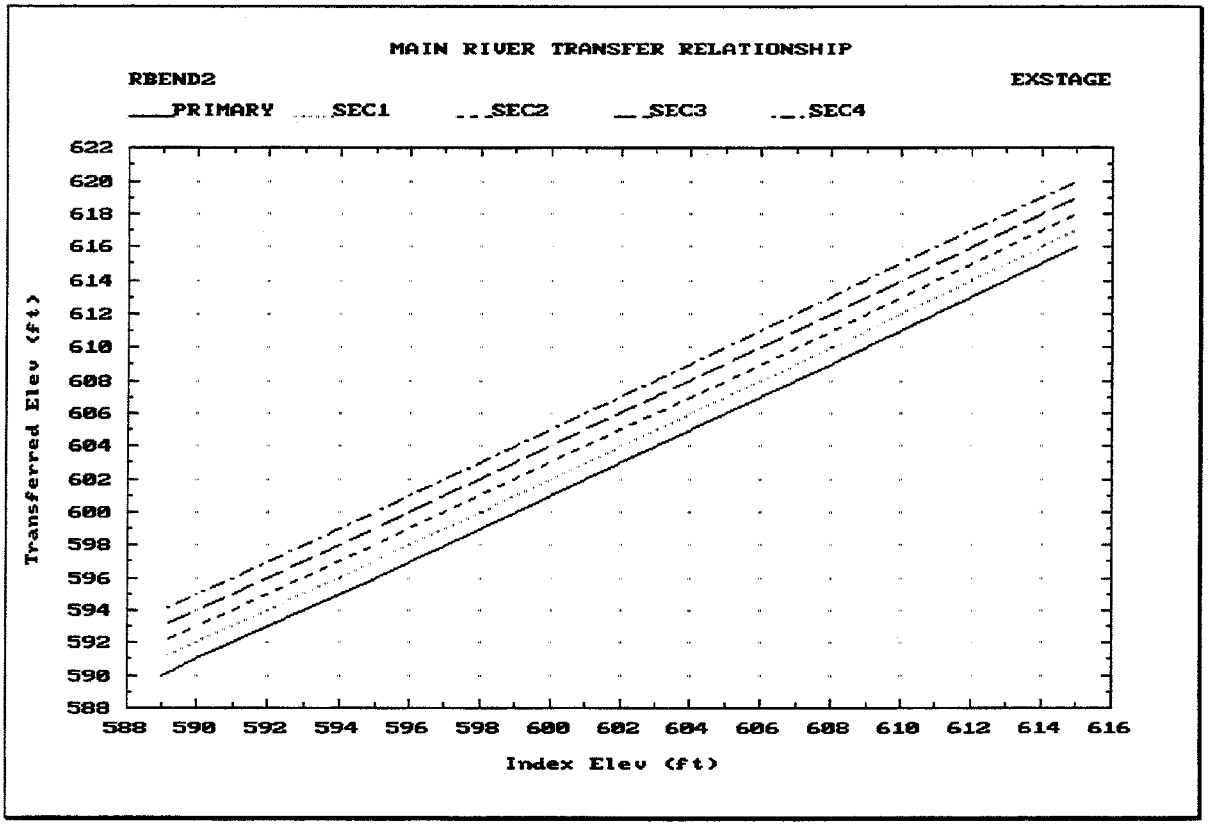


FIGURE 8.9 Main River Transfer Relationship Plot

The transferred elevation for the Primary Gravity Outlet is assumed to apply to all pumping units used in the interior analysis. Transferred elevations must be provided for all locations at which gravity outlets are present. However, it is not necessary to enter transferred elevations for outlet locations which will not be used. For example, if an interior analysis will be performed using only a Primary Gravity Outlet and pumps, then no transferred elevations are required for any of the Secondary Gravity Outlets.

Pressing the F9 key causes the main river transfer relationship table to be plotted on the computer screen. Figure 8.9 illustrates the plot. As shown, a separate curve is plotted for each transferred elevation column.

8.2.1.2. Index Stage Hydrograph Options

As illustrated on Figure 8.5, three options are available for providing the Index Stage Hydrograph or Hydrographs:

- **Enter/Import**: This option is used if the exterior stage hydrograph is already available in tabulated form, either on paper or in an external HEC-DSS file.
- **Compute from Entered/Imported Discharge Hydrograph and Rating**: This option is used if the exterior discharge hydrograph is already available in tabulated form, either on paper or in an external HEC-DSS file. A rating table for the exterior channel must also be available so that the discharge hydrograph can be converted to a stage hydrograph.
- **Compute from Rainfall-Runoff and Rating**: This option is used if the exterior discharge hydrograph is to be computed by HEC-IFH using rainfall and runoff data. A rating table for the exterior channel must also be available for this option.

8.2.1.2.1. Enter/Import Index Stage Hydrograph(s)

If the option to Enter/Import Index Stage Hydrograph is selected from the Index Stage Options Menu for a Continuous Simulation Analysis, the Exterior Stage Data Entry Screen illustrated in Figure 8.10 is displayed.

The **Starting Period** and **Ending Period** of the exterior stage hydrograph must be entered. These use the standard HEC-DSS format for date and time values. The starting period is the end of the first computation interval, and the ending period is the end of the last computation interval in the time series. For example, a record consisting of hourly values for the month of October 1990 would have a starting period of 01OCT1990/0100 and an ending period of 31OCT1990/2400. If the exterior stage hydrograph for October 1990 consisted of daily instead of hourly values, the starting period would be 01OCT1990/2400 (the end of the first day), but the ending period would still be 31OCT1990/2400. The ending period must be later than the starting period.

The **Time Increment** must be entered as a number combined with a unit of time. Time increments must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The time increment must be consistent with the starting and ending period. For example, a time increment of 2HOUR would not be consistent with a starting period of 01OCT1990/0100, but a time increment of 1HOUR would be.

After entering the starting and ending times and time interval, the HEC-IFH program is ready to receive **Elevation** values for each time period. The user may enter these values or import them from an external HEC-DSS file on disk. All elevation values must be within the valid range of elevations described in Chapter 2.

```
CSA 01.01.00                                                        EXST04
Study ID  RBEND2           Exterior Stage (EXSTAGE)           Index Location
Module ID EXSTAGE
                     Enter/Import Exterior Stage Hydrograph

Starting Period         01OCT1950/2400   Date/Time         Elevation
 (e.g. 01JAN1989/1300)                   DaMonYear/HrMn      (ft)

Ending Period           30SEP1960/2400   01OCT1950/2400    581.12
                                         02OCT1950/2400    581.08
Time Interval           1DAY             03OCT1950/2400    581.08
 (e.g. 1HOUR, 1DAY, ...)                 04OCT1950/2400    581.12
                                         05OCT1950/2400    581.12
                                         06OCT1950/2400    581.12
                                         07OCT1950/2400    581.39
                                         08OCT1950/2400    582.27
                                         09OCT1950/2400    581.97
                                         10OCT1950/2400    581.53
                                         11OCT1950/2400    581.39
                                         12OCT1950/2400    581.24
                                         13OCT1950/2400    581.20
                                         14OCT1950/2400    581.24
1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
                  Press <F10> to Save Data and Exit
```

FIGURE 8.10 CSA Exterior Stage Data Entry Screen

To import an exterior stage time series, press the F7 key after entering the time increment but before entering any elevation values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated.

Pressing the F4 Goto key during data entry instructs HEC-IFH to move directly to any specified time interval in the time series. Chapter 2 provides further details.

After entering or importing exterior stages, the F9 key causes the HEC-IFH program to plot the exterior index stage hydrograph. Figure 8.11 illustrates a multi-year plot of annual maximum exterior stage values for a 10-year record. If you have entered enough data values, you may "zoom" to a one-year plot of daily peak values, a one-month plot of actual values (as shown in Figure 8.12), or a one-day plot of actual values. From the one-year, one-month, or one-day plots, you may "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

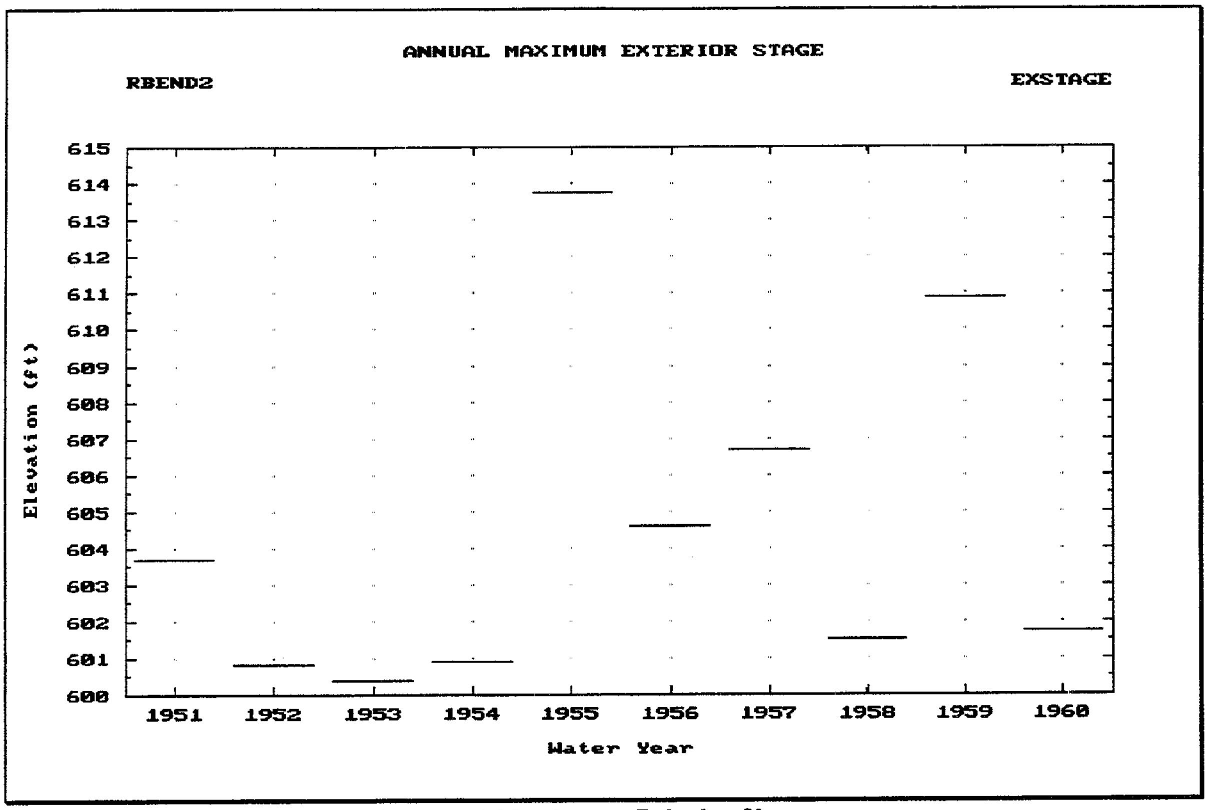


FIGURE 8.11 Multi-Year Plot of Annual Maximum Exterior Stage

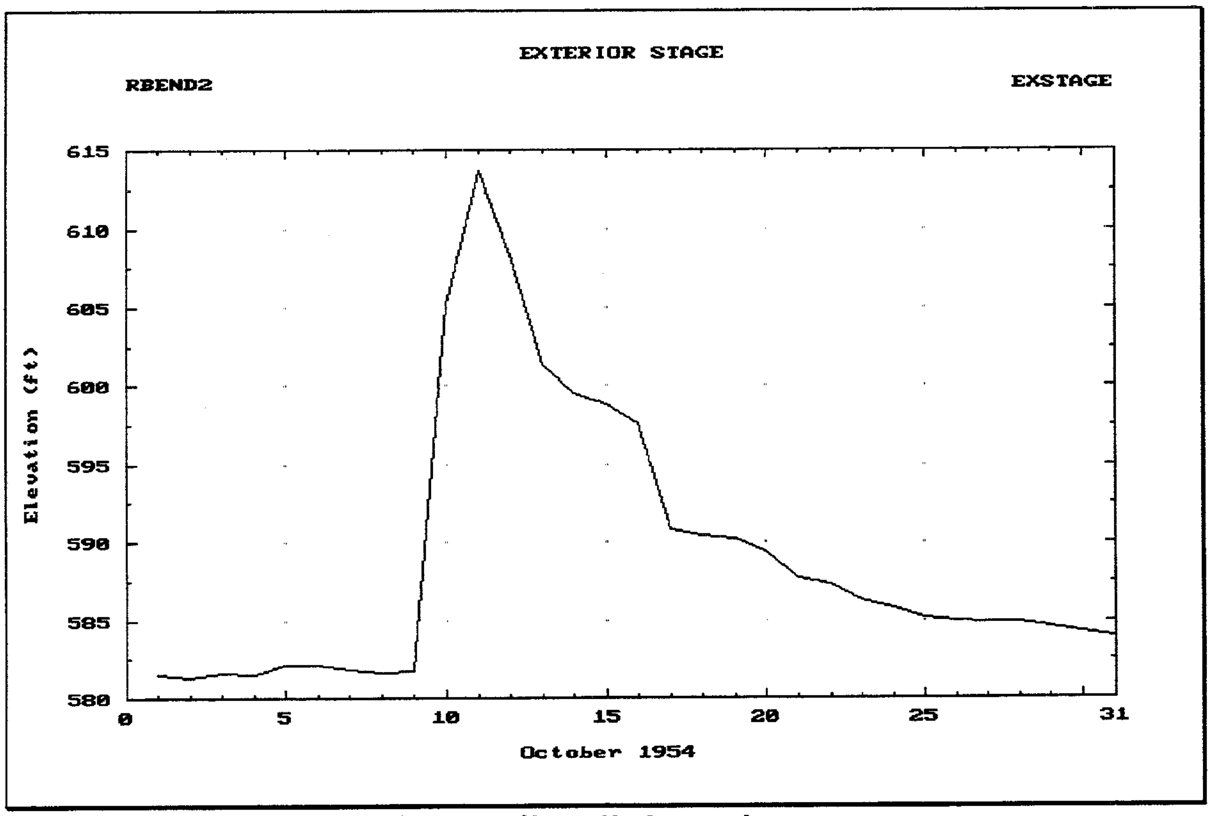


FIGURE 8.12 One-Month Plot of Exterior Stage Hydrograph

If the option to Enter/Import Index Stage Hydrograph is selected from the Index Stage Options Menu for a Hypothetical Event Analysis, the Exterior Stage Data Entry Screen illustrated in Figure 8.13 is displayed.

HEA 01.01.00 | Exterior Stage (EXSTAGE) | EXST11
Study ID SILVERCR | Primary Outlet Location
Module ID EXSTAGE
Enter/Import Exterior Stage Hydrographs (ft) | Time Interval 1HOUR
Initially set all elevations to: 581.0 | Number of Intervals 480

Da/HrMn	Hyp.Frq 50%	Hyp.Frq 20%	Hyp.Frq 10%	Hyp.Frq 4%	Hyp.Frq 2%	Hyp.Frq 1%	Hyp.Frq 0.2%	SPF
1/0100	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0200	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0300	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0400	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0500	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0600	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0700	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0800	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0900	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
				1.0	581.0	581.0	581.0	581.0
				1.0	581.0	581.0	581.0	581.0
				1.0	581.0	581.0	581.0	581.0
				1.0	581.0	581.0	581.0	581.0

Select Flood Events

50%	20%	10%	4%	2%	1%	0.2%	SPF
Y	Y	Y	Y	Y	Y	Y	Y

6DOS 7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 8.13 HEA Exterior Stage Data Entry Screen

The **Time Interval** must be entered as a number combined with a unit of time. Time increments must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY.

The **Number of Intervals** may be any integer number up to 10,000, as long as the number of days does not exceed 99. Together, the Time Interval and the Number of Intervals determine the total length of the exterior index stage hydrographs.

After entering the starting and ending times and time interval, the HEC-IFH program is ready to receive **Elevation** values for each time period. The user may enter these values or import them from an external HEC-DSS file on disk. All elevation values must be within the valid range of elevations described in Chapter 2.

A convenient feature of HEC-IFH is the ability to automatically set all elevations to a specified initial value. In many cases, a single exterior stage value is sufficient for a Hypothetical Event Analysis. If more detail is required for any or all of the exterior stage hydrographs, individual elevation values may be changed as needed.

To import an exterior stage time series, press the F7 key after entering the time interval but before entering any elevation values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

For Hypothetical Event Analysis, HEC-IFH allows the user to specify up to 8 different values for Part F of the HEC-DSS path name. These represent the different storm events which may be analyzed in a single HEA plan analysis. If one or more storm events will not be used in a particular plan analysis, the user may enter SKIP for the corresponding Part F. The time series for that storm event will not be imported.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated.

Pressing the F4 Goto key during data entry instructs HEC-IFH to move directly to any specified time interval in the time series. Chapter 2 provides further details.

8.2.1.2.2. Compute Stage Hydrograph from Discharge Hydrograph and Rating Curve

If a stage hydrograph for the exterior is not available from other sources, one may be computed from a discharge hydrograph and an exterior channel rating table. The exterior discharge hydrograph may be input directly, read from an external file, or computed by the HEC-IFH program. The exterior channel rating table, which is input directly, is used to determine the water surface elevation for each discharge value.

The Exterior Discharge Data Entry Screen illustrated in Figure 8.14 provides a convenient means of entering, importing, and plotting exterior discharge hydrograph values.

```
CSA 01.01.00                                                         EXST05
Study ID  RBENDZ         | Exterior Stage (EXSTAGE) |   Primary Outlet Location
Module ID EXSTAGE
                    Enter/Import Exterior Discharge Hydrograph

Starting Period            01OCT1950/2400   |   Date/Time    |  Discharge |
 (e.g. 01JAN1989/1300)                      | DaMonYear/HrMn |    (cfs)   |
                                            |----------------|------------|
Ending Period              30SEP1960/2400   | 10OCT1954/2400 |     605.2  |
                                            | 11OCT1954/2400 |     613.7  |
Time Interval              1DAY             | 12OCT1954/2400 |     608.3  |
 (e.g. 1HOUR, 1DAY, ...)                    | 13OCT1954/2400 |     601.4  |
                                            | 14OCT1954/2400 |     599.6  |
                                            | 15OCT1954/2400 |     598.8  |
                                            | 16OCT1954/2400 |     597.6  |
                                            | 17OCT1954/2400 |     590.8  |
                                            | 18OCT1954/2400 |     590.4  |
                                            | 19OCT1954/2400 |     590.2  |
                                            | 20OCT1954/2400 |     589.4  |
                                            | 21OCT1954/2400 |     587.7  |
                                            | 22OCT1954/2400 |     587.3  |
                                            | 23OCT1954/2400 |     586.3  |

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
                      Press <F10> to Save Data and Exit
```

FIGURE 8.14 Exterior Discharge Hydrograph Data Entry Screen

The **Starting Period** and **Ending Period** of the exterior discharge hydrograph must be entered. Like all time series data sets in HEC-IFH, these use the standard HEC-DSS format for date and time values. The starting period is the end of the first computation interval, and the ending period is the end of the last computation interval in the time series. For example, a record consisting of hourly values for the month of October 1990 would have a starting period of 01OCT1990/0100 and an ending period of

31OCT1990/2400. If the exterior discharge hydrograph for October 1990 consisted of daily instead of hourly values, the starting period would be 01OCT1990/2400 (the end of the first day), but the ending period would still be 31OCT1990/2400. The ending period must be later than the starting period.

The **Time Increment** must be entered as a number combined with a unit of time. Time increments must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The time increment must be consistent with the starting and ending period. For example, a time increment of 2HOUR would not be consistent with a starting period of 01OCT1990/0100, but a time increment of 1HOUR would be.

After entering the starting and ending times and time interval, the HEC-IFH program is ready to receive **Discharge** values for each time period. The user may enter these values or import them from an external HEC-DSS file on disk. All discharge values must be zero (0) or greater.

To import an exterior discharge time series, press the F7 key after entering the time increment but before entering any discharge values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the summary to be printed.

The F9 Plot key causes the HEC-IFH program to display a plot of discharges. If data values for more than one full year are available, the first plot displays a multi-year plot of maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily maxima or peaks (see Figure 8.15), a one-month plot of actual values (Figure 8.16), and a one-day plot of actual values. From the one-year, one-month, or one-day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

After the discharge hydrograph has been entered, the exterior channel rating table is input directly to the HEC-IFH program in the form of a table of water surface elevations and corresponding channel discharges. Up to 20 data points may be used. Figure 8.17 illustrates the appearance of the data entry screen for the rating table. The exterior channel rating table is assumed to apply to the Primary Outlet Location.

The **Discharge** values always begins with zero (0) corresponding to the first **Elevation** value. All elevation values must fall within the allowable minimum and maximum values described in Chapter 2. Each discharge and elevation value should equal or exceed the previously entered value.

Pressing the F9 key causes the exterior channel rating table to be plotted on the computer screen. Figure 8.18 illustrates the plot.

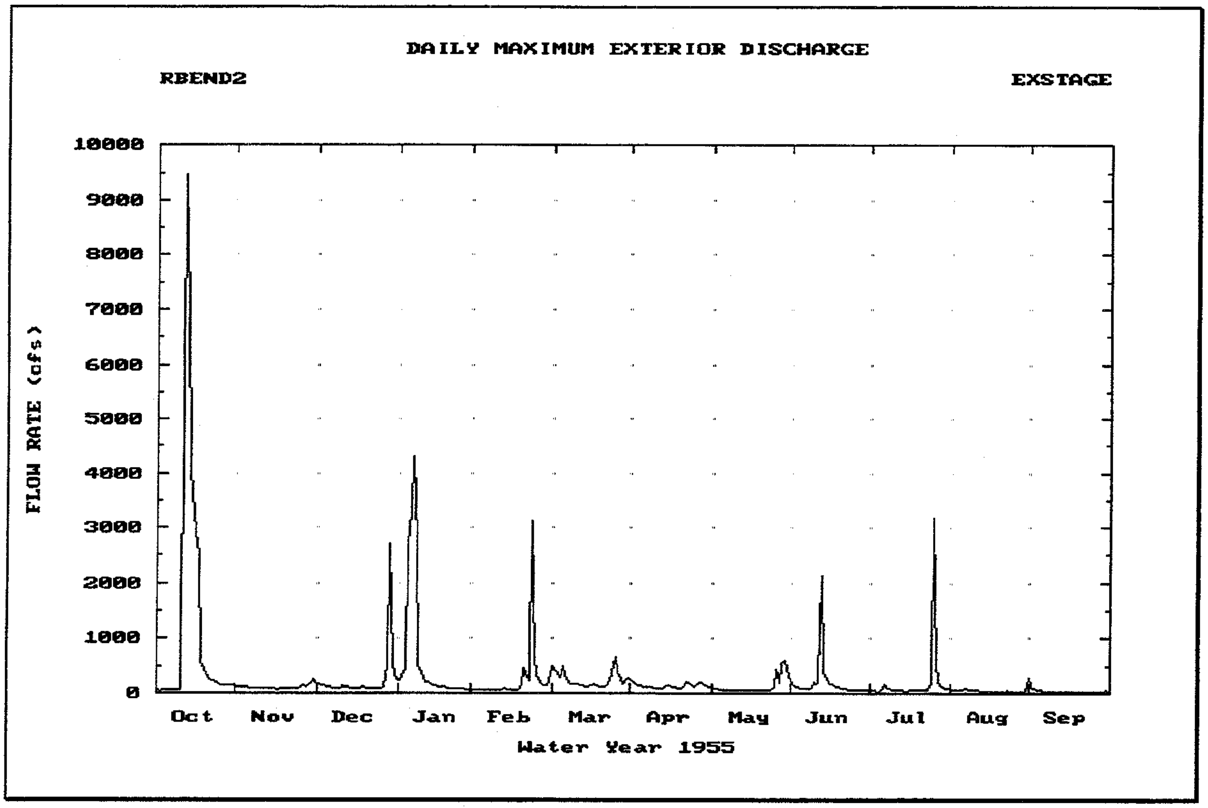


FIGURE 8.15 One-Year Plot of Daily Maximum Exterior Discharges

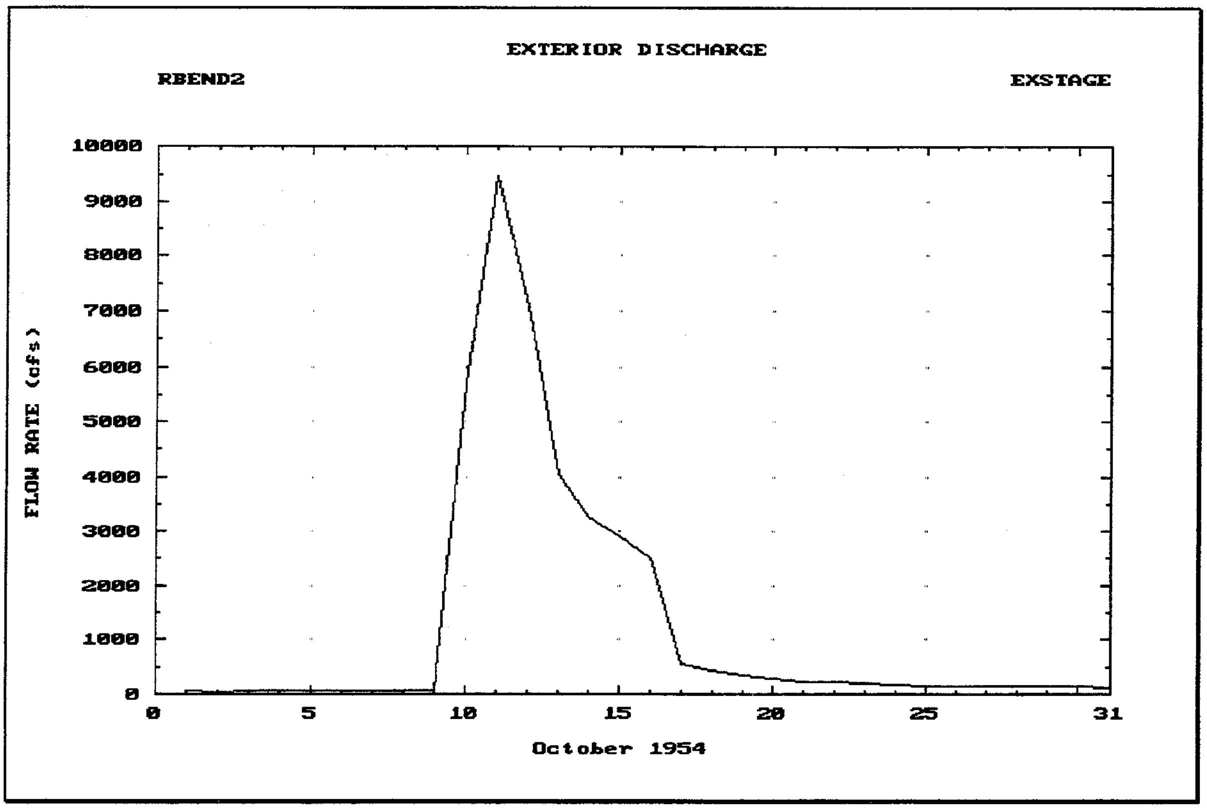
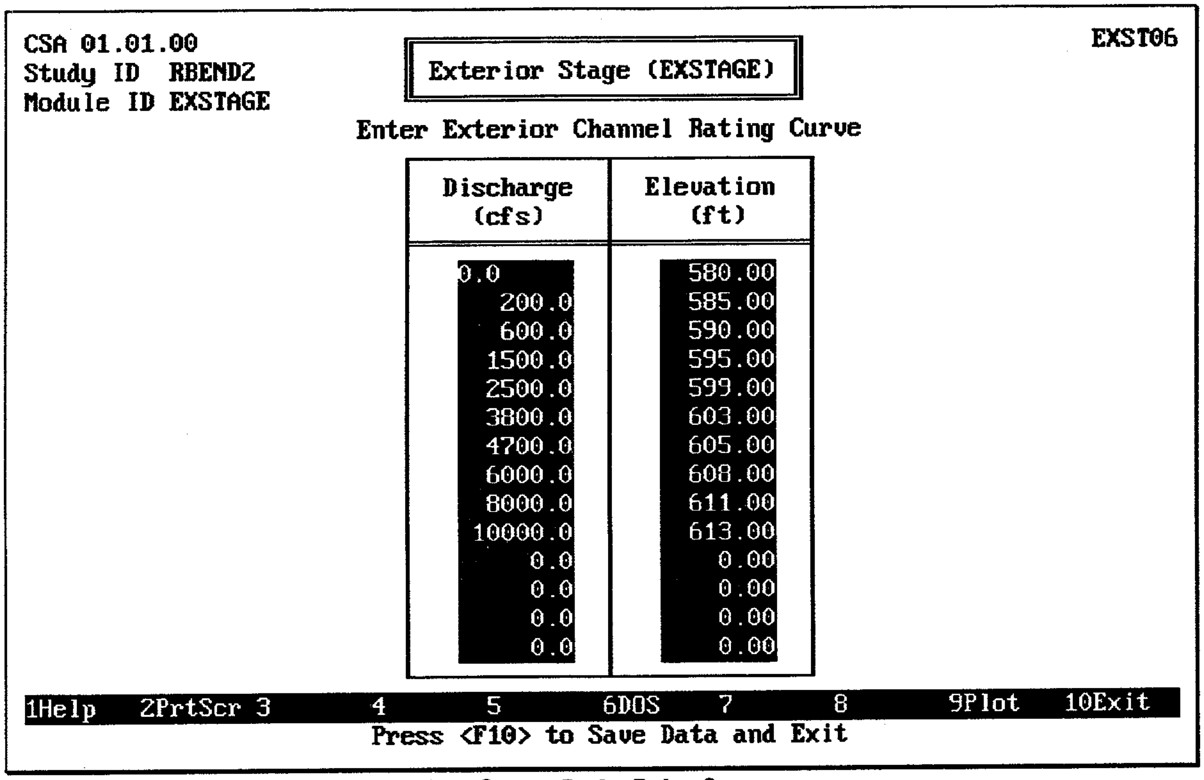


FIGURE 8.16 Plot of Exterior Discharges


CSA 01.01.00
Study ID RBEND2
Module ID EXSTAGE

Exterior Stage (EXSTAGE)

EXST06

Enter Exterior Channel Rating Curve

Discharge (cfs)	Elevation (ft)
0.0	580.00
200.0	585.00
600.0	590.00
1500.0	595.00
2500.0	599.00
3800.0	603.00
4700.0	605.00
6000.0	608.00
8000.0	611.00
10000.0	613.00
0.0	0.00
0.0	0.00
0.0	0.00
0.0	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Save Data and Exit

FIGURE 8.17 Exterior Channel Rating Curve Data Entry Screen

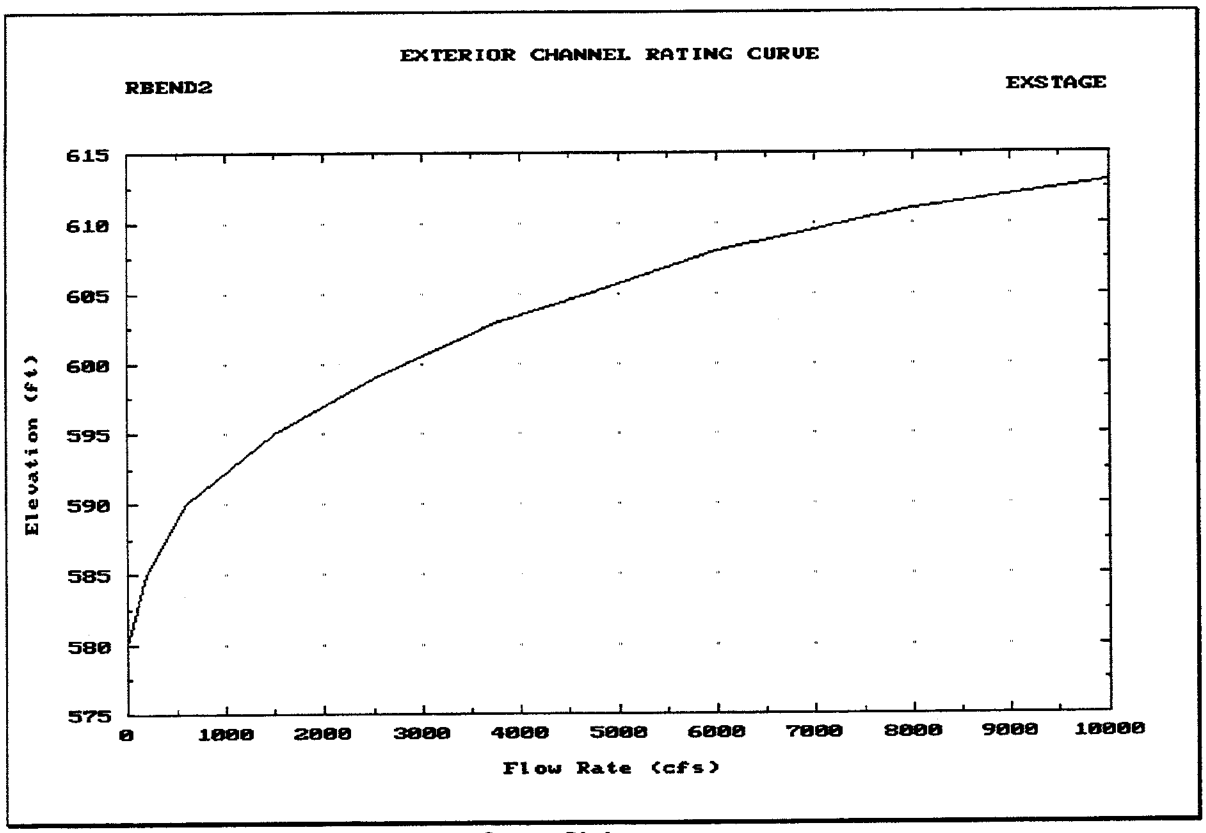


FIGURE 8.18 Exterior Channel Rating Curve Plot

8.2.1.2.3. Compute Discharge Hydrograph from PRECIP and RUNOFF

If a discharge hydrograph for the exterior basin is required for stage hydrograph computations, and one is not available from other sources, a discharge hydrograph may be computed using any of the runoff computation features provided in the HEC-IFH computer program. Computing a discharge hydrograph requires the following items of information:

- A Precipitation Time Series, which is identified by a **Precipitation Record ID**. The precipitation time series provides a set of precipitation values extending throughout the period of analysis, at a fixed time increment. Precipitation data sets are described in Chapter 3 of this manual.
- A set of Basin Runoff Parameters, which are identified by a **Basin ID**. The basin runoff parameters always include a unit hydrograph and drainage area. Generally, loss rate parameters, percent impervious, and monthly base flow rates are also included. These data items are described in Chapter 4 of this manual.

The precipitation data and basin runoff data used to compute the discharge for the exterior basin are entered in the same way as the data values used for interior sub-basin computations. The data entry screens in the PRECIP and RUNOFF modules are used to enter or import these data items and store them under the appropriate IDs.

The Precipitation Record ID and Basin ID are selected using the data entry screen shown in Figure 8.19. The F3 Index key displays a list of available record or basin IDs. The HEC-IFH program displays the 40-character description for each record or basin to help ensure that the correct data are used.

```
CSA 01.01.00                                                    EXST07
Study ID  RBEND2          | Exterior Stage (EXSTAGE) |
Module ID EXSTAGE
   Specify PRECIP and RUNOFF Data for Computing Exterior Discharge Hydrograph

      |                  | ID      | Description                      |
      | Precip Station   | PRECIPM | Precip for Main River Basin      |
      | Runoff Basin ID  | MAINRIV | Main River Runoff Parameters     |

1Help  2PrtScr 3Index  4     5     6DOS    7     8     9     10Exit
                    Press <F10> to Save Data and Exit
```

FIGURE 8.19 Computing Exterior Discharge Hydrograph

When HEC-IFH eventually computes the exterior stage hydrograph from the discharge hydrograph, it first performs the following computations:

- **Rainfall Excess**: The program uses the loss rate and percent impervious information from the basin runoff data to compute a rainfall excess time series from the original precipitation time series.
- **Runoff**: The program uses hydrograph convolution to compute a runoff hydrograph from the rainfall excess hyetograph and the unit hydrograph supplied as part of the basin runoff data. The monthly base flow values, if any, are also added to produce total basin runoff.

The computed discharge hydrograph has the same starting period, ending period, and time increment as the precipitation time series used in its computation.

The exterior channel rating table is input directly to the HEC-IFH program in the form of a table of water surface elevations and corresponding channel discharges (see page 137).

8.2.2. Primary Outlet Locations on Tributary

Figure 8.20 illustrates the HEC-IFH program menu screen which controls the various options when the primary outlet is on the tributary channel. The menu screen used for Continuous Simulation Analysis and Hypothetical Event Analysis, except that the HEA screen refers to Hydrographs (plural) rather than Hydrograph (singular). This reflects the fact that the Hypothetical Event Analysis method requires a separate hydrograph for each storm frequency which is to be analyzed.

```
CSA 01.01.00                                                      EXST17
Study ID  RBEND2          Exterior Stage (EXSTAGE)
Module ID EXSTAGE

            Primary Outlet Location      Main River [Tributary]

                          Tributary
   Main River Stage Hydrograph
     [Enter/Import                                               ]
      Compute from Entered/Imported Discharge Hydrograph and Rating
      Compute from Rainfall-Runoff and Rating

   Transfer Main River Stage Hydrograph
     [Transfer Main River Stage Hydrograph to Tributary Confluence]
      Main River Stage Hydrograph is at Tributary Confluence

   Tributary Discharge Hydrograph
     [Enter/Import               ]
      Compute from Precipitation

1Help  2PrtScr 3      4      5      6DOS    7      8      9     10Exit
Press SPACE to select;Press <F10> for the Next Input Screen
```

FIGURE 8.20 Menu Screen for Primary Outlet Location on Main River

This menu screen is used to select three types of options:

- **Main River Stage Hydrograph(s)**: Options which control the source of the Main River Stage Hydrograph or Hydrographs.

- **Transfer Main River Stage Hydrographs**: Options which control the computations which may be used to transfer the main river stage hydrograph or hydrographs from the index location to the tributary confluence.
- **Tributary Discharge Hydrograph(s)**: Options which control the source of the Tributary Discharge Hydrograph or Hydrographs.

8.2.2.1. Main River Stage Hydrograph Options

As illustrated on Figure 8.5, three options are available for providing the Main River Stage Hydrograph or Hydrographs:

- **Enter/Import**: This option is used if the main river stage hydrograph is already available in tabulated form, either on paper or in an external HEC-DSS file. For a Continuous Simulation Analysis, data entry, import, and function keys for this option operate in the same manner as described for Index Stage Hydrographs for CSA (see page 131). For a Hypothetical Event Analysis, the instructions provided for Index Stage Hydrographs for HEA are applicable (see page 133).
- **Compute from Entered/Imported Discharge Hydrograph and Rating**: This option is used if the main river discharge hydrograph is already available in tabulated form, either on paper or in an external HEC-DSS file. A rating table for the main river must also be available so that the discharge hydrograph can be converted to a stage hydrograph. Data entry, import, and function keys for this procedure operate in the same manner as described for Index Discharge Hydrographs for CSA (see page 134). After the discharge hydrograph has been entered, the main river rating table is input directly to the HEC-IFH program in the form of a table of water surface elevations and corresponding channel discharges (see page 137).
- **Compute from Rainfall-Runoff and Rating**: This option is used if the main river discharge hydrograph is to be computed by HEC-IFH using rainfall and runoff data. A rating table for the main river must also be available for this option. Defining the data for Main River discharge hydrograph computation is identical to the procedure for defining the Exterior Discharge hydrograph (see page 138).

8.2.2.2. Transfer Main River Stage Hydrograph

A Transfer Relationship is used to transfer main river stage data to the tributary confluence. Transfer Relations are used to account for slope in the water surface profile of a river between a remote gaging station and the tributary confluence. For each of a series of main river index elevations, the corresponding water surface elevation at the tributary confluence location may be specified. The main river stage values are at the **index location**. This is often a stream gaging station. The index location may be upstream or downstream of the tributary confluence.

Figure 8.21 illustrates the transfer relationship data entry screen. As indicated, the transfer relationship consists of a table with up to 20 rows. Each row includes a single **Index Elevation** and a single **Confluence Elevation**. All elevation values must be within the valid range of elevations described in Chapter 2. Each index elevation value should exceed the previous value.

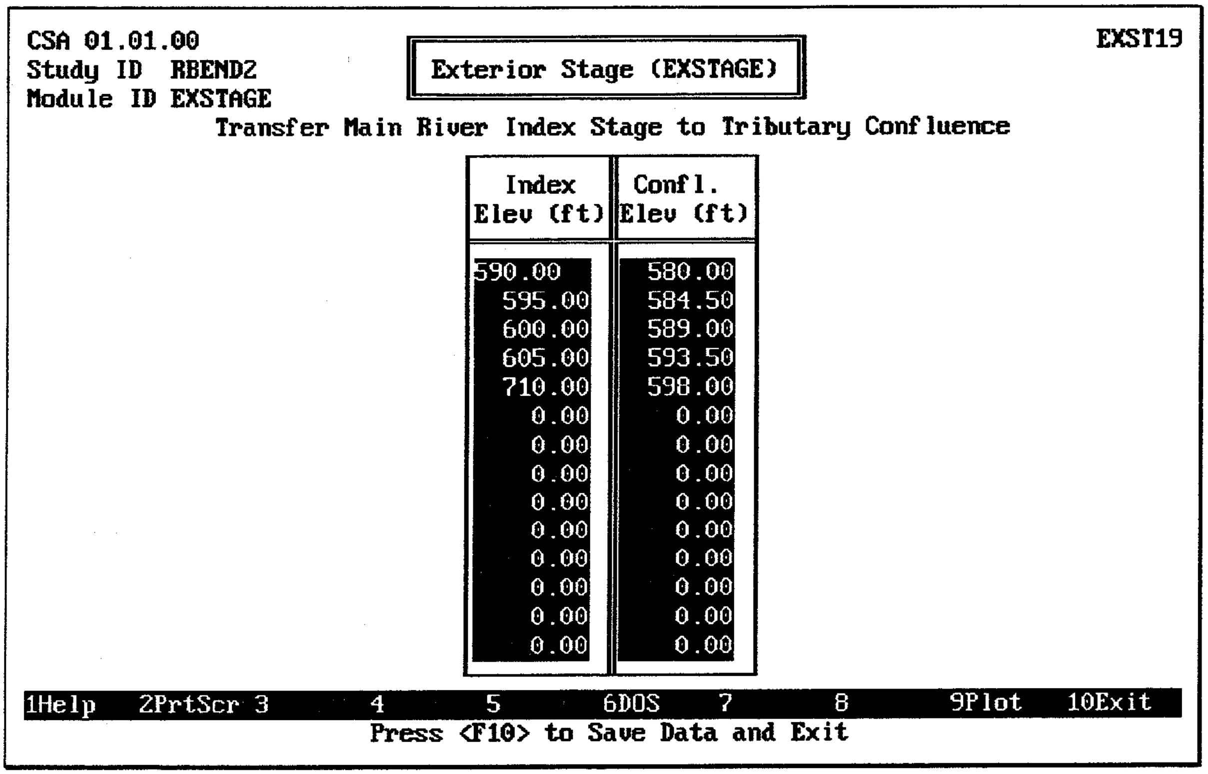


FIGURE 8.21 Transfer Relationship Data Entry Screen

8.2.2.3. Tributary Discharge Hydrograph Options

As illustrated on Figure 8.20, two options are available for providing the Tributary Discharge Hydrograph or Hydrographs:

- **Enter/Import**: This option is used if the tributary discharge hydrograph is already available in tabulated form, either on paper or in an external HEC-DSS file. The data entry, import, and function keys for this option operate in the same manner as described for Index Discharge Hydrographs for CSA (see page 134).
- **Compute from Precipitation**: This option is used if the exterior discharge hydrograph is to be computed by HEC-IFH using rainfall and runoff data. Defining the data for tributary discharge hydrograph computation is identical to the procedure for defining the Exterior Discharge hydrograph (see page 138).

8.2.2.4. Tributary Rating Table

The Tributary Rating Table is used to transfer main river stage data to a point along a tributary stream which corresponds to the location of pump or gravity outlets. A family of tributary flow rate versus water surface elevation curves are established for the outlet location. Each curve corresponds to a different main river (ocean or lake) elevation. These curves are used to determine the exterior stage along the tributary for a particular main river stage and tributary flow rate.

Figure 8.23 illustrates a situation in which a tributary rating table could be applied. As indicated, the index location for a tributary rating table is always the confluence of the tributary with the main stream. When a tributary rating table is used, all gravity outlets and pumps are assumed to be at the same location. The program cannot account for differences between exterior stages at different locations along the tributary channel.

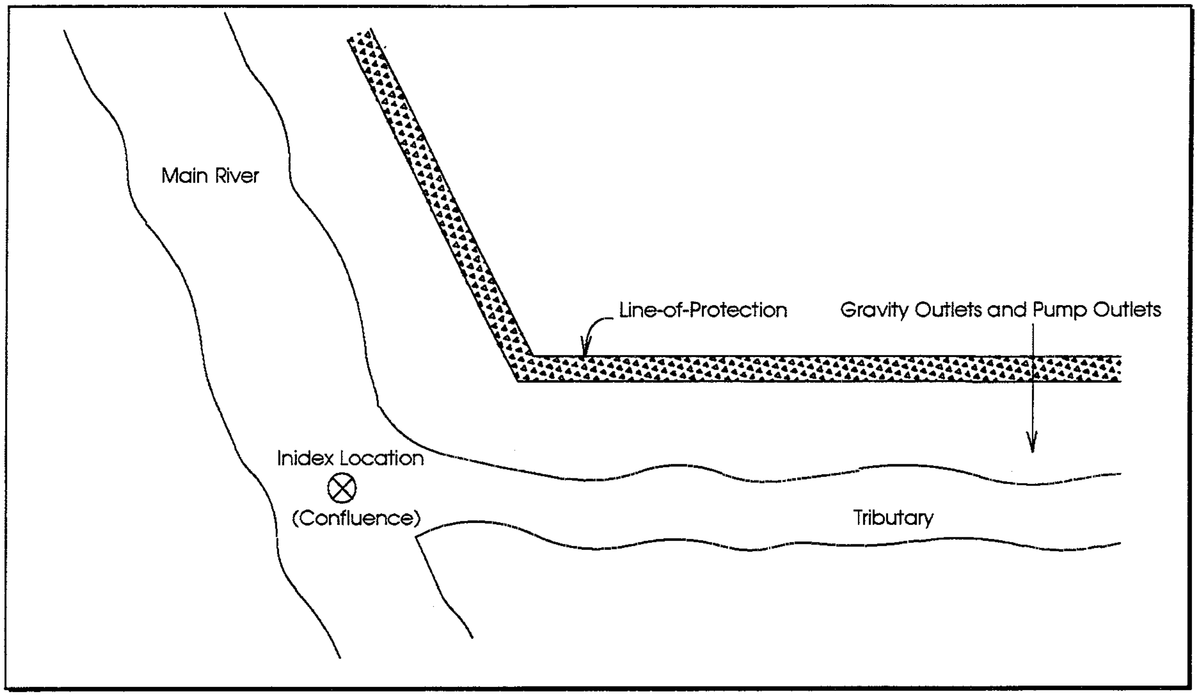


FIGURE 8.22 Tributary Rating Table Concepts: Plan View

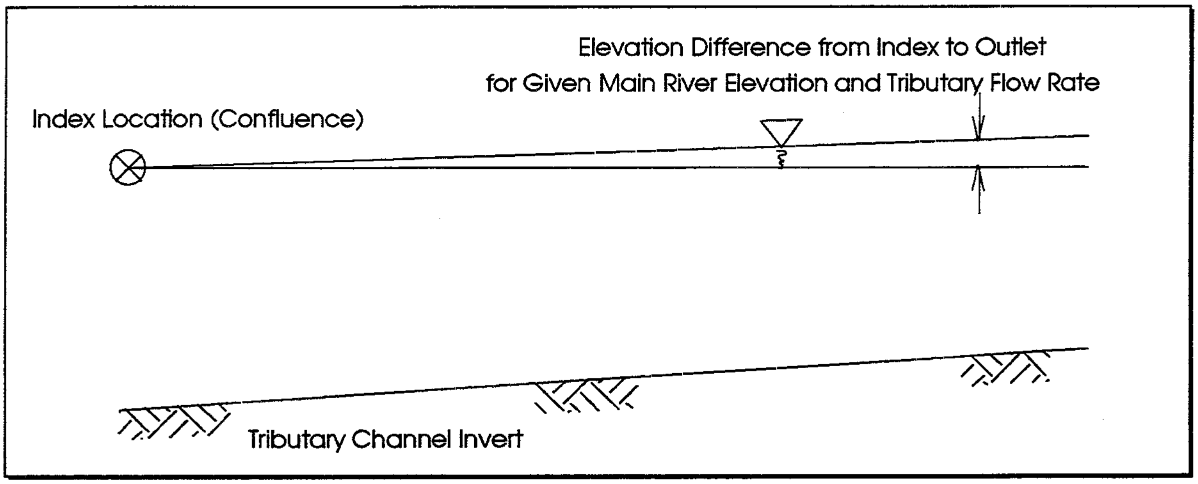


FIGURE 8.23 Tributary Rating Table Concepts: Profile View

Figure 8.24 illustrates the tributary rating table data entry screen. As indicated, the rating table contains up to 20 rows. Each row includes a single **Tributary Flow** rate and up to 7 **Tributary Elevations** which correspond to that flow rate. Each tributary elevation also corresponds to a different **Main River Elevation** at the confluence. These main river elevations must also be entered across the top of the table. All main river elevations and tributary elevations must be within the valid range of elevations described in Chapter 2.

The first tributary flow rate is always zero (0). Each main river elevation value and tributary flow rate should exceed the previous value.

Pressing the F9 key causes the tributary transfer relationship table to be plotted on the computer screen. Figure 8.25 illustrates the plot. As shown, a separate curve is plotted for each main river elevation.

CSA 01.01.00 EXST10
Study ID RBEND2
Module ID EXSTAGE

Exterior Stage (EXSTAGE)

Tributary Rating Table

Tributary Flow (cfs)	Tributary Elevations (ft)						
	Main River Elev (1)	Main River Elev (2)	Main River Elev (3)	Main River Elev (4)	Main River Elev (5)	Main River Elev (6)	Main River Elev (7)
	589.00	590.00	591.00	592.00	593.00	594.00	595.00
0.0	589.00	590.00	591.00	592.00	593.00	594.00	595.00
100.0	590.00	591.00	592.00	593.00	594.00	595.00	596.00
500.0	591.00	592.00	593.00	594.00	595.00	596.00	597.00
1000.0	592.00	593.00	594.00	595.00	596.00	597.00	598.00
5000.0	593.00	594.00	595.00	596.00	597.00	598.00	599.00
10000.0	594.00	595.00	596.00	597.00	598.00	599.00	600.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Save Data and Exit

FIGURE 8.24 Tributary Transfer Relationship Data Entry Screen

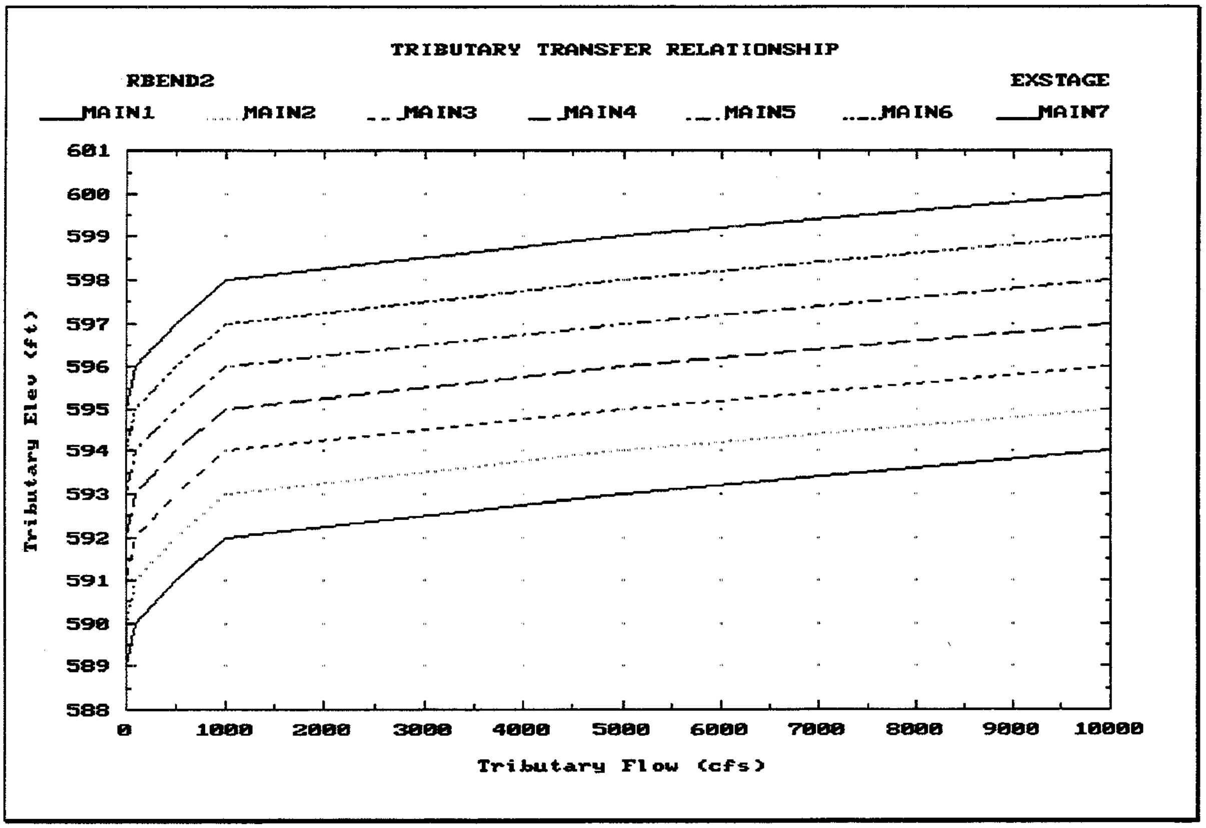


FIGURE 8.25 Tributary Transfer Relationship Plot

8.3. VIEW EXTERIOR STAGE HYDROGRAPH AT PRIMARY OUTLET

Figure 8.26 illustrates the Continuous Simulation Analysis **Exterior Stage Hydrograph at Primary Outlet**, which includes the following data values:

- **Date/Time**: The date and time at the end of each tabulation interval.
- **Elevation**: The water surface elevation in the exterior channel at the end of each tabulation interval.

If this is a computed hydrograph, HEC-IFH indicates the progress of the computations as they are performed.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. The F9 Plot key causes the HEC-IFH program to plot the exterior stage hydrograph. Figure 8.27 illustrates a typical annual exterior stage hydrograph plot. If you have entered enough data values, you may "zoom" to a one-year plot of monthly peak values, a one-month plot of actual values (as shown in Figure 8.28), or a one-day plot of actual values. From the one-year, one-month, or one-day plots, you may "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

Figure 8.29 illustrates the Hypothetical Event Analysis **Exterior Stage Hydrograph at Primary Outlet**, which includes the exterior stage hydrographs for all of the storm events considered in the analysis.

CSA 01.01.00 Exterior Stage (EXSTAGE) EXST18
Study ID RBEND2
Module ID EXSTAGE

View Exterior Stage Hydrograph at Primary Outlet

Date/Time DaMonYear/HrMn	Elevation (ft)
01OCT1950/2400	581.12
02OCT1950/2400	581.08
03OCT1950/2400	581.08
04OCT1950/2400	581.12
05OCT1950/2400	581.12
06OCT1950/2400	581.12
07OCT1950/2400	581.39
08OCT1950/2400	582.27
09OCT1950/2400	581.97
10OCT1950/2400	581.53
11OCT1950/2400	581.39
12OCT1950/2400	581.24
13OCT1950/2400	581.20
14OCT1950/2400	581.24

1Help 2PrtScr 3 4Goto 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Save Data and Exit

FIGURE 8.26 CSA Exterior Stage Hydrograph at Primary Outlet

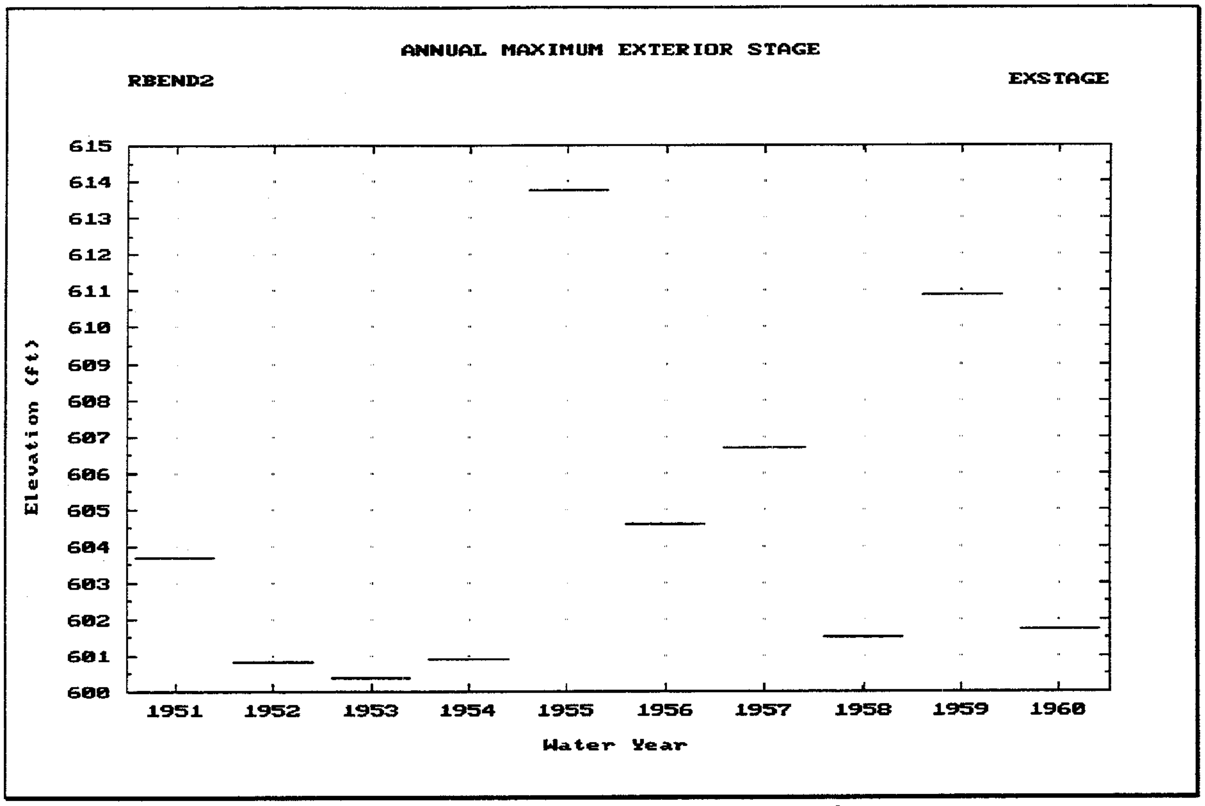


FIGURE 8.27 Plot of Annual Maximum Exterior Stages at Primary Outlet

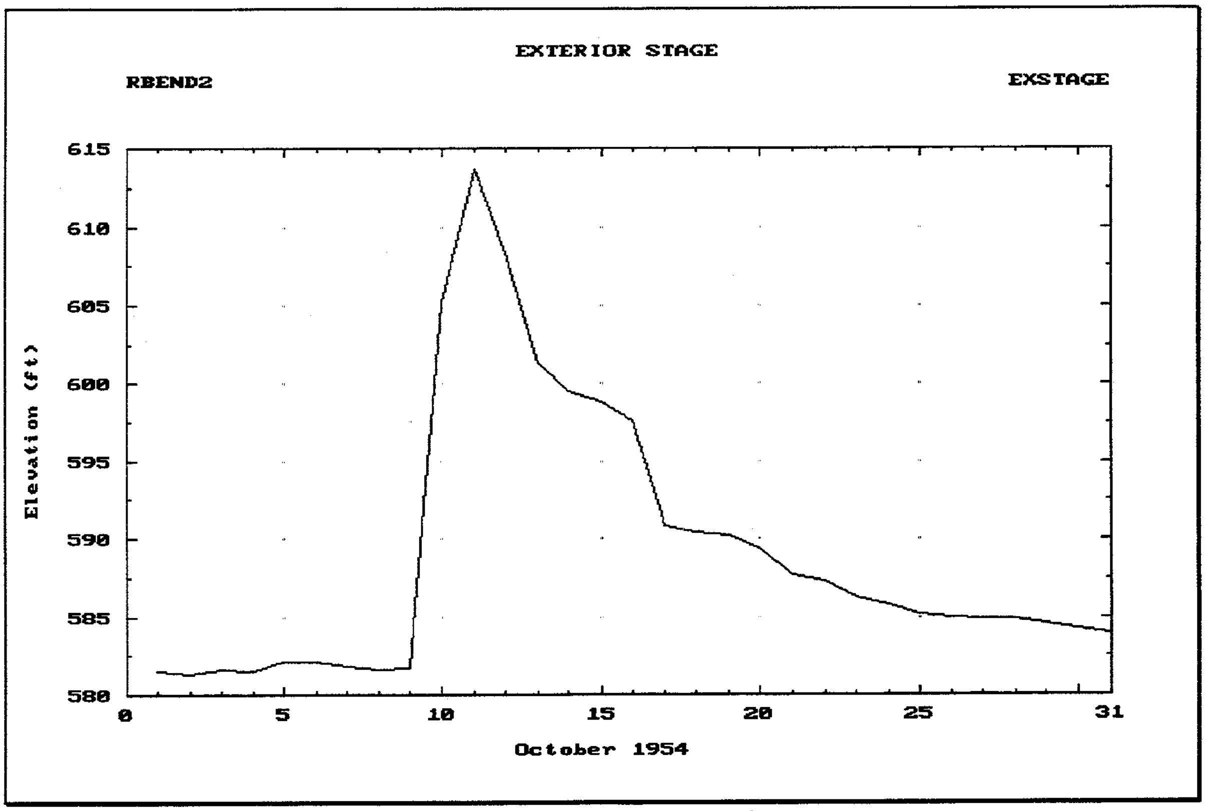


FIGURE 8.28 Plot of Exterior Stage Hydrograph at Primary Outlet

HEA 01.01.00
Study ID SILVERCR
Module ID EXSTAGE

Exterior Stage (EXSTAGE)

EXST22

View Exterior Stage Hydrographs at Primary Outlet (ft)

Da/HrMn	Hyp.Frq 50%	Hyp.Frq 20%	Hyp.Frq 10%	Hyp.Frq 4%	Hyp.Frq 2%	Hyp.Frq 1%	Hyp.Frq 0.2%	SPF
1/0100	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0200	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0300	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0400	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0500	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0600	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0700	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0800	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/0900	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/1000	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/1100	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/1200	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/1300	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0
1/1400	581.0	581.0	581.0	581.0	581.0	581.0	581.0	581.0

1Help 2PrtScr 3 4Goto 5 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 8.29 HEA Exterior Stage Hydrographs at Primary Outlet

8.4. TABULATE PRIMARY OUTLET EXTERIOR STAGE EXCEEDANCE DURATION

After an exterior stage hydrograph at the primary outlet location is entered, imported, or specified for computation, HEC-IFH can generate an exceedance duration table from the stage hydrograph. The computed data may then be used to establish a relationship between exterior stage and storm frequency. No further data entry is required for this operation. The HEC-IFH program demonstrates the progress of the computations as they are performed.

The exceedance duration table is not available for the Hypothetical Event Analysis method because the relatively short time base of the stage hydrograph would make the results meaningless. For the Continuous Simulation Method, the exceedance duration table is included as an optional method of analyzing the exterior stage hydrograph, so that the user can have the best possible understanding of the data.

Figure 8.30 illustrates the determination of stage versus frequency data. The following computations are required:

1. **Determine Extreme Stage Values**: The exterior stage hydrograph is analyzed to determine the maximum and minimum stage values. This range of values is divided into a number of increments. The first column in Table 8.1 shows an example of such a series of incremental elevations.

2. **Determine Days in which Stages are Exceeded**: The exterior stage hydrograph is analyzed again to total the number of days that the exterior stage exceeds each incremental elevation. The second column in Table 8.1 lists the number of days in which each incremental elevation is exceeded for the example data set.

3. **Convert Days to Percentage**: The percent of time exceeded is computed by dividing the days exceeded for an elevation value by the total days of the record. The third column in Table 8.1 illustrates the results.
4. **Interpolate Standard Percentages**: The percentages listed in Table 8.1 are interpolated to determine the exterior elevation corresponding to each of sixteen standard percentage values (0.2, 0.5, 1, 2, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 99, 100).
5. **Interpolate Flow Rates**: If an exterior channel rating curve is also available, the program also interpolates the flow rate corresponding to each computed exterior stage value.

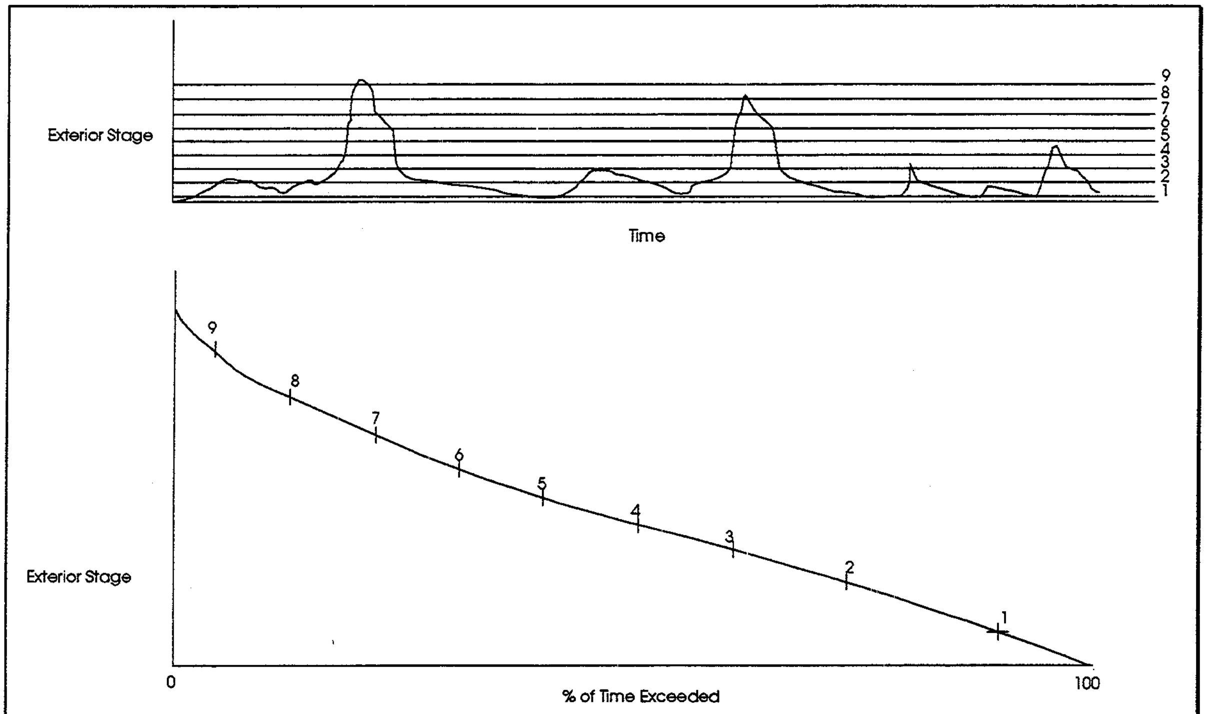


FIGURE 8.30 Elevation - Percent Time Exceeded - Frequency

TABLE 8.1 Exterior Elevation vs. Percent Time Exceeded Example

Elevation/Stage (ft.)	No. of Days Exceeded	Percent of Time Exceeded	Flow cfs
430	3,650	100.0	100
432	3,560	99.5	1,050
434	3,010	82.5	3,870
436	2,175	60.0	8,920
438	1,400	38.4	15,800
440	928	25.4	23,600
442	580	15.9	45,100
444	275	7.5	73,000
446	58	1.6	120,000
450	0	0.0	293,000

Figure 8.31 illustrates the screen which displays the results of the exceedance duration computation. This table is really a completed version of Table 8.1, although the numbers in the two tables do not match in this case, because they are based on different data sets.

As indicated, Stage and No. of Values are provided for each of the sixteen standard percentages ranging from 0.2% through 100%. In this example, a rating curve for the exterior channel is provided, so the table also lists interpolated flow rate values for each percentage. If a rating table is not available, all Flow values are zero (0.0).

Pressing the F9 key causes the Exceedance Duration table to be plotted on the computer screen. Figure 8.32 illustrates the plot.

CSA 01.01.00
Study ID RBEND2
Module ID EXSTAGE

Exterior Stage (EXSTAGE)

EXST08

Tabulate Exceedance Duration

% Time Exceeded	Flow (cfs)	Stage (ft)	No. of Values
100%	37.9	580.95	3653.
99%	40.0	581.00	3616.
90%	51.4	581.29	3288.
80%	61.0	581.53	2922.
70%	69.3	581.73	2557.
60%	77.2	581.93	2192.
50%	90.7	582.27	1827.
40%	121.9	583.05	1461.

% Time Exceeded	Flow (cfs)	Stage (ft)	No. of Values
30%	190.5	584.76	1096.
20%	347.8	586.85	731.
10%	703.9	590.58	365.
4%	1729.3	595.92	146.
2%	2466.6	598.87	73.
1%	2802.9	599.93	37.
0.5%	3207.6	601.18	18.
0.2%	4644.3	604.88	7.

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE 8.31 Exceedance Duration Table

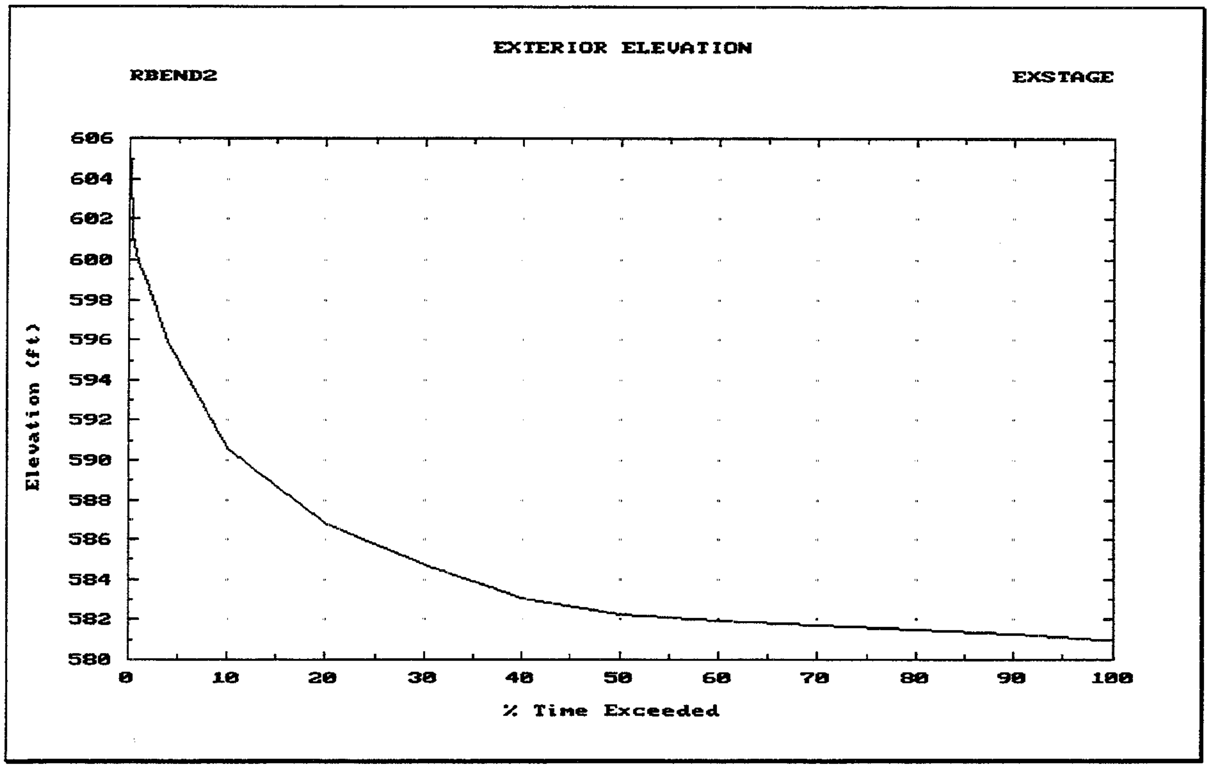


FIGURE 8.32 Exceedance Duration Plot

CHAPTER 9.
Auxiliary Inflow/Outflow

9.1. INTRODUCTION

Auxiliary inflows include any inflows to the interior area other than sub-basin runoff or base flow. Auxiliary outflows include any outflows from the interior area that may occur other than gravity or pump outlet discharge. The following types of auxiliary flows may be considered when using HEC-IFH:

1. **Auxiliary inflows** for each interior sub-basin. Auxiliary inflows enter the interior system and combine with runoff to form total inflows. Auxiliary inflows can account for overflows or diversions from other drainage areas, or provide a way for the user to input hydrographs computed using methods other than the built-in HEC-IFH runoff routines.
2. **Flow Diversions** out of the upper interior sub-basin. A pressure conduit or diversion channel might carry such a diversion. Diverted flows leave the interior system.
3. **Overflows** out of the lower interior sub-basin. Overflows may occur as the water surface elevation in the interior ponding area rises to a level that causes flows to spill out of the interior area. Overflows generally enter an adjacent interior area. The HEC-IFH program assumes that the flow leaves the interior system.
4. **Seepage** into the interior pond. Seepage occurs because of the permeability of the line of protection or the soil underlying the line of protection. High water levels in the exterior channel provide the force that drives seepage. The program can account for seepage from the exterior river to the interior area based on a user-specified head vs. discharge relationship.

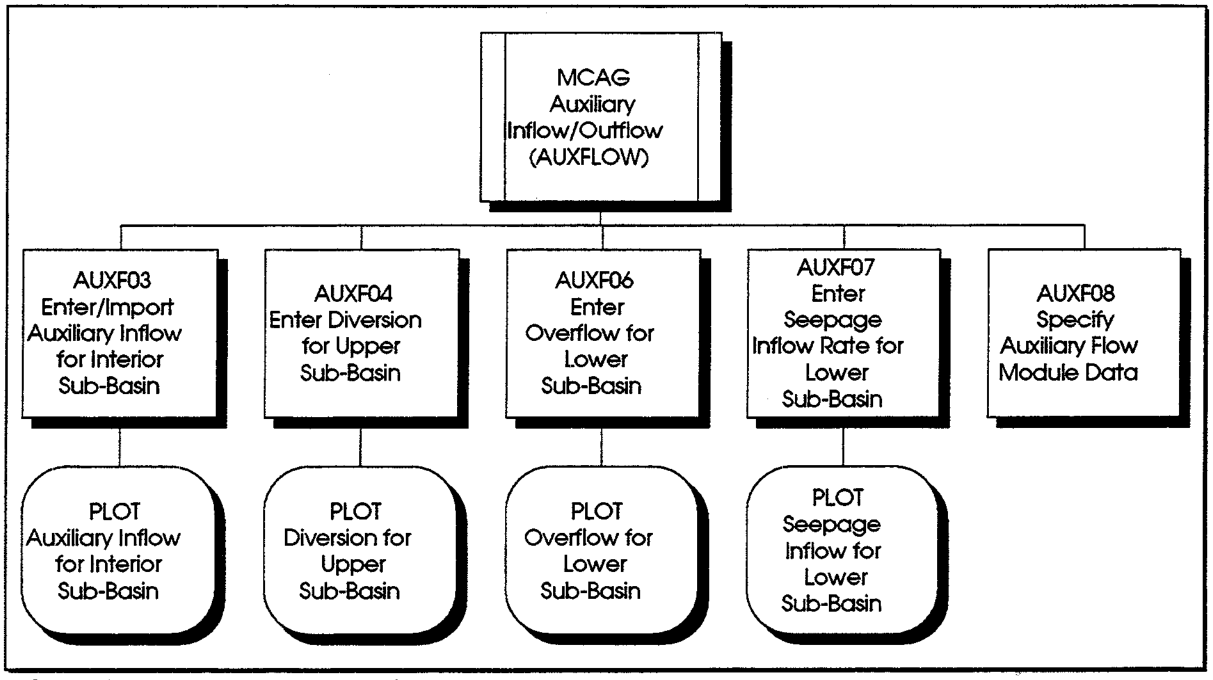


FIGURE 9.1 AUXFLOW Module Structure

Figure 9.1 shows the structure of the HEC-IFH program screens which deal with data entry and plotting for auxiliary flows. As shown, HEC-IFH provides several data entry screens and plots for auxiliary flow data. The Continuous Simulation and Hypothetical Event analysis approaches both use the same auxiliary flow data, except that auxiliary inflows cannot be specified for the upper interior sub-basin for Hypothetical Event Analyses.

Figure 9.2 illustrates the main menu screen of the AUXFLOW module for Continuous Simulation Analysis. The corresponding Hypothetical Event Analysis screen is almost identical.

```
CSA 01.01.00                                                          MCAG
Study ID  RBENDZ       Auxiliary Inflow/Outflow (AUXFLOW)



        Select Option:

          A. Enter/Import Auxiliary Inflow for Interior Sub-Basins
          B. Enter Diversion Rates for Upper Sub-Basin
          C. Enter Overflow Rates for Lower Sub-Basin
          D. Enter Seepage Inflow Rates for Lower Sub-Basin
          E. Specify Auxiliary Flow Module Data



1Help  2PrtScr 3     4     5     6DOS   7     8     9     10Exit
           Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 9.2 Auxiliary Inflow/Outflow Menu Screen

9.2. AUXILIARY INFLOWS FOR INTERIOR SUB-BASINS

Although HEC-IFH provides runoff computation routines, it may be convenient to compute the runoff for one or both of the interior basins by other means. For example, if the interior study involved a complex interior area requiring sub-division into more than two sub-basins, a rainfall-runoff program such as HEC-1 could be used to generate the interior runoff. The runoff hydrograph could be written to HEC-DSS and subsequently imported into HEC-IFH as lower sub-basin auxiliary flow.

Auxiliary inflows also may be used to represent additional sources of inflow into the interior system that can be added to the runoff generated from rainfall. Examples include diversions or overflows from other drainage areas.

9.2.1. Auxiliary Inflows for Continuous Simulations

Figure 9.3 illustrates the data entry screen used to enter auxiliary inflow data for a Continuous Simulation Analysis. Each Auxiliary Inflow time series must be identified by a unique 8-character **Auxiliary Inflow ID**. This ID is used later when specifying which data will be used for each computation. A 40-character **Description** provides further background information on the auxiliary inflows.

```
CSA 01.01.00                                                      AUXF03
Study ID  RBEND2      Auxiliary Inflow/Outflow (AUXFLOW)

            Enter/Import Auxiliary Inflow for Interior Sub-Basin

Auxiliary Inflow ID        AUXFLOW1       Date/Time        Aux Inflow
  Description:                            DaMonYear/HrMn     (cfs)
 Aux Inflow Interior data WY1950-WY1960
                                          09OCT1954/2400       50.0
Starting Period            01OCT1950/2400 10OCT1954/2400     5710.0
 (e.g. 01JAN1989/1300)                    11OCT1954/2400     9460.0
                                          12OCT1954/2400     7090.0
Ending Period              30SEP1960/2400 13OCT1954/2400     4039.0
                                          14OCT1954/2400     3262.0
Time Interval              1DAY           15OCT1954/2400     2917.0
 (e.g. 1HOUR, 1DAY, ...)                  16OCT1954/2400     2518.0
                                          17OCT1954/2400      534.0
                                          18OCT1954/2400      420.0
                                          19OCT1954/2400      351.0
                                          20OCT1954/2400      282.0
                                          21OCT1954/2400      231.0
                                          22OCT1954/2400      218.0

1Help  2PrtScr 3Index  4    5     6DOS    7    8    9    10Exit
                 Press <F10> to Save Data and Return
```

FIGURE 9.3 Auxiliary Inflows Data Entry Screen

Several auxiliary inflow hydrographs may be entered or imported, each one stored under a different Auxiliary Inflow ID. When the cursor is on the Auxiliary Inflow ID field, the [F3] key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding inflow hydrographs will be displayed for editing.

The **Starting Period** and **Ending Period** of the auxiliary inflows must be entered. These use the standard HEC-DSS format for date and time values. The starting period is the end of the first computation interval, and the ending period is the end of the last computation interval in the time series. For example, a record consisting of hourly values for the month of October 1990 would have a starting period of 01OCT1990/0100 and an ending period of 31OCT1990/2400. If the auxiliary inflows for October 1990 consisted of daily instead of hourly values, the starting period would be 01OCT1990/2400 (the end of the first day), but the ending period would still be 31OCT1990/2400. The ending period must be later than the starting period.

The **Time Interval** must be entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The time increment must be consistent with the starting and ending period. For example, a time interval of 2HOUR would not be consistent with a starting period of 01OCT1990/0100, but a time increment of 1HOUR would be.

After entering the starting and ending times and time interval, the HEC-IFH program is ready to receive **Auxiliary Inflow** values for each time period. The user may enter these values or import them from an external HEC-DSS file on disk. All auxiliary inflow values must be equal to or greater than zero (0).

To import an auxiliary inflow time series, press the F7 key after entering the time increment but before entering any auxiliary inflow values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated.

Pressing the F4 Goto key during data entry instructs HEC-IFH to move directly to any specified time interval in the time series. Chapter 2 provides further details.

After entering or importing auxiliary inflows, the F9 key causes the HEC-IFH program to plot the auxiliary inflow hydrograph. Figure 9.4 illustrates a typical annual total auxiliary inflow plot. If enough data values are available, you may "zoom" to a one-year plot of daily totals (as shown in Figure 9.5) or a one-month plot of actual inflow values (as shown in Figure 9.6). From the one-year or one-month plots, you may "pan" to plots of different years or months, if available. The zoom and pan options are described in Chapter 2.

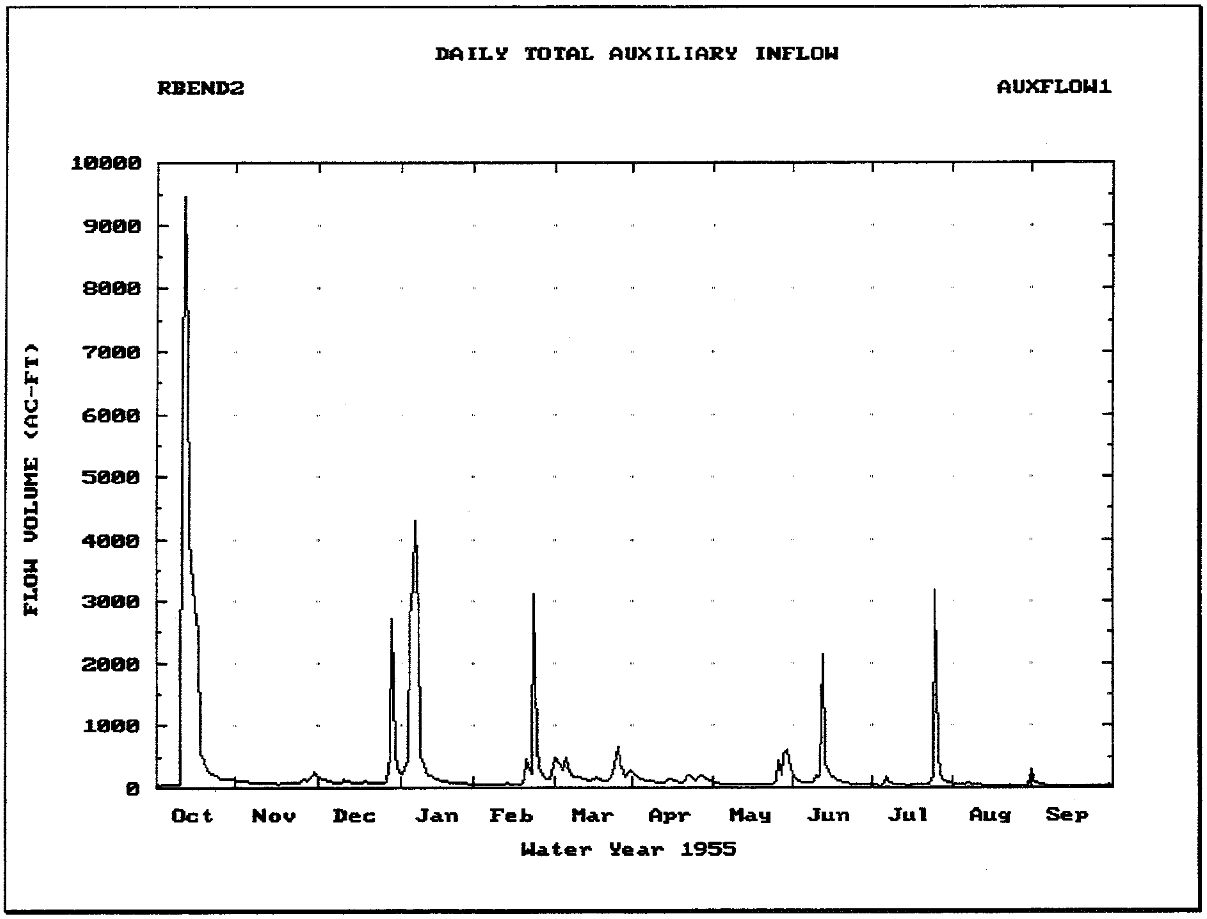


FIGURE 9.5 Plot of Daily Auxiliary Inflow Totals

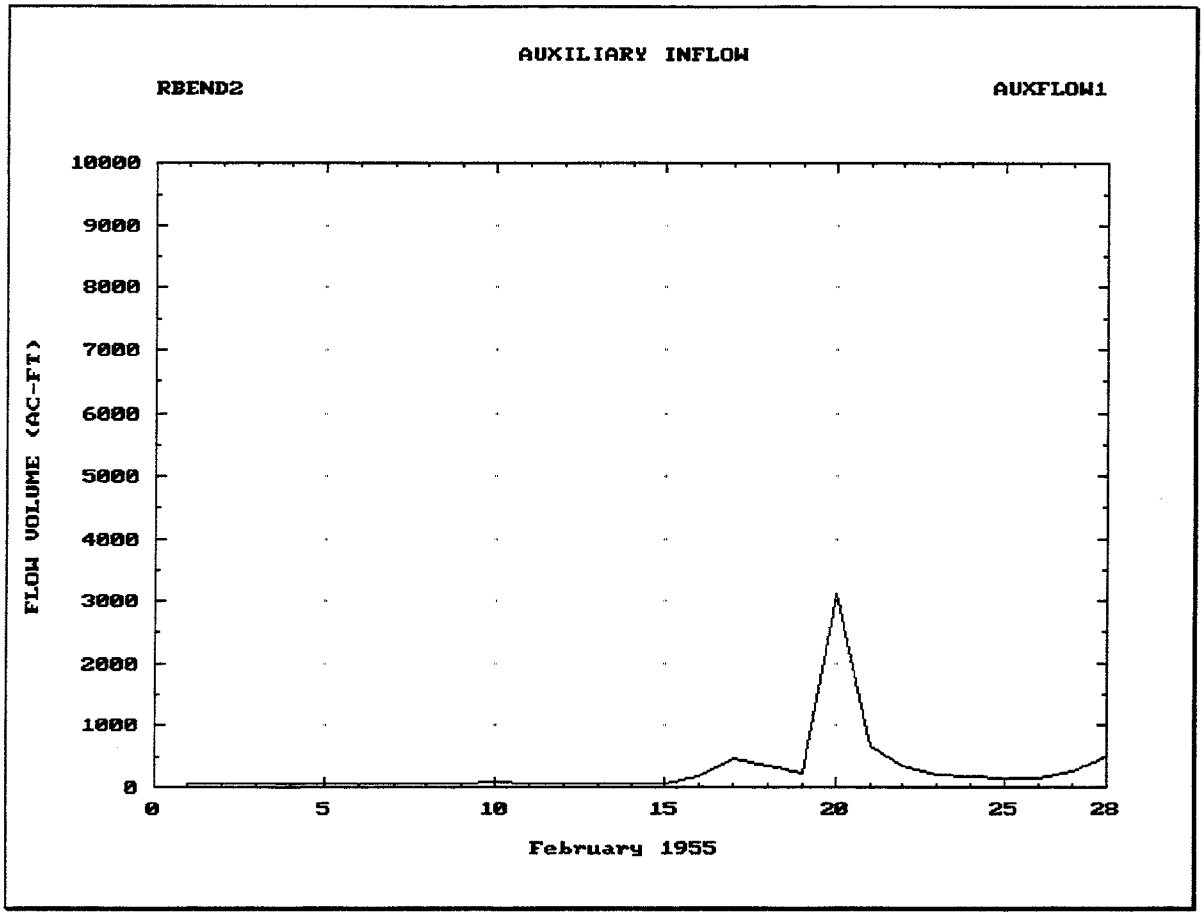


FIGURE 9.6 Plot of Periodic Auxiliary Inflow Values

9.2.2. Auxiliary Inflows for Hypothetical Event Analyses

Figure 9.7 illustrates the data entry screen used to enter auxiliary inflow data for a Hypothetical Event Analysis. Each event-set of Auxiliary Inflow time series must be identified by a unique 8-character **Auxiliary Inflow ID**. This ID is used later when specifying which data will be used for each computation. A 40-character **Description** provides further background information on the auxiliary inflows.

The **Time Interval** must be entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY.

The **Number of Intervals** determines the number of auxiliary inflow hydrograph ordinates which will be entered or imported. The number of intervals may be computed by dividing the storm duration by the time interval. For example, a 10-day storm analyzed using a 5-minute time interval would require 2,880 time intervals. Any integer number of intervals up to 10,000 is acceptable, as long as the number of days does not exceed 99.

After entering the time interval and number of intervals, the HEC-IFH program is ready to receive **Auxiliary Inflow** values for each time period for each of the standard storm events used in Hypothetical Event Analyses. The user may enter these values or import them from an external HEC-DSS file on disk. All auxiliary inflow values must be equal to or greater than zero (0). Inflow hydrographs may be entered for some storm events and omitted for others.

HEA 01.01.00 | Auxiliary Inflow/Outflow (AUXFLOW) | AUXF10
Study ID SILVERCR

Enter/Import Auxiliary Inflow for Lower Sub-Basin (cfs)
Aux. Inflow ID AUXINFLO Description Example Aux Inflow - 10%,4%,2%,1% freq.
Time Interval 1HOUR Number of intervals 60

Da/HrMn	Hyp.Frq 50%	Hyp.Frq 20%	Hyp.Frq 10%	Hyp.Frq 4%	Hyp.Frq 2%	Hyp.Frq 1%	Hyp.Frq 0.2%	SPF
1/0100	0.	0.	50.	50.	51.	51.	0.	0.
1/0200	0.	0.	50.	50.	51.	51.	0.	0.
1/0300	0.	0.	51.	52.	53.	53.	0.	0.
1/0400	0.	0.	54.	56.	57.	57.	0.	0.
1/0500	0.	0.	58.	60.	63.	63.	0.	0.
1/0600	0.	0.	62.	66.	70.	70.	0.	0.
1/0700	0.	0.	66.	71.	76.	76.	0.	0.
1/0800	0.	0.	71.	77.	88.	90.	0.	0.
1/0900	0.	0.	76.	86.	118.	125.	0.	0.
1/1000	0.	0.	91.	116.	183.	201.	0.	0.
1/1100	0.	0.	132.	194.	300.	339.	0.	0.
1/1200	0.	0.	240.	363.	496.	573.	0.	0.

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 9.7 HEA Auxiliary Inflows Data Entry Screen

To import an auxiliary inflow time series, press the F7 key after entering the time interval but before entering any auxiliary inflow values. As described in Chapter 2, the file name of the HEC-DSS file and the HEC-DSS path name of the time series must be provided in order to import data. If the HEC-IFH program cannot locate the specified file or HEC-DSS path name, an error message is displayed.

For Hypothetical Event Analysis, HEC-IFH allows the user to specify up to 8 different values for Part F of the HEC-DSS path name. These represent the different storm events which may be analyzed in a single HEA plan analysis. If one or more storm events will not be used in a particular plan analysis, the user may enter SKIP for the corresponding Part F. The time series for that storm event will not be imported.

The HEC-IFH program checks all imported values to detect missing data. If data values are missing, the missing data values can be replaced with zeroes, or the import procedure can be terminated.

Pressing the F4 Goto key during data entry instructs HEC-IFH to move directly to any specified time interval in the time series. Chapter 2 provides further details.

After entering or importing auxiliary inflows, the F9 key causes the HEC-IFH program to plot the auxiliary inflow hydrographs for each selected storm frequency (see Figure 9.8). Figure 9.9 illustrates a typical auxiliary inflow plot. If enough data values are available, you may "zoom" to a one-day plot of inflow values (as shown in Figure 9.10). From the one-day plot, you may "pan" to plots of different days, if available. The zoom and pan options are described in Chapter 2. On a color computer monitor, each event would be plotted using a different color.

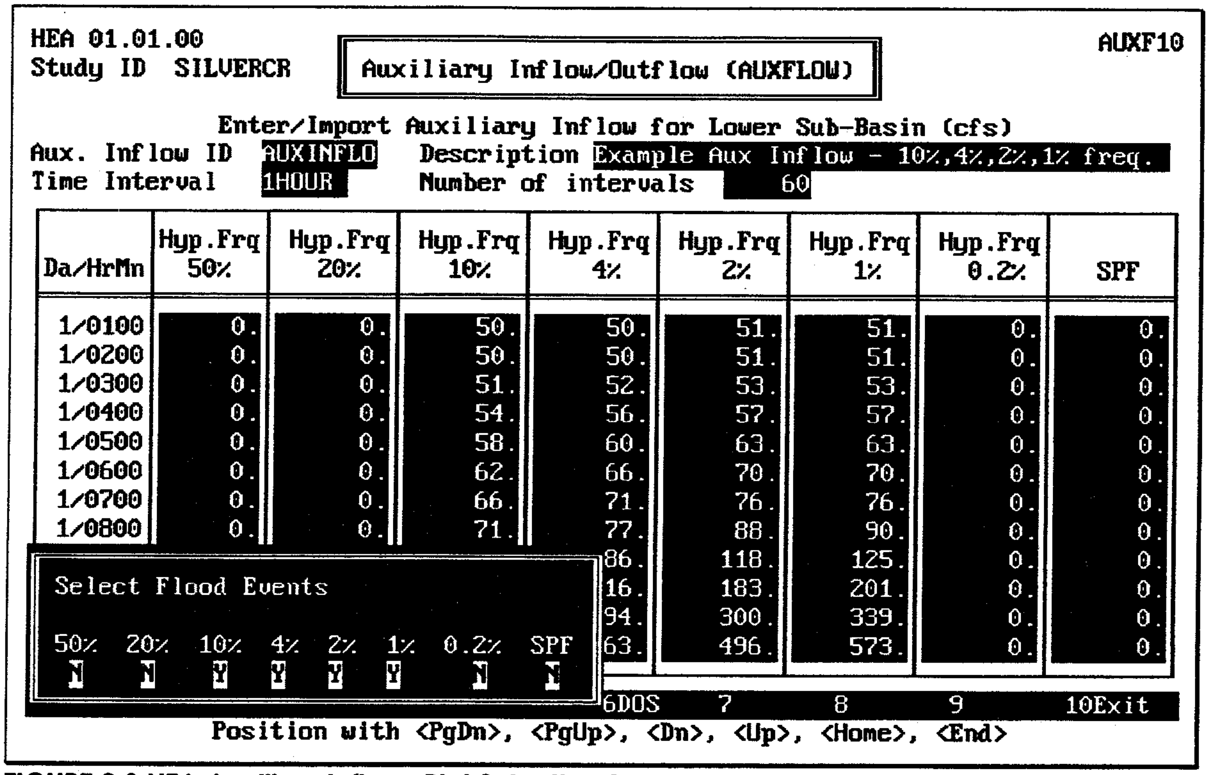


FIGURE 9.8 HEA Auxiliary Inflows Plot Selection Screen

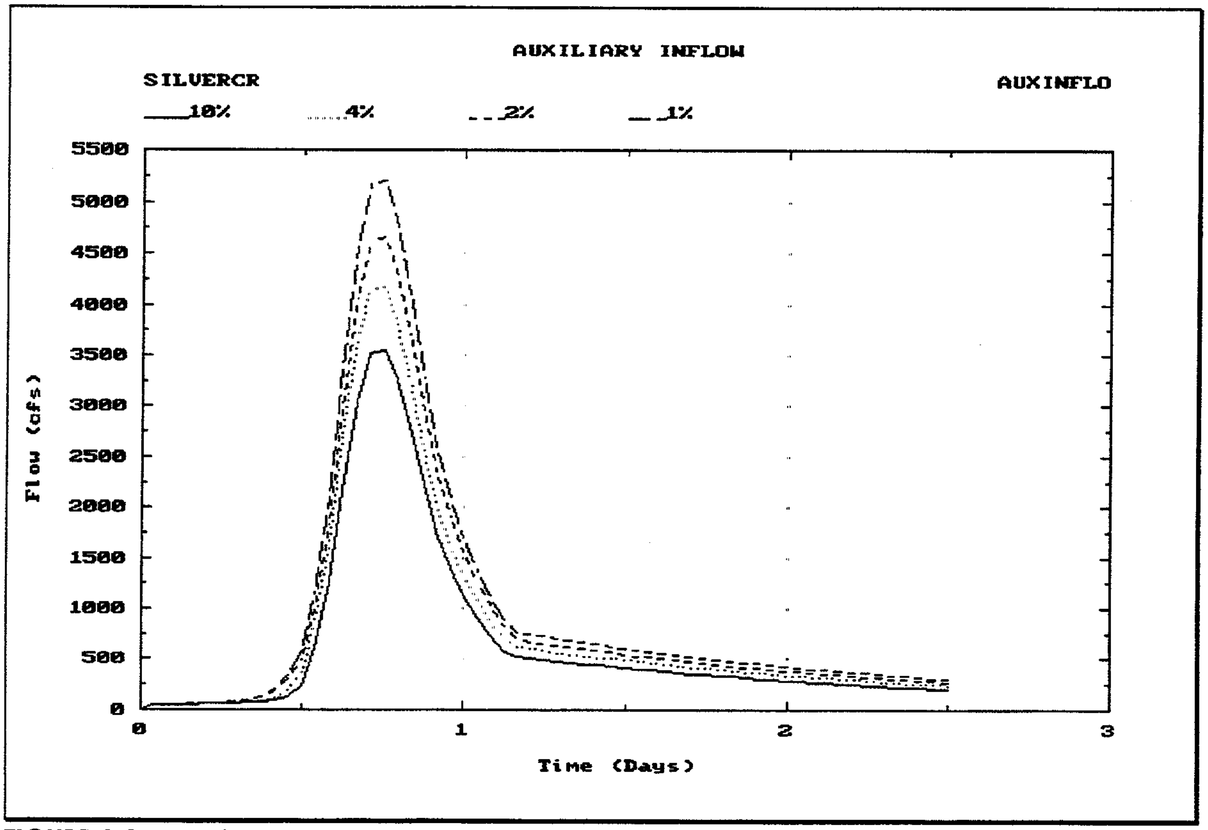


FIGURE 9.9 Plot of HEA Auxiliary Inflow for Analysis Record

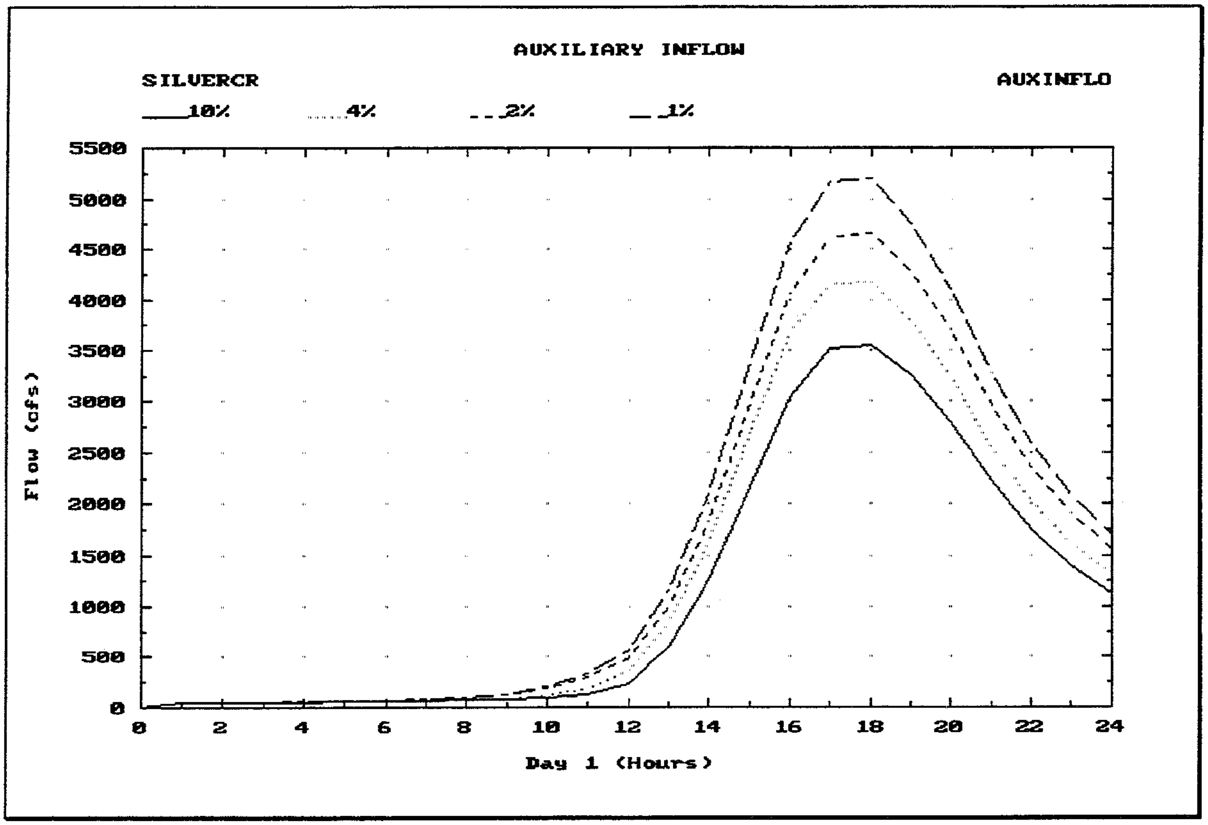


FIGURE 9.10 Plot of HEA Zoomed Auxiliary Inflow Values

9.3. DIVERSION FOR UPPER SUB-BASIN

For some interior systems, a portion of the runoff from the interior area may be diverted out of the interior system. These ***diversions*** generally originate in the upper portion of the drainage area, so that gravity can be used to convey the diverted flow around the interior area, or through the line-of-protection in a pressure conduit. Therefore, HEC-IFH allows diversions only for the upper interior sub-basin.

A diversion table is used to describe the capacity of the diversion in relation to the total inflow rate for the upper sub-basin. The diversion table is input directly to the HEC-IFH program as a table of total inflow rates and corresponding diversion flow rates. The total inflow rates include the runoff rate for the upper sub-basin, plus the auxiliary inflow rate described earlier in this chapter. Up to 20 data points may be used. Figure 9.11 illustrates the diversion table data entry screen.

Several diversion tables may be entered, each one stored under a different **Diversion Table ID**. When the cursor is on the Diversion Table ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding table will be loaded for editing. The 40-character **Description** provides documentation for each diversion table.

The **Runoff + Auxiliary Inflow** and the **Diverted Flow** columns always begin with values of zero (0). Each succeeding value should equal or exceed the previously-entered value. The diverted flow cannot exceed the corresponding Runoff + Auxiliary Inflow value.

Pressing the F9 key causes the diversion table to be plotted on the computer screen. Figure 9.12 illustrates the plot.

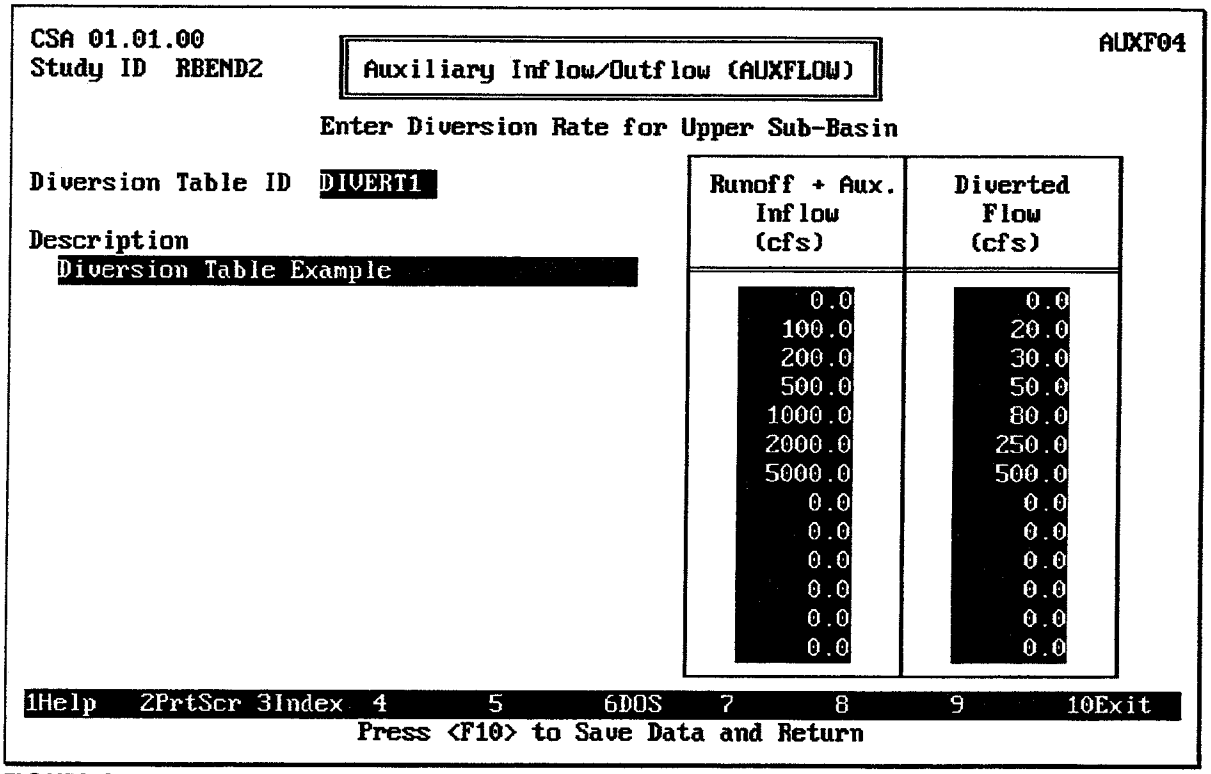


FIGURE 9.11 Diversion Table Data Entry Screen

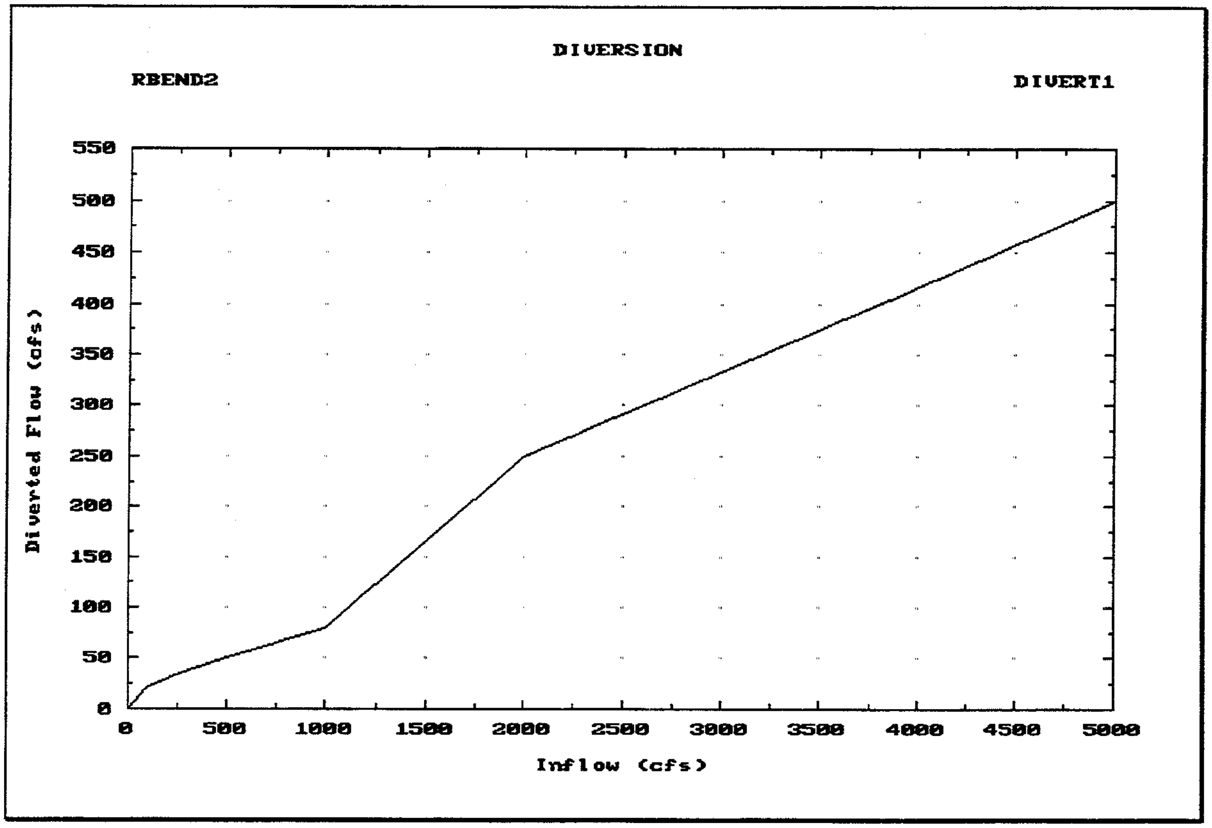


FIGURE 9.12 Diversion Table Plot

9.4. OVERFLOW FOR LOWER SUB-BASIN

For some interior systems, there is a low area adjacent to the interior ponding area. Water from the interior pond may begin to spill, or ***overflow***, into the adjacent low area as the interior pond elevation rises during a storm event. The adjacent low area may be connected to another pond or channel, or the overflow may simply spill into another watershed area. HEC-IFH allows overflows only for the lower interior sub-basin, where the interior ponding area is located.

An overflow table describes the capacity of the overflow in relation to the interior pond elevation. The overflow table is input directly to the HEC-IFH program as a table of pond elevations and corresponding overflow rates. Up to 20 data points may be used. Figure 9.13 illustrates the overflow table data entry screen.

Several overflow tables may be entered, each one stored under a different **Overflow Table ID**. When the cursor is on the Overflow Table ID field, the [F3] key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding table will be loaded for editing. The 40-character **Description** provides documentation for each overflow table.

The first **Drainage Basin Overflow** value is always zero (0). Each **Interior Pond Elevation** value and Drainage Basin Overflow should equal or exceed the previously-entered value. All interior pond elevation values must fall within the valid range of elevations described in Chapter 2 of this manual.

Pressing the [F9] key causes the overflow table to be plotted on the computer screen. Figure 9.14 illustrates the plot.

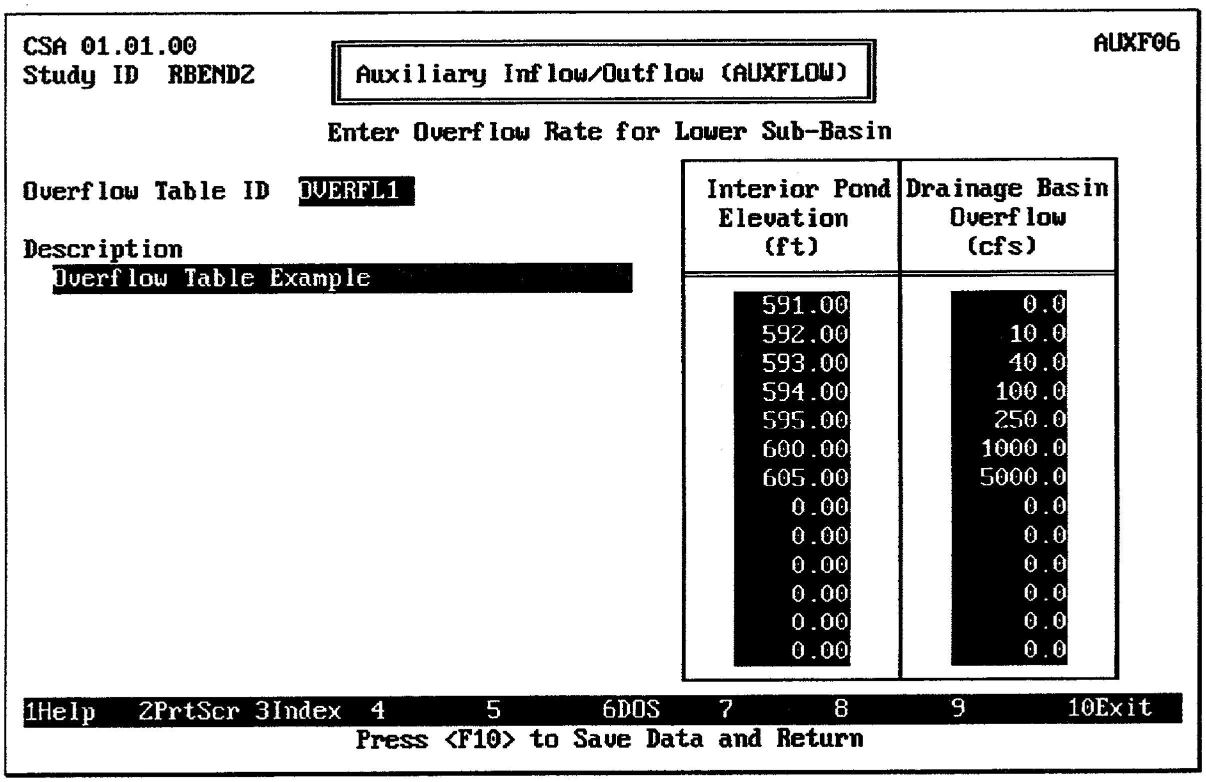


FIGURE 9.13 Overflow Table Data Entry Screen

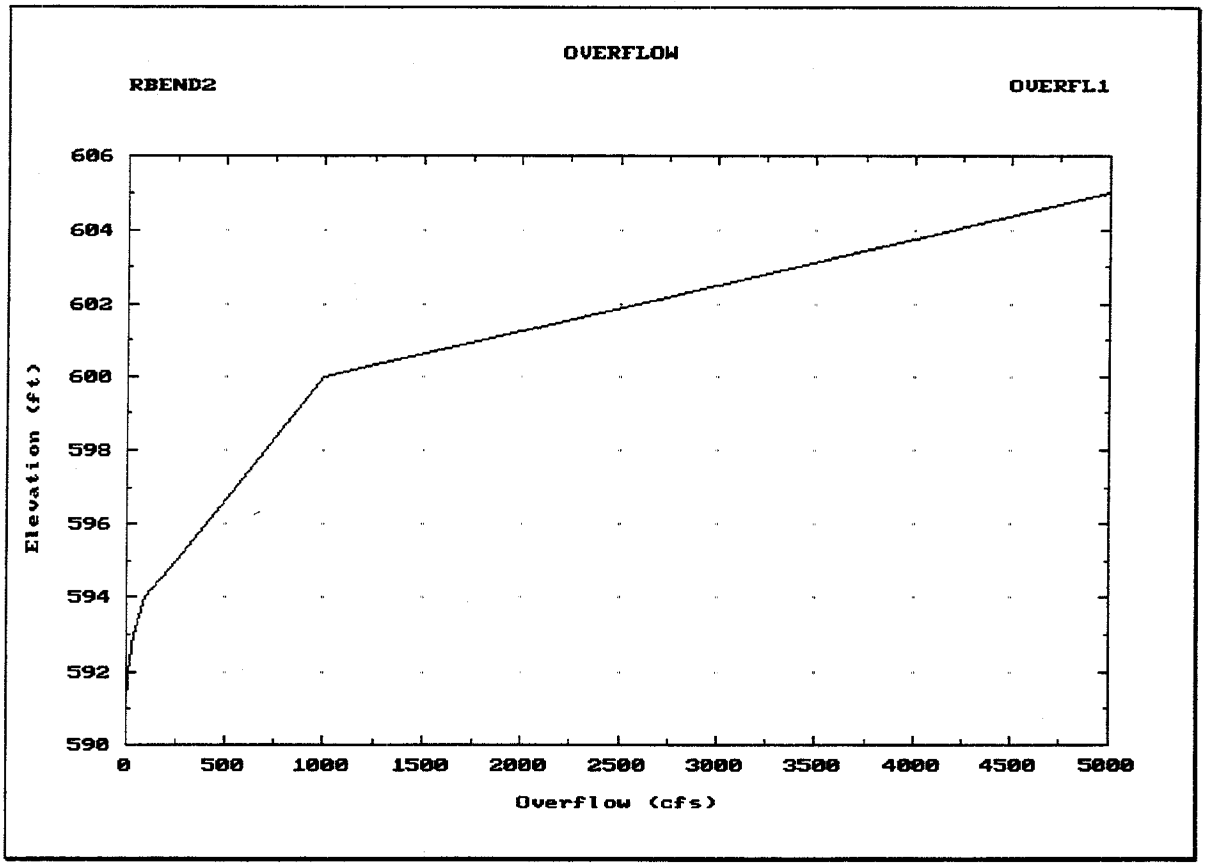


FIGURE 9.14 Overflow Table Plot

9.5. SEEPAGE INFLOW FOR LOWER SUB-BASIN

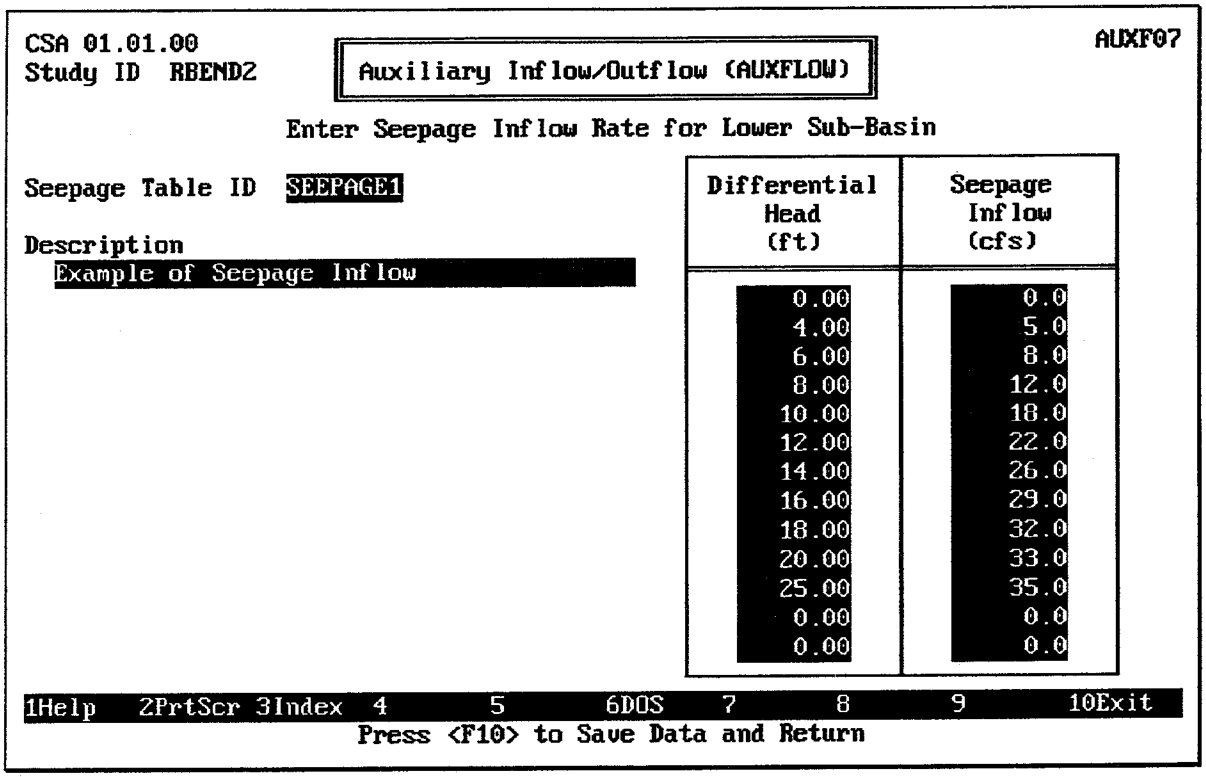
The line-of-protection is generally not completely impervious to ***seepage***, which may pass through or beneath the levee. Seepage occurs because of the difference in water surface elevations on each side of the line-of-protection. If the exterior water surface elevation is higher than the interior water surface elevation, then seepage may enter the interior ponding area as inflow. In the design of the HEC-IFH program, it is assumed that seepage can occur as inflow from the exterior to the interior only and may not be lagged in time.

HEC-IFH uses a seepage table to describe the seepage flow rate in relation to the head differential across the line-of-protection. The seepage table is input directly to the HEC-IFH program as a table of differential heads and corresponding seepage flow rates. Up to 20 data points may be used. Figure 9.15 illustrates the seepage table data entry screen.

Several seepage tables may be entered, with each one stored under a different **Seepage Table ID**. When the cursor is on the Seepage Table ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding seepage table will be loaded for editing. The 40-character **Description** provides documentation for each seepage table.

The first **Differential Head** and **Seepage Inflow** values are always zero (0). Each succeeding value should exceed the previous value.

Pressing the F9 key causes the seepage table to be plotted on the computer screen. Figure 9.16 illustrates the plot.



CSA 01.01.00
Study ID RBEND2

Auxiliary Inflow/Outflow (AUXFLOW)

AUXF07

Enter Seepage Inflow Rate for Lower Sub-Basin

Seepage Table ID SEEPAGE1

Description
Example of Seepage Inflow

Differential Head (ft)	Seepage Inflow (cfs)
0.00	0.0
4.00	5.0
6.00	8.0
8.00	12.0
10.00	18.0
12.00	22.0
14.00	26.0
16.00	29.0
18.00	32.0
20.00	33.0
25.00	35.0
0.00	0.0
0.00	0.0

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE 9.15 Seepage Table Data Entry Screen

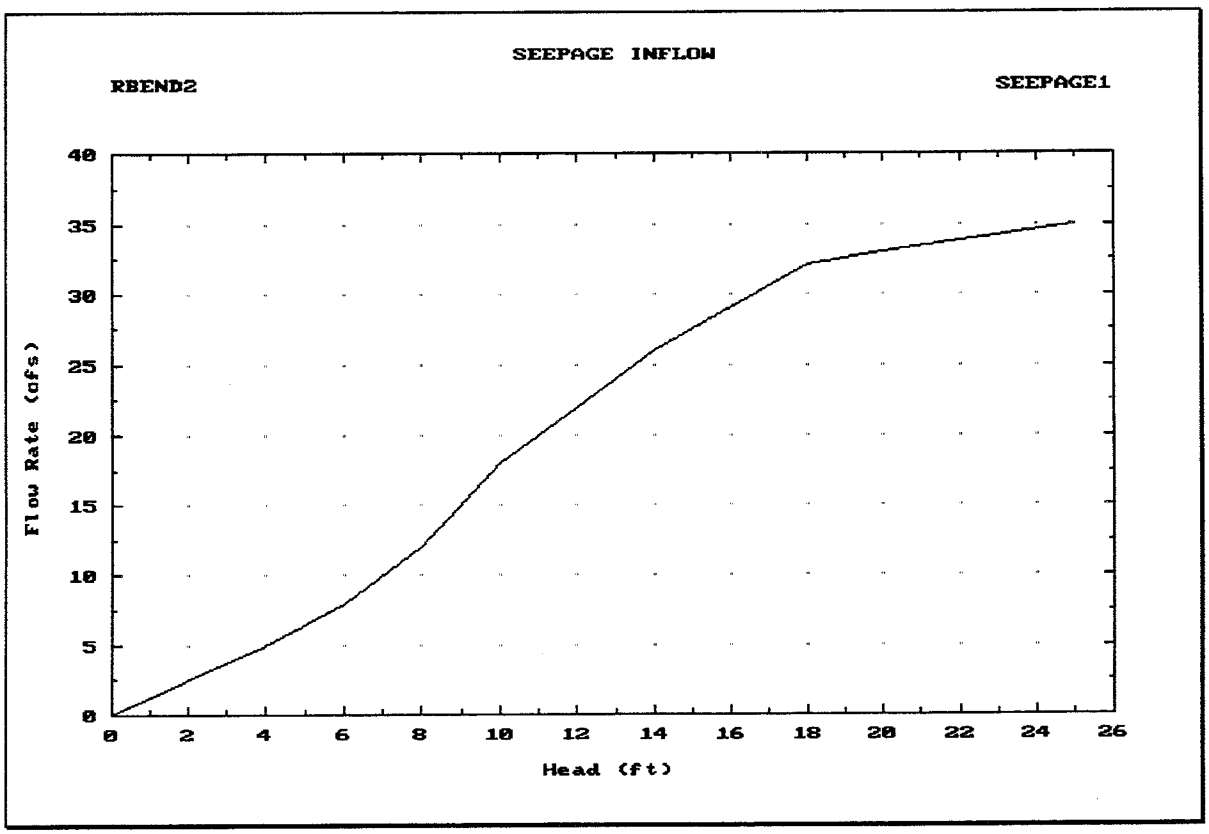


FIGURE 9.16 Seepage Table Plot

9.6. SPECIFYING AUXILIARY INFLOW/OUTFLOW DATA

Figure 9.17 shows the screen used to specify the auxiliary flow conditions which, when combined, make up a particular AUXFLOW data module for a Continuous Simulation Analysis. Figure 9.18 illustrates the corresponding screen for Hypothetical Event Analyses.

Like other HEC-IFH data entry modules, the AUXFLOW module data is stored under a **Module ID**. Several AUXFLOW module data sets may be stored under different IDs. When the cursor is on the Module ID field, the F3 key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding data will be loaded for editing. The 40-character **Description** provides documentation for each AUXFLOW Module data set.

The AUXFLOW module data includes up to two optional **Auxiliary Inflow IDs** (one for the upper interior sub-basin and the other for the lower interior sub-basin). When the cursor is on each ID field, the F3 key displays a list of previously-stored Auxiliary Inflow IDs. Any of these previous IDs may be selected. One or both of these IDs may be omitted if there are no auxiliary inflows for the sub-basin.

The AUXFLOW module data also includes optional diversion, overflow, and seepage tables. Each of these tables is identified by its ID. Any ID already entered for the present STUDYID may be selected. When the cursor is on each ID field, the F3 key displays a list of previously-stored IDs. Any of these table IDs may be selected or omitted. As each ID is entered, the HEC-IFH program displays the 40-character description for that ID. This helps the user to verify that the program is using the correct data.

The user may reenter the AUXFLOW module later in order to change or add IDs for any of the auxiliary flow data elements. New AUXFLOW modules may also be defined.

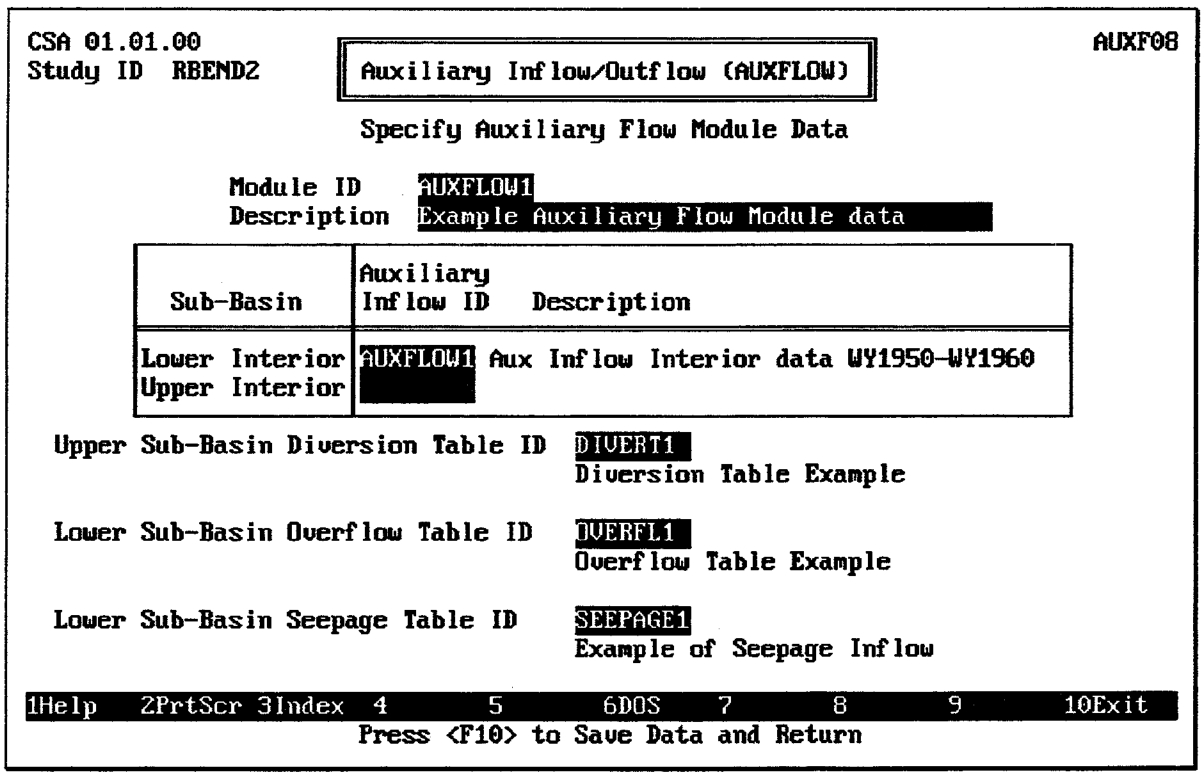


FIGURE 9.17 Auxiliary Flow Data Screen for Continuous Simulations

```
HEA 01.01.00                                                          AUXF09
Study ID  SILVERCR       Auxiliary Inflow/Outflow (AUXFLOW)

                              Specify Auxiliary Flow Data

              Module ID      AUXLFOW2
              Description    Example Auxiliary Flow Data.

  Lower Sub-Basin Auxiliary Inflow ID AUXINFLO
                                      Example Aux Inflow - 10%,4%,2%,1% freq.

  Upper Sub-Basin Diversion Table ID  DIVERT1
                                      Diversion Table Example

  Lower Sub-Basin Overflow Table ID   OVERF1
                                      Overflow Table Example

  Lower Sub-Basin Seepage Table ID    SEEPAGE1
                                      Example of Seepage Inflow Table

1Help   2PrtScr 3Index  4      5      6DOS    7      8      9      10Exit
                     Press <F10> to Save Data and Return
```

FIGURE 9.18 Auxiliary Flow Data Screen for Hypothetical Event Analyses

CHAPTER 10.
Interior Analysis

10.1. INTRODUCTION

After all of the required modular input data described in Chapters 3 through 9 of this manual have been entered, the interior analysis computations may be performed. To perform the interior analysis, a ***plan*** is defined which represents a unique combination of precipitation, runoff, exterior stage, and interior area facilities. Figure 10.1 shows the data entry screen which is used to assemble the various data modules which make up a plan.

```
CSA 01.01.00                                                     MCB+
Study ID  RBEND2         Perform Interior Analysis

   Plan ID  PLANP     Description  4x4 Box culv. with 200-cfs pump. PARTIAL

                                 Module
         Module                    ID              Description

Basin Average Precipitation    PRECIP1   Precip. data for App. C.
Runoff Hydrograph Parameters   RUNOFF1   Runoff data for App. C. example.
Interior Pond                  INTPOND1  Interior pond module data for App. C.
Gravity Outlets                OUTLET1   1 - 4x4 box at the primary location.
Pump Data                      PUMPMOD1  Pump module for App. C example.
Exterior Stage                 EXSTAGE   Exterior stage data for App. C example.
Auxiliary Flow

     Beginning Date for Analysis (DaMonYear/HrMn)         01OCT1950/0100
     Ending Date for Analysis (DaMonYear/HrMn)            30SEP1960/2400
     Computation Time Interval (e.g. 1HOUR, 1DAY, ...)    1HOUR

1Help   2PrtScr 3Index   4      5      6DOS     7      8      9     10Exit
                    Press <F10> to Proceed to the Menu
```

FIGURE 10.1 Plan Specification Screen

A study typically has several plans. Different plans can be described having specific components which define configurations requiring evaluation. For example, the first plan may describe a minimum gravity outlet facility, a second plan may describe additional gravity outlet capacity, and a third plan may include a pumping station.

As Figure 10.1 indicates, each plan must be given a unique **Plan ID**. The Plan ID identifies the plan when the HEC-IFH program reports results or produces comparisons of several plans. Several sets of plan data may be stored under different IDs. When the cursor is on the Plan ID field, the [F3] key displays a list of previously-stored IDs. Any of these previous IDs may be selected, and the corresponding data will be loaded for editing. The 40-character **Description** provides documentation for each plan data set.

The plan may include **Module IDs** for any or all data entry modules. When the cursor is on each Module ID field, the [F3] key displays a list of previously-stored IDs. Any of these previous IDs may be selected. As each ID is entered, the HEC-IFH program displays the

40-character description for that ID. This helps to verify that the program is using the correct data. One or more Module IDs may be omitted if not required for the particular analysis. For example, a plan which does not consider any pumping capacity can omit the Pump Module ID. A new Plan ID can be entered and Module IDs edited to describe the new plan.

The **Beginning Date for Analysis** and **Ending Date for Analysis** must be entered. These use the standard HEC-DSS format for date and time values. The beginning date is the end of the first computation interval, and the ending date is the end of the last computation interval in the analysis. For example, hourly values for the month of October 1990 would have a beginning date of 01OCT1990/0100 and an ending date of 31OCT1990/2400. If the analysis of October 1990 consisted of daily instead of hourly values, the starting date would be 01OCT1990/2400 (the end of the first day), but the ending date would still be 31OCT1990/2400.

The ending date must be later than the beginning date for the analysis. In addition, the specified beginning and ending date should be consistent with the starting and ending periods of time series used as input for the calculations. After the beginning and ending date are specified, the HEC-IFH program automatically checks all precipitation, exterior stage, and auxiliary inflow time series used in the plan. If any of these time series start after the beginning date of the interior analysis, or end before the ending date of the analysis, the interior analysis will proceed using zero (0) for all missing values. If this situation exists, the HEC-IFH program will write a warning message to the error warning message file.

The **Computation Time Interval** is used as the time step for all sub-basin runoff, channel routing, and pond routing computations for the interior analysis. It must be entered as a number combined with a unit of time. Time intervals must be between 5 minutes and 24 hours. Any of the following time intervals are acceptable: 5MIN, 10MIN, 15MIN, 30MIN, 1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR, and 1DAY. The time increment must be consistent with the beginning and ending date. For example, a time increment of 2HOUR would not be consistent with a beginning date of 01OCT1990/0100, as would a time interval of 1HOUR.

The selection of a computation time interval can affect the validity and numerical stability of several computations performed during the interior analysis. If the time interval chosen is too long, the degree of accuracy of the results required may be foregone. If a shorter time interval than required is selected, the time required to run the analysis will be longer than necessary and the volume of the output will be much larger than needed.

If the interior area is such that the problem is essentially providing facilities to handle the volume of water reaching the line-of-protection (such as would be the case for a typical agricultural area with a large ponding area), then a long computational time interval of up to 1 day may be appropriate. If the situation includes a requirement to handle peak flow reaching the line-of-protection (such as would be the case for urban areas with little or no ponding area), then a shorter time interval, which provides good definition of the peak flow rate using the specified unit hydrograph, may be required.

A good test as to whether a shorter computation time interval is required would be to analyze a plan configuration with a short and long interval and compare resulting stage-frequency relationships. If differences are significant, a shorter time interval would be chosen for all plans being evaluated.

The HEC-IFH program interpolates or aggregates the required input time series data for use in the analysis. The program checks the specific computation time interval with unit hydrograph and routing parameters during the analysis and writes messages to the plan message file if required. For a description of these messages, see Appendix F.

The HEC-IFH program checks the specified computation time interval against the following values:

1. **Time Increment of Precipitation Station Record**: If the rainfall time record is at a longer time interval than the interior analysis, rainfall values will be interpolated for each analysis interval. However, better results will be achieved if a rainfall record with a shorter time interval is available. This is true for auxiliary inflow and exterior stage time series as well.
2. **SCS Lag Value**: If the computation time interval exceeds 0.29 times the given SCS dimensionless unit hydrograph lag value, the computations are performed. However, a better definition of the unit hydrograph would be provided with a shorter computation time interval.
3. **Clark Time of Concentration (TC)**: If TC is less than the interior analysis computation time interval, it is adjusted to equal the computation time interval. However, a better definition of the unit hydrograph would be provided with a shorter computation time interval.
4. **Clark Watershed Storage Coefficient (R)**: If R is less than one-half of the computation time interval, it is adjusted to equal one-half the computation interval. However, a better definition of the unit hydrograph would be provided with a shorter computation time interval.
5. **Unit Hydrograph Time Interval**: If the user has entered unit hydrograph ordinates, the computation time interval must match the unit hydrograph duration, which is equal to the tabulation interval of the input unit hydrograph. If not, runoff computations may not be accurate. Unlike the computed Clark, Snyder, and SCS Unit Hydrographs, HEC-IFH cannot adjust the duration of a user-supplied unit hydrograph.
6. **Muskingum K Coefficient**: If the K coefficient is less than one-half of the computation time interval, no channel routing will be performed.
7. **Channel Routing Lag Value**: If the routing lag value is less than one-half of the computation time interval, no channel routing will be performed.

In addition to the starting and ending dates and the computation time interval, the HEC-IFH program also checks many other input data values. Many of these input data values can be validated completely only after the plan is specified. This validation is necessary in order to insure that the specified plan components and data elements will function properly together. Data values from different data entry modules may be acceptable individually but conflict when used together. The following data values are checked:

1. **Rainfall Record**: If no rainfall record is specified for a particular sub-basin, then no runoff computations will be performed for that sub-basin.
2. **Gravity Outlet Elevations**: If the interior invert elevation of any of the gravity outlets is below the minimum elevation of interior pond, then pond routing computations may be unstable.
3. **Pump Outlet Elevations**: If any monthly pump start or stop elevation is below the minimum elevation, or above the maximum elevation, of the interior pond. The corresponding pump unit will not operate during this month.
4. **Overflow Elevation**: If the flowline elevation of the overflow is below the minimum elevation of the interior pond, pond routing computations may be unstable.

If any of the conditions described above are detected, HEC-IFH issues a warning message before proceeding with the interior analysis.

10.2. SEQUENCE OF INTERIOR ANALYSIS COMPUTATIONS

After the plan is specified, the menu screen illustrated in Figure 10.2 is displayed. This menu controls how many of the interior analysis computations are performed in a single operation.

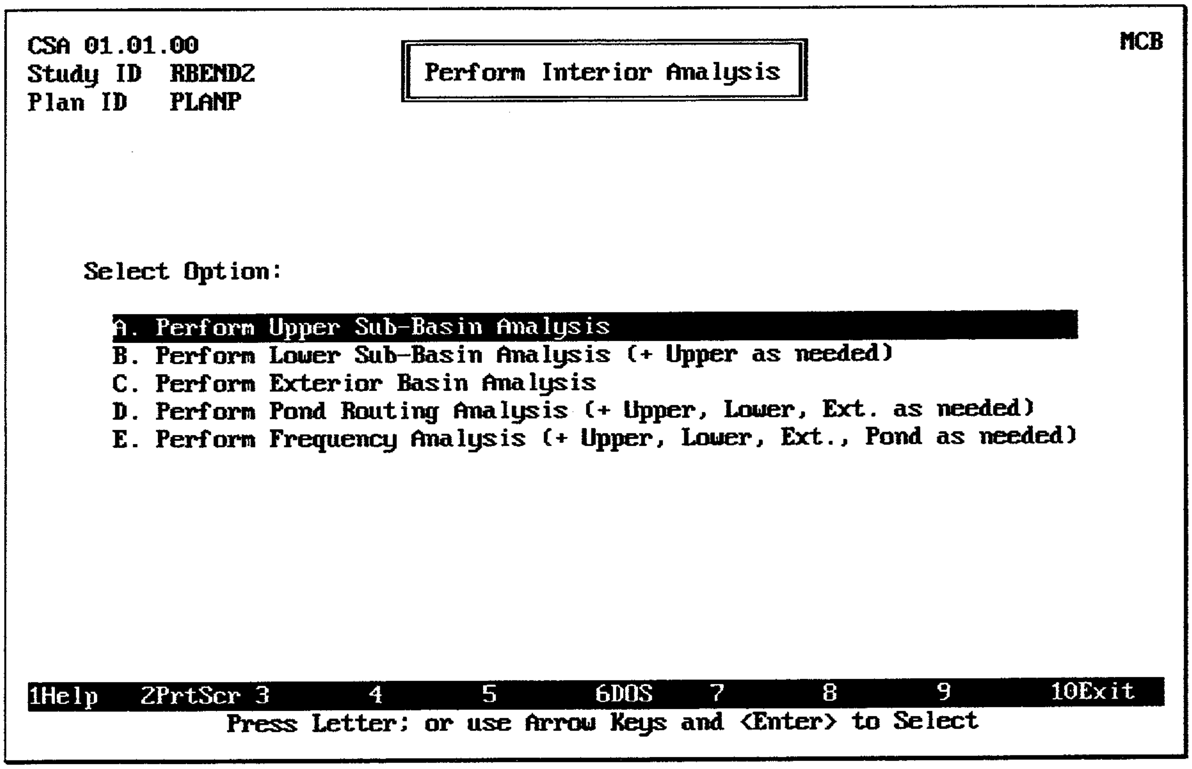


FIGURE 10.2 Interior Analysis Menu

As indicated, 5 different options are available:

A. **Perform Upper Sub-Basin Analysis**: Using the precipitation record from the PRECIP module, and the infiltration loss, unit hydrograph, and base flow parameters from the RUNOFF module, compute the runoff hydrograph for the upper interior sub-basin. Add the auxiliary inflow for the upper sub-basin, if any. Subtract the diversion from the upper sub-basin, if any. Route the resulting hydrograph downstream to the lower sub-basin.

B. **Perform Lower Sub-Basin Analysis (+ Upper as needed)**: Execute Step A, if appropriate and if not already executed. Then, using the precipitation record, infiltration loss, base flow and unit hydrograph parameters, compute a runoff hydrograph for the lower interior sub-basin. Add the auxiliary inflow for the lower sub-basin, if any. Add the routed hydrograph from the upper sub-basin, if present as a result of Step A above.

C. **Perform Exterior Basin Analysis**: Execute Steps A and B, if appropriate and if not already executed. Then, using the data specified in the Exterior Stage module, compute the exterior stage hydrograph at the primary outlet location.

D. **Perform Pond Routing Analysis (+ Upper, Lower, Ext. as needed)**: Execute Steps A, B, and C, if appropriate and if not already executed. Then, using the data for the interior pond, gravity outlets, pumps, seepage, overflow, exterior stage, and combined inflow hydrograph, compute the pond stages and outflows for each time period throughout the analysis.

E. **Perform Frequency Analysis (+ Upper, Lower, Ext., Pond as needed)**: Execute Steps A, B, C, and D, if appropriate and if not already executed. Then, using the computed interior stage hydrograph, compute a graphical annual or partial duration series interior area elevation-frequency and duration relationship.

As indicated, options B through D each depend upon the results of the previous option. The user can execute options A, B, C, or D and view Hydrologic Analysis Summaries with partial results. Chapter 11 describes the Hydrologic Analysis Summaries available in HEC-IFH. After Options A or B (interior sub-basin analyses) are executed, the following Hydrologic Analysis Summaries are available:

A. Data Management Analysis Input Summary

B. Rainfall-Runoff Analysis Input Summary (partial results only)

E. Rainfall-Runoff Data Calculation Period Summary (partial results only)

K. Average Monthly Rainfall Summary (partial results only)

N. Rainfall-Runoff Data Annual Summary (partial results only)

After Option C: Exterior Sub-basin Analysis is completed, Hydrologic Analysis Summaries B, E, K, and N are complete. The completion of Option D: Pond Routing, makes the following Hydrologic Analysis Summaries available:

C. Gravity Outlet Data Analysis Input Summary

D. Pump Station Data Analysis Input Summary

F. Interior-Exterior Data Calculation Period Summary

G. Detailed Inflow Data Calculation Period Summary

H. Detailed Outflow Data Calculation Period Summary

I. Detailed Gravity Outflow Data Calculation Period Summary

J. Area Flooded Data Calculation Period Summary

L. Interior-Exterior Data Monthly Summary

M. Pump Operation Data Monthly Summary

O. Interior/Exterior/Pump Data Annual Summary

P. Maximum Interior Area Flooded Annual Summary

Q. Maximum Values Analysis Record Summary

R. Inflows and Outflows Analysis Record Summary

V. Pump Operation Analysis Record Summary

The remaining Hydrologic Analysis Summaries present the results of Option E: Frequency Analysis:

S. Exceedance Duration Table Analysis Record Summary

T. Plotting Position Table Analysis Record Summary

U. Stage-Frequency Table Analysis Record Summary

When each step listed above is executed, the HEC-IFH program determines whether required supporting computations have already been completed. The program does not repeat those calculations if no input data values have been changed. If the previous step has not been completed, however, the HEC-IFH program automatically completes it before continuing with computations. For example, if the user chooses option B first, the program will complete upper sub-basin computations (option A) before proceeding with lower sub-basin computations (option B).

10.3. INTERIOR POND ROUTING PARAMETERS

If Option D is selected from the Interior Analysis Menu (Figure 10.2), a data entry screen appears to allow the specification of starting conditions and control parameters for the pond routing computations. Figure 10.3 illustrates this data entry screen.

The **Starting Pond Elevation** is the water surface elevation in the interior storage pond at the beginning of the interior analysis. The value entered must be within the valid range of elevations described in Chapter 2. In addition, the starting pond elevation must be within the range of elevations specified in the pond elevation versus surface area table. If the starting pond elevation is below the minimum elevation, or above the maximum elevation, HEC-IFH adjusts the starting elevation up to the minimum or down to the maximum value as appropriate and writes a warning message to the plan message file.

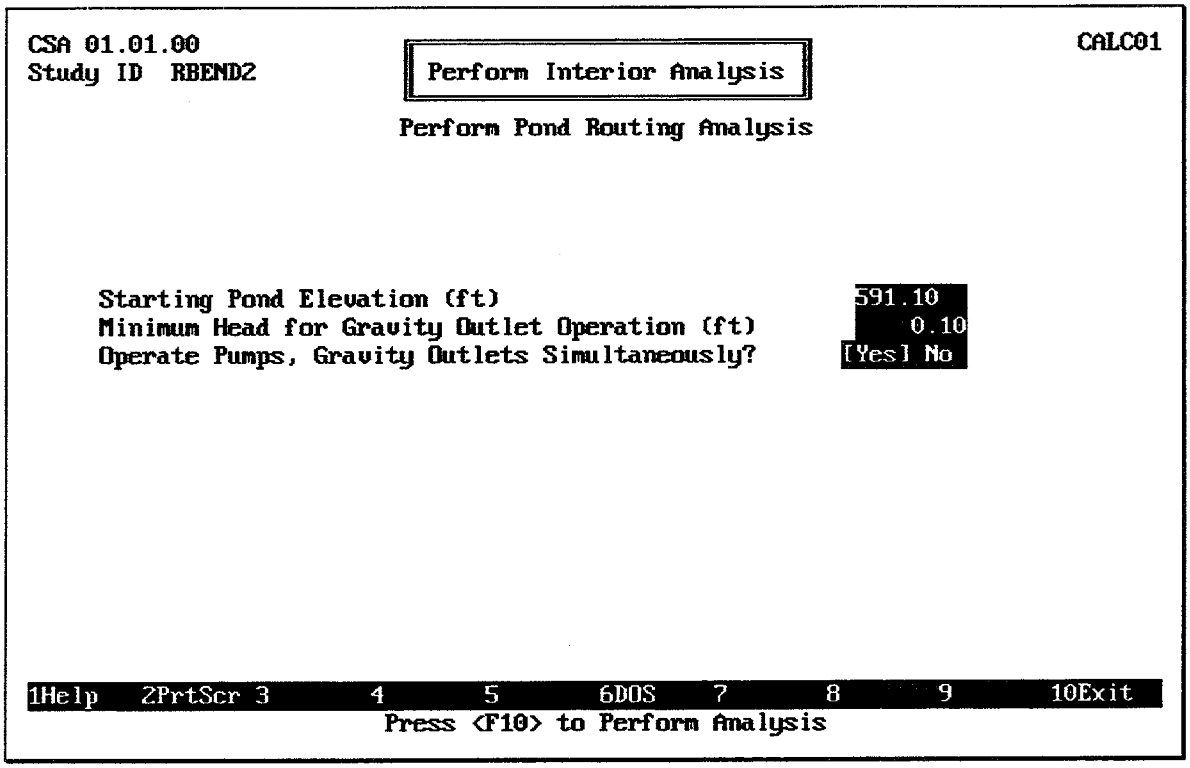


FIGURE 10.3 Pond Starting Conditions Screen

The **Minimum Head for Gravity Outlet Operation** specifies the minimum positive differential head (interior minus exterior water surface elevation) necessary before the gravity outlets will operate. Some levee systems close the gravity outlets when the exterior water surface elevation rises to a level close to the interior water surface elevation. The user may incorporate flap gates on gravity outlets which may require a small head differential before the outlet will open. This input variable allows the HEC-IFH program to model these conditions. Any value of zero (0) or greater may be entered.

A "Yes No" menu is presented for **Operate Pumps, Gravity Outlets Simultaneously?** Use the cursor keys to move from one selection to another, and press the space bar to make a selection from this menu. If "No" is selected, then pumps and gravity outlets do not operate simultaneously. In this case, the pumps are assumed to stop when the gravity outlets are discharging. If "Yes" is selected, then the pumps and gravity outlets operate independently according to their individual operating criteria and characteristics. In following these operating criteria, they may be operating simultaneously at certain times during the interior analysis.

After all of the interior pond routing parameters shown on Figure 10.3 are specified, press the [F10] key to perform the interior analysis. The HEC-IFH program will analyze the upper interior sub-basin, the lower interior sub-basin, the exterior basin, and perform the pond routing computations. As discussed earlier in this chapter, the program will automatically omit any or all of the sub-basin computations if no data values are entered for that sub-basin, or if the sub-basin analysis has already been performed with the same input data.

The pond routing technique used in the HEC-IFH program consists of Runge-Kutta-Fehlberg level pool routing. A fourth and firth order Runge-Kutta solution approximation of the end-of-period pond elevation (based on beginning-of-period elevation, inflow, and outflow and end-of-period inflow) is made. The technique incorporates an adaptive time step based on the difference in these approximations. If the difference is greater than a set tolerance, the approximations are rejected. The current computation time interval is sub-divided, within a maximum and minimum range, based on the magnitude of the difference. The approximations are then recomputed. This continues until the difference in the approximations is within the tolerance. The fifth order estimate of the pond elevation for the end of the current full or sub-divided time step is then accepted and the routing continues from that point in time. An advantage in the technique is that the time interval is broken down into finer steps only when necessary (when storage is changing rapidly).

The time required to perform the routing varies with length-of-period, the amount of time that pond inflow is occurring during that period, and the time interval. A default minimum pond surface area of one-tenth acre is used to eliminate potential instabilities near the pond bottom. This has no effect on the analysis results and simply means that the pond bottom is represented as being flat instead of pointed.

10.4. FREQUENCY ANALYSIS

If Option E is selected from the Interior Analysis Menu (Figure 10.2), a data entry screen appears to allow the specification of starting conditions and control parameters for the frequency analysis as well as the pond routing computations. Figure 10.4 illustrates this data entry screen.

If Option D was not executed prior to Option E, then selecting Option E will cause the HEC-IFH program to perform the interior pond routing analysis as well as the frequency analysis. For this reason, the data entry screen shown in Figure 10.4 includes the same interior pond routing parameters as the data entry screen for Option D (Figure 10.3). These parameters are described in the previous section of this manual.

The remaining portions of this data entry screen control the HEC-IFH Frequency Analysis.

A simple menu is presented for **Generate Annual Series or Partial Series?** Use the cursor keys to move from one selection to another, and press the space bar to make a selection from this menu. If "Annual" is selected, then the frequency analysis will be performed using the maximum interior storage values for each water year during the interior analysis. If "Partial" is selected, then the frequency analysis will be performed using all of the interior storage values which meet the selection criteria determined by the following two items of input data.

The **Threshold Elevation for events** and the **Minimum days between events** determine what constitutes a flood "event" to be used in the partial series frequency analysis. When the interior water surface elevation rises above the threshold elevation, the HEC-IFH program compares the date of the occurrence with the date of the previous storm event which also exceeded the threshold elevation. If the time span between the two occurrences exceeds the specified minimum days between events, then the two occurrences are considered to be separate flood events, and both of them are included in the partial series frequency analysis. Otherwise, the highest of the two elevations is selected as the event. The pond elevation must drop below the threshold elevation, stay there for at least the specified minimum number of days between events, and subsequently rise above the threshold elevation before a new event will be included in the partial duration series.

The threshold elevation for events is needed only when a partial series frequency analysis is selected. It must be within the valid range of elevations described in Chapter 2. In addition, the value entered must be within the range of elevations specified in the pond elevation versus surface area table. If the threshold elevation is below the minimum elevation, or above the maximum elevation, in that table, HEC-IFH writes an error message to the error message file and does not perform a frequency analysis.

The minimum days between events must be greater than zero (0) and is based on assumptions concerning the statistical independence of the events and the recovery period between flood damage events.

The HEC-IFH program also checks the duration of the interior analysis. The reliability of frequency estimates is low if the interior analysis includes less than ten complete water years of data. The HEC-IFH program issues a warning message if this is the case.

```
CSA 01.01.00                                                        CALC02
Study ID  RBEND2         Perform Interior Analysis

          Perform Frequency Analysis (Plus Pond Routing as Needed)

   For New Pond Routing Analysis, enter or change:

     Starting Pond Elevation (ft)                          591.10
     Minimum Head for Gravity Outlet Operation (ft)          0.10
     Operate Pumps, Gravity Outlets Simultaneously?      [Yes] No

   For Frequency Analysis, set:

     Generate Annual Series or Partial Series?           Annual [Partial]
     For Partial Series:
       Threshold Elevation for events (ft)                 598.00
       Minimum days between events                              7

1Help  2PrtScr 3     4     5     6DOS    7     8     9     10Exit
                    Press <F10> to Perform Analysis
```

FIGURE 10.4 Frequency Analysis Screen

After all of the interior pond routing parameters shown on Figure 10.4 are specified, press the [F10] key to perform the interior analysis. The HEC-IFH program will analyze the upper interior sub-basin, the lower interior sub-basin, the exterior basin, perform the pond routing computations, and complete the frequency analysis. As discussed earlier in this chapter, the program will automatically omit any or all of the sub-basin computations if no data values are entered for that sub-basin, or if the sub-basin analysis has already been performed with the same input data. The pond routing analysis will also not be performed if it has already been completed with the same input data.

10.5. INTERIOR ANALYSIS COMPUTATIONS

As the interior analysis computations are performed, the Interior Analysis Status Report Screen (Figure 10.5) is displayed.

```
CSA 01.01.00                                                      CALC05
Study ID  RBEND2        | Perform Interior Analysis |   Begin 01OCT1950/0100
Plan ID   PLANP                                         End   30SEP1960/2400

                                                  %   HH:MM:SS  Estimated
                                                Done  Thus Far  remaining
     Upper Sub-Basin
        Composite PRECIP
        Losses; Runoff Hydrograph                100   0:19:55   0:00:00
        AUXFLOW; Diversion; Channel Routing      100   0:09:16   0:00:00
     Lower Sub-Basin
        Composite PRECIP
        Losses; Runoff Hydrograph                100   0:20:00   0:00:00
        AUXFLOW; Combine Upper Hydrograph        100   0:07:59   0:00:00
     Exterior Basin
        Composite PRECIP
        Losses; Runoff Hydrograph
        Stage
     Pond
        Routing                                  100   0:38:32   0:00:00
        Totals                       Pass 4/4:   100   0:01:40   0:00:00
        Frequencies          Step 4 of 4:  Plotting Position...

1Help   2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                  *** Analysis Complete ***        Press <F10>
```

FIGURE 10.5 Interior Analysis Status Report Screen

This screen summarizes the progress of the interior analysis, including the following twelve individual steps:

1. Upper Sub-Basin Composite Precipitation Computation
2. Upper Sub-Basin Losses and Runoff Hydrograph Computation
3. Upper Sub-Basin Auxiliary Inflow, Diversion, and Channel Routing Computation
4. Lower Sub-Basin Composite Precipitation Computation
5. Lower Sub-Basin Losses and Runoff Hydrograph Computation
6. Lower Sub-Basin Auxiliary Inflows and Upper Hydrograph Combination
7. Exterior Sub-Basin Composite Precipitation Computation
8. Exterior Sub-Basin Losses and Runoff Hydrograph Computation

9. Exterior Sub-Basin Stage Hydrograph Computation
10. Interior Pond Routing Computation
11. Interior Pond Total Values Computation
12. Interior Pond Frequency Analysis

During each of these12 steps, the HEC-IFH program reports the progress in three columns:

% Done: The approximate percentage of the present step which is completed. This value is updated only at convenient points within the computations, so screen updates are irregular.

HH:MM:SS Thus Far: The elapsed clock time since the beginning of the present step. This does not include the time spent changing from the previous step to the present step. This time is expressed in hours, minutes, and seconds. For example, a value of 1:13:34 would represent an elapsed time of 1 hour, 13 minutes, and 34 seconds. This value is updated only at convenient points within the computations, so screen updates are irregular.

Estimated Remaining: The approximate clock time remaining for the present step. This value is computed using the elapsed time thus far and the percentage done. This may lead to fluctuations in the estimated remaining time, especially during the early portions of computations for a particular step. This fluctuation is normal. The estimated remaining time generally stabilizes and decreases regularly as each step in the computation continues.

The HEC-IFH program checks input data values even during the interior analysis. The purpose of this checking is to identify numerical instability problems, and assessing whether a sufficient range of values has been entered for various input data tables. For each table whose maximum value is exceeded, the program generates a warning message that is written to a file which may be viewed (see Appendix F). The following tables are checked:

1. **Modified Puls Routing Table**: If this table is exceeded, then channel routing computations may be incorrect.
2. **Pond Elevation versus Surface Area Table**: If this table is exceeded, then pond routing computations may be incorrect.
3. **Gravity Outlet Rating Table**: If this table is exceeded, then gravity discharge values may be incorrect.
4. **Main River Transfer Relationship**: If this table is exceeded, then exterior stage computations may be incorrect.
5. **Tributary Transfer Relationship**: If this table is exceeded, then exterior stage computations may be incorrect.
6. **Diversion Table for Upper Sub-Basin**: If this table is exceeded, then diversion flow rate computations may be incorrect.
7. **Overflow Table for Lower Sub-Basin**: If this table is exceeded, then overflow rate computations may be incorrect.
8. **Seepage Table for Interior Pond**: If this table is exceeded, then seepage inflow rate computations may be incorrect.

In addition, the program checks for negative flow rates generated during channel routing computations. Negative flow rates are set to zero (0), and a warning message is issued.

10.6. PERFORMING INTERIOR ANALYSIS IN BATCH MODE

As mentioned in Chapter 2, interior analysis may also be performed in ***batch mode***. Using batch mode, a single command from the operating system initiates program operations and performs interior analysis computations using data already entered using the program's interactive mode of operation. By using batch mode, the HEC-IFH user can enter the data necessary for several analyses, then create a batch file containing the commands necessary to perform the computations for each analysis. Under the control of the batch file, the program can then perform the computations for all analyses without further user intervention. These computations can be performed during a lunch break, overnight, or even over a weekend, depending upon the complexity and length of the analysis.

10.6.1. Basic Batch Mode Operations

Plan analysis in batch mode is accomplished by editing a DOS batch file to include separate command lines for each plan analysis. The batch file can have any legal DOS file name such as **RUNIFH.BAT**. An example batch file to perform an interior analysis, up to and including frequency analysis, using Plan 1 and Plan 2 of the Big Creek study would include the following lines:

```
HECIFH STUDYID=BIGCREEK PLANID=PLAN1 TYPE=E
HECIFH STUDHID=BIGCREEK PLANID=PLAN2 TYPE=E
```

"**STUDYID=**", "**PLANID=**", and "**TYPE=**" are keywords that must be included in the command line. **Study ID** and **Plan ID** are study and plan names representing complete data sets that have previously been defined using the HEC-IFH interactive data entry operations. **Type** is the letter of the analysis option as described and illustrated in Figure 10.2. As the figure indicates, option "E" of the menu generates a complete interior analysis, including frequency analysis.

10.6.2. Optional Batch Mode Features

Other optional features are available in batch mode to provide further documentation of interior analysis results. These optional features are controlled through the use of the following command line parameters:

- **PRINTB**: Print status screen (Figure 10.5) after analysis is complete. (Note: the sytem must have a printer on-line and ready to print when this option is selected.)
- **TIME**: Display the computation step start times on the interior analysis report screen (Figure 10.5).
- **DTS**: Display the date-time stamp in the upper right-hand corner of the screen.

An example batch file to analyze Plans A and B of the Basin 1 study, through and including pond routing (no frequency analysis), and to produce a printed copy of the status report screen for each plan analysis, showing the starting time for each computation step and the date and time of execution, would include the following lines:

```
HECIFH TIME DTS PRINTB STUDYID=BASIN1 PLANID=PLANA TYPE=D
HECIFH TIME DTS PRINTB STUDYID=BASIN1 PLANID=PLANB TYPE=D
```

CHAPTER 11.
CSA Hydrologic Analysis Summaries

11.1. INTRODUCTION

The HEC-IFH program includes very extensive reporting capabilities, including:

- **Hydrologic Analysis Summaries**, which report the results of one analysis (one plan)
- **Plan Comparison Summaries**, which report the results of several selected analyses (plans).

This chapter describes the Hydrologic Analysis Summaries which are available for Continuous Simulation Analysis. Chapter 12 deals with the Hydrologic Analysis Summaries available for Hypothetical Event Analysis. Chapter 13 describes Plan Comparison Summaries.

Different Hydrologic Analysis Summaries are available for Continuous Simulations and Hypothetical Event Analyses. Table 11.**Error! Bookmark not defined.** lists the Hydrologic Analysis Summaries which contain particular types of output available for each method of analysis.

TABLE 11.1 Overview of HEC-IFH Hydrologic Analysis Summaries

Type of Output	Continuous Simulation Analysis	Hypothetical Event Analysis
Input Data	Analysis Input Summaries	Analysis Input Summaries
Detailed Output	Calculation Period Summaries	Analysis by Events
Monthly Totals/Averages	Monthly Summaries	—
Annual Totals/Averages	Water Year Annual Summaries	—
Summary of All Results	Analysis Record Summaries	Event Comparisons
Error Messages	Analysis Error Messages	Analysis Error Messages

Note: See Chapter 12 for details on Hypothetical Event Analysis summaries

11.2. HEC-IFH NUMERIC DISPLAY FORMATS

All HEC-IFH summaries are displayed using tables formed by horizontal and vertical lines. Numeric output values displayed in such tables are generally limited to a fixed number of digits and a fixed decimal point location. The total number of digits and the position of the decimal point for each output value have been carefully selected to display a very wide range of values. However, the values may occasionally overflow the number of digits available. In such cases, HEC-IFH automatically modifies the display format to provide appropriate values within the space available, rather than simply printing the uninformative "*****.*" value which is the FORTRAN default output.

For example, assume that a particular summary displays peak runoff rate to the nearest 0.1 unit using seven total characters. The highest peak runoff rate which could normally be displayed in such a summary would be 99999.9 units. However, if a peak runoff rate of 4,189,876 units is computed, HEC-IFH automatically eliminates the decimal point and the digit right of the decimal point, and 4189876 is displayed as a seven-digit integer.

HEC-IFH will automatically use exponential notation to display output values which are too large for display even as integers. For example, if the computed runoff rate in the example above were 13,894,176 units, it could not be displayed in seven total characters, even as an integer. In such a case, HEC-IFH would automatically display the value as 13894E3, which is 13,894 times 10^3, or 13,894,000.

11.3. SELECTION OF CSA HYDROLOGIC ANALYSIS SUMMARIES

Figure 11.1 illustrates the screen used to select the Plan ID for the Hydrologic Analysis Summaries. In order for a Hydrologic Analysis Summary to be generated, the plan computations must have already been completed. The F3 Index key may be used to display a list of valid Plan IDs. When a Plan ID is specified, the corresponding Plan Description is displayed for verification.

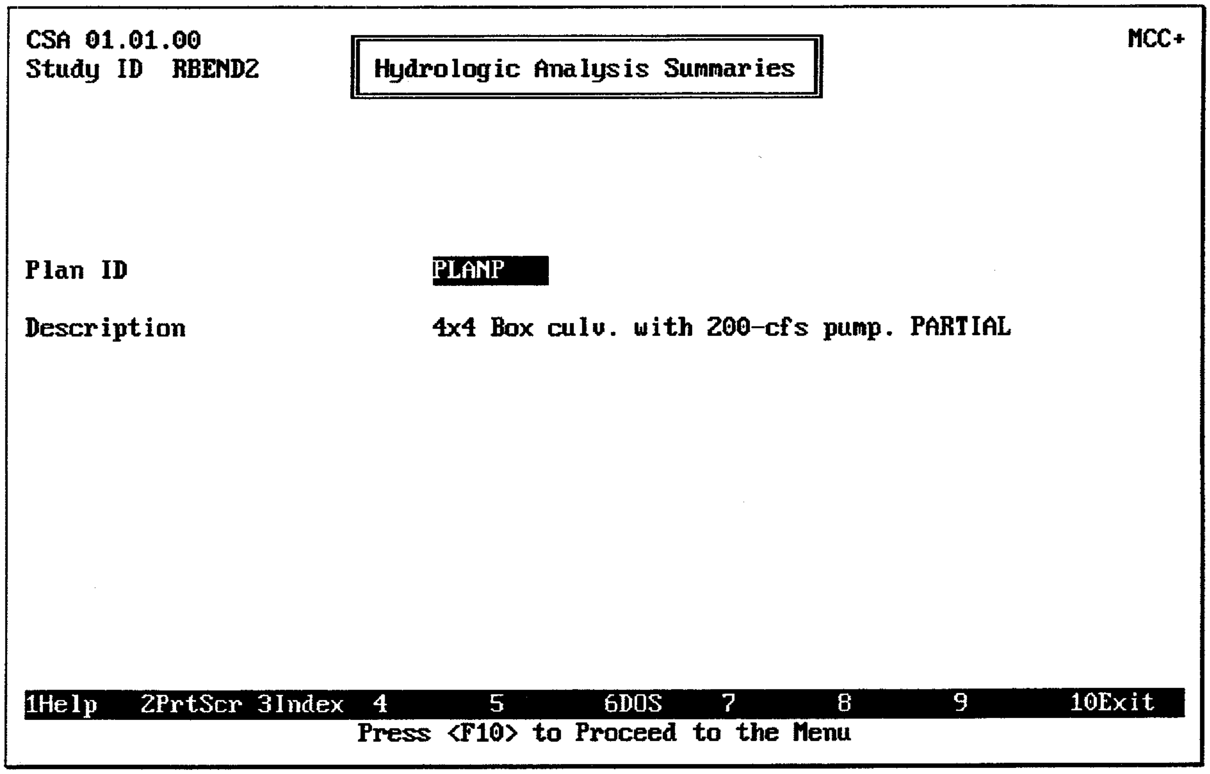


FIGURE 11.1 Continuous Simulation Hydrologic Analysis Summaries Master Screen

Twenty-three (23) different Hydrologic Analysis Summary reports are available for Continuous Simulation Analysis. These reports are divided into six categories:

1. **Analysis Input Summaries**, which describe the input data for a plan analysis:
2. **Calculation Period Summaries**, which list and summarize the results of the analysis for each calculation period during the entire analysis.
3. **Monthly Summaries**, which summarize the result of the analysis for each calendar month during the analysis.
4. **Water Year Annual Summaries**, which summarize the results of the analysis for each water year (October through September) during the analysis.
5. **Analysis Record Summaries**, which summarize and total the results of the analysis for the entire duration of the analysis.
6. **Analysis Error Messages**, which lists the error messages generated during the analysis.

Figure 11.2 illustrates the menu screen which is used to select the Hydrologic Analysis Summaries for display or printing. Some of the Hydrologic Analysis Summaries are only long enough to fill 1 or 2 computer screens or printed pages. Others, however, can be extremely long. For example, a Calculation Period Summary listing the results of an analysis of 50 years of hourly data would require over 8,000 printed pages! For this reason, HEC-IFH displays the number of printed pages required for all Calculation Period Summaries, on the "pop-up" window which appears when the user presses the F5 Report key.

```
CSA 01.01.00                                                     MCC
Study ID  RBEND2    Hydrologic Analysis Summaries    Begin 01OCT1950/0100
Plan ID   PLANP                                      End   30SEP1960/2400

Analysis Input Summaries                    Water Year Annual Summaries
   A. Data Management Summary                  N. Rainfall-Runoff Data
   B. Rainfall-Runoff Summary                  O. Interior/Exterior/Pump Data
   C. Gravity Outlet Data                      P. Maximum Area Flooded
   D. Pump Station Data

Calculation Period Summaries                Analysis Record Summaries
   E. Rainfall-Runoff Data                     Q. Maximum Values
   F. Interior/Exterior Data                   R. Inflows and Outflows
   G. Detailed Inflow Data                     S. Exceedance Duration Table
   H. Detailed Outflow Data                    T. Plotting Position Table
   I. Detailed Grav. Outflow Data              U. Stage-Frequency Table
   J. Area Flooded Data                        V. Pump Operation

Monthly Summaries                           Analysis Error Messages
   K. Average Monthly Rainfall                 W. List Warning/Error Messages
   L. Interior/Exterior Data
   M. Pump Operation

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
            Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 11.2 Menu of Continuous Simulation Hydrologic Analysis Summaries

11.4. CONTINUOUS SIMULATION ANALYSIS INPUT SUMMARIES

There are four ***Analysis Input Summaries*** which describe the input data for a Continuous Simulation plan analysis:

1. **Data Management Summary**: A brief overview of the input data used for a particular analysis.
2. **Rainfall-Runoff Summary**: A brief summary of the rainfall and runoff data used for each of the sub-basins used in the analysis.
3. **Gravity Outlet Data**: An overview of the gravity outlets, including the type (BOX, PIPE, TABLE), Size, Number, Invert Elevations, Length, Slope, and Gate Closure elevations. Each screen refers to a different location (PRIMARY, SECONDARY 1, SECONDARY 2, SECONDARY 3, SECONDARY 4), and includes the stream station at that location.
4. **Pump Station Data**: An overview of the pump outlets, including the pump unit ID, capacity, start and stop elevations, and the maximum static head on the pump.

Figure 11.3 illustrates the Continuous Simulation Analysis **Data Management Summary**, which includes the following data values for the specified plan:

- **Date of Execution**: The date on which the plan analysis was performed.

- **Module ID**: The module ID for the following data sets: Basin Average Precipitation (PRECIP), Runoff Hydrograph Parameters (RUNOFF), Interior Pond (POND), Gravity Outlets (GRAVITY), Pump Data (PUMP), Exterior Stage (EXSTAGE), and Auxiliary Flow (AUXFLOW).
- **Description**: The 40-character description for each of the input data modules (PRECIP, RUNOFF, POND, GRAVITY, PUMP, EXSTAGE, and AUXFLOW).

```
CSA 01.01.00                                                      SUMM03
Study ID  RBEND2     Hydrologic Analysis Summaries      Begin 01OCT1950/0100
Plan ID   PLANP                                         End   30SEP1960/2400
              A. Analysis Input Summaries - Data Management Summary

                     Date of Execution 29FEB1992/0726
```

Module	Module ID	Description
Basin Average Precipitation	PRECIP1	Precip. data for App. C.
Runoff Hydrograph Parameters	RUNOFF1	Runoff data for App. C. example.
Interior Pond	INTPOND1	Interior pond module data for App. C.
Gravity Outlets	OUTLET1	1 - 4x4 box at the primary location.
Pump Data	PUMPMOD1	Pump module for App. C example.
Exterior Stage	EXSTAGE	Exterior stage data for App. C example.
Auxiliary Flow		

```
1Help  2PrtScr 3   4   5   6DOS   7   8   9   10Exit
                Press <F10> to Return
```

FIGURE 11.3 CSA Data Management Summary

Figure 11.4 illustrates the Continuous Simulation Analysis **Rainfall-Runoff Input Summary**, which includes the following data values for the specified plan:

- **PRECIP Module ID and Description**: The module ID and 40-character description for the Basin Average Precipitation (PRECIP) data set. (See Chapter 3.)
- **RUNOFF Module ID and Description**: The module ID and 40-character description for the Runoff Hydrograph Parameters (RUNOFF) data set (See Chapter 4).
- **Rainfall Station ID**: The identifier for the individual rainfall station or composite rainfall record used for each sub-basin. (See Chapter 3.)
- **Source of Record**: The method used to record or compute the rainfall data used for each sub-basin. (See Chapter 3.)
- **Basin ID**: The identifier for the set of basin runoff parameters used for each sub-basin which was included in the analysis. (See Chapter 4.)
- **Loss Rate Method**: The computational method used to estimate the infiltration and other losses for each sub-basin included in the analysis. The following Loss Rate Methods are available: INITIAL-UNIFORM-RE (Initial and Uniform with Recovery), GEN-RUNOFF-COEF (Generalized Runoff Coefficients), NO LOSSES. (See Chapter 4.)

- **Unit Hydrograph Method**: The method used to compute or otherwise provide the unit hydrograph for each sub-basin included in the analysis. Four Unit Hydrograph Methods are available: CLARK, SNYDER, SCS, and ENTER. (See Chapter 4.)
- **Channel Routing ID**: The identifier for the set of channel routing data used for routing the upper sub-basin hydrograph to the interior ponding area. The Channel Routing ID is applicable to the upper sub-basin only.
- **Channel Routing Method**: The computational method used to route the upper sub-basin hydrograph to the interior ponding area. The Channel Routing Method is applicable to the upper sub-basin only. The following Channel Routing Methods are available: MODIFIED PULS, MUSKINGUM, LAG, and NONE. (See Chapter 4.)

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM04
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

B. Analysis Input Summaries - Rainfall-Runoff Summary

PRECIP Module ID: PRECIP1 Precip. data for App. C.
RUNOFF Module ID: RUNOFF1 Runoff data for App. C. example.

	Lower Sub-Basin	Upper Sub-Basin	Exterior Basin
Rainfall Station ID Source of Record	GAGE2 ENTER/IMPORT	UPPER COMPOSITE	UPPER COMPOSITE
Basin ID Loss Rate Method Unit Hydrograph Method	LOWER INIT-UNIFORM-RE SCS	UPPER INIT-UNIFORM-RE SCS	UPPER INIT-UNIFORM-RE SCS
Channel Routing ID Channel Routing Method		ROUTE1 MUSKINGUM	

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 11.4 CSA Rainfall-Runoff Input Summary

Figure 11.5 illustrates one of the Continuous Simulation **Analysis Gravity Outlet Data** summaries, which includes the following data values for the specified plan:

- **Outlet Location**: The location of all of the gravity outlets (up to five) on the current screen. The Primary outlet location is always the first to be displayed. The Secondary 1, Secondary 2, Secondary 3, and Secondary 4 outlet locations may be displayed, one at a time, by pressing the PgDn or F10 keys. Pressing the PgUp key displays the data for the previous outlet location.
- **River/Levee Station**: The relative location of the outlet structure with respect to distance along the receiving stream or line or protection. This station is used only as a reference for those using HEC-IFH or viewing HEC-IFH results. It is not used by the HEC-IFH program for any computations.
- **Outlet ID**: The identifiers for each of the gravity outlets at the current outlet location.

- **Outlet Type**: The type of each of the gravity outlets at the current outlet location. The Outlet Type is BOX or CIRCULAR for computed gravity outlet rating tables. For gravity outlet rating tables entered by the user, the program displays the first 8 characters of the description for the Outlet Type.
- **Opening Size**: The total cross-sectional area of each of the gravity outlets at the current outlet location. This is computed from the outlet dimensions for box or circular culverts, and is given by the user for user-specified gravity outlet rating tables. Since each gravity outlet may actually represent multiple instances of identical structures, the opening size may be much greater than the cross-sectional area of a single structure.
- **No. of Identical Outlets**: The number of multiple instances of identical structures at each of the gravity outlets at the current outlet location.
- **Interior Invert Elev.**: The interior (land side) minimum elevation of each of the gravity outlets at the current outlet location.
- **Exterior Invert Elev.**: The exterior (river side) minimum elevation of each of the gravity outlets at the current outlet location.
- **Length of Outlet**: The center-line length of the culvert.
- **Slope of Outlet**: The slope of each of the gravity outlets at the current location, as computed using the exterior and interior invert elevations and the length of the outlet.
- **Exterior Elev. for Gate Closure**: The exterior elevation at which gravity flows through the line of protection are assumed to cease (gravity outlet is closed), for each of the gravity outlets at the current outlet location.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM05
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

C. Analysis Input Summaries - Gravity Outlet Data

Outlet Location: Primary
River/Levee Station (mi): 0.00

Outlet ID	4X4BOX				
Outlet Type	Box				
Opening Size (sqft)	16.00				
No. of Identical Outlets	1				
Interior Invert Elev. (ft)	591.00				
Exterior Invert Elev. (ft)	589.00				
Length of Outlet (ft)	200.00				
Slope of Outlet (ft/ft)	0.01000				
Exterior Elev. for Gate Closure (ft)	605.00				

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <PgDn>, <PgUp> or <F10> for other locations; <Esc> to Return

FIGURE 11.5 CSA Gravity Outlet Data Summary

See Chapter 6 for further details on the information displayed on the Gravity Outlet Data Summary.

Figure 11.6 illustrates the Continuous Simulation **Pump Station Data** summary, which includes the following data values for the specified plan:

- **PUMP Module ID and Description**: The module ID and 40-character description for the Pump Data (PUMP) data set.
- **Pump Unit ID**: The identifier for each of the pumping units included in the analysis.
- **Maximum Capacity**: The total maximum capacity of each of the pumping units included in the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Pump Start Elevation**: The pump start elevation entered for each of the pumping units available for the analysis.
- **Pump Stop Elevation**: The pump stop elevation entered for each of the pumping unit modelled in the analysis.
- **Maximum Total Head**: The highest total head value entered in the total head versus capacity table for each of the pumping units available for the analysis.

```
CSA 01.01.00                                                    SUMM06
Study ID  RBEND2      Hydrologic Analysis Summaries     Begin 01OCT1950/0100
Plan ID   PLANP                                         End   30SEP1960/2400
               D. Analysis Input Summaries - Pump Station Data

    PUMP Module ID PUMPMOD1    Pump module for App. C example.
```

Pump Number	Pump Unit ID	Maximum Capacity (cfs)	Pump Start Elevation (ft)	Pump Stop Elevation (ft)	Maximum Total Head (ft)
1	PUMP1	200.0	600.00	598.00	30.00
2					
3					
4					
5					
6					
7					
8					
9					
10					

```
1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
                  Press <F10> to Return
```

FIGURE 11.6 CSA Pump Station Data Summary

11.5. CONTINUOUS SIMULATION CALCULATION PERIOD SUMMARIES

There are six ***Calculation Period Summaries*** which list and summarize the results of the analysis for each calculation period during the entire analysis. Users may move through these summaries a line or a screen at a time, or use the F4 Goto key to move to a specific time value.

1. **Rainfall-Runoff Data**: The Precipitation Depths, Losses, and Runoff Rate for each of the three sub-basins for each time period during the analysis.
2. **Interior/Exterior Data**: The Interior and Exterior water surface elevations, the head (the difference between the interior and exterior elevations), and the total inflow into the interior storage pond. The total gravity outflow rate, the total pump outflow rate, and the total outflow rate from all sources is also listed for each time period during the analysis.
3. **Detailed Inflow Data**: The inflow rate to the interior storage pond for each time period during the analysis. The routed inflows from the upper sub-basin, direct runoff from the lower sub-basin, seepage inflows, and lower sub-basin auxiliary inflows are each listed.
4. **Detailed Outflow Data**: The outflow rate from the interior basin for each time period during the analysis. The total outflows from all gravity outlets, the total outflows from all pump outlets, the diversion, and overflow outflows are all listed.
5. **Detailed Gravity Outflow**: The outflow rate from each of the five gravity outlet locations, along with the total gravity outflows, for each time period during the analysis.
6. **Area Flooded Data**: The exterior and interior water surface elevations, the interior surface area flooded, and the pond storage volume at each time period during the analysis.

Figure 11.7 illustrates the **Rainfall-Runoff Data** Calculation Period Summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each computation interval during the analysis.
- **Precip**: The incremental precipitation values for each computation interval, for each of the sub-basins used in the analysis.
- **Losses**: The incremental precipitation loss values for each computation interval, for each of the sub-basins used in the analysis. These values are computed using the infiltration loss rate method specified for each sub-basin.
- **Runoff**: The runoff rate at the end of each computation interval, for each of the sub-basins used in the analysis. These values are computed using the incremental rainfall excess values (precipitation minus losses) and the unit hydrograph for each sub-basin.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the analysis. Pressing the F5 Report key causes the summary to be printed.

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.7 illustrates. Three different plots are available: one for each of the sub-basins. Figure 11.8 illustrates one of these plots. As shown, the rainfall and loss values are plotted down from the upper edge of the plot according to the "Depth" axis on the right. The runoff values are plotted up from the lower edge of the plot according to the "Discharge" axis on the left. On a computer monitor with color display capabilities, each line is displayed using a different color.

If data values for more than one full year are available, the first plot displays annual total rainfall and maximum runoff rates, as shown in Figure 11.8. Pressing the down-arrow key "zooms" to a one-year plot of daily rainfall-runoff, as shown in Figure 11.9. Pressing the down-arrow key again zooms to a one-month plot of actual rainfall-runoff values (Figure 11.10). Pressing the down-arrow key while viewing the one-month plot zooms to a one-day plot, as shown in Figure 11.11. From the one-year, one-month, or one-day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

CSA 01.01.00 SUMM07
Study ID RBEND2 **Hydrologic Analysis Summaries** Begin 01OCT1950/0100
Plan ID PLANP End 30SEP1960/2400

E. Calculation Period Summaries - Rainfall-Runoff Data

	Lower Sub-Basin			Upper Sub-Basin			Exterior Basin		
Date/Time DaMonYear/HrMn	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)
10OCT1954/0100	1.13	0.02	479	0.20	0.02	2057	0.20	0.00	0
10OCT1954/0200	0.38	0.02	757	0.14	0.02	1949	0.14	0.00	0
10OCT1954/0300	0.28	0.02	1072	0.14	0.02	1698	0.14	0.00	0
10OCT1954/0400	0.12	0.02	1214	0.22	0.02	1388	0.22	0.00	0
10OCT1954/0500	0.23	0.02	1186	0.29	0.02	1202	0.29	0.00	0
10OCT1954/0600	0.17	0.02	1059	0.22	0.02	1106	0.22	0.00	0
10OCT1954/0700	0.22	0.02	894	0.10	0.02	1052	0.10	0.00	0
					01	997	0.01	0.00	0
					02	905	0.03	0.00	0
					02	781	0.18	0.00	0
					02	661	0.14	0.00	0
					02	575	0.03	0.00	0

Select Option:

A. Plot Lower Sub-Basin Rainfall-Runoff
B. Plot Upper Sub-Basin Rainfall-Runoff
C. Plot Exterior Sub-Basin Rainfall-Runoff

7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.7 Calculation Period Summary of Rainfall-Runoff Data

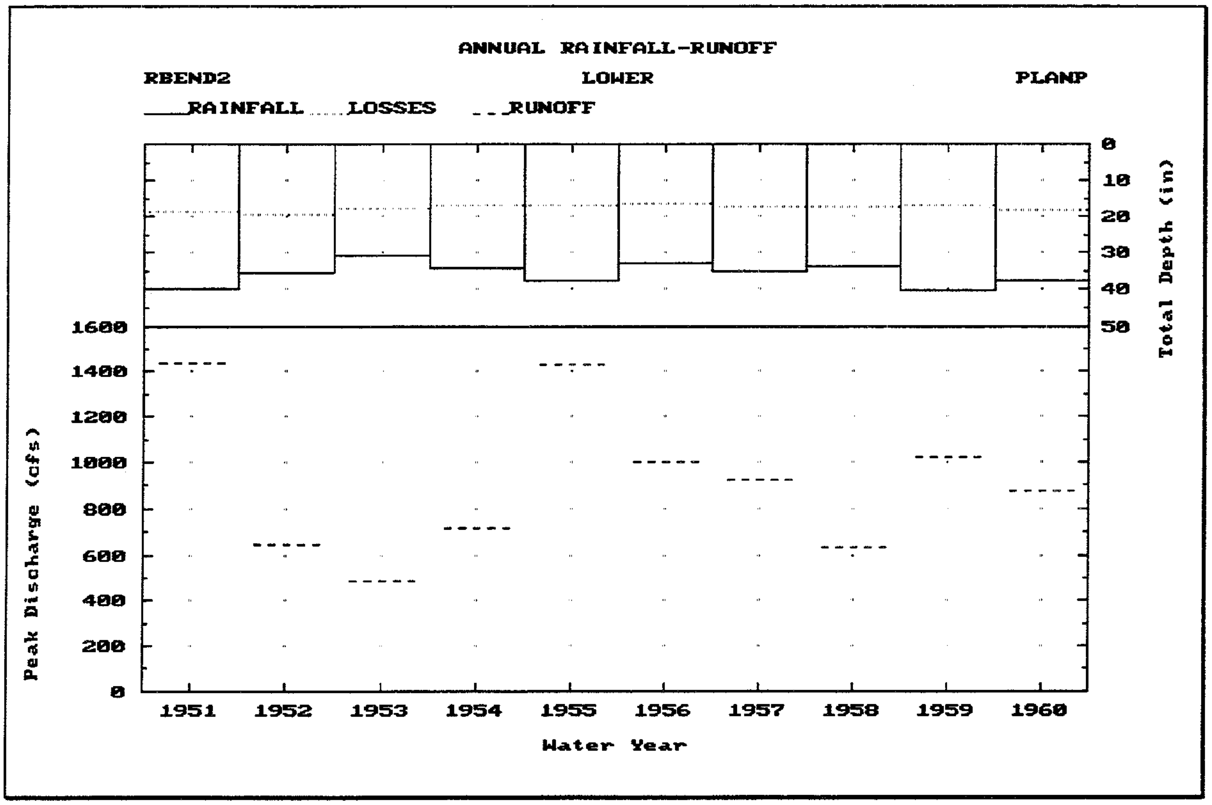


FIGURE 11.8 Multi-Year Plot of Annual Total Rainfall-Runoff

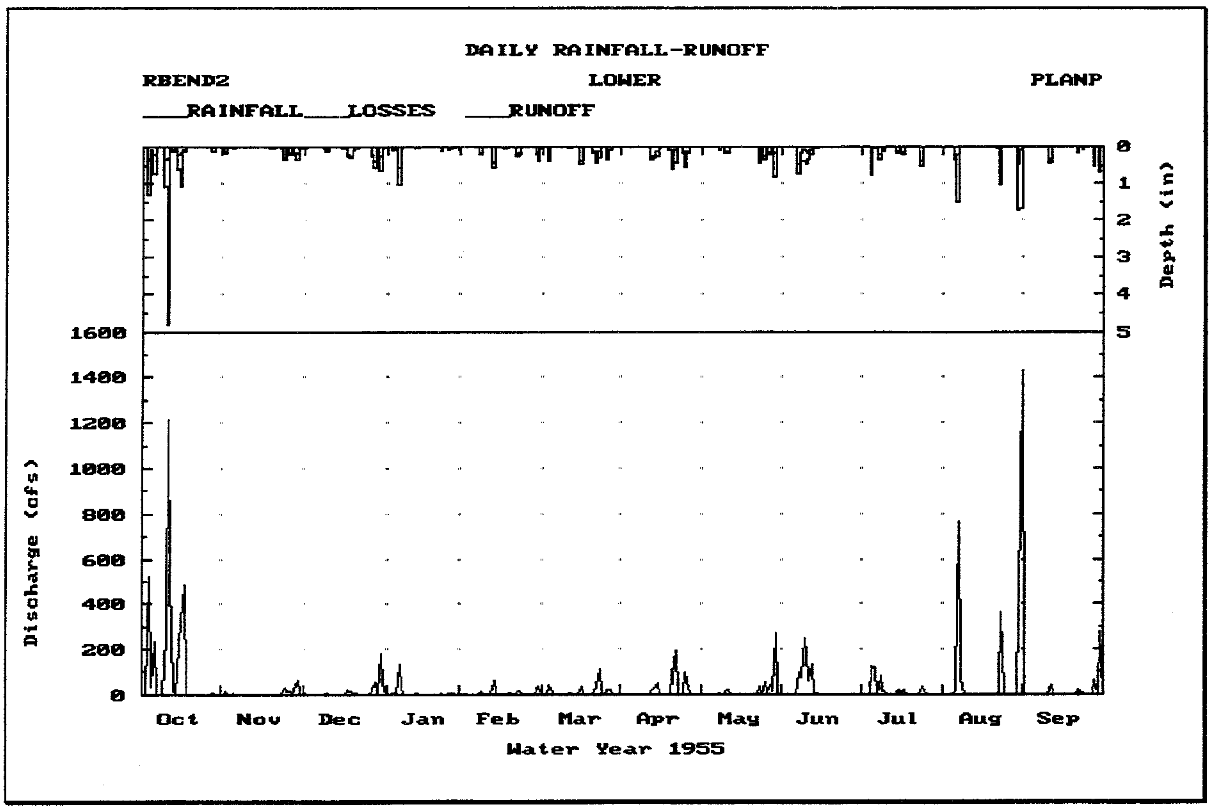


FIGURE 11.9 One-Year Plot of Daily Total Rainfall-Runoff

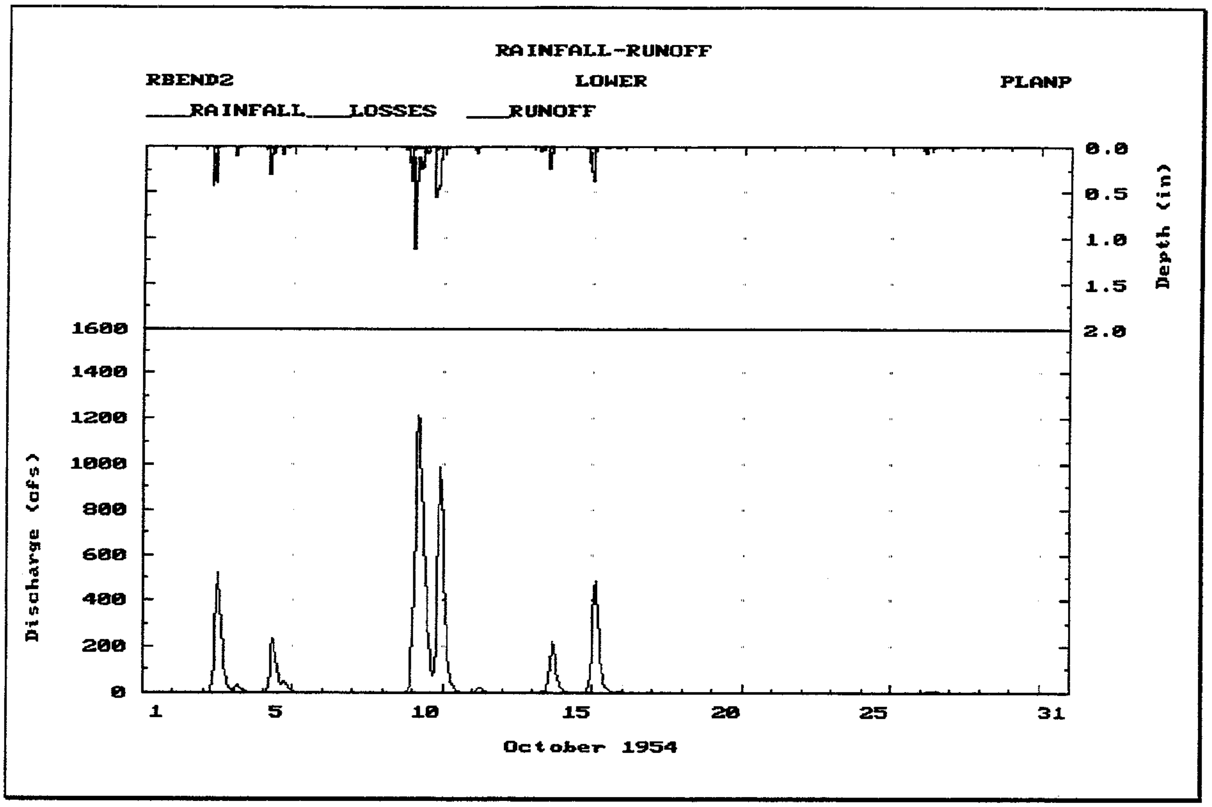


FIGURE 11.10 One-Month Plot of Actual Values

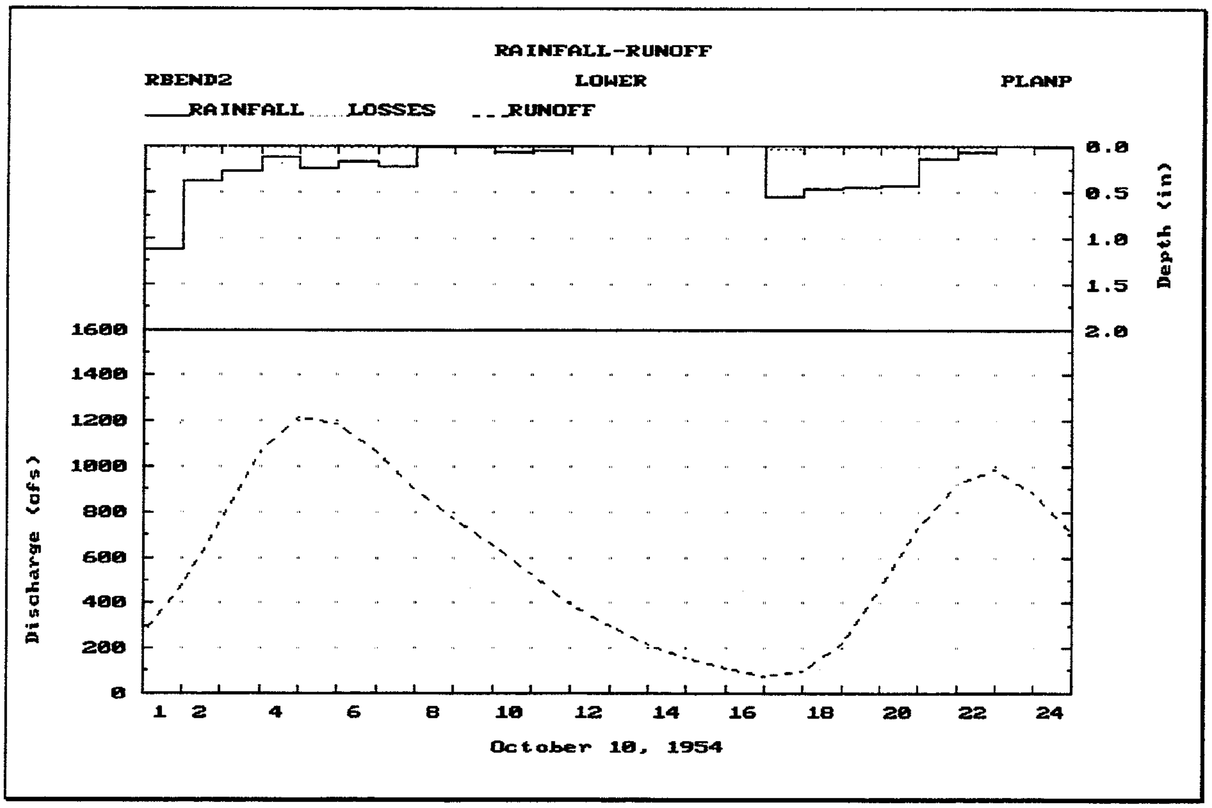


FIGURE 11.11 One-Day Plot of Rainfall-Runoff

Figure 11.12 illustrates the **Interior-Exterior Data** calculation period summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each computation interval during the analysis.
- **Interior Elev.**: The computed water surface elevation in the interior ponding area at the end of each computation interval during the analysis.
- **Exterior Elev.**: The water surface elevation in the exterior channel at the end of each computation interval during the analysis.
- **Head**: The computed differential head between the water surface elevations in the interior ponding area and the exterior channel, at the end of each computation interval during the analysis. The differential head is positive when the interior elevation is higher.
- **Total Inflow**: The total computed rate of inflow into the interior ponding area at the end of each computation interval during the analysis. The total inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, the lower basin auxiliary inflow hydrograph, and any seepage inflow computed by the analysis.
- **Gravity Outflow**: The total computed rate of outflow from all gravity outlets at the end of each computation interval during the analysis.
- **Pump Outflow**: The total computed rate of discharge from all pumping units at the end of each computation interval during the analysis.
- **Total Outflow**: The total computed rate of outflow from the interior ponding area at the end of each computation interval during the analysis. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the summary to be printed.

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.12 illustrates. Four different series of plots are available:

1. **Interior and Exterior Elevations**, as illustrated in Figures 11.13 and 11.14.
2. **Differential Head**, as illustrated in Figures 11.15 and 11.16.
3. **Total Inflow and Total Outflow**, as illustrated in Figures 11.17 and 11.18.
4. **Gravity and Pump Outflow**, as illustrated in Figures 11.19 and 11.20.

If data values for more than one full year are available, the first plot displays maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily totals, as shown in Figure 11.13. Pressing the down-arrow key again zooms to a one-month plot of actual values, as shown in Figure 11.14, and then finally to a one-day plot of actual values. From the one-year, one-month, or one-year plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2. On a computer monitor with color display capabilities, each curve is displayed using a different color.

CSA 01.01.00 SUMM08
Study ID RBEND2 **Hydrologic Analysis Summaries** Begin 01OCT1950/0100
Plan ID PLANP End 30SEP1960/2400

F. Calculation Period Summaries - Interior/Exterior Data

Date/Time DaMonYear/HrMn	Interior Elev. (ft)	Exterior Elev. (ft)	Head (ft)	Total Inflow (cfs)	Gravity Outflow (cfs)	Pump Outflow (cfs)	* Total Outflow (cfs)
10OCT1954/0100	594.86	582.65	12.21	641.5	84.6	0.0	84.6
10OCT1954/0200	595.63	583.63	12.00	1194.9	109.0	0.0	109.0
10OCT1954/0300	596.52	584.61	11.91	1961.9	124.5	0.0	124.5
10OCT1954/0400	597.42	585.59	11.83	2623.4	145.7	0.0	145.7
10OCT1954/0500	598.24	586.57	11.67	2980.2	163.5	0.0	163.5
10OCT1954/0600	598.91	587.55	11.36	3000.4	176.6	0.0	176.6
10OCT1954/0700	599.44	588.53	10.91	2768.2	186.3	0.0	186.3
				2438.2	193.6	0.0	193.6
				2081.9	199.0	199.3	398.4
				1767.0	202.7	199.3	402.0
				1526.1	205.4	199.3	404.7
				1350.0	207.6	199.3	406.9

Select Option:

A. Plot Interior and Exterior Elevations
B. Plot Differential Head
C. Plot Total Inflow and Total Outflow
D. Plot Gravity and Pump Outflow

7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.12 Calculation Period Summary of Interior/Exterior Data

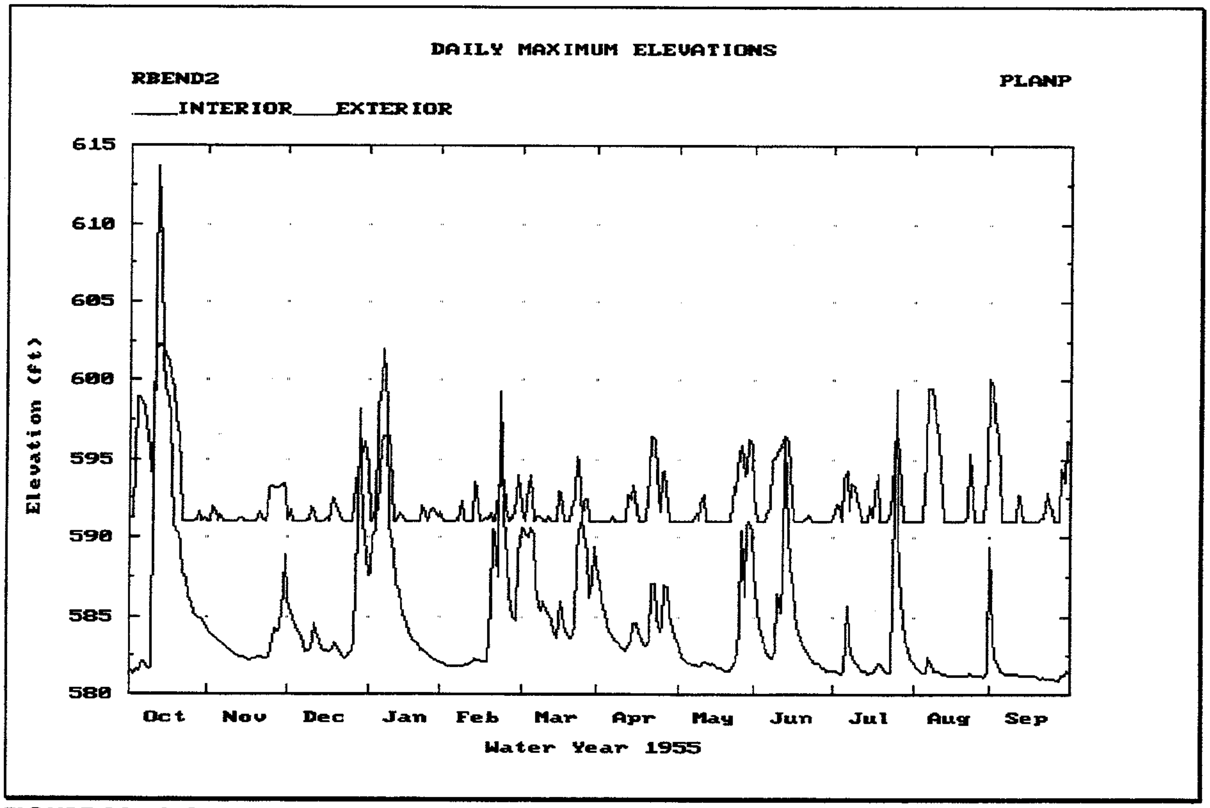


FIGURE 11.13 One-Year Plot of Daily Maximum Elevations

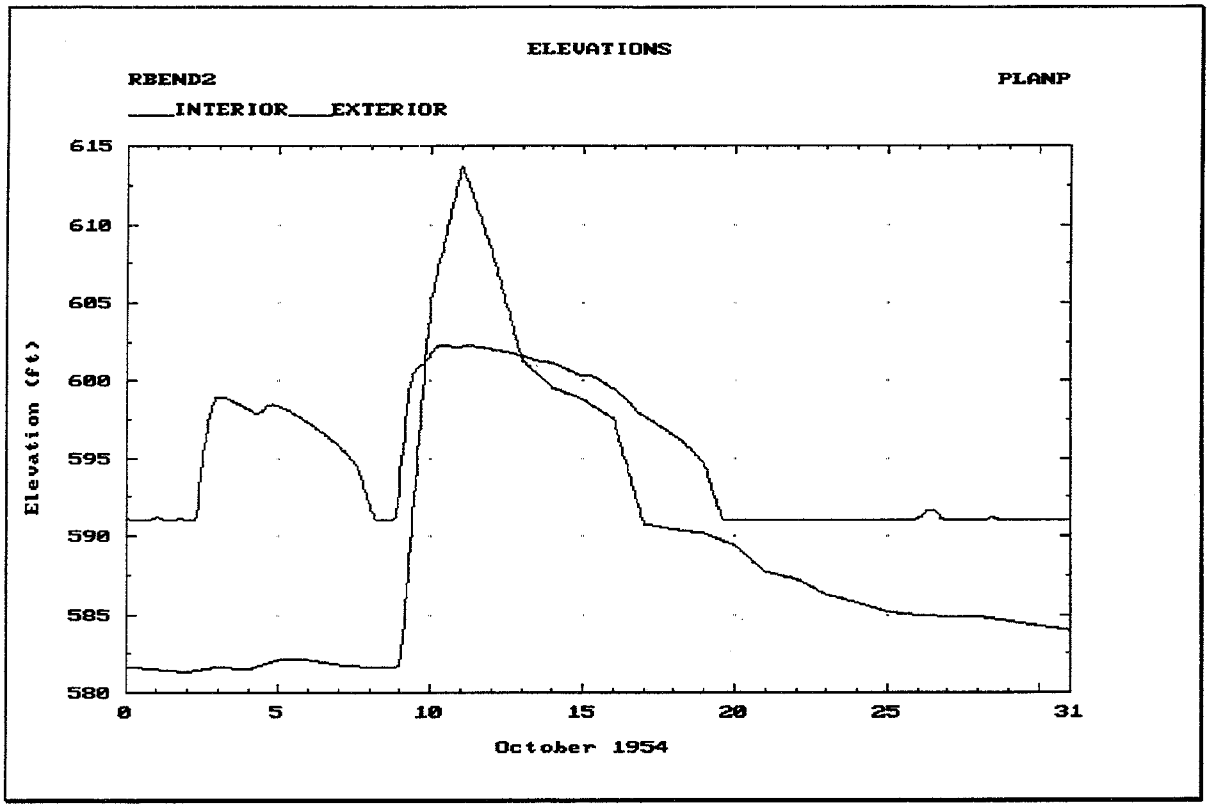


FIGURE 11.14 Plot of Interior and Exterior Elevations

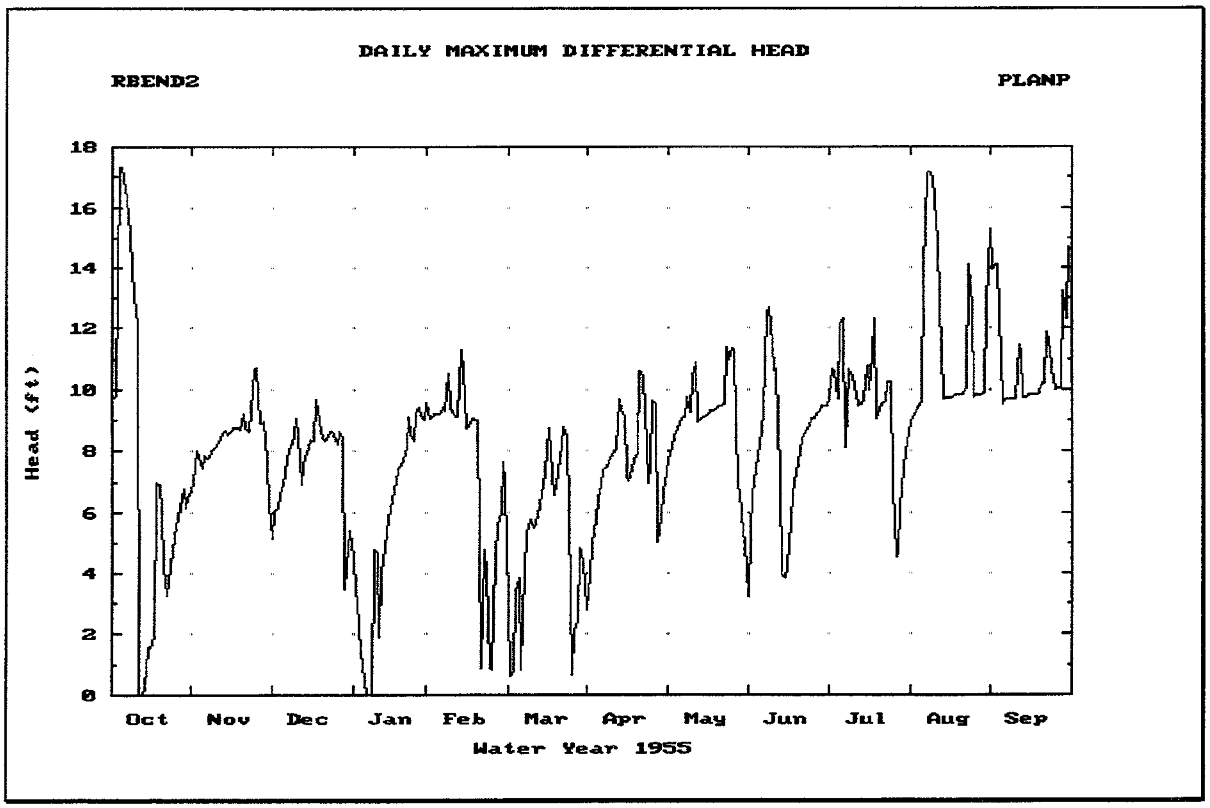


FIGURE 11.15 One-Year Plot of Daily Maximum Differential Head

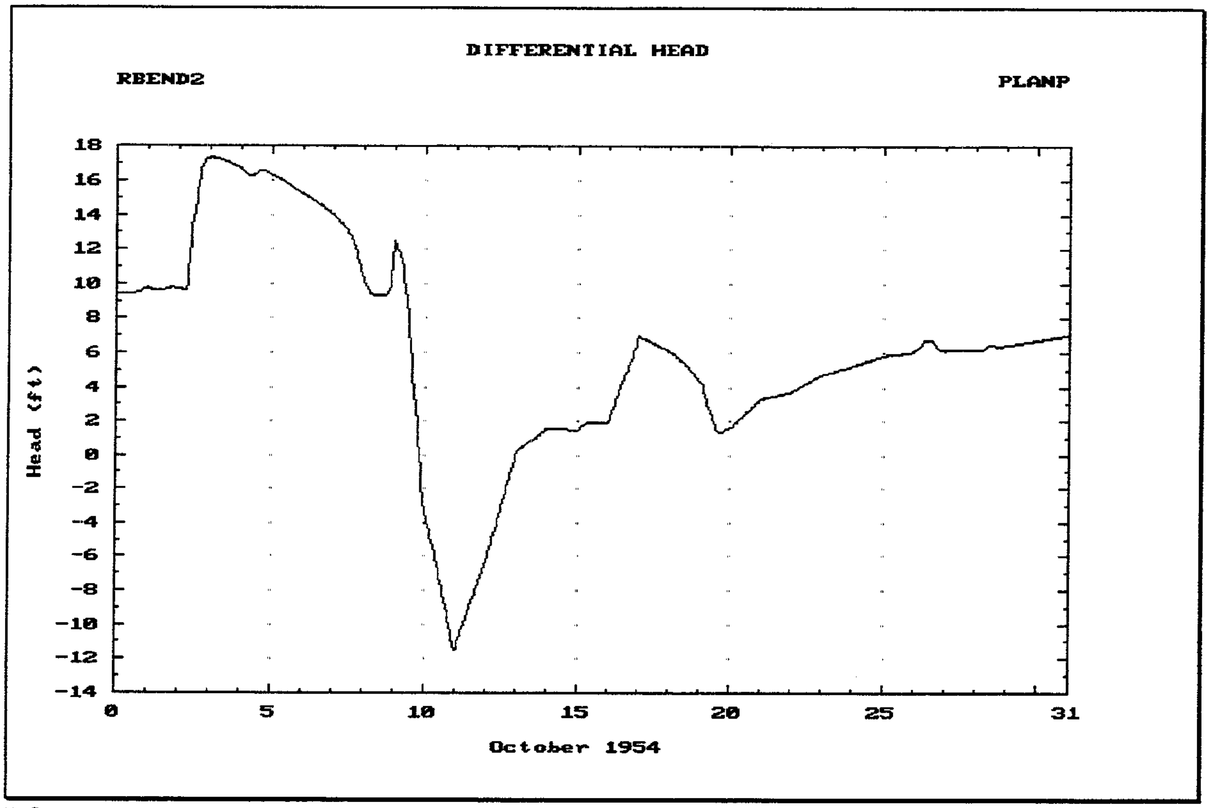


FIGURE 11.16 Plot of Differential Head

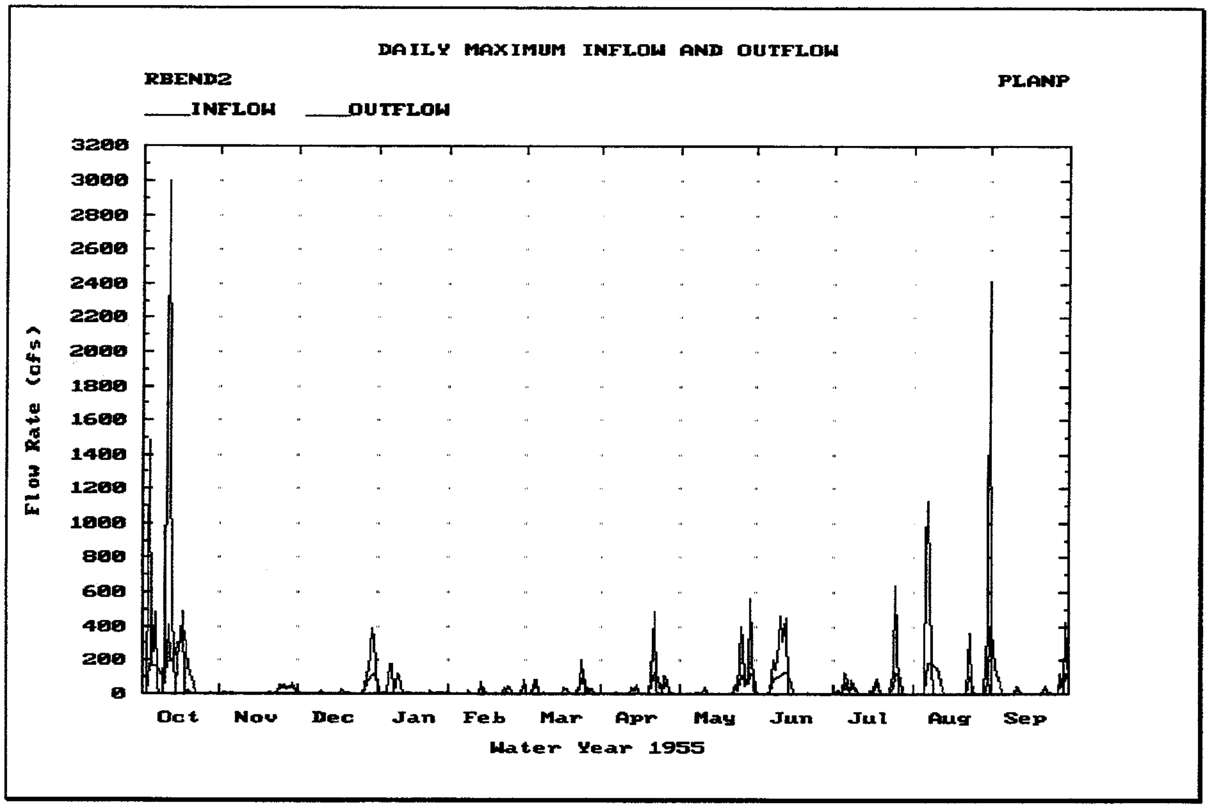


FIGURE 11.17 One-Year Plot of Daily Maximum Inflows and Outflows

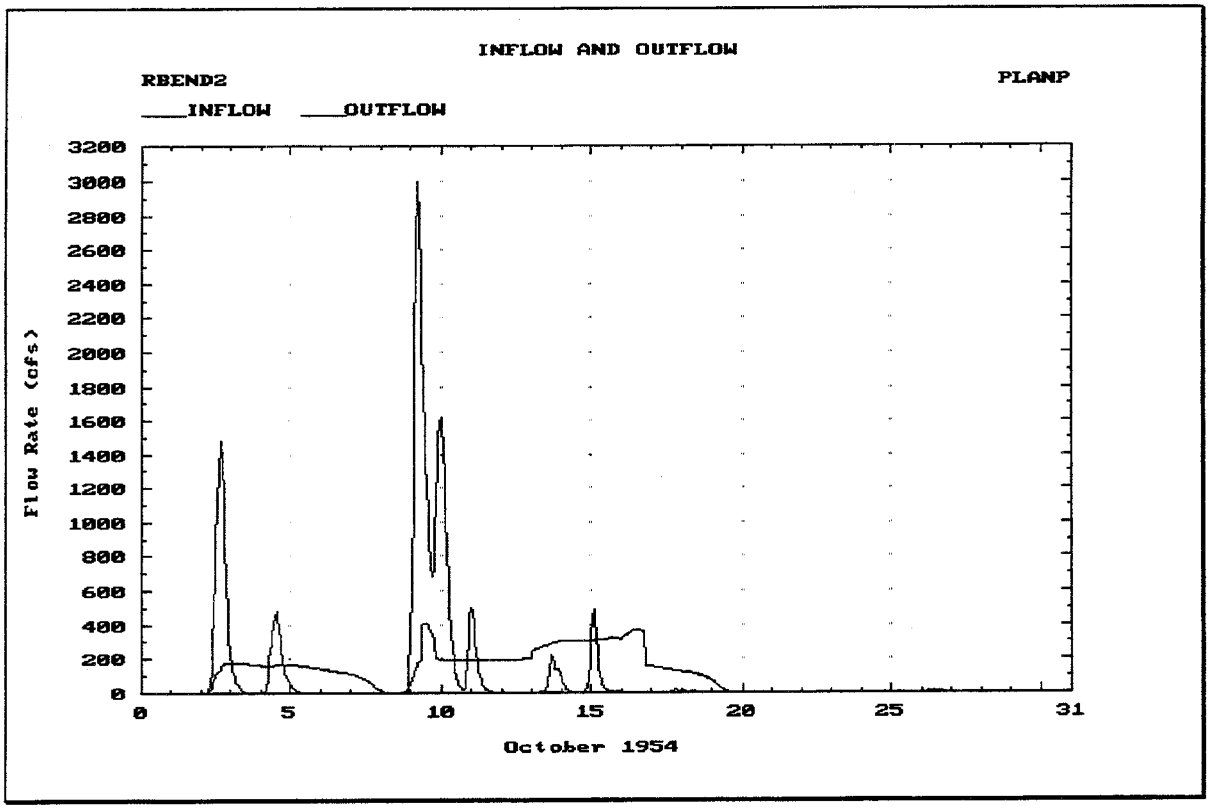


FIGURE 11.18 Plot of Inflows and Outflows

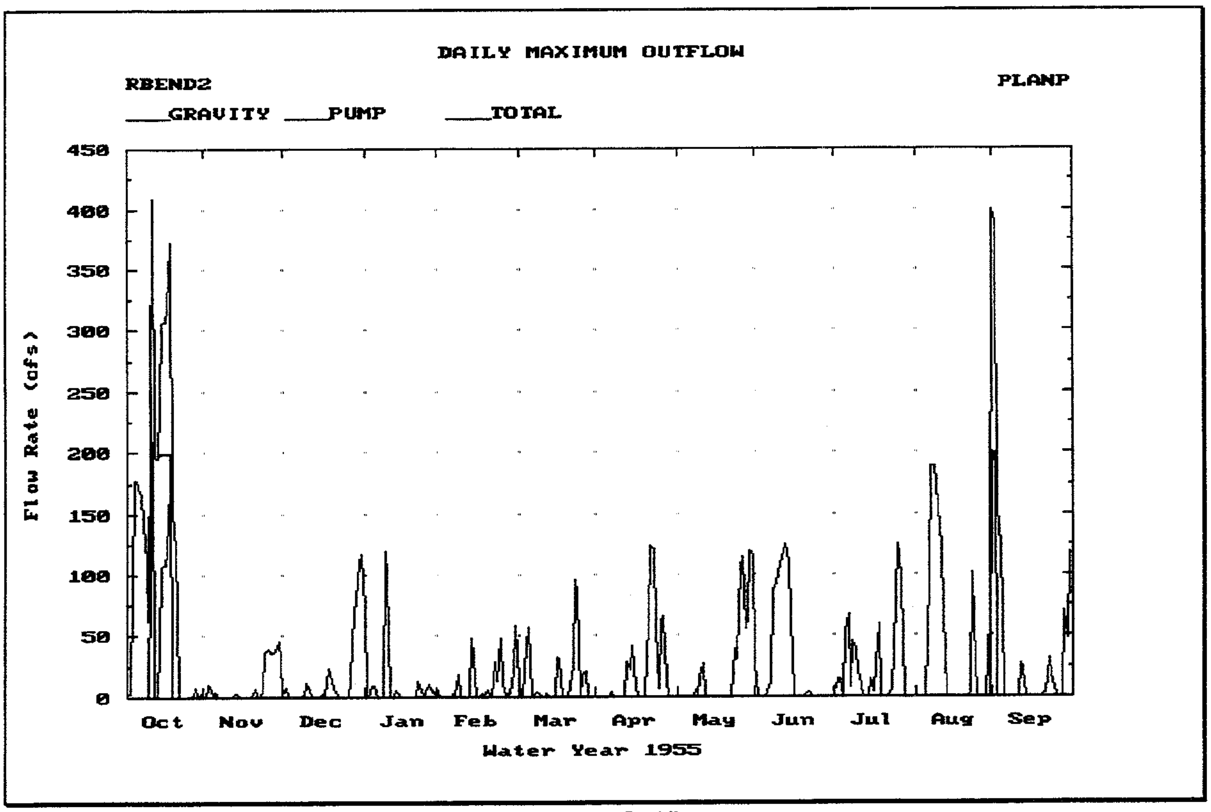


FIGURE 11.19 One-Year Plot of Daily Maximum Outflows

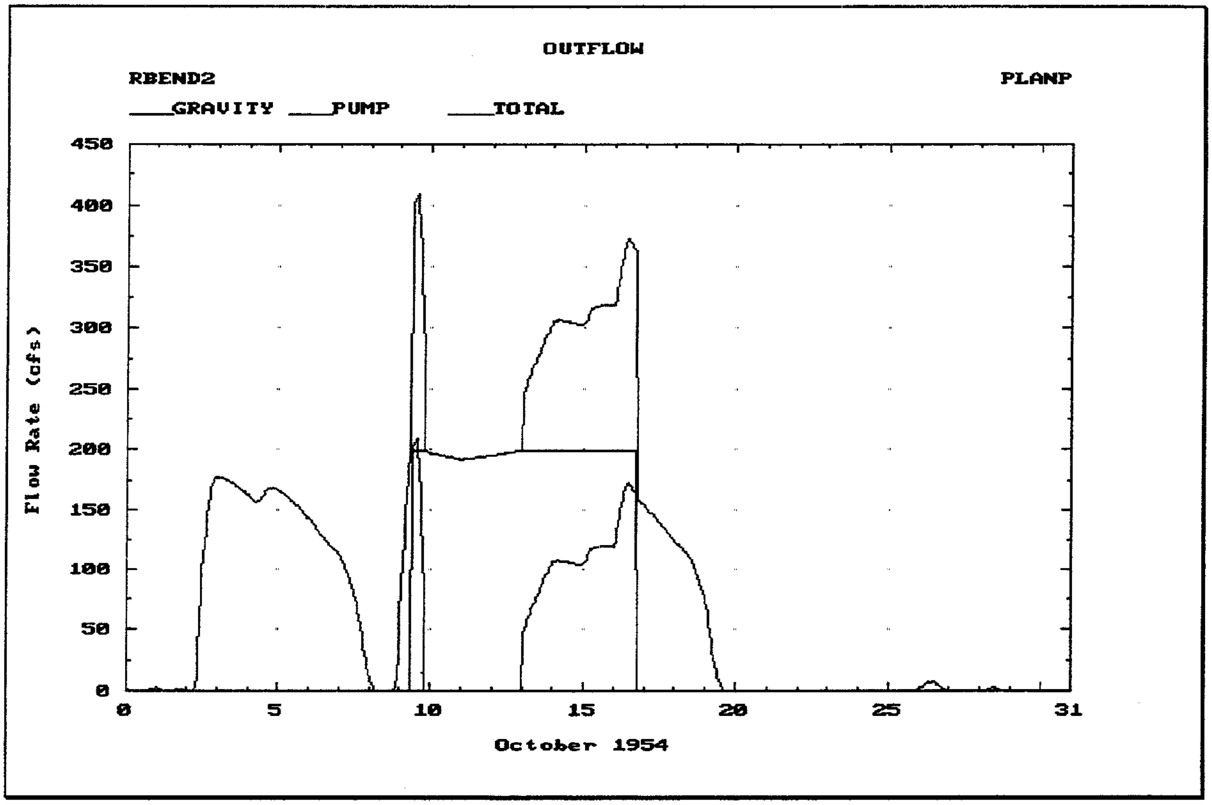


FIGURE 11.20 Plot of Outflows

Figure 11.21 illustrates the Continuous Simulation **Detailed Inflow** summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each time interval during the analysis.
- **Upper Routed**: The computed flow rates of the hydrograph routed from the upper sub-basin at the end of each computation interval. See Chapter 4. These values are available after performing at least selection B of the Perform Interior Analysis menu (See Chapter 10).
- **Lower Runoff**: The computed flow rates of the runoff hydrograph from the lower sub-basin at the end of each computation interval. Chapter 4 provides further details. These values are available after performing at least selection B of the Perform Interior Analysis menu (See Chapter 10).
- **Auxiliary**: The flow rates of the entered or imported auxiliary inflow hydrograph at the interior ponding area at the end of each computation interval. See Chapter 9. These values are available after performing at least selection B of the Perform Interior Analysis menu (See Chapter 10).
- **Interior Inflow**: The sum of the Routed, Runoff, and Auxiliary flow rates at the interior ponding area at the end of each computation interval. See Chapter 9. These values are available after performing at least selection B of the Perform Interior Analysis menu (See Chapter 10).
- **Seepage**: The total computed rate of seepage inflow into the interior ponding area at the end of each computation interval. Seepage is described in Chapter 9. These

values are available only after performing at least selection D of the Perform Interior Analysis menu (See Chapter 10).

- **Total**: The total computed rate of inflow to the interior ponding area at the end of each computation interval. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, auxiliary inflows, and seepage inflow, if applicable. These values are available only after performing at least selection D of the Perform Interior Analysis menu (See Chapter 10).

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the summary to be printed.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM09
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

G. Calculation Period Summaries - Detailed Inflow Data

Date/Time	Inflow (cfs)					
DaMonYear/HrMn	Upper Routed	Lower Runoff	Auxiliary	Interior Inflow	Seepage	Total
10OCT1954/0100	163.0	478.6	0.0	641.5	0.0	641.5
10OCT1954/0200	437.8	757.1	0.0	1194.9	0.0	1194.9
10OCT1954/0300	889.8	1072.1	0.0	1961.9	0.0	1961.9
10OCT1954/0400	1409.3	1214.2	0.0	2623.4	0.0	2623.4
10OCT1954/0500	1793.9	1186.3	0.0	2980.2	0.0	2980.2
10OCT1954/0600	1941.0	1059.4	0.0	3000.4	0.0	3000.4
10OCT1954/0700	1873.9	894.3	0.0	2768.2	0.0	2768.2
10OCT1954/0800	1670.1	768.1	0.0	2438.2	0.0	2438.2
10OCT1954/0900	1427.5	654.3	0.0	2081.9	0.0	2081.9
10OCT1954/1000	1243.2	523.8	0.0	1767.0	0.0	1767.0
10OCT1954/1100	1128.9	397.1	0.0	1526.1	0.0	1526.1
10OCT1954/1200	1054.5	295.5	0.0	1350.0	0.0	1350.0

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.21 Calculation Period Summary of Detailed Inflow Data

The F9 Plot key causes the HEC-IFH program to display a plot of inflows. If data values for more than one full year are available, the first plot displays maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily totals, as shown in Figure 11.22. Pressing the down-arrow key again zooms to a one-month plot of actual values, as shown in Figure 11.23. From the one-month plot, pressing the down-arrow again zooms to a one-day plot of actual values. From the one-year, one-month, or one-day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. On a color monitor, each line is displayed using a different color.

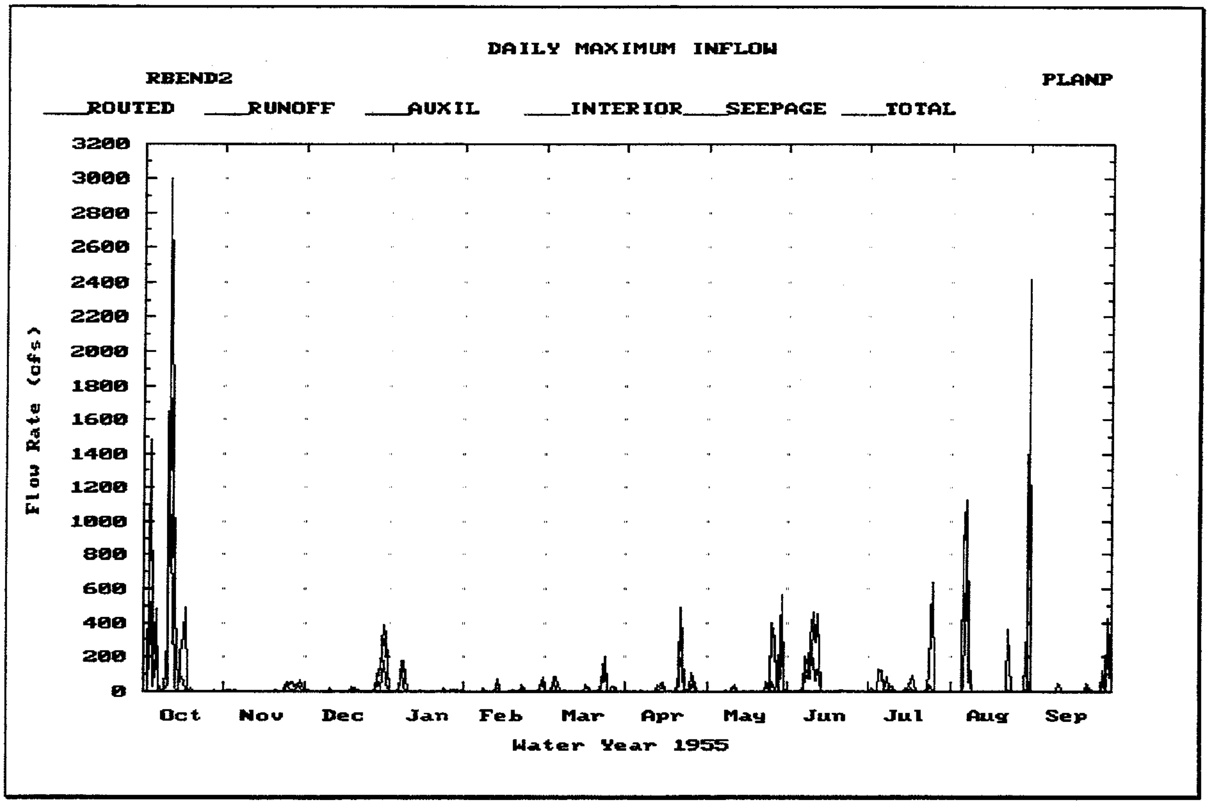


FIGURE 11.22 One-Year Plot of Detailed Daily Maximum Inflows

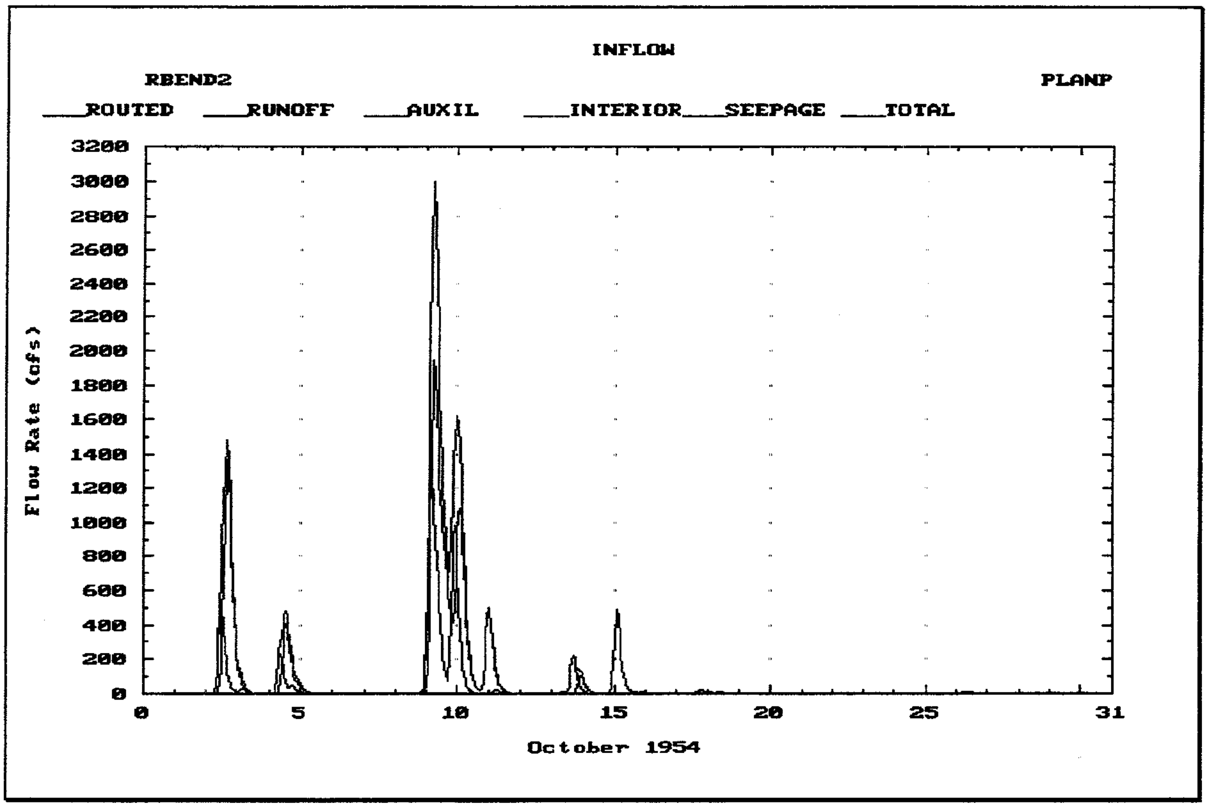


FIGURE 11.23 One-Month Plot of Detailed Inflows

Figure 11.24 illustrates the Continuous Simulation **Detailed Outflow** summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each computation interval during the analysis.
- **Total Gravity**: The total computed rate of outflow from all gravity outlets at the end of each computation interval during the analysis. See Chapter 6.
- **Pump**: The total computed rate of discharge from all pumping units at the end of each computation interval during the analysis. See Chapter 7.
- **Diversion**: The computed rate of discharge from diversion at the end of each computation interval during the analysis. Diversions are assumed to apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area, located in the lower interior sub-basin. See Chapter 9 for further details.
- **Overflow**: The computed rate of overflow from the interior ponding area at the end of each computation interval during the analysis. See Chapter 9.
- **Total Outflow**: The total computed rate of outflow from the interior ponding area at the end of each computation interval during the analysis. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the summary to be printed.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM10
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

H. Calculation Period Summaries - Detailed Outflow Data

	Outflow (cfs)				
Date/Time DaMonYear/HrMn	Total Gravity	Pump	Diversion	Overflow	* Total
10OCT1954/0100	84.6	0.0	0.0	0.0	84.6
10OCT1954/0200	109.0	0.0	0.0	0.0	109.0
10OCT1954/0300	124.5	0.0	0.0	0.0	124.5
10OCT1954/0400	145.7	0.0	0.0	0.0	145.7
10OCT1954/0500	163.5	0.0	0.0	0.0	163.5
10OCT1954/0600	176.6	0.0	0.0	0.0	176.6
10OCT1954/0700	186.3	0.0	0.0	0.0	186.3
10OCT1954/0800	193.6	0.0	0.0	0.0	193.6
10OCT1954/0900	199.0	199.3	0.0	0.0	398.4
10OCT1954/1000	202.7	199.3	0.0	0.0	402.0
10OCT1954/1100	205.4	199.3	0.0	0.0	404.7

* Note: Diversion is not part of Total Pond Outflow

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.24 Calculation Period Summary of Detailed Outflows

The F9 Plot key causes the HEC-IFH program to display a plot of inflows. If data values for more than one full year are available, the first plot displays maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily totals, as shown in Figure 11.25. Pressing the down-arrow key again zooms to a one-month plot of actual values, as shown in Figure 11.26. While viewing the one-month plot, pressing the down-arrow zooms to a one-day plot of actual values. From the one-year, one-month, or one-day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2. On a computer monitor with color display capabilities, each curve is displayed using a different color.

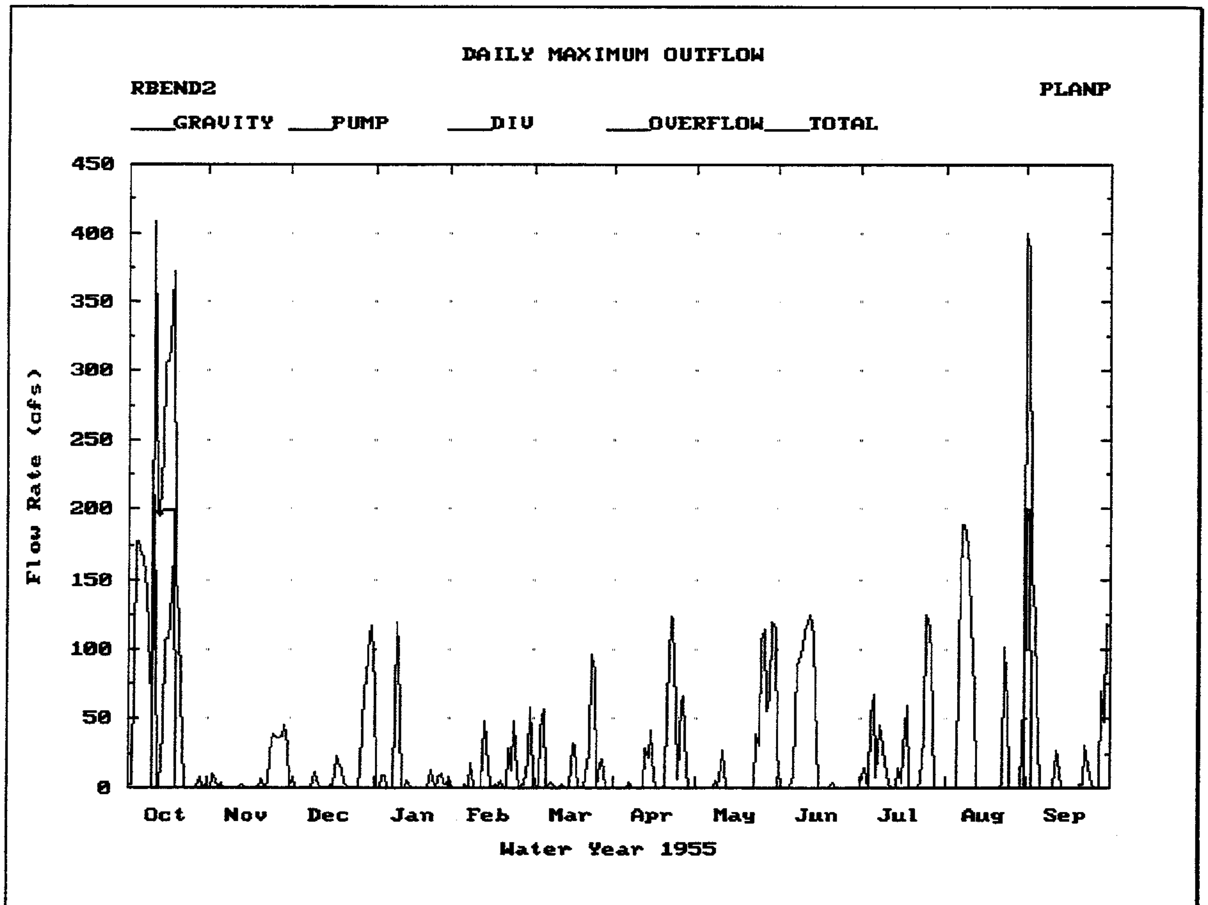


FIGURE 11.25 One-Year Plot of Detailed Maximum Daily Outflows

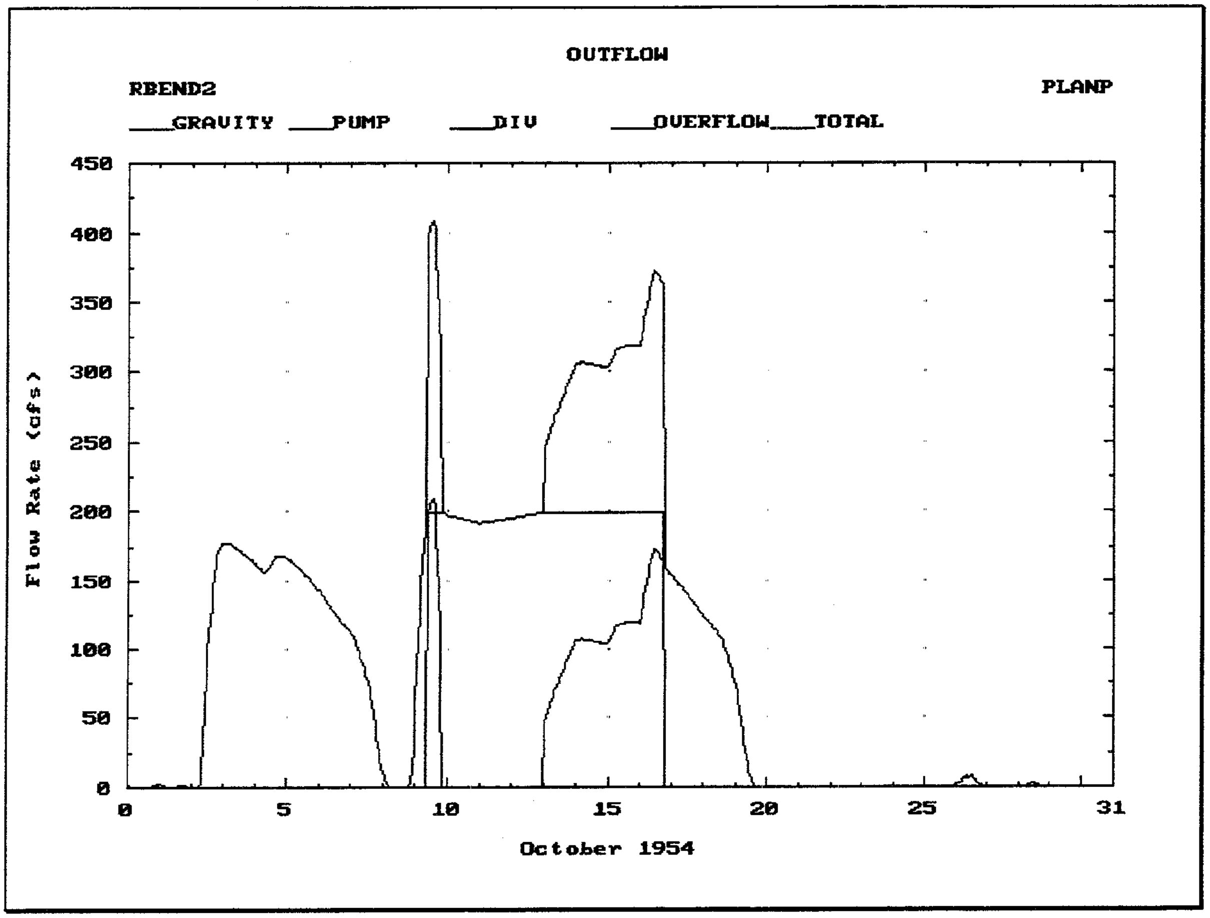


FIGURE 11.26 One-Month Plot of Detailed Outflows

Figure 11.27 illustrates the **Detailed Gravity Outflow** calculation period summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each computation interval during the analysis.
- **Primary**: The total computed rate of outflow from all the gravity outlets at the Primary outlet location at the end of each computation interval during the analysis.
- **Sec. 1**: The total computed rate of outflow from all the gravity outlets at the Secondary 1 outlet location at the end of each computation interval during the analysis.
- **Sec. 2**: The total computed rate of outflow from all the gravity outlets at the Secondary 2 outlet location at the end of each computation interval during the analysis.
- **Sec. 3**: The total computed rate of outflow from all the gravity outlets at the Secondary 3 outlet location at the end of each computation interval during the analysis.
- **Sec. 4**: The total computed rate of outflow from all the gravity outlets at the Secondary 4 outlet location at the end of each computation interval during the analysis.

- **Total**: The total computed rate of outflow from all gravity outlets at the end of each computation interval during the analysis.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the summary to be printed.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM11
Study ID RBEND2 | | Begin 01OCT1950/0100
Plan ID PLANP | | End 30SEP1960/2400

I. Calculation Period Summaries - Detailed Gravity Outflow Data

Date/Time DaMonYear/HrMn	Gravity Outflow (cfs) Primary	Sec. 1	Sec. 2	Sec. 3	Sec 4.	Total
10OCT1954/0100	84.6	0.0	0.0	0.0	0.0	84.6
10OCT1954/0200	109.0	0.0	0.0	0.0	0.0	109.0
10OCT1954/0300	124.5	0.0	0.0	0.0	0.0	124.5
10OCT1954/0400	145.7	0.0	0.0	0.0	0.0	145.7
10OCT1954/0500	163.5	0.0	0.0	0.0	0.0	163.5
10OCT1954/0600	176.6	0.0	0.0	0.0	0.0	176.6
10OCT1954/0700	186.3	0.0	0.0	0.0	0.0	186.3
10OCT1954/0800	193.6	0.0	0.0	0.0	0.0	193.6
10OCT1954/0900	199.0	0.0	0.0	0.0	0.0	199.0
10OCT1954/1000	202.7	0.0	0.0	0.0	0.0	202.7
10OCT1954/1100	205.4	0.0	0.0	0.0	0.0	205.4
10OCT1954/1200	207.6	0.0	0.0	0.0	0.0	207.6
10OCT1954/1300	209.3	0.0	0.0	0.0	0.0	209.3

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.27 Calculation Period Summary of Detailed Gravity Outflow Data

The F9 Plot key causes the HEC-IFH program to display a plot of gravity outflows. If data values for more than one full year are available, the first plot displays maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily totals, as shown in Figure 11.28. Pressing the down-arrow key again zooms to a one-month plot of actual values, as shown in Figure 11.29. While viewing the one-month plot, pressing the down-arrow key zooms to a one-day plot of actual values. From the one-year, one-month, or one day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2. On a computer monitor with color display capabilities, each line is displayed using a different color.

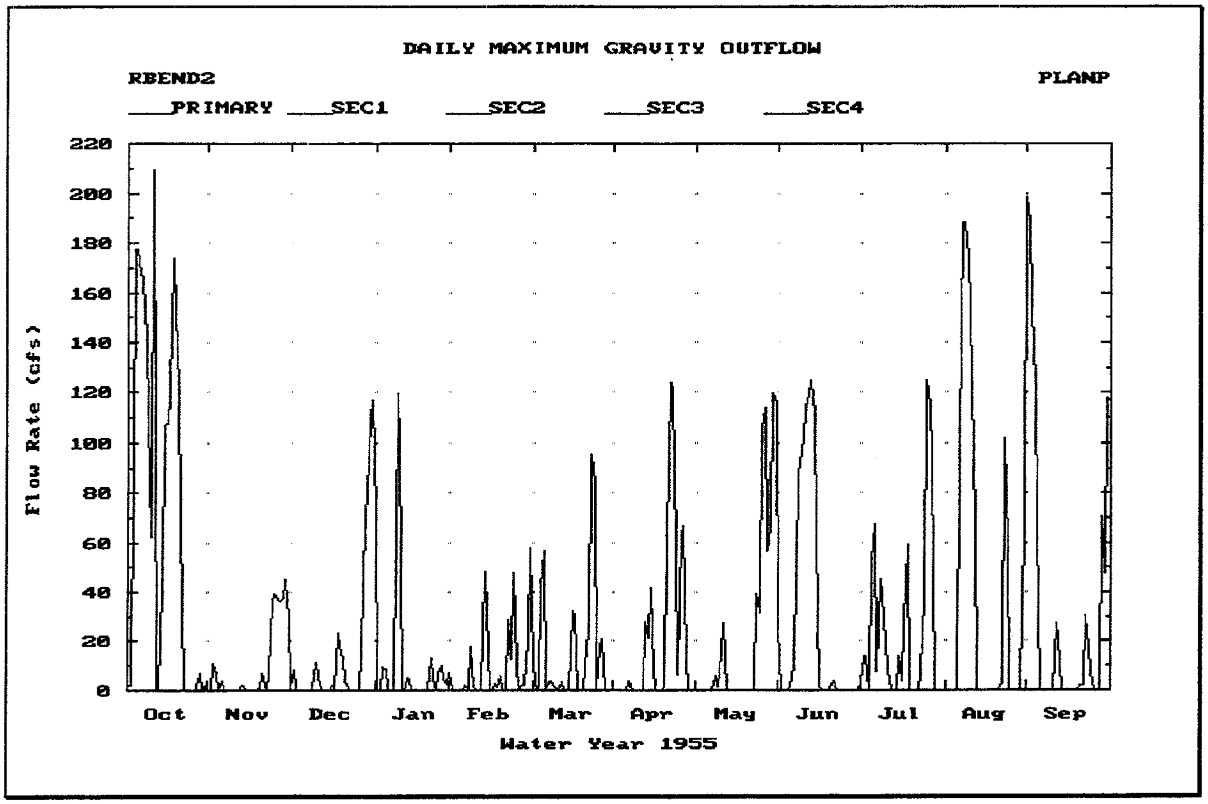


FIGURE 11.28 One-Year Plot of Detailed Daily Maximum Gravity Outflows

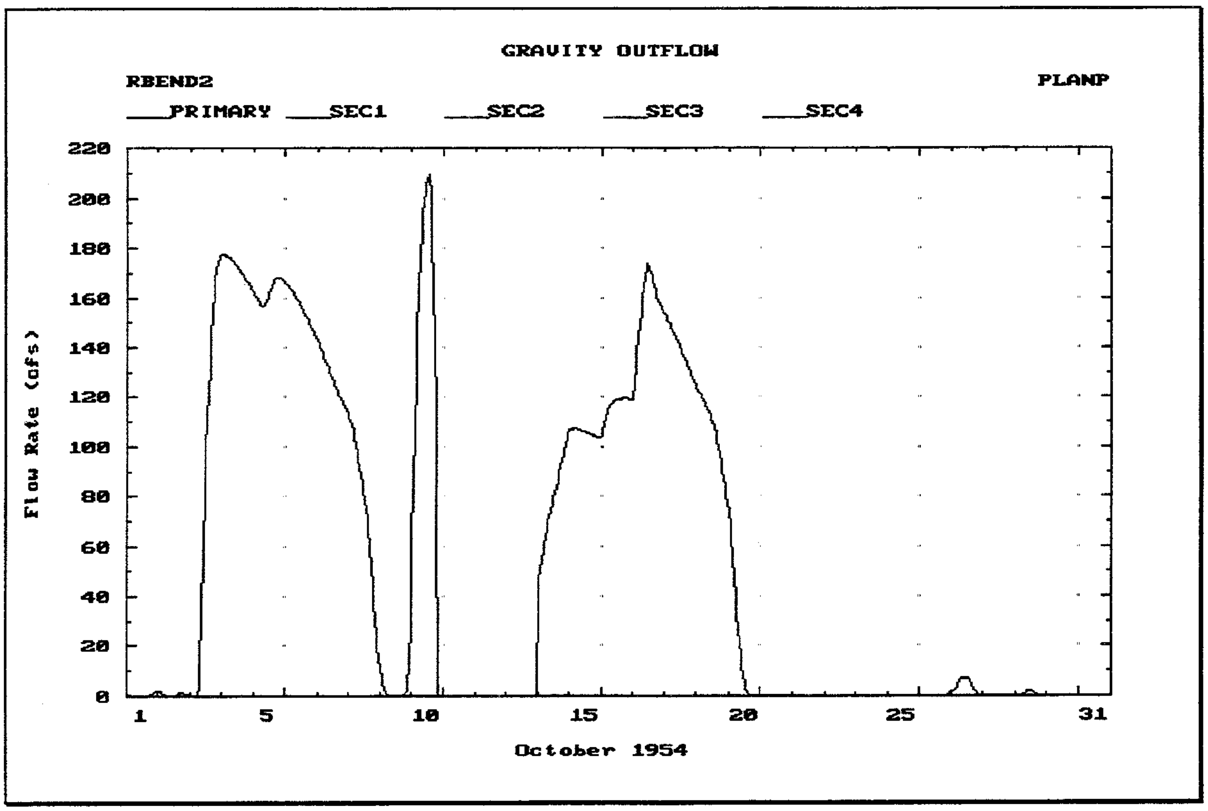


FIGURE 11.29 One-Month Plot of Detailed Gravity Outflows

Figure 11.30 illustrates the **Area Flooded Data** calculation period summary, which includes the following data values for the specified plan:

- **Date/Time**: The date and time at the end of each computation interval during the analysis.
- **Exterior Elevation**: The water surface elevation in the exterior channel at the end of each computation interval during the analysis.
- **Interior Elevation**: The computed water surface elevation in the interior ponding area at the end of each computation interval during the analysis.
- **Area Flooded**: The computed surface area of the interior ponding area at the end of each computation interval during the analysis.
- **Pond Stor. Volume**: The computed storage volume of the interior ponding area at the end of each computation interval during the analysis.

Pressing the [F4] Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the [F5] Report key causes the summary to be printed.

CSA 01.01.00 **Hydrologic Analysis Summaries** SUMM12
Study ID RBEND2 Begin 01OCT1950/0100
Plan ID PLANP End 30SEP1960/2400

J. Calculation Period Summaries - Area Flooded Data

Date/Time DaMonYear/HrMn	Exterior Elevation (ft)	Interior Elevation (ft)	Area Flooded (ac)	Pond Stor. Volume (ac-ft)
01OCT1950/0100	581.12	591.10	0.5	0.0
01OCT1950/0200	581.12	591.01	0.1	0.0
01OCT1950/0300	581.12	591.00	0.1	0.0
01OCT1950/0400	581.12	591.00	0.1	0.0
01OCT1950/0500	581.12	591.00	0.1	0.0
01OCT1950/0600	581.12	591.00	0.1	0.0
01OCT1950/0700	581.12	591.00	0.1	0.0
01OCT1950/0800	581.12	591.00	0.1	0.0
01OCT1950/0900	581.12	591.00	0.1	0.0
01OCT1950/1000	581.12	591.00	0.1	0.0
01OCT1950/1100	581.12	591.00	0.1	0.0
01OCT1950/1200	581.12	591.00	0.1	0.0
01OCT1950/1300	581.12	591.00	0.1	0.0

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>

FIGURE 11.30 Calculation Period Summary of Interior Area Flooded Data

The [F9] Plot key causes the HEC-IFH program to display a plot of the area flooded. If data values for more than one full year are available, the first plot displays maximum annual values. Pressing the down-arrow key "zooms" to a one-year plot of daily totals, as shown in Figure 11.31. Pressing the down-arrow key again zooms to a one-month plot of actual values, as shown in Figure 11.32. While viewing the one-month plot, pressing the down-arrow key zooms to a one-day plot of actual values. From the one-year, one-month, or one-day plots, the left-arrow and right-arrow keys "pan" to plots of different years, months, or days, if available. The zoom and pan plot options are described in Chapter 2.

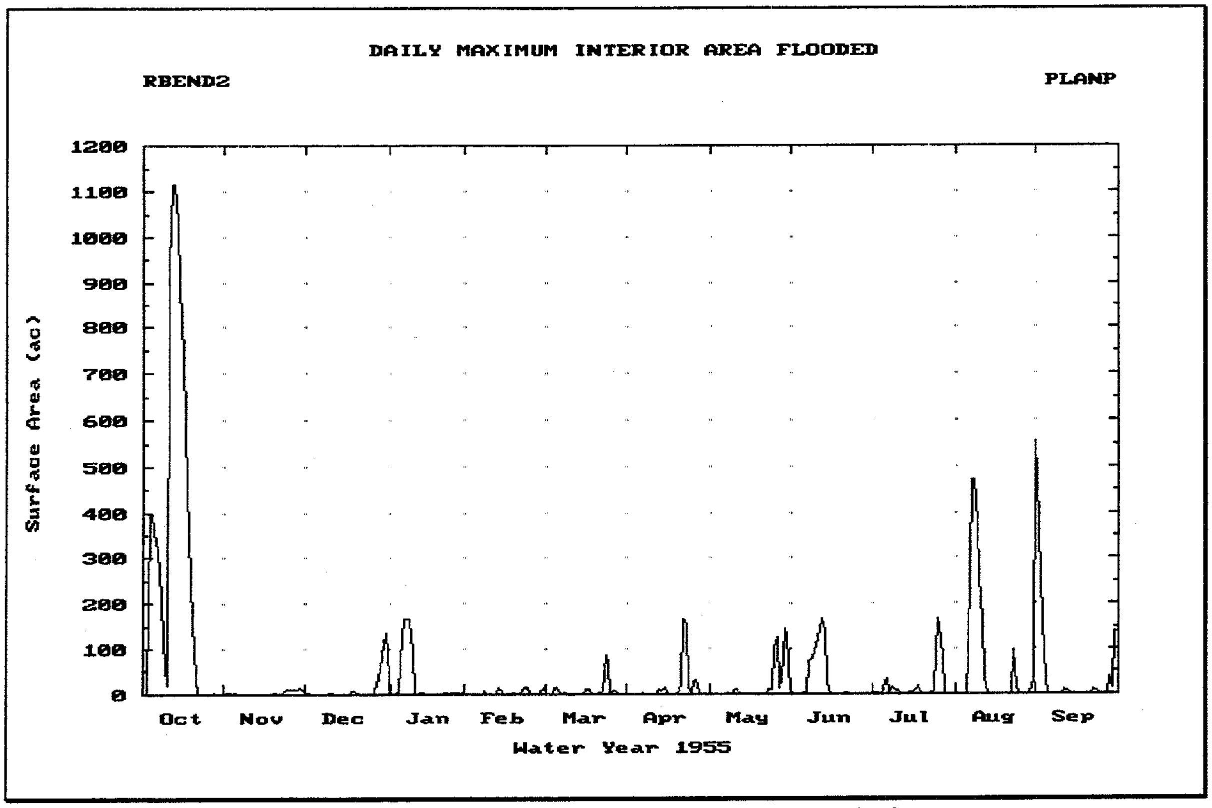


FIGURE 11.31 One-Year Plot of Daily Maximum Interior Area Flooded

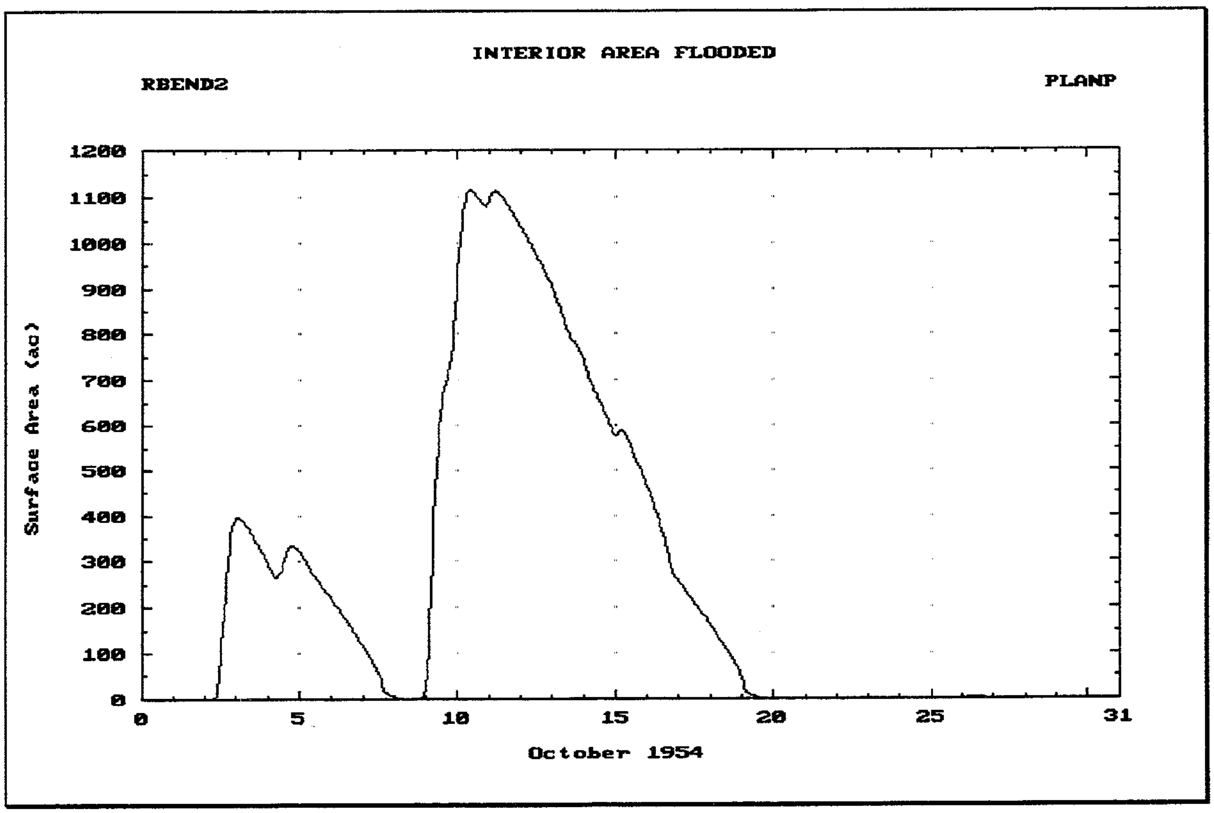


FIGURE 11.32 Plot of Interior Area Flooded

11.6. CONTINUOUS SIMULATION MONTHLY SUMMARIES

There are three ***Monthly Summaries*** which summarize the results of the analysis for each monthly period during the analysis:

1. **Average Monthly Rainfall**: The average precipitation depth, losses, and percent loss for each of the three sub-basins for each calendar month.
2. **Interior/Exterior Data**: The maximum, minimum, and average exterior elevation, interior elevation, and differential head values for each calendar month.
3. **Pump Operation**: The total and average volume pumped and operating time for each calendar month. The maximum and average pump head values and the total pump energy are also listed for each month.

Figure 11.33 illustrates the **Average Monthly Rainfall** summary, which includes the following data values for the specified plan:

- **Precip**: The average monthly total precipitation values for each calendar month, for each of the areas used in the analysis. If only a portion of a month is included in the analysis, the partial month results are extrapolated to give an approximate monthly total.
- **Losses**: The average monthly total infiltration loss values for each calendar month, for each of the sub-basins used in the analysis. These values are computed using the loss rate method specified for each sub-basin.
- **Percent Loss**: The percentage of the total monthly precipitation which is lost (does not contribute directly to runoff) for each calendar month, for each of the sub-basins used in the analysis.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM13
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

K. Monthly Summaries - Average Monthly Rainfall

Month	Lower Sub-Basin			Upper Sub-Basin			Exterior Basin		
	Precip (in)	Losses (in)	Percent Loss	Precip (in)	Losses (in)	Percent Loss	Precip (in)	Losses (in)	Percent Loss
Oct	3.63	1.34	36.84	3.35	1.35	40.41			
Nov	2.36	1.41	59.57	2.08	1.39	66.64			
Dec	1.93	1.32	68.11	1.76	1.26	71.77			
Jan	1.97	1.23	62.42	1.70	1.04	61.00			
Feb	2.09	1.33	63.58	1.75	1.20	68.57			
Mar	2.43	1.46	60.06	2.56	1.61	63.09			
Apr	4.04	1.93	47.78	3.44	1.65	47.92			
						50.29			
						44.81			
						41.59			
						43.40			
						52.68			

Select Option:

A. Plot Monthly Lower Sub-Basin Rainfall
B. Plot Monthly Upper Sub-Basin Rainfall
C. Plot Monthly Exterior Sub-Basin Rainfall

8 9 10Exit

Press <F10> to Return

FIGURE 11.33 Monthly Summary of Average Rainfall

After the report is displayed on the screen, the F2 PrtScr key may be used to generate a printed copy of the report.

The F9 Plot key causes the HEC-IFH program to display a menu of available rainfall plots, as Figure 11.33 illustrates. Three different plots are available: one for each of the sub-basins. Figure 11.34 illustrates one of these plots.

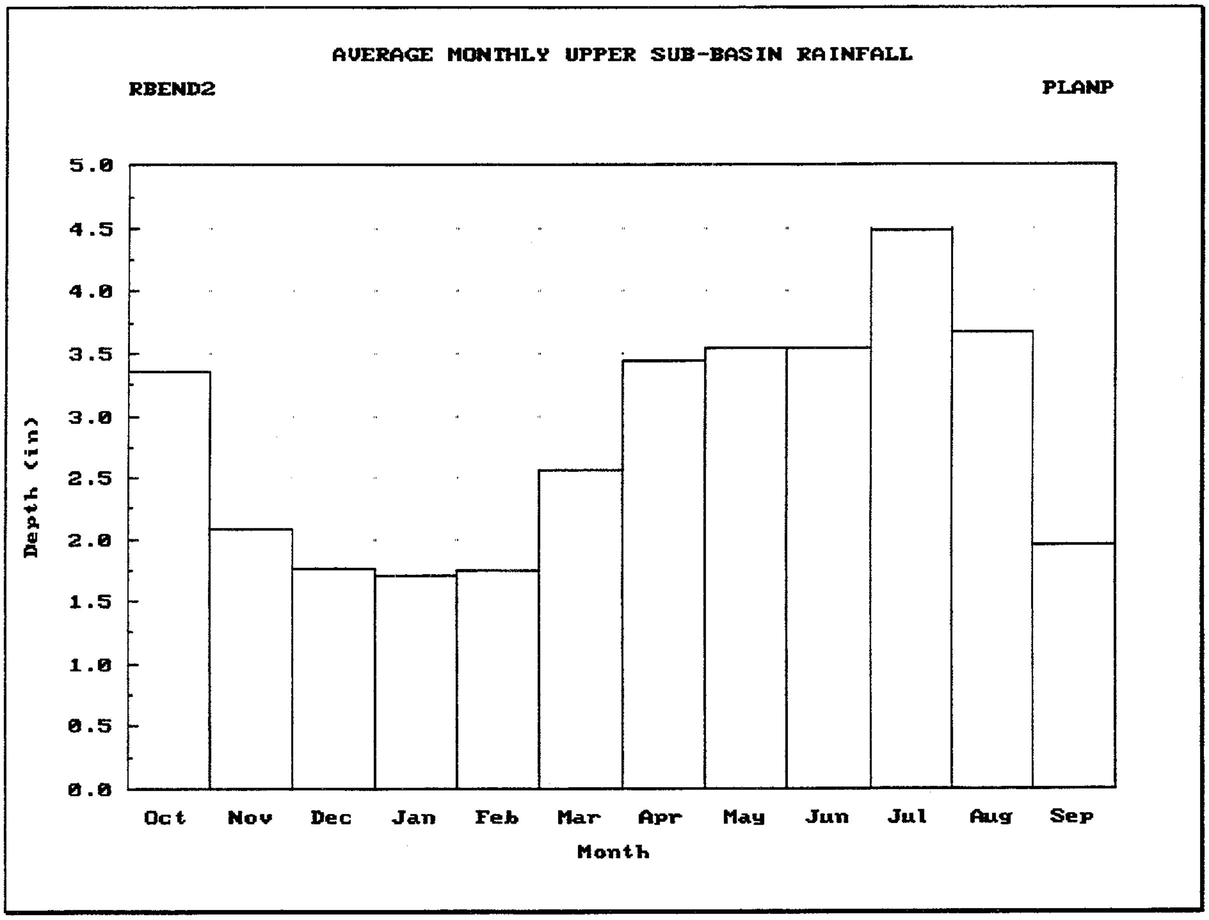


FIGURE 11.34 Plot of Average Monthly Rainfall

Figure 11.35 illustrates the **Interior-Exterior Data** monthly summary, which includes the following data values for the specified plan:

- **Maximum Exterior Elevation**: The maximum water surface elevation in the exterior channel for each calendar month during the analysis.
- **Minimum Exterior Elevation**: The minimum water surface elevation in the exterior channel for each calendar month during the analysis.
- **Average Exterior Elevation**: The average water surface elevation in the exterior channel for each calendar month during the analysis.
- **Maximum Interior Elevation**: The maximum computed water surface elevation in the interior ponding area for each calendar month during the analysis.
- **Minimum Interior Elevation**: The minimum computed water surface elevation in the interior ponding area for each calendar month during the analysis.

- **Average Interior Elevation**: The average computed water surface elevation in the interior ponding area for each calendar month during the analysis.
- **Maximum Differential Head**: The maximum computed differential head between the water surface elevations in the interior ponding area and the exterior channel, for each calendar month during the analysis. The differential head is positive when the interior elevation is higher.
- **Minimum Differential Head**: The minimum computed differential head between the water surface elevations in the interior ponding area and the exterior channel, for each calendar month during the analysis. The differential head is positive when the interior elevation is higher.
- **Average Differential Head**: The average computed differential head between the water surface elevations in the interior ponding area and the exterior channel, for each calendar month during the analysis. The differential head is positive when the interior elevation is higher.

After the report is displayed on the screen, the F2 PrtScr key may be used to generate a printed copy of the report.

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.35 illustrates. Three different plots are available:

1. **Monthly Exterior Elevations**, as illustrated in Figure 11.36.
2. **Monthly Interior Elevations**, as illustrated in Figure 11.37.
3. **Monthly Differential Head**, as illustrated in Figure 11.38.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM14
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

L. Monthly Summaries - Interior/Exterior Data

	Exterior Elevation (ft)			Interior Elevation (ft)			Differential Hd (ft)		
Mon	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.
Oct	613.74	580.95	582.70	602.28	591.00	591.99	17.34	-11.53	9.29
Nov	600.39	581.06	583.34	598.07	591.00	591.62	14.72	-2.32	8.27
Dec	598.67	581.00	582.97	596.07	591.00	591.39	14.04	-5.40	8.42
Jan	601.99	580.98	584.31	599.59	591.00	591.63	14.69	-7.73	7.32
Feb	601.03	581.23	585.81	598.12	591.00	591.77	12.83	-6.53	5.96
Mar	600.54	581.47	587.52	598.78	591.00	591.84	13.95	-9.30	4.33
Apr	610.88	582.27	587.62	600.57	591.00	592.26	10.61	-10.97	4.64
May	604.59	581.31	586.21	600.25	591.00	592.32	13.19	-6.76	6.11
					591.00	592.36	15.54	-3.62	7.56
					591.00	592.27	15.08	-5.70	8.97
					591.00	592.16	17.16	-4.64	10.01
					591.00	591.59	17.18	7.83	10.21

Select Option:

A. Plot Monthly Exterior Elevations
B. Plot Monthly Interior Elevations
C. Plot Monthly Differential Head

DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 11.35 Monthly Summary of Interior/Exterior Data

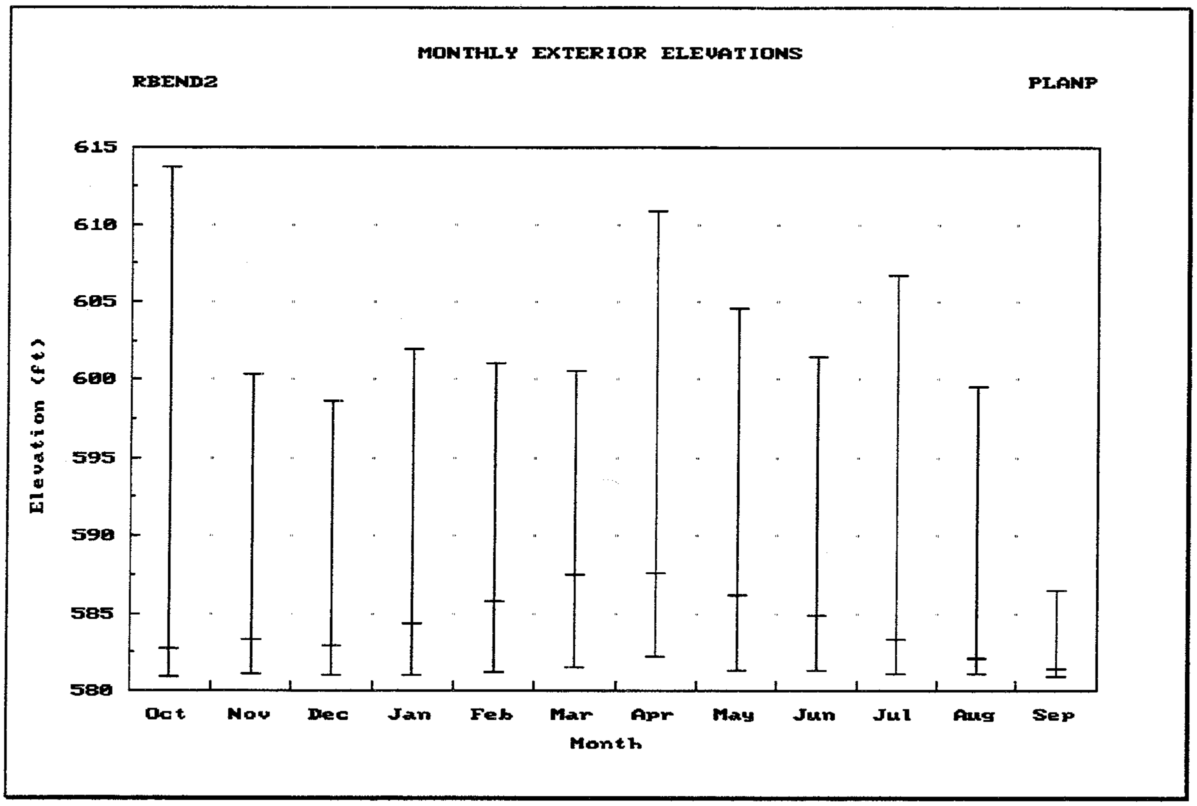


FIGURE 11.36 Plot of Monthly Exterior Elevations

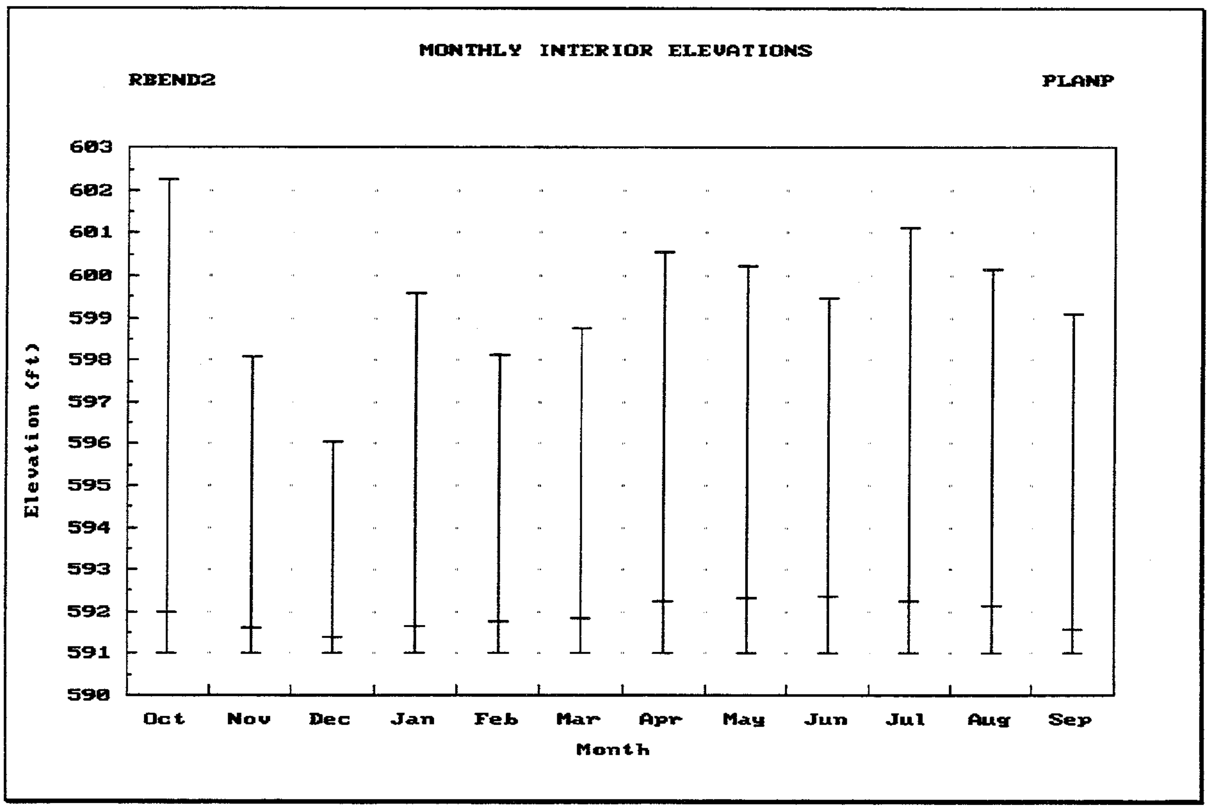


FIGURE 11.37 Plot of Monthly Interior Elevations

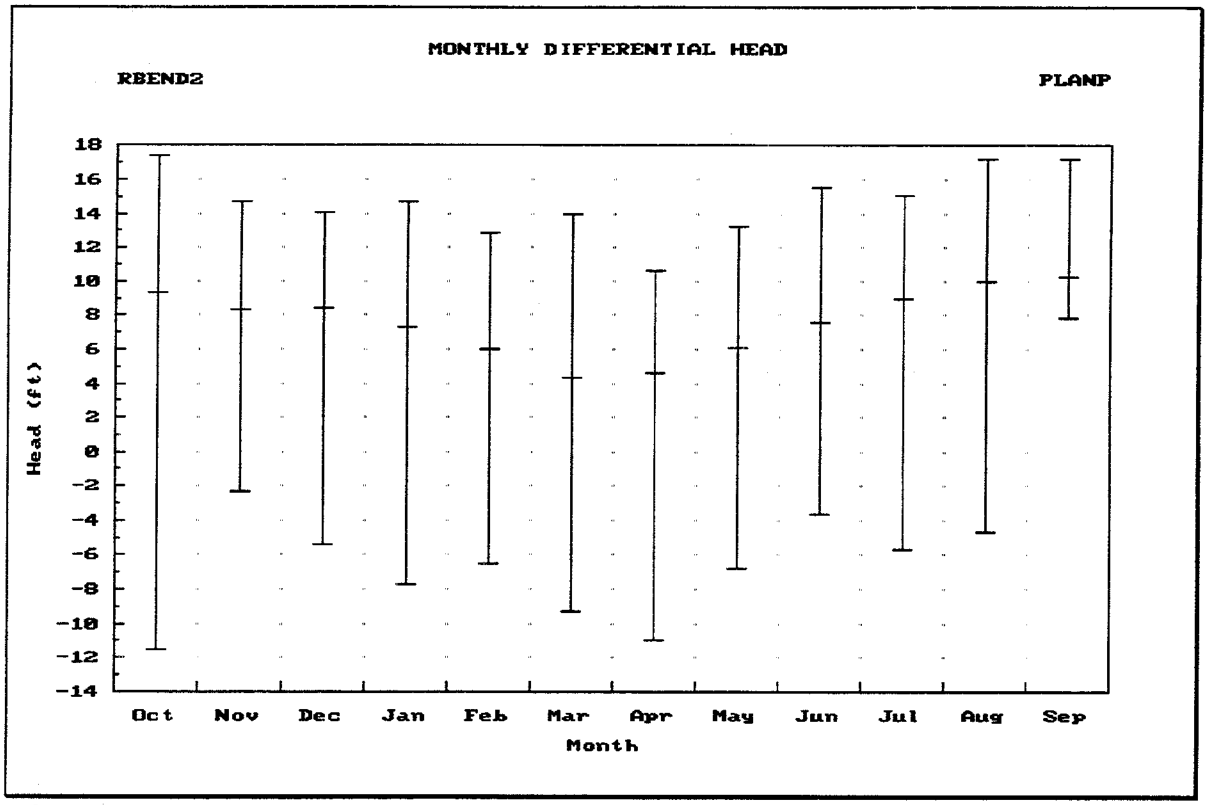


FIGURE 11.38 Plot of Monthly Differential Head

Figure 11.39 illustrates the **Pump Operation** monthly summary, which includes the following data values for the specified plan:

- **Total Volume Pumped**: The total volume discharged by all pumping units for each calendar month during the analysis. This is the sum of the individual volumes pumped during each time period of each month by each pump. For example, the total for January would include every unit of volume pumped during every January during the entire analysis.
- **Average Volume Pumped**: The average volume of water discharged by all pumping units, for each calendar month during the analysis. This is the Total Volume Pumped (see description above) divided by the number of times this particular calendar month occurred during the analysis.
- **Total Operating Time**: The total number of hours during which at least one of the pumping units discharged for each calendar month during the analysis. HEC-IFH keeps a running total of operating time for each pump for each month.
- **Average Operating Time**: The average number of hours during which at least one pumping unit discharged for each calendar month during the analysis. HEC-IFH keeps a running total of time periods during which at least one pump operated. From this running total, the program computes the monthly average values.
- **Maximum Pump Head**: The maximum computed pump head for each calendar month during the analysis. **Pump head** is the exterior elevation minus the interior elevation, and equals zero (0) when the difference is negative. Pump head is defined only when at least one pumping unit is operating.

- **Average Pump Head**: The average computed pump head (see definition above) for each calendar month during the analysis.
- **Avg. Pump Energy**: The average number of megawatt-hours of energy required for all of the pumping units, for each calendar month during the analysis. HEC-IFH keeps a running total of energy use for each computation interval of the analysis, computed for each pumping unit by the following equation:

$$E = \frac{HQ}{Ce} \Delta t$$

In which:

E = Energy Consumption during each time interval (mW-hrs)

H = Total Pump Head at end of time interval (ft or m)

Q = Pump Flow Rate interpolated from Pump Head vs. Capacity relationship (cfs or m^3/s)

C = Constant used for unit conversions

e = Pump Efficiency interpolated from Pump Head vs. Efficiency relationship

Δt = computation interval (hr)

CSA 01.01.00 SUMM15
Study ID RBEND2 **Hydrologic Analysis Summaries** Begin 01OCT1950/0100
Plan ID PLANP End 30SEP1960/2400

M. Monthly Summaries - Pump Operation

Month	Volume (ac-ft) Total	Volume (ac-ft) Average	Operating Time (hrs) Total	Operating Time (hrs) Average	Pump Head (ft) Maximum	Pump Head (ft) Average	Avg. Pump Energy (mW-hrs)
Oct	3516.2	351.6	215.	22.	11.53	2.17	1.94
Nov	0.0	0.0	0.	0.	0.00	0.00	0.00
Dec	0.0	0.0	0.	0.	0.00	0.00	0.00
Jan	0.0	0.0	0.	0.	0.00	0.00	0.00
Feb	0.0	0.0	0.	0.	0.00	0.00	0.00
Mar	0.0	0.0	0.	0.	0.00	0.00	0.00
Apr	1603.7	160.4	99.	10.	10.97	4.99	1.67
May	1559.9	156.0	95.	10.	3.75	0.97	0.59
				0.	0.00	0.00	0.00
				10.	5.70	2.33	0.95
				3.	0.00	0.00	0.11
				0.	0.00	0.00	0.00

Select Option:

A. Plot Monthly Volume Pumped
B. Plot Monthly Operating Time
C. Plot Month-Average Pump Energy

6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 11.39 Monthly Summary of Pump Operation Data

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.39 illustrates. Three different plots are available:

1. **Monthly Volume Pumped**, as illustrated in Figure 11.40.
2. **Monthly Operating Time**, as illustrated in Figure 11.41.
3. **Month-Average Pump Energy**, as illustrated in Figure 11.42.

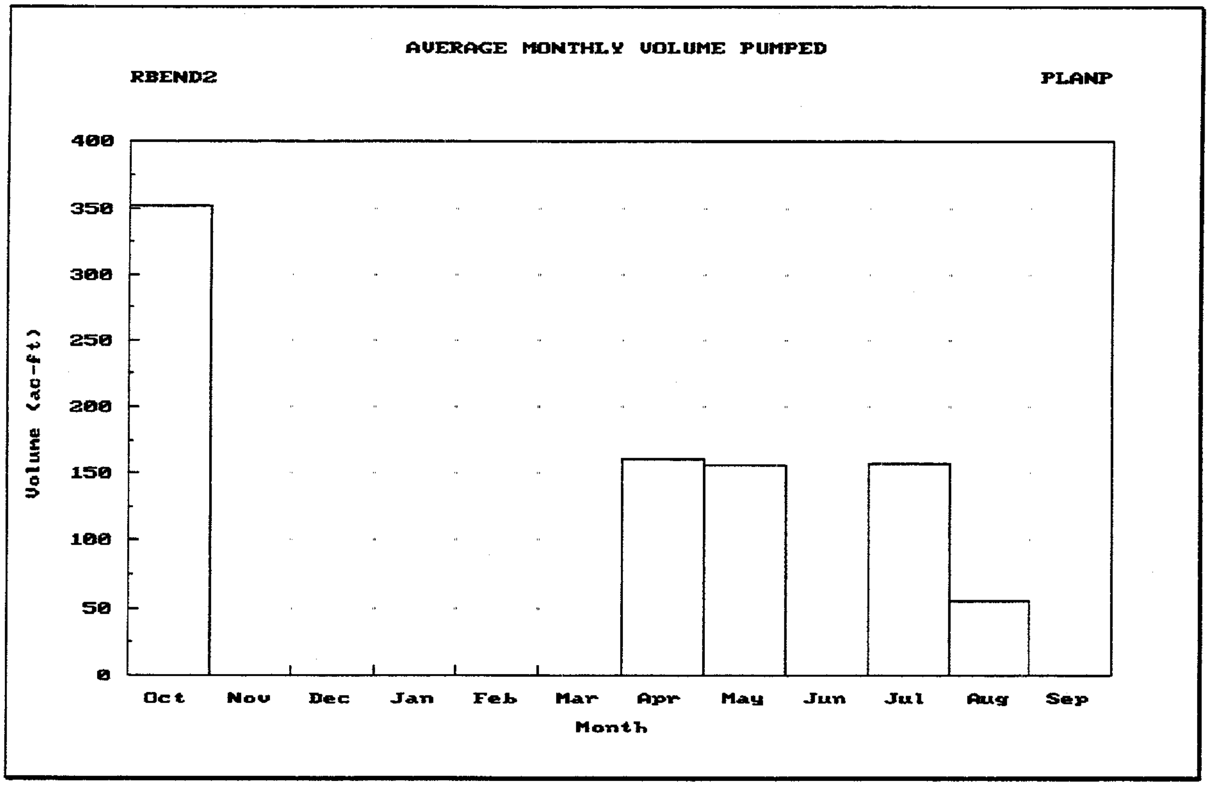


FIGURE 11.40 Plot of Average Monthly Volume Pumped

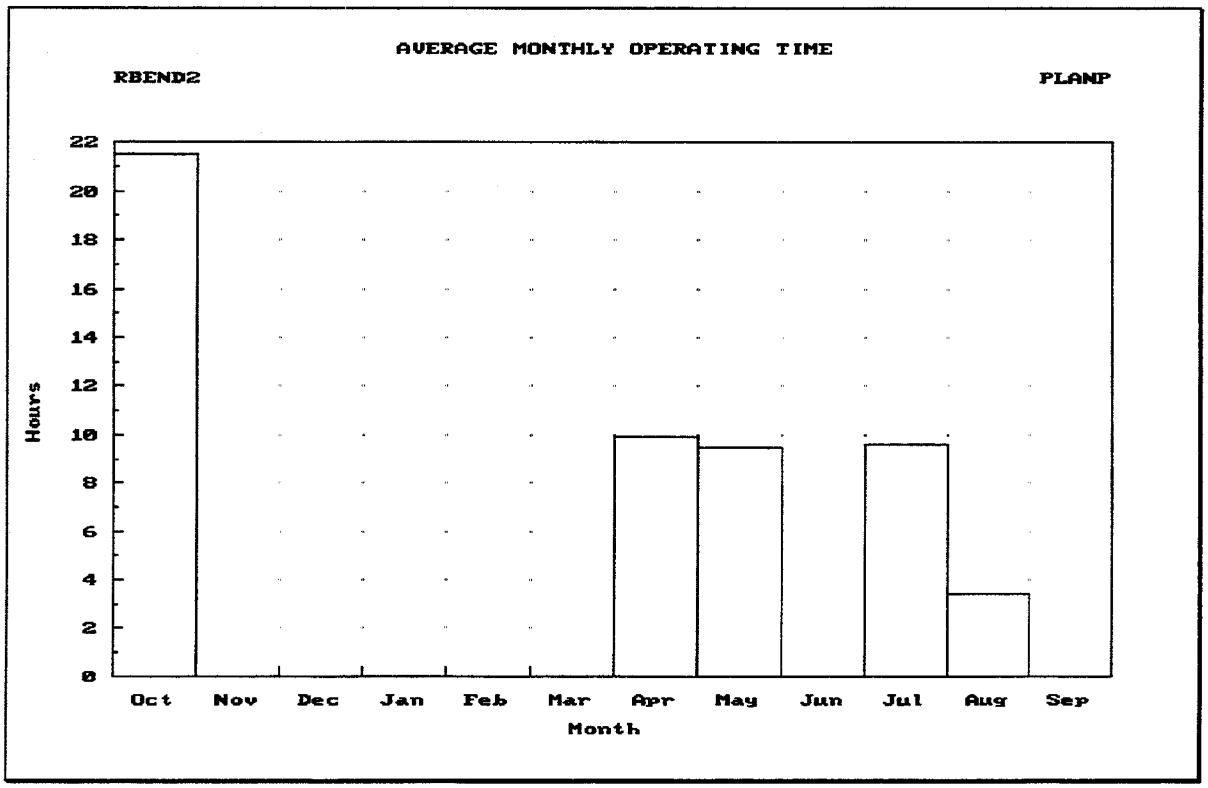


FIGURE 11.41 Plot of Average Monthly Operating Time

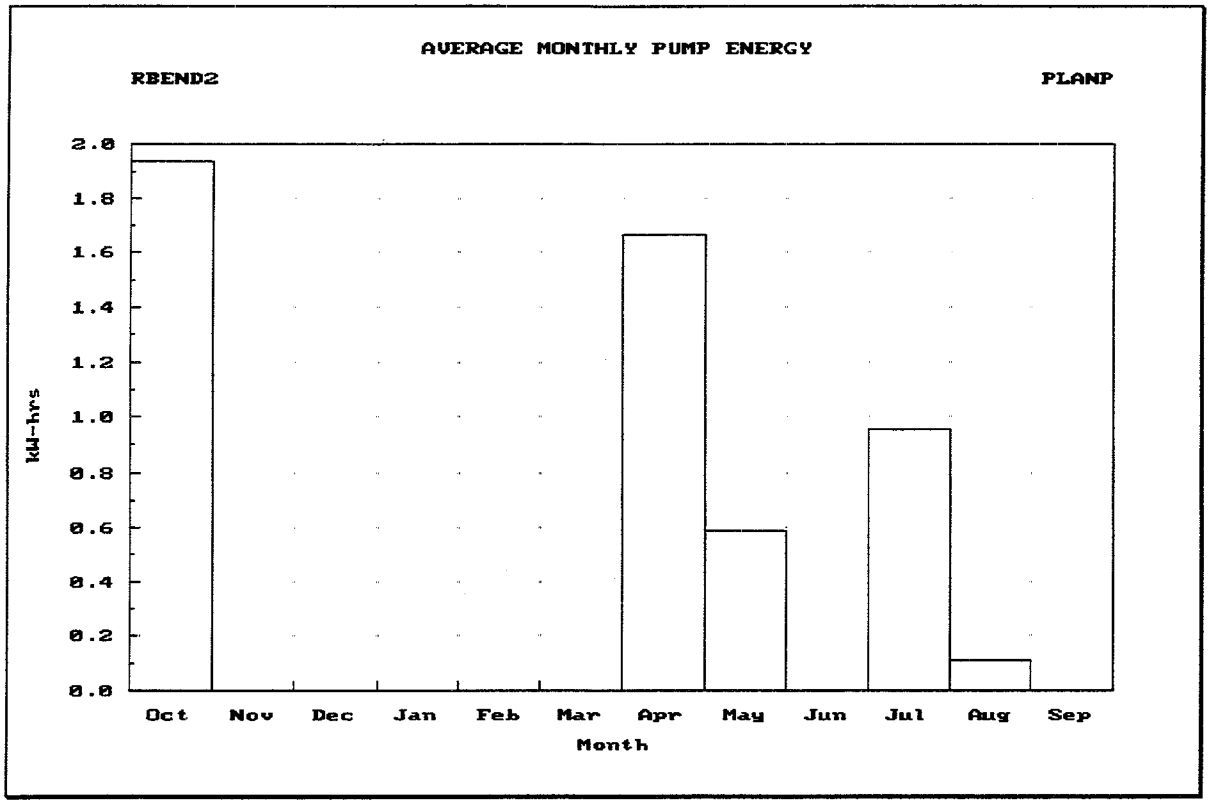


FIGURE 11.42 Plot of Average Monthly Pump Energy

11.7. CONTINUOUS SIMULATION WATER YEAR ANNUAL SUMMARIES

There are three ***Water Year Annual Summaries*** which summarize and total the results of the analysis for each yearly period during the analysis. A Water Year is a period which extends from 1 October through 30 September. For example, water year 1950 began on 1 October 1949.

1. **Rainfall-Runoff Data**: The average precipitation depth, losses, and peak runoff rate for each of the three sub-basins for each water year.
2. **Interior/Exterior/Pump Data**: The minimum and maximum interior and exterior water surface elevations, and the maximum positive differential head, negative differential head, and pump head for each water year. The total pumping time and pump energy are also listed.
3. **Maximum Area Flooded**: The maximum interior elevation and the corresponding area flooded for each water year.

Figure 11.43 illustrates the **Rainfall-Runoff Data** water year annual summary, which includes the following data values for the specified plan:

- **Year**: Each water year (October through September) or portion of a water year included in the analysis.
- **Total Precip**: The total precipitation for each water year of the analysis, for each of the sub-basins used in the analysis.

- **Total Losses**: The total precipitation losses for each water year of the analysis, for each of the sub-basins used in the analysis. These values are computed using the loss rate method specified for each sub-basin.
- **Peak Runoff**: The maximum computed flow rate of the runoff hydrograph for each of the sub-basins used during the analysis, for each complete water year of the analysis.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the analysis. Pressing the F5 Report key causes the summary to be printed.

CSA 01.01.00 SUMM16
Study ID RBEND2 Hydrologic Analysis Summaries Begin 01OCT1950/0100
Plan ID PLANP End 30SEP1960/2400

N. Water Year Annual Summaries - Rainfall-Runoff Data

	Lower Sub-Basin			Upper Sub-Basin			Exterior Basin		
Year	* Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)	* Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)	* Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)
1951	39.82	18.51	1439	40.01	19.24	1128	40.01	0.00	604
1952	35.50	19.47	645	31.72	18.79	711	31.72	0.00	601
1953	30.54	17.56	489	26.02	14.51	1086	26.02	0.00	600
1954	34.23	16.99	715	37.46	18.33	1475	37.46	0.00	601
1955	37.43	16.61	1430	40.17	16.45	2057	40.17	0.00	614
1956	32.67	16.55	997	27.59	15.53	1442	27.59	0.00	605
						2543	37.92	0.00	607
						1366	31.09	0.00	602
						1634	35.27	0.00	611
						1205	31.69	0.00	602

Select Option:

A. Plot Lower Sub-Basin Rainfall-Runoff
B. Plot Upper Sub-Basin Rainfall-Runoff
C. Plot Exterior Sub-Basin Rainfall-Runoff

ile, not just for plan period.

7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 11.43 Water Year Annual Summary of Rainfall-Runoff Data

The F9 Plot key causes the HEC-IFH program to display a menu of available rainfall plots, as Figure 11.43 illustrates. Three different plots are available: one for each of the sub-basins. Figure 11.44 illustrates one of these plots. On a computer monitor with color display capabilities, each line is each displayed using a different color.

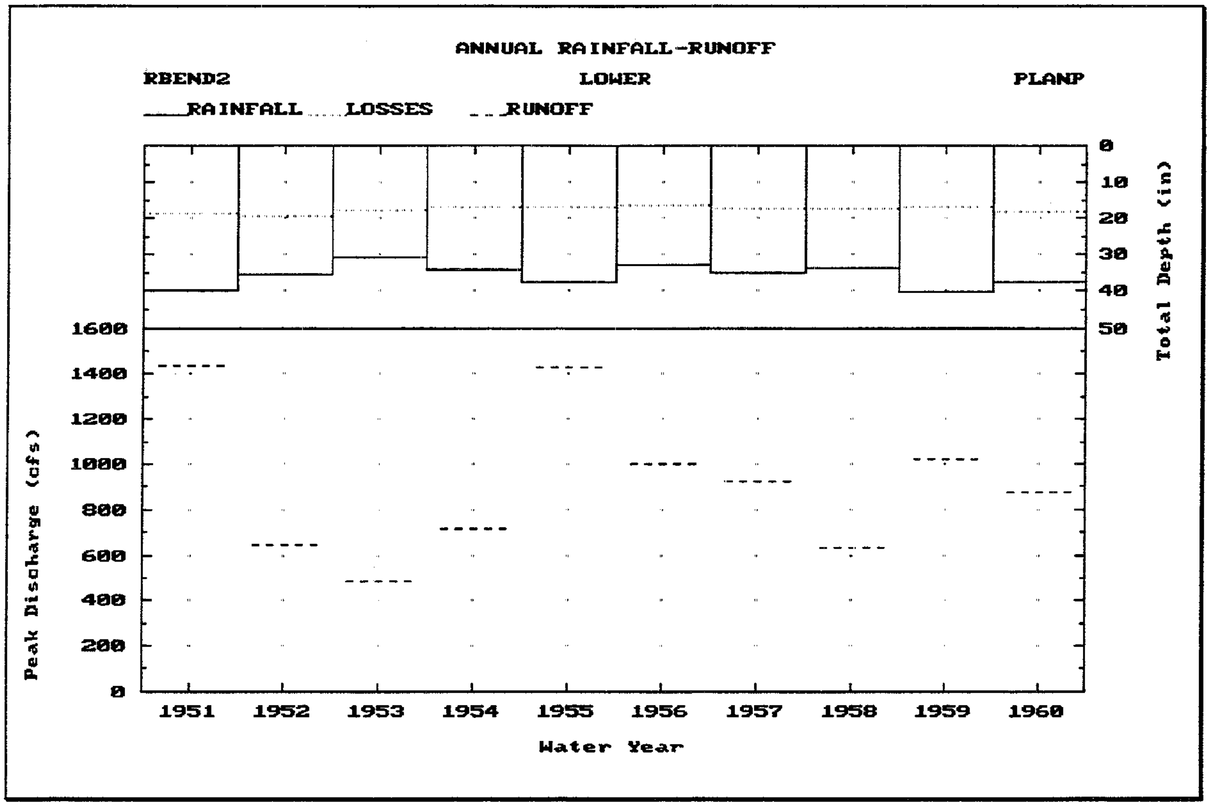


FIGURE 11.44 Plot of Annual Total Rainfall-Runoff

Figure 11.45 illustrates the **Interior/Exterior/Pump Data** water year annual summary, which includes the following data values for the specified plan:

- **Year**: Each water year (October through September) or portion of a water year included in the analysis.
- **Minimum Interior Elev**: The minimum computed water surface elevation in the interior ponding area for each water year during the analysis.
- **Maximum Interior Elev**: The maximum computed water surface elevation in the interior ponding area for each water year during the analysis.
- **Minimum Exterior Elev**: The minimum water surface elevation in the exterior channel for each water year during the analysis.
- **Maximum Exterior Elev**: The maximum water surface elevation in the exterior channel for each water year during the analysis.
- **Maximum Positive Head**: The maximum computed positive differential head, between the water surface elevations in the interior ponding area and the exterior channel, for each water year during the analysis. The differential head is positive when the interior elevation is higher.
- **Maximum Negative Head**: The maximum computed negative differential head, between the water surface elevations in the interior ponding area and the exterior channel, for each complete water year during the analysis. The differential head is negative when the exterior elevation is higher.

- **Maximum Pump Head**: The maximum computed pump head, between the water surface elevations in the interior ponding area and the exterior channel, for each complete water year during the analysis. Pump head is measured only when at least one pumping unit is operating.
- **Pumping Time**: The number of hours during which at least one of the pumping units discharged during each complete water year of the analysis.
- **Pump Energy**: The number of megawatt-hours of energy required for all of the pumping units, during each complete water year of the analysis.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the analysis. Pressing the F5 Report key causes the summary to be printed.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM17
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400
O. Water Year Annual Summaries - Interior/Exterior/Pump Data

Year	Interior Elev(ft) Minimum	Interior Elev(ft) Maximum	Exterior Elev(ft) Minimum	Exterior Elev(ft) Maximum	Maximum Head (ft) Pos.	Maximum Head (ft) Neg.	Maximum Head (ft) Pump	Pumping Time (hr)	Pump Energy (mW-hrs)
1951	591.00	600.25	581.08	603.69	17.18	-4.49	3.75	62	4.24
1952	591.00	598.07	581.09	600.83	14.61	-7.73	0.00	0	0.00
1953	591.00	597.98	581.02	600.38	15.54	-4.10	0.00	0	0.00
1954	591.00	599.40	580.98	600.91	14.56	-4.13	0.00	0	0.00
1955	591.00	602.28	580.95	613.74	17.34	-11.53	11.53	212	19.30
1956	591.00	600.57	580.95	604.59	15.99	-6.24	3.31	110	7.11
						-5.70	5.70	96	9.53
						-6.53	0.00	0	0.00
						-10.97	10.97	59	12.45
						-9.30	0.00	0	0.00

Select Option:

A. Plot Annual Max/Min Interior Elevations
B. Plot Annual Max/Min Exterior Elevations
C. Plot Annual Maximum Heads
D. Plot Annual Pumping Time
E. Plot Annual Pump Energy

7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 11.45 Water Year Annual Summary of Interior/Exterior/Pump Data

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.45 illustrates. Five different plots are available:

1. **Annual Max/Min Interior Elevations.**
2. **Annual Max/Min Exterior Elevations.**
3. **Annual Maximum Heads.**
4. **Annual Pumping Time**, as illustrated in Figure 11.46.
5. **Annual Pump Energy**, as illustrated in Figure 11.47.

On a computer monitor with color display capabilities, each line is each displayed using a different color.

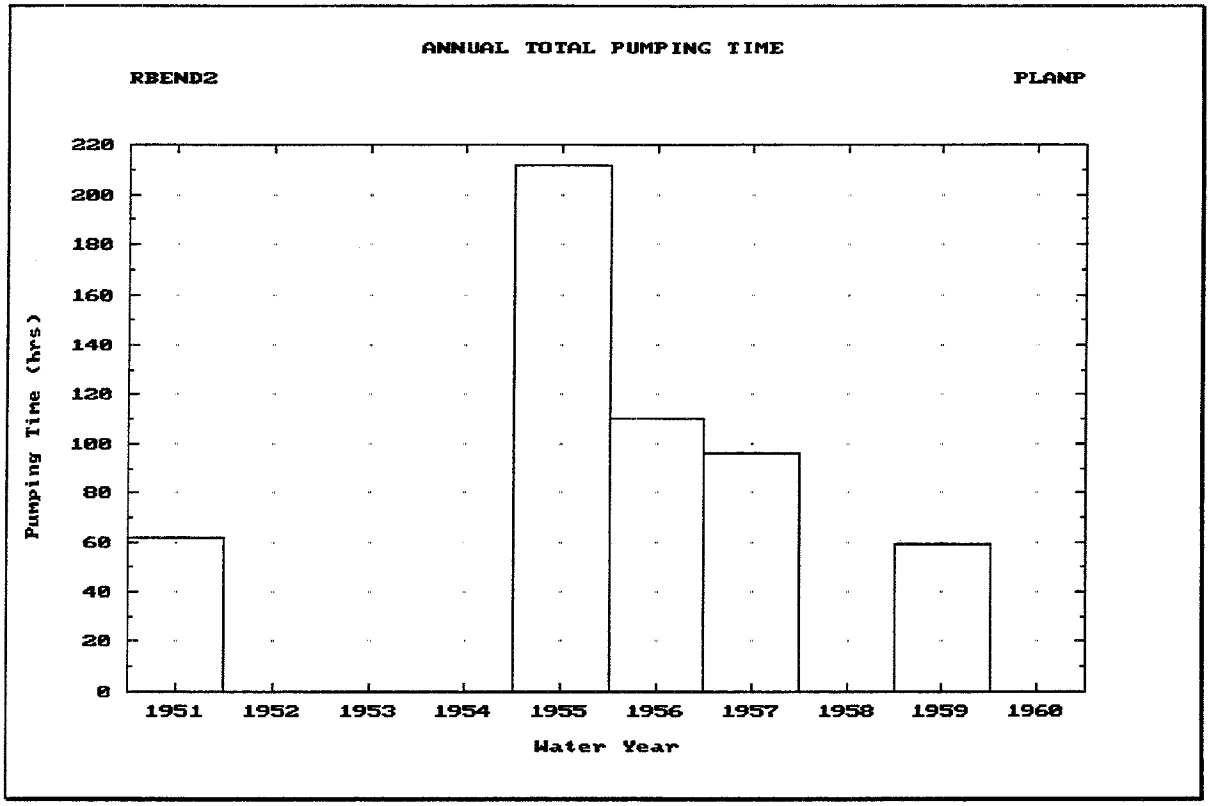


FIGURE 11.46 Plot of Annual Total Pumping Time

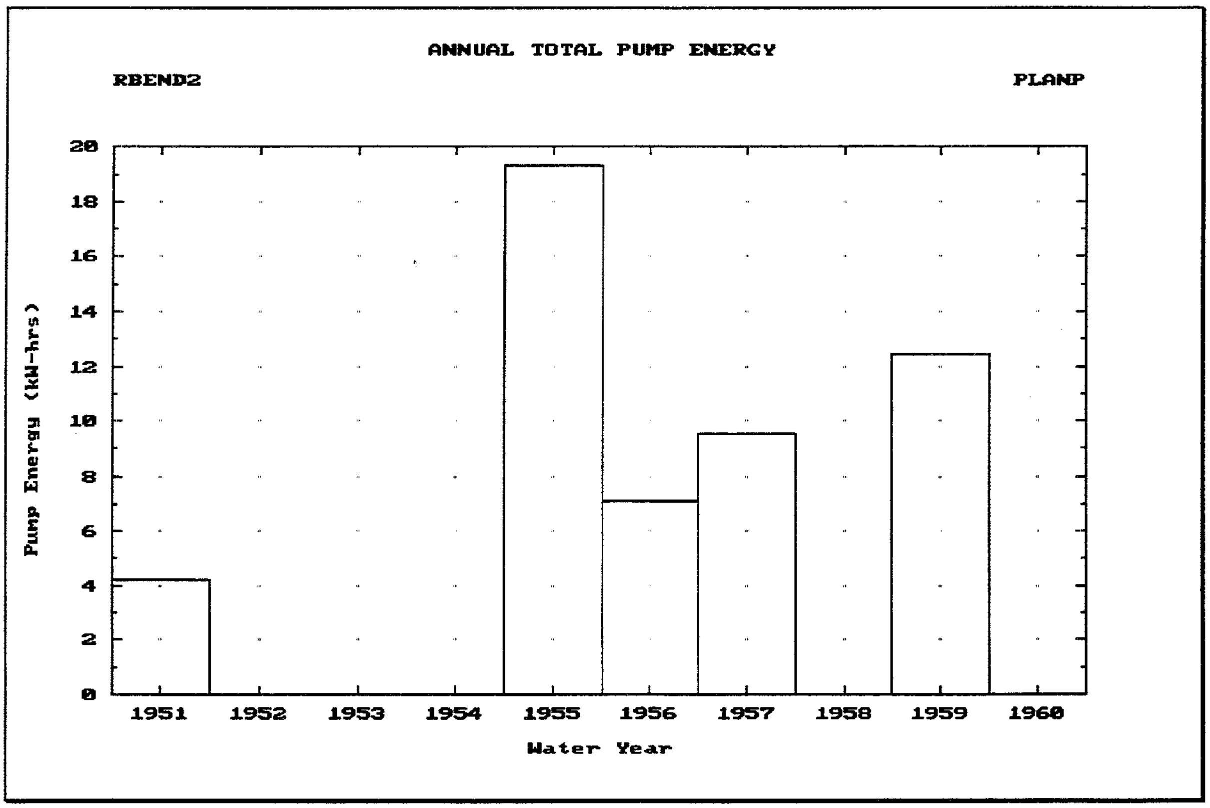


FIGURE 11.47 Plot of Annual Total Pump Energy

Figure 11.48 illustrates the **Maximum Area Flooded** water year annual summary, which includes the following data values for the specified plan:

- **Year**: Each water year (October through September) or portion of a water year included in the analysis.
- **Interior Elevation**: The computed maximum water surface elevation in the interior ponding area during each water year of the analysis.
- **Interior Area Flooded**: The computed maximum surface area of the interior ponding area during each water year of the analysis.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the analysis. Pressing the F5 Report key causes the summary to be printed.

The F9 Plot key causes the HEC-IFH program to display a plot of Annual Maximum Area Flooded, as shown in Figure 11.49.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM18
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

P. Water Year Annual Summaries - Maximum Area Flooded

Year	Interior Elevation (ft)	Interior Area Flooded (ac)
1951	600.25	568.0
1952	598.07	283.4
1953	597.98	273.4
1954	599.40	450.3
1955	602.28	1114.5
1956	600.57	624.2
1957	601.12	739.8
1958	599.46	457.1
1959	600.06	535.2
1960	599.59	474.3

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 11.48 Water Year Annual Summary of Maximum Interior Area Flooded

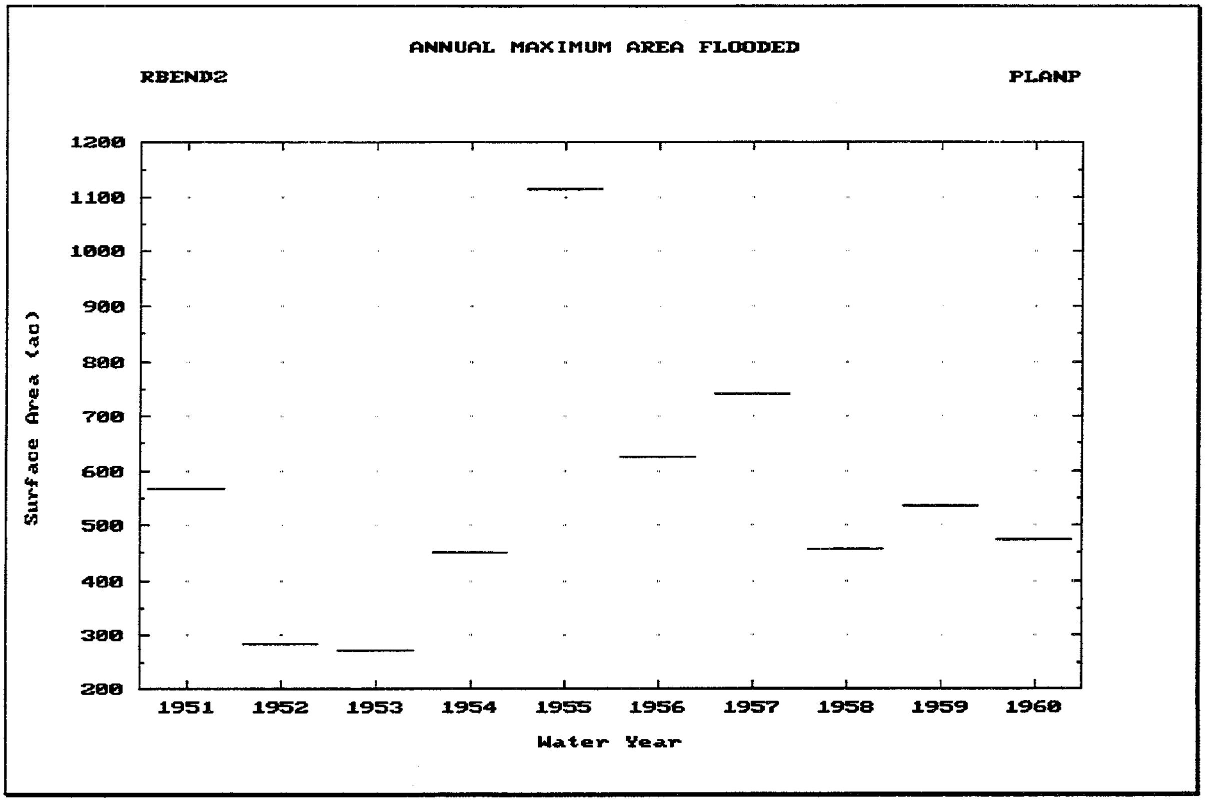


FIGURE 11.49 Plot of Annual Maximum Interior Area Flooded

11.8. CONTINUOUS SIMULATION ANALYSIS RECORD SUMMARIES

There are five ***Analysis Record Summaries*** which summarize and total the results of the analysis for the entire duration of the analysis:

1. **Maximum Values**: The maximum interior elevation, interior area flooded, interior storage volume, exterior elevation, positive differential head, negative differential head, and pump head values recorded during the entire analysis, along with the corresponding time of occurrence for each value.

2. **Inflows and Outflows**: The maximum rate and the total volume of inflows routed from the upper sub-basin, direct runoff into the lower sub-basin, the lower sub-basin auxiliary inflow, seepage inflow, and total inflow during the entire analysis, along with the corresponding time of occurrence for each maximum value. The maximum rate and the total volume of outflow from the pump outlets, the gravity outlets, diversion, overflow, and total outflow, along with the corresponding time for each maximum value, are also listed.

3. **Exceedance Duration Table**: An analysis of the interior and exterior water surface elevations and pump heads, listing a range of values with the number of periods and the percent of total periods in which each elevation is exceeded.

4. **Plotting Position Table**: A list of the interior stage values above the specified threshold elevation (for partial series) or the maximum interior stage values for each water year (for annual series), along with the corresponding date, time, water year, peak storage value, peak interior stage value, and median plotting position.

5. **Stage-Frequency Table**: A summary of the computed interior storage and stage values for eight storm frequencies, along with the method of computation. The user

may also enter adjusted stages in the table. These adjusted values are then stored for future displays of the plot and for plan comparisons.

Figure 11.50 illustrates the **Maximum Values** summary, which includes the following data values for the specified plan:

- **Interior Elevation**: The maximum computed water surface elevation in the interior ponding area during the analysis.
- **Interior Area Flooded**: The maximum computed surface area of the interior ponding area during the analysis.
- **Interior Storage**: The maximum computed storage volume of the interior ponding area during the analysis.
- **Exterior Elevation**: The maximum water surface elevation in the exterior channel during the analysis.
- **Maximum Head**: The maximum computed differential head between the water surface elevations in the interior ponding area and the exterior channel, during the analysis. The differential head is positive when the interior elevation is higher.
- **Minimum Head**: The maximum computed differential head between the water surface elevations in the exterior channel and the interior ponding area, during the analysis. The differential head is negative when the exterior elevation is higher.
- **Pump Head**: The maximum computed differential head between the water surface elevations in the exterior channel and the interior ponding area, during a computation interval in which at least one of the pumping units operated.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM19
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

Q. Analysis Record Summaries - Maximum Values

	Maximum Value	Date/Time DaMonYear/HrMn
Interior Elevation (ft)	602.28	11OCT1954/1000
Interior Area Flooded (ac)	1114.5	11OCT1954/1000
Interior Storage (ac-ft)	3141.0	11OCT1954/1000
Exterior Elevation (ft)	613.74	11OCT1954/2400
Maximum Head (ft)	17.34	04OCT1954/0200
Minimum Head (ft)	-11.53	11OCT1954/2400
Pump Head (ft)	11.53	11OCT1954/2400

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 11.50 Analysis Record Summary of Maximum Values

For each of the maximum values listed in this table, the corresponding **Date/Time** value is the date and time at the end of each time interval in which the maximum conditions occurred during the storm event.

After the report is displayed on the screen, the [F2] PrtScr key may be used to generate a printed copy of the report.

Figure 11.51 illustrates the **Inflows and Outflows** summary, which includes the following data values for the specified plan:

- **Inflow Routed from Upper**: The maximum computed flow rate and total volume of the hydrograph routed from the upper sub-basin during the analysis. See Chapter 4.
- **Inflow Runoff from Lower**: The maximum computed flow rate and total volume of the runoff hydrograph from the lower sub-basin during the analysis. See Chapter 4.
- **Lower Auxiliary Inflow**: The maximum computed flow rate and total volume of the auxiliary inflow hydrograph at the interior ponding area during the analysis. See Chapter 9.
- **Seepage Inflow**: The maximum computed rate and total volume of seepage inflow into the interior ponding area during the analysis. Seepage is described in Chapter 9.
- **Total Inflow**: The maximum computed rate and total volume of total inflow to the interior ponding area during the analysis. The total inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, lower sub-basin auxiliary inflows, and seepage inflow, if applicable.
- **Pump Outflow**: The maximum computed rate of discharge and the total discharge volume from all pumping units during the analysis. See Chapter 7.
- **Gravity Outlet Outflow**: The maximum computed rate of outflow and the total outflow volume from all gravity outlets during the analysis. See Chapter 6.
- **Diversion Outflow**: The maximum computed rate of discharge and the total discharge volume from diversion during the analysis. Diversions apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area (which is in the lower interior sub-basin). See Chapter 9 for further details.
- **Overflow Outflow**: The maximum computed rate of outflow and the total outflow volume as a result of overflows from the interior ponding area during the analysis.
- **Total Outflow**: The maximum computed rate of outflow and the total outflow volume from the interior ponding area during the analysis. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

For each of the maximum values listed in this table, the corresponding **Date/Time** value is the date and time at the end of each time interval in which the maximum conditions occurred during the storm event.

After the report is displayed on the screen, the [F2] PrtScr key may be used to generate a printed copy of the report.

```
CSA 01.01.00                                                        SUMM20
Study ID   RBENDZ      Hydrologic Analysis Summaries      Begin 01OCT1950/0100
Plan ID    PLANP                                          End   30SEP1960/2400
              R. Analysis Record Summaries - Inflows and Outflows
```

Flows		Max. Value (cfs)	Date/Time DaMonYear/HrMn	Total Volume (ac-ft)
Inflow	Routed from Upper	2459.7	13JUL1957/0500	65895.6
	Runoff from Lower	1439.1	06AUG1951/0800	48276.5
	Lower Auxiliary	0.0		0.0
	Seepage	0.0		0.0
	Total	3109.1	13JUL1957/0400	114171.1
Outflow	Pump	199.3	11MAY1951/0400	8809.1
	Gravity Outlet	209.3	10OCT1954/1300	105570.8
	*Diversion	0.0		0.0
	Overflow	0.0		0.0
	*Total	408.6	10OCT1954/1300	114379.8

```
             * Diversion is not part of total POND outflow.
1Help  2PrtScr 3     4     5     6DOS    7     8     9     10Exit
                        Press <F10> to Return
```

FIGURE 11.51 Analysis Record Summary of Inflows and Outflows

Figure 11.52 illustrates the **Exceedance Duration** analysis record summary, which includes the following data values for the specified plan:

- **% Time Exceeded**: The percentage of the total duration of the analysis in which the corresponding values were exceeded.
- **Exterior Elevation**: The water surface elevation in the exterior channel which was exceeded during the corresponding percentage of the analysis.
- **Interior Elevation**: The computed water surface elevation in the interior ponding area which was exceeded during the corresponding percentage of the analysis.
- **Pump Head**: The computed differential head between the water surface elevations in the exterior channel and the interior ponding area which was exceeded during the corresponding percentage of the analysis. Pump head is measured only when at least one pumping unit is operating.

After the report is displayed on the screen, the [F2] PrtScr key may be used to generate a printed copy of the report.

The [F9] Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 11.52 illustrates. Two different plots are available:

1. **Elevation Exceedance Duration Data**, as illustrated in Figure 11.53. On a computer monitor with color display capabilities, each line is each displayed using a different color.
2. **Pump Head Exceedance Duration Data**, as illustrated in Figure 11.54.

CSA 01.01.00 | Hydrologic Analysis Summaries | SUMM21
Study ID RBEND2 | Begin 01OCT1950/0100
Plan ID PLANP | End 30SEP1960/2400

S. Analysis Record Summaries - Exceedance Duration Table

% Time Exceeded	Exterior Elev. (ft)	Interior Elev. (ft)	Pump Head (ft)
100%	580.95	591.00	0.00
99%	581.00	591.06	0.07
90%	581.29	591.10	0.12
80%	581.53	591.12	0.14
70%	581.73	591.14	0.16
60%	581.93	591.15	0.19
50%	582.27	591.17	0.62

% Time Exceeded	Exterior Elev. (ft)	Interior Elev. (ft)	Pump Head (ft)
30%	584.76	591.35	3.12
20%	586.85	592.34	5.34
10%	590.58	594.98	7.54
4%	595.92	597.14	9.76
2%	598.87	598.13	10.49
1%	599.93	599.01	10.86
0.5%	601.18	599.60	11.12
2%	604.88	600.45	11.37

Select Option:

A. Plot Elevation Exceedance Duration Data
B. Plot Pump Head Exceedance Duration Data

7 8 9 10Exit

Press <F10> to Return

FIGURE 11.52 Exceedance Duration Table

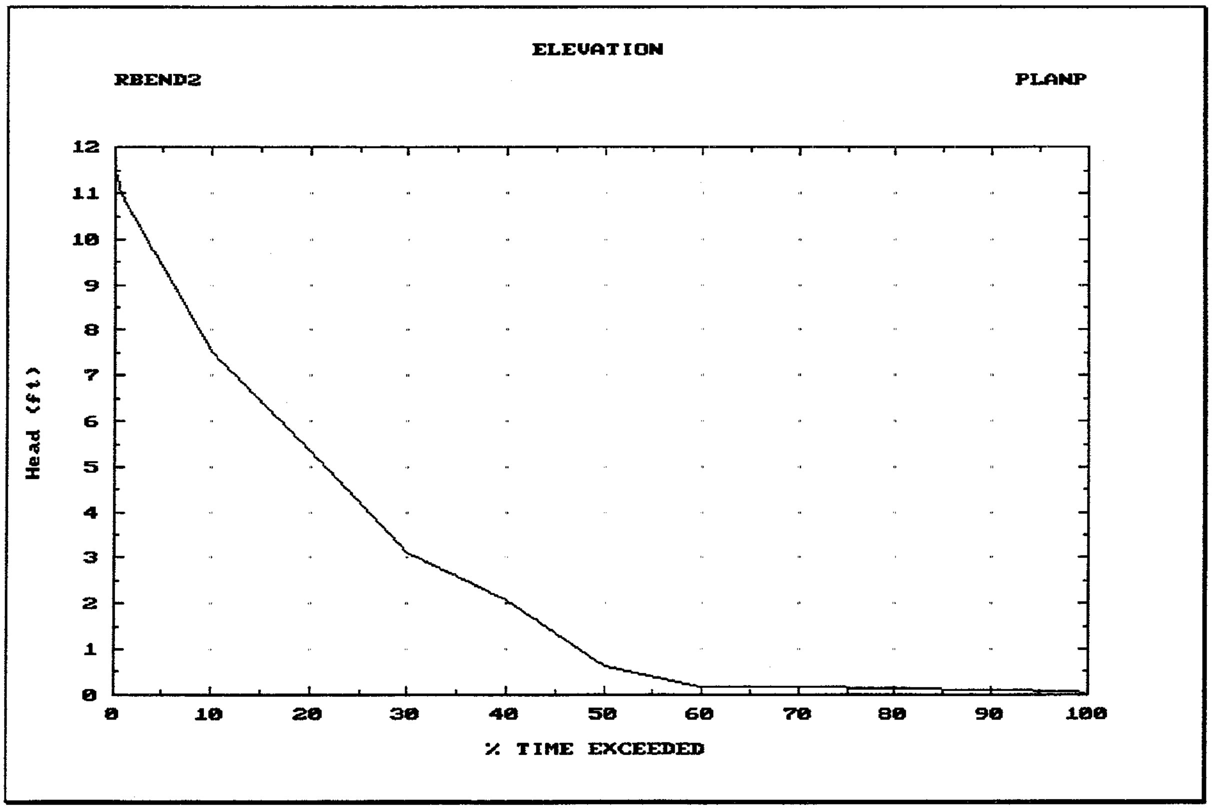


FIGURE 11.53 Plot of Elevation Exceedance-Duration

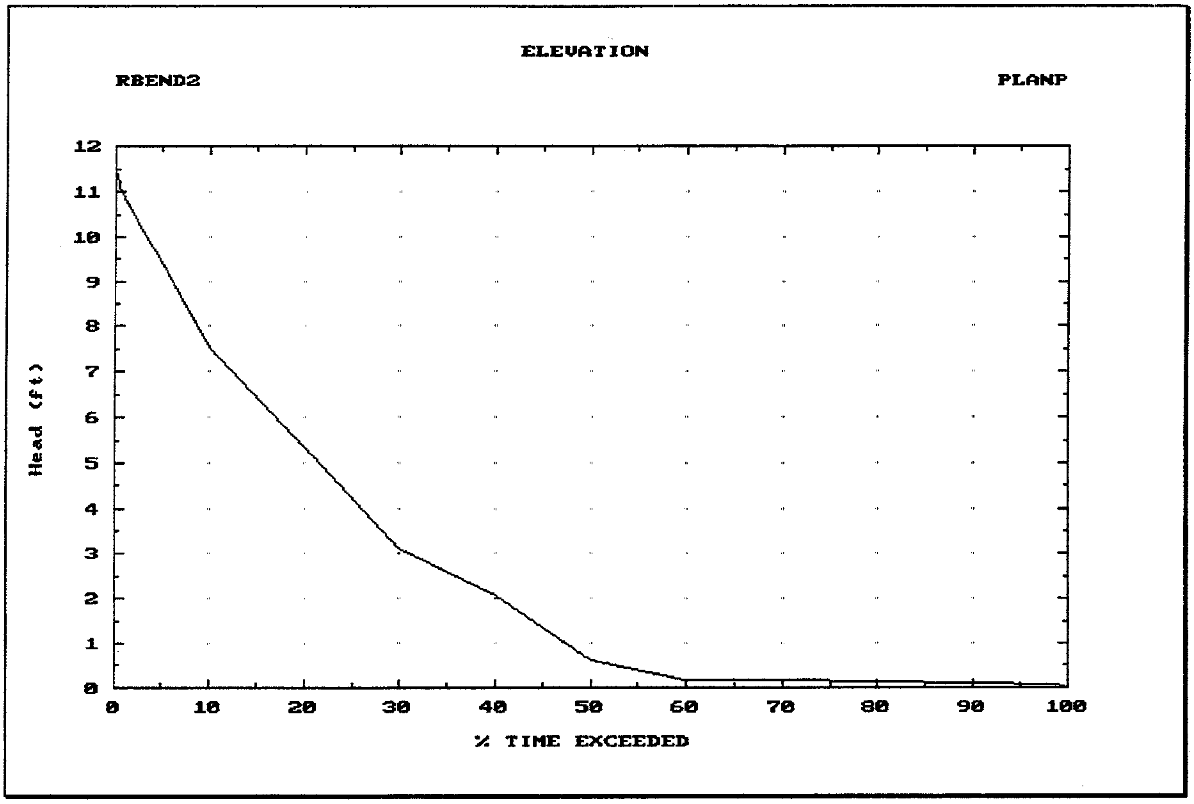


FIGURE 11.54 Plot of Differential Head Exceedance Duration

Figure 11.55 illustrates the Partial Series **Plotting Position Table**. The Annual Series Plotting Position Table is very similar. These tables includes the following data values for the specified plan:

- **Type of Series**: ANNUAL or PARTIAL. As noted in Chapter 10, the Frequency Analysis portion of a Continuous Simulation may be based on Annual Series or Partial Duration Series Frequency Analysis.
- **Threshold Elevation** (Partial Series only): The minimum interior water surface elevation required for HEC-IFH to identify an independent event for a partial series frequency analysis.
- **Rank**: The numeric sequence of the event, beginning with the event producing the largest storage volume.
- **Date/Time**: the date and time at the end of each time interval in which the event occurred during the analysis.
- **Peak Storage**: The maximum computed storage volume of the interior ponding area during the ranked event.
- **Peak Interior Stage**: The maximum computed water surface elevation in the interior ponding area during the ranked event.
- **Median Plotting Position**: The frequency of the ranked event, as computed using the median plotting positions equations.

For annual series, the plotting position, P_1, of the largest event is obtained by use of the following equation [USACE, 15 November 1988, Section 2-4c, Equation 2-2a]:

$$P_1 = 100\left[1-(0.5)^{1/N}\right] \tag{11.1}$$

In which:

N = the number of years of record

The plotting position for the smallest event (P_N) is the complement (1-P_1) of this value, and all the other plotting positions are interpolated linearly between these two.

The median plotting positions can be approximated by the following equation, which is used for partial series [USACE, 15 November 1988, Section 2-4c, Equation 2-2b]:

$$P_m = 100\frac{m-0.3}{N+0.4} \tag{11.2}$$

In which:

m = the order number of the event

CSA 01.01.00 — Hydrologic Analysis Summaries — SUMM22
Study ID RBEND2 — Begin 01OCT1950/0100
Plan ID PLANP — End 30SEP1960/2400

T. Analysis Record Summaries - Plotting Position Table

Partial Series   Threshold Elevation: 598.00

Rank	Date/Time DaMonYear/HrMn	Water Year	Peak Storage (ac-ft)	Peak Interior Stage (ft)	Median Plotting Position
1	11OCT1954/1000	1955	3141.0	601.86	6.731
2	13JUL1957/1400	1957	2072.2	601.07	16.346
3	29APR1956/1700	1956	1697.2	600.53	25.962
4	07OCT1955/0600	1956	1509.4	600.23	35.577
5	11MAY1951/1100	1951	1505.8	600.22	45.192
6	30AUG1955/1300	1955	1460.4	600.15	54.808
7	28APR1959/1600	1959	1402.5	600.05	64.423
8	24JUL1959/0100	1959	1293.9	599.83	74.038
9	29APR1957/0200	1957	1263.0	599.77	83.654
10	15JAN1960/1400	1960	1168.9	599.56	93.269

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 11.55 Analysis Record Plotting Position Table

After the report is displayed on the screen, the F2 PrtScr key may be used to generate a printed copy of the report.

While the summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 11.56. This probability-scaled plot shows the relationship between water surface elevations and frequency for each plan.

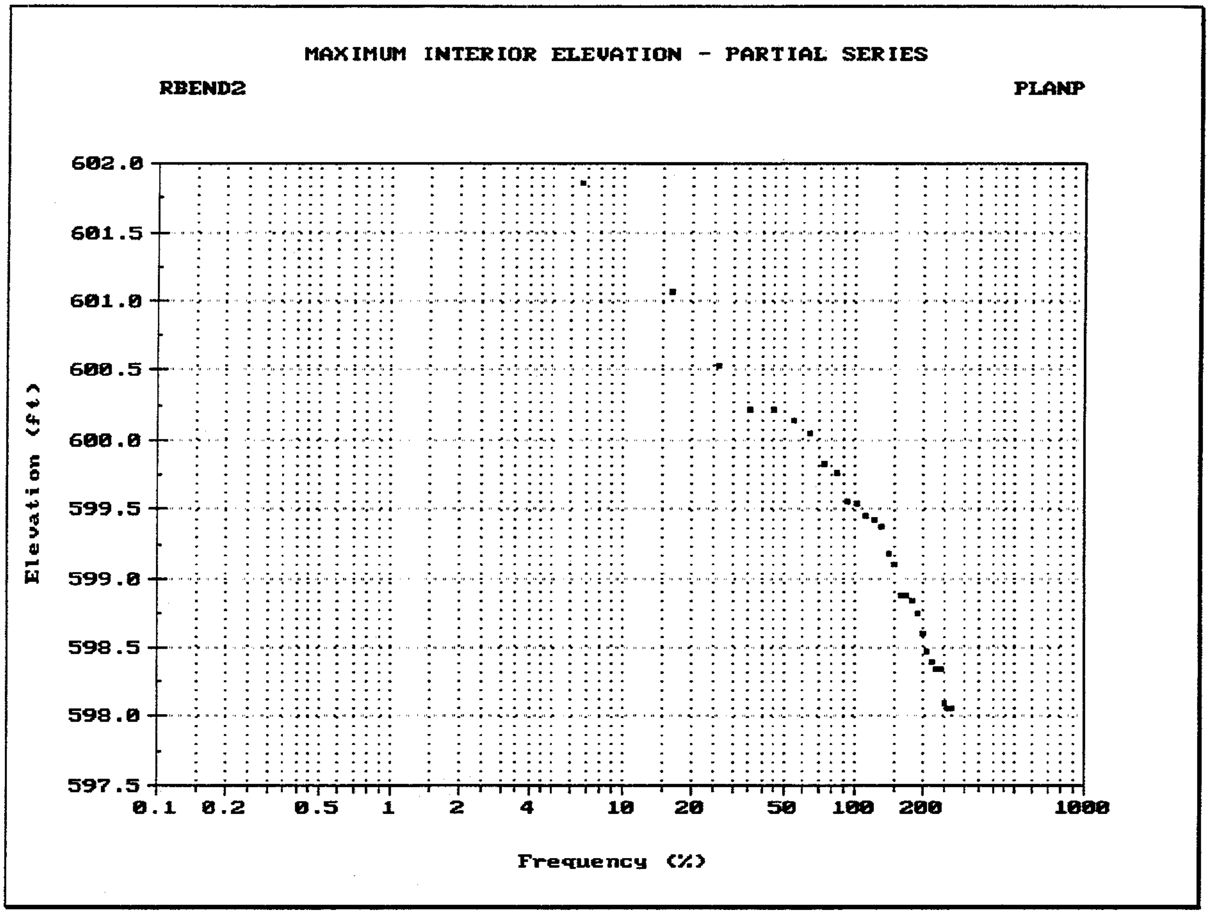


FIGURE 11.56 Plot of Partial Series Maximum Interior Elevations

Figure 11.57 illustrates the Partial Series **Stage-Frequency Table**. The Annual Series Stage-Frequency Table is very similar. The following data values are included for the specified plan:

- **Type of Series**: ANNUAL or PARTIAL. As noted in Chapter 10, the Frequency Analysis portion of a Continuous Simulation may be based on Annual Series or Partial Duration Series Frequency Analysis.
- **Threshold Elevation** (Partial Series only): The minimum interior water surface elevation required for HEC-IFH to identify an independent event for a partial series frequency analysis.
- **% Chance Exceeded**: The standard storm frequencies at which the corresponding interior storage and stage values have been computed by the frequency analysis.
- **Method of Computation**: INTERPOLATION or EXTRAPOLATION. Values corresponding to frequencies lying within the duration of the analysis are computed by interpolation. Values corresponding to other frequencies are computed by extrapolation. For example, if the duration of the analysis is 10 years, then the 200%, 150%, 100%, 90%, 50%, 20%, and 10% storage and stage values would be interpolated from actual values computed during the analysis. Values for larger events would be extrapolated.
- **Computed Storage**: The computed storage volume of the interior ponding area corresponding to each of the standard storm frequencies.

- **Computed Interior Stage**: The computed interior stage corresponding to each of the standard storm frequencies.
- **Adjusted Interior Stage**: Initially equal to the Computed Interior Stage, these values may be changed by the user to allow the frequency curve to be "smoothed".

After the report is displayed on the screen, the F2 PrtScr key may be used to generate a printed copy of the report.

CSA 01.01.00 — Hydrologic Analysis Summaries — SUMM24
Study ID RBEND2 — Begin 01OCT1950/0100
Plan ID PLANP — End 30SEP1960/2400

U. Analysis Record Summaries - Stage-Frequency Table

Partial Series Threshold Elevation: 598.00

% Chance Exceeded	Method of Computation	Computed Storage (ac-ft)	Computed Interior Stage (ft)	Adjusted Interior Stage (ft)
200%	Interpolation	770.1	598.59	598.59
150%	Interpolation	959.5	599.11	599.11
100%	Interpolation	1161.7	599.55	599.55
90%	Interpolation	1192.2	599.61	599.61
50%	Interpolation	1487.9	600.19	600.19
20%	Interpolation	1894.3	600.85	600.85
10%	Interpolation	2598.4	601.46	601.46
4%	Extrapolation	4046.3	602.53	602.53
2%	Extrapolation	5669.7	603.73	603.73
1%	Extrapolation	7944.4	605.00	605.00
0.5%	Extrapolation	11131.7	605.00	605.00
0.2%	Extrapolation	17387.0	605.00	605.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE 11.57 Analysis Record Stage-Frequency Table

While the summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 11.58. This probability-scaled plot shows the relationship between water surface elevations and frequency for each plan. The plot illustrates the original water surface elevations computed by the frequency analysis, as well as the adjusted water surface elevations entered by the user. On a computer monitor with color display capabilities, each line is displayed using a different color.

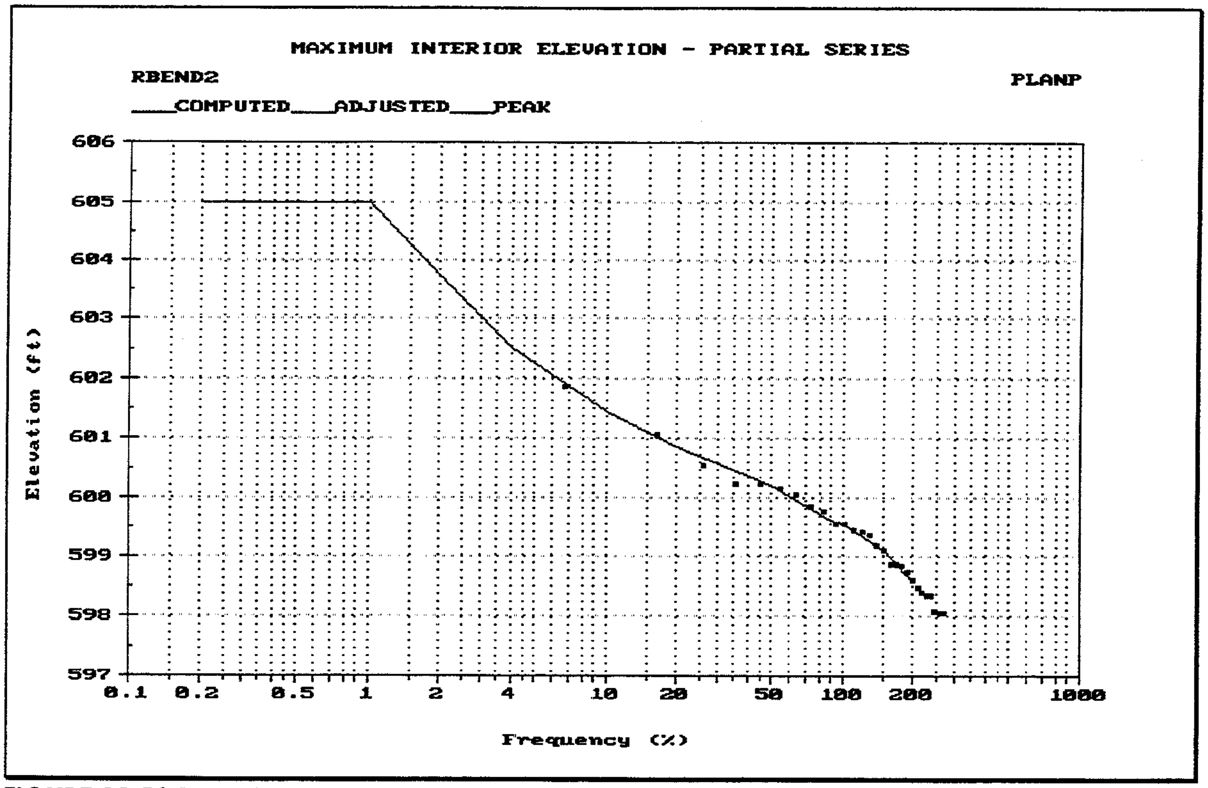


FIGURE 11.58 Plot of Maximum Interior Elevations

Figure 11.59 illustrates the **Pump Operation** analysis record summary, which includes the following data values for the specified plan:

- **Pump Unit ID**: The identifier for each of the pumping units available for the analysis.
- **Minimum Stop Elev.**: The lowest monthly pump stop elevation entered for each of the pumping units available for the analysis.
- **Minimum Start Elev.**: The lowest monthly pump start elevation entered for each of the pumping units available for the analysis.
- **Total Hours Pumped**: The total number of hours during which each of the pumping units discharged for each water year during the analysis.
- **Average Annual hrs Pumped**: The average number of hours during which each of the pumping units discharged for each water year during the analysis.
- **Total Energy**: The total number of megawatt-hours of energy required for each of the pumping units during the analysis.
- **Avg. Annual Energy**: The average number of megawatt-hours of energy required for each of the pumping units, for each water year during the analysis.

Figure 11.60 illustrates the **Error Messages** analysis record summary, which includes the error messages and warning messages generated by HEC-IFH during each analysis. Since these error messages may be too numerous to fit on one screen, a "file browser" or "list" utility program is used to provide access to the entire range of error and warning messages. The file browser allows the messages to be scrolled in increments of one line or one screen at a time, either up or down.

Appendix F of this manual provides a listing of all error and warning messages with further background information.

```
CSA 01.01.00                                                     SUMM26
Study ID  RBEND2     Hydrologic Analysis Summaries     Begin 01OCT1950/0100
Plan ID   PLANP                                        End   30SEP1960/2400
            V. Analysis Record Summaries - Pump Operation
```

Pump Number	Pump Unit ID	Minimum Stop Elev.(ft)	Minimum Start Elev.(ft)	Total Hours pumped	Average Annual hrs pumped	Total Energy (mW-hrs)	Av.Annual Energy (mW-hrs)
1	PUMP1	598.00	600.00	539	53	52.63	5.26
2							
3							
4							
5							
6							
7							
8							
9							
10							

```
1Help  2PrtScr 3     4     5     6DOS   7     8     9     10Exit
                    Press <F10> to Return
```

FIGURE 11.59 Analysis Record Summary of Pump Operation

```
LIST      1      17     02/29/92 07:26 ♦ RBEND2\PLANP.ERR
Plan PLANP                   Errors and Warnings             29FEB1992/072607

+----------------------------------------------------------------------+
|   Exterior Discharge Hydrograph Calculations         28FEB1992/103453 |
+----------------------------------------------------------------------+
WARNING: Clark unit hydrograph TC increased to computation time interval

WARNING: Clark unit hydrograph R increased to half of computation time interval

Command▶   *** End-of-file ***          Keys: ↑↓→← PgUp PgDn F10=exit F1=Help
```

FIGURE 11.60 Analysis Record Summary of Error Messages

CHAPTER 12
HEA Hydrologic Analysis Summaries

12.1. INTRODUCTION

As noted in the introduction to Chapter 11, Hydrologic Analysis Summaries report the results of one analysis (one plan). This chapter describes the Hydrologic Analysis Summaries which are available for the Hypothetical Event Analysis option.

Different Hydrologic Analysis Summaries are available for Continuous Simulations and Hypothetical Event Analyses. Table 12.1 lists the Hydrologic Analysis Summaries which contain particular types of output available for each method of analysis.

TABLE 12.1 Overview of HEC-IFH Hydrologic Analysis Summaries

Type of Output	Continuous Simulation Analysis	Hypothetical Event Analysis
Input Data	Analysis Input Summaries	Analysis Input Summaries
Detailed Output	Calculation Period Summaries	Analysis by Events
Monthly Totals/Averages	Monthly Summaries	—
Annual Totals/Averages	Water Year Annual Summaries	—
Summary of All Results	Analysis Record Summaries	Event Comparisons
Error Messages	Analysis Error Messages	Analysis Error Messages

Note: See Chapter 11 for details on Continuous Simulation Analysis summaries.

12.2. HEC-IFH NUMERIC DISPLAY FORMATS

As noted in Chapter 11, all HEC-IFH summaries are displayed using tables formed by horizontal and vertical lines. Numeric output values displayed in such tables are generally limited to a fixed number of digits and a fixed decimal point location. The total number of digits and the position of the decimal point for each output value have been carefully selected to display a very wide range of values, for. However, the values may occasionally overflow the number of digits available. In such cases, HEC-IFH automatically modifies the display format to provide appropriate values within the space available, rather than simply printing the uninformative "*****.*" value which is the FORTRAN default output.

For example, assume that a particular summary displays peak runoff rate to the nearest 0.1 unit using seven total characters. The highest peak runoff rate which could normally be displayed in such a summary would be 99999.9 units. However, if a peak runoff rate of 4,189,876 units is computed, HEC-IFH automatically eliminates the decimal point and the digit right of the decimal point, and 4189876 is displayed as a seven-digit integer.

HEC-IFH will automatically use exponential notation to display output values which are too large for display even as integers. For example, if the computed runoff rate in the example above were 13,894,176 units, it could not be displayed in seven total characters, even as an integer. In such a case, HEC-IFH would automatically display the value as 13894E3, which is 13,894 times 10^3, or 13,894,000.

12.3. SELECTION OF HEA HYDROLOGIC ANALYSIS SUMMARIES

Figure 12.1 illustrates the screen used to select the Plan ID for the Hydrologic Analysis Summaries. In order for a Hydrologic Analysis Summary to be generated, the plan computations must have already been completed. The [F3] Index key may be used to display a list of valid Plan IDs. When a Plan ID is specified, the corresponding Plan Description is displayed for verification.

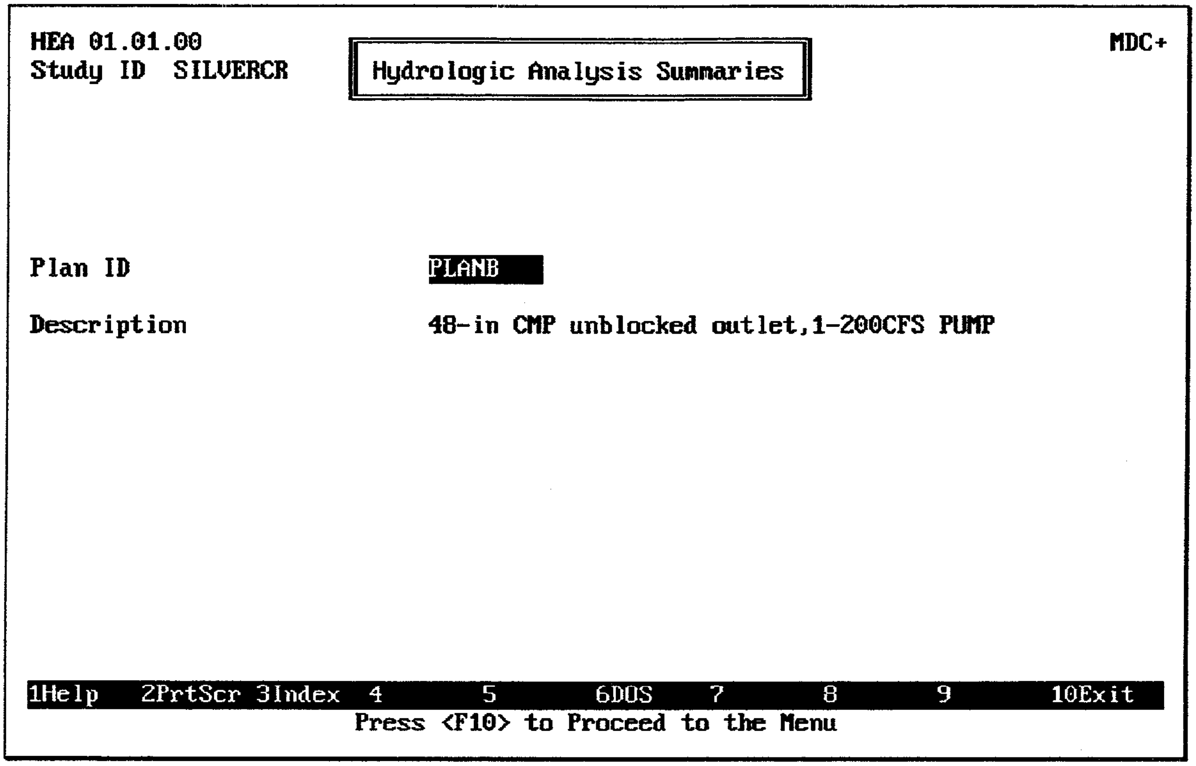


FIGURE 12.1 Hypothetical Event Hydrologic Analysis Summaries Master Screen

Nineteen (19) different Hydrologic Analysis Summary reports are available for Hypothetical Event Analysis. These reports are divided into four categories:

1. **Analysis Input Summaries**, which describe the input data for a plan analysis:
2. **Analysis by Events**, which list and summarize the results of the analysis for one of the eight standard storm events available for Hypothetical Frequency Analyses.
3. **Event Comparisons**, which list and compare the results of the analysis for two or more of the eight standard storm events available for Hypothetical Frequency Analyses.
4. **Analysis Error Messages**, which lists the error messages generated during the analysis.

Figure 12.2 illustrates the menu screen which is used to select the Hypothetical Event Hydrologic Analysis Summaries for display or printing.

```
HEA 01.01.00                                                    MDC
Study ID  SILVERCR     Hydrologic Analysis Summaries
Plan ID   PLANB

 Analysis Input Summaries              Event Comparisons
    A. Data Management Summary            M. Rainfall-Runoff Data
    B. Rainfall-Runoff Summary            N. Maximum Flows
    C. Gravity Outlet Data                O. Flood Volumes
    D. Pump Station Data                  P. Gravity Outlet Analysis
                                          Q. Pump Analysis
                                          R. Frequency Analysis
 Analysis by Events
    E. Rainfall-Runoff Data            Analysis Error Messages
    F. Interior/Exterior Data             S. List Warning/Error Messages
    G. Detailed Inflow Data
    H. Detailed Outflow Data
    I. Detailed Grav. Outflow Data
    J. Area Flooded Data
    K. Maximum Values
    L. Inflows and Outflows

1Help  2PrtScr 3     4     5     6DOS    7     8     9     10Exit
         Press Letter: or use Arrow Keys and <Enter> to Select
```

FIGURE 12.2 Menu of Hypothetical Event Hydrologic Analysis Summaries

12.4. HYPOTHETICAL EVENT ANALYSIS INPUT SUMMARIES

There are four ***Analysis Input Summaries*** which describe the input data for a plan analysis:

1. **Data Management Summary**: A brief overview of the input data used for a particular analysis.
2. **Rainfall-Runoff Summary**: A brief summary of the rainfall and runoff data used for each of the sub-basins used in the analysis.
3. **Gravity Outlet Data**: An overview of the gravity outlets, including the type (BOX, PIPE, TABLE), Size, Number, Invert Elevations, Length, Slope, and Gate Closure elevations. Each screen refers to a different location (PRIMARY, SECONDARY 1, SECONDARY 2, SECONDARY 3, SECONDARY 4), and includes the stream station at that location.
4. **Pump Station Data**: An overview of the pump outlets, including the pump unit ID, capacity, start and stop elevations, and the maximum total head on the pump.

Figure 12.3 illustrates the Hypothetical Event Analysis **Data Management Summary**, which includes the following data values for the specified plan:

- **Date of Execution**: The date on which the plan analysis was performed.
- **Module ID**: The module ID for the following data sets: Basin Average Precipitation (PRECIP), Runoff Hydrograph Parameters (RUNOFF), Interior Pond (POND), Gravity Outlets (GRAVITY), Pump Data (PUMP), Exterior Stage (EXSTAGE), and Auxiliary Flow (AUXFLOW).

- **Description**: The 40-character description for each of the input data modules (PRECIP, RUNOFF, POND, GRAVITY, PUMP, EXSTAGE, and AUXFLOW).

HEA 01.01.00 | **Hydrologic Analysis Summaries** | SUMM03
Study ID SILVERCR | Begin 01/0100
Plan ID PLANB | End 06/2400

A. Analysis Input Summaries - Data Management Summary

Date of Execution 29FEB1992/2025

Module	Module ID	Description
Basin Average Precipitation	STORM1	Precip. depth-duration data.
Runoff Hydrograph Parameters	ROMOD1	One area- same rainfall-runoff for each.
Interior Pond	PONDMOD	Natural ponding area at the primary loc.
Gravity Outlets	OUTLET1	1-48 in CMP at the primary location.
Pump Data	PUMPMOD1	1-200 CFS PUMP
Exterior Stage	EXSTAGE	Constant stage = 581.00 (unblocked)
Auxiliary Flow		

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 12.3 HEA Data Management Summary

Figure 12.4 illustrates the Hypothetical Event Analysis **Rainfall-Runoff Summary**, which includes the following data values for the specified plan:

- **PRECIP Module ID and Description**: The module ID and 40-character description for the Basin Average Precipitation (PRECIP) data set. (See Chapter 3.)
- **RUNOFF Module ID and Description**: The module ID and 40-character description for the Runoff Hydrograph Parameters (RUNOFF) data set (See Chapter 4).
- **Rainfall Station ID**: For Hypothetical Event Analysis, the same rainfall data is always used for all sub-basins, so the Rainfall Station ID is simply the PRECIP Module ID. (See Chapter 3.)
- **Source of Record**: The method used to record or compute the rainfall data used for each sub-basin. For Hypothetical Event Analyses, the Source of Record is always HYPOTHETICAL for all sub-basins. (See Chapter 3.)
- **Basin ID**: The identifier for the set of basin runoff parameters used for each sub-basin which was included in the analysis. (See Chapter 4.)
- **Loss Rate Method**: The computational method used to estimate the infiltration and other losses for each sub-basin included in the analysis. The following Loss Rate Methods are available: INITIAL-UNIFORM, SCS CURVE, HOLTAN, GREEN-AMPT, and NONE. (See Chapter 4.)
- **Unit Hydrograph Method**: The method used to compute or otherwise provide the unit hydrograph for each sub-basin included in the analysis. The following Unit

Hydrograph Methods are available: CLARK, SNYDER, SCS, and ENTER. (See Chapter 4.)

- **Channel Routing ID**: The identifier for the set of channel routing data used for routing the upper sub-basin hydrograph to the interior ponding area. The Channel Routing ID is applicable to the upper sub-basin only.
- **Channel Routing Method**: The computational method used to route the upper sub-basin hydrograph to the interior ponding area. The Channel Routing Method is applicable to the upper sub-basin only. The following Channel Routing Methods are available: MODIFIED PULS, MUSKINGUM, MUSKINGUM-CUNGE, LAG, and NONE. (See Chapter 4.)

HEA 01.01.00 SUMM04
Study ID SILVERCR **Hydrologic Analysis Summaries** Begin 01/0100
Plan ID PLANB End 06/2400

B. Analysis Input Summaries - Rainfall-Runoff Summary

PRECIP Module ID: STORM1 Precip. depth-duration data.
RUNOFF Module ID: ROMOD1 One area- same rainfall-runoff for each.

	Lower Sub-Basin	Upper Sub-Basin	Exterior Basin
Rainfall Station ID Source of Record	STORM1 HYPOTHETICAL		
Basin ID Loss Rate Method Unit Hydrograph Method	SILVER INIT-UNIFORM SCS		
Channel Routing ID Channel Routing Method			

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 12.4 HEA Rainfall-Runoff Input Summary

Figure 12.5 illustrates one of the Hypothetical Event Analysis **Gravity Outlet Data** summaries, which includes the following data values for the specified plan:

- **Outlet Location**: The location of all of the gravity outlets (up to five) on the current screen. The Primary outlet location is always the first to be displayed. The Secondary 1, Secondary 2, Secondary 3, and Secondary 4 outlet locations may be displayed, one at a time, by pressing the PgDn or F10 keys. Pressing the PgUp key displays the data for the previous outlet location.
- **River/Levee Station**: The relative location of the outlet structure with respect to distance along the receiving stream or line or protection. This station is used only as a reference for those using HEC-IFH or viewing HEC-IFH results. It is not used by the HEC-IFH program for any computations.
- **Outlet ID**: The identifiers for each of the gravity outlets at the current outlet location.

- **Outlet Type**: The type of each of the gravity outlets at the current outlet location. The Outlet Type is BOX or CIRCULAR for computed gravity outlet rating tables. For gravity outlet rating tables entered by the user, the program displays the first 8 characters of the description for the Outlet Type.
- **Opening Size**: The total cross-sectional area of each of the gravity outlets at the current outlet location. This is computed from the outlet dimensions for box or circular culverts, and is given by the user for user-specified gravity outlet rating tables. Since each gravity outlet may actually represent multiple instances of identical structures, the opening size may be much greater than the cross-sectional area of a single structure.
- **No. of Identical Outlets**: The number of multiple instances of identical structures at each of the gravity outlets at the current outlet location.
- **Interior Invert Elev.**: The interior (land side) minimum elevation of each of the gravity outlets at the current outlet location.
- **Exterior Invert Elev.**: The exterior (river side) minimum elevation of each of the gravity outlets at the current outlet location.
- **Length of Outlet**: The center-line length of the culvert.
- **Slope of Outlet**: The slope of each of the gravity outlets at the current location, as computed using the exterior and interior invert elevations and the length of the outlet.
- **Exterior Elev. for Gate Closure**: The exterior stage elevation at which gravity flows through the line of protection are assumed to cease, for each of the gravity outlets at the current outlet location.

```
HEA 01.01.00                                                       SUMM05
Study ID  SILVERCR    | Hydrologic Analysis Summaries |   Begin 01/0100
Plan ID   PLANB                                           End   06/2400
             C. Analysis Input Summaries - Gravity Outlet Data

                    Outlet Location:           Primary
                    River/Levee Station (mi):     0.00
```

Outlet ID	1-48CMP				
Outlet Type	Circular				
Opening Size (sqft)	12.57				
No. of Identical Outlets	1				
Interior Invert Elev. (ft)	593.00				
Exterior Invert Elev. (ft)	589.00				
Length of Outlet (ft)	200.00				
Slope of Outlet (ft/ft)	0.02000				
Exterior Elev. for Gate Closure (ft)	0.00				

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <PgDn>, <PgUp> or <F10> for other locations; <Esc> to Return

FIGURE 12.5 HEA Gravity Outlet Data Summary

See Chapter 6 for further details on the information displayed on the Gravity Outlet Data Summary.

Figure 12.6 illustrates the Hypothetical Event **Pump Station Data** summary, which includes the following data values for the specified plan:

- **PUMP Module ID and Description**: The module ID and 40-character description for the Pump Data (PUMP) data set.
- **Pump Unit ID**: The identifier for each of the pumping units available for the analysis.
- **Maximum Capacity**: The total maximum capacity of each of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Pump Start Elevation**: The pump start elevation entered for each of the pumping units available for the analysis.
- **Pump Stop Elevation**: The pump stop elevation entered for each of the pumping unit available for the analysis.
- **Maximum Total Head**: The highest pump head value entered in the pump head versus capacity table for each of the pumping units available for the analysis.

```
HEA 01.01.00                                                    SUMM06
Study ID  SILVERCR    Hydrologic Analysis Summaries    Begin 01/0100
Plan ID   PLANB                                        End   06/2400
             D. Analysis Input Summaries - Pump Station Data

   PUMP Module ID PUMPMOD1     1-200 CFS PUMP
```

Pump Number	Pump Unit ID	Maximum Capacity (cfs)	Pump Start Elevation (ft)	Pump Stop Elevation (ft)	Maximum Total Head (ft)
1	PUMP1	200.0	600.00	598.00	30.00
2					
3					
4					
5					
6					
7					
8					
9					
10					

```
1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
              Press <F10> to Return
```

FIGURE 12.6 HEA Pump Station Data Summary

12.5. HYPOTHETICAL EVENT ANALYSIS BY EVENTS

There are eight ***Analysis by Events*** reports which list and summarize the results of the analysis for each calculation period during the entire analysis, for a selected storm event. The following summaries are available:

1. **Rainfall-Runoff Data**: The Precipitation Depths, Losses, and Runoff Rate for each of the sub-basins used in the analysis, for each time period during the analysis.
2. **Interior/Exterior Data**: The Interior and Exterior water surface elevations, the head (the difference between the interior and exterior elevations), and the total inflow into the interior storage pond. The total gravity outflow rate, the total pump outflow rate, and the total outflow rate from all sources is also listed for each time period during the analysis.
3. **Detailed Inflow**: The inflow rate to the interior storage pond for each time period during the analysis. The routed inflows from the upper sub-basin, direct runoff from the lower sub-basin, lower sub-basin auxiliary inflows, and seepage inflows are each listed.
4. **Detailed Outflow**: The outflow rate from the interior storage pond for each time period during the analysis. The total outflows from all gravity outlets, the total outflows from all pump outlets, the diversion, and overflow outflows are all listed.
5. **Detailed Gravity Outflow**: The outflow rate from each of the five gravity outlet locations, along with the total gravity outflows, for each time period during the analysis.
6. **Area Flooded Data**: The exterior and interior water surface elevations, and resulting interior surface area flooded, at each time period during the analysis.
7. **Maximum Values**: The maximum interior elevation, interior area flooded, interior storage volume, exterior elevation, positive head, negative head, and pump head values recorded during the entire analysis, along with the corresponding time for each value.
8. **Inflows and Outflows**: The maximum rate and the total volume of runoff into the lower sub-basin, flow routed from the upper sub-basin, lower sub-basin auxiliary inflow, seepage inflow, and total inflow during the entire analysis, along with the corresponding time for each maximum value. The maximum rate and the total volume of outflow from the pump outlets, the gravity outlets, diversion, overflow, and total outflow, along with the corresponding time for each maximum value, are also listed.

Figure 12.7 illustrates the Hypothetical Event **Rainfall-Runoff Data** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Precip**: The incremental precipitation values for each computation interval, for each of the sub-basins used in the analysis. These values are computed using the hypothetical storm distributions.
- **Losses**: The incremental precipitation loss values for each computation interval, for each of the sub-basins used in the analysis. These values are computed using the loss rate methods specified for each sub-basin.
- **Runoff**: The runoff rate at the end of each computation interval, for each of the sub-basins used in the analysis. These values are computed using the incremental

rainfall excess values (precipitation minus losses) and the unit hydrograph for each sub-basin.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the entire summary to be printed.

HEA 01.01.00 SUMM02
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

E. Analysis by Events - Rainfall-Runoff Data
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

	Lower Sub-basin			Upper Sub-basin			Exterior Basin		
Da/HrMn	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)
1/0100	0.04	0.04	50.	0.00	0.00	0.	0.00	0.00	0.
1/0200	0.04	0.04	50.	0.00	0.00	0.	0.00	0.00	0.
1/0300	0.05	0.04	52.	0.00	0.00	0.	0.00	0.00	0.
1/0400	0.05	0.05	56.	0.00	0.00	0.	0.00	0.00	0.
1/0500	0.06	0.05	60.	0.00	0.00	0.	0.00	0.00	0.
1/0600	0.06	0.06	66.	0.00	0.00	0.	0.00	0.00	0.
						0.	0.00	0.00	0.
						0.	0.00	0.00	0.
						0.	0.00	0.00	0.
						0.	0.00	0.00	0.
						0.	0.00	0.00	0.

Select Option:

A. Plot Lower Sub-Basin Rainfall-Runoff
B. Plot Upper Sub-Basin Rainfall-Runoff
C. Plot Exterior Basin Rainfall-Runoff

7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.7 Summary of Rainfall-Runoff Data for Hypothetical Event

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 12.7 illustrates. Three different plots are available: one for each of the sub-basins. Figure 12.8 illustrates one of these plots. As shown, the rainfall and loss values are plotted down from the upper edge of the plot according to the "Total Depth" axis on the right. The runoff values are plotted up from the lower edge of the plot according to the "Discharge" axis on the left.

If the selected plan analysis period extends over more than 24 hours, these plots will initially display the entire duration of the plan analysis (up to 99 days). Pressing the down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. The zoom and pan plot options are described in Chapter 2.

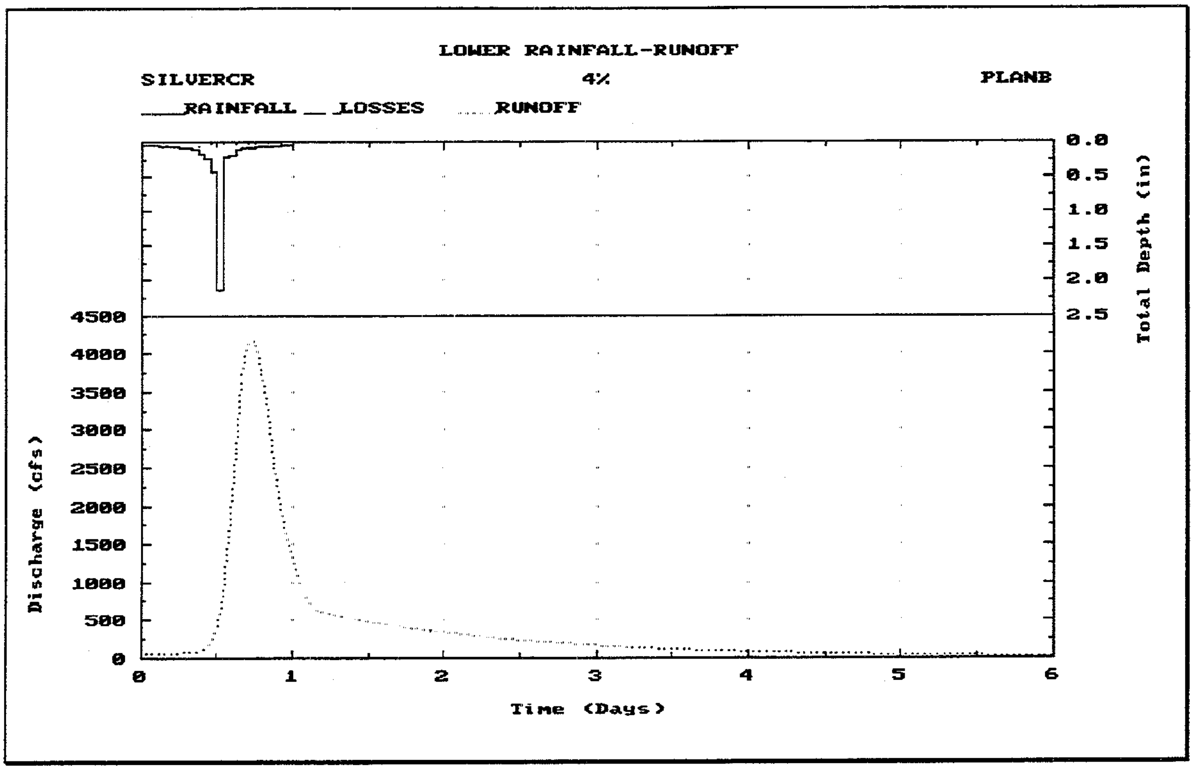


FIGURE 12.8 Plot of Rainfall-Runoff Data for Hypothetical Event

Figure 12.9 illustrates the Hypothetical Event **Interior-Exterior Data** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Interior Elev.**: The computed water surface elevation in the interior ponding area at the end of each computation interval.
- **Exterior Elev.**: The water surface elevation in the exterior channel at the end of each computation interval.
- **Head**: The computed differential head between the water surface elevations in the interior ponding area and the exterior channel, at the end of each computation interval. The differential head is positive when the interior elevation is higher.
- **Total Inflow**: The total computed rate of inflow into the interior ponding area at the end of each computation interval. The total inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, lower sub-basin auxiliary inflows, and seepage inflows, if applicable.
- **Gravity Outflow**: The total computed rate of outflow from all gravity outlet locations at the end of each computation interval.
- **Pump Outflow**: The total computed rate of discharge from all pumping units at the end of each computation interval.

- **Total Outflow**: The total computed rate of outflow from the interior ponding area at the end of each computation interval. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the entire summary to be printed.

HEA 01.01.00 Hydrologic Analysis Summaries SUMM27
Study ID SILVERCR
Plan ID PLANB

F. Analysis by Events - Interior/Exterior Data
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

Da/HrMn	Interior Elev. (ft)	Exterior Elev. (ft)	Head (ft)	Total Inflow (cfs)	Gravity Outflow (cfs)	Pump Outflow (cfs)	* Total Outflow (cfs)
1/0100	593.95	581.00	12.95	50.5	6.9	0.0	6.9
1/0200	594.54	581.00	13.54	50.5	15.6	0.0	15.6
1/0300	594.86	581.00	13.86	52.2	21.9	0.0	21.9
1/0400	595.09	581.00	14.09	55.7	26.7	0.0	26.7
1/0500	595.24	581.00	14.24	60.4	30.1	0.0	30.1
1/0600	595.36	581.00	14.36	65.8	32.9	0.0	32.9
				2	35.4	0.0	35.4
				6	37.8	0.0	37.8
				9	40.3	0.0	40.3
				3	43.4	0.0	43.4
				8	48.4	0.0	48.4

Select Option:

A. Plot Interior and Exterior Elevations
B. Plot Differential Head
C. Plot Total Inflow and Total Outflow
D. Plot Gravity and Pump Outflow

7 8 9 10Exit
Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.9 Summary of Interior/Exterior Data for Hypothetical Event

The F9 Plot key causes the HEC-IFH program to display a menu of available plots, as Figure 12.9 illustrates. Four different plots are available:

1. **Interior and Exterior Elevations**, as illustrated in Figure 12.10.
2. **Differential Head**, as illustrated in Figure 12.11.
3. **Total Inflow and Total Outflow**, as illustrated in Figure 12.12.
4. **Gravity and Pump Outflow**, as illustrated in Figure 12.12.

If the plan analysis period extends over more than 24 hours, these plots will initially display the entire duration of the plan analysis (up to 99 days). The down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. The zoom and pan plot options are described in Chapter 2.

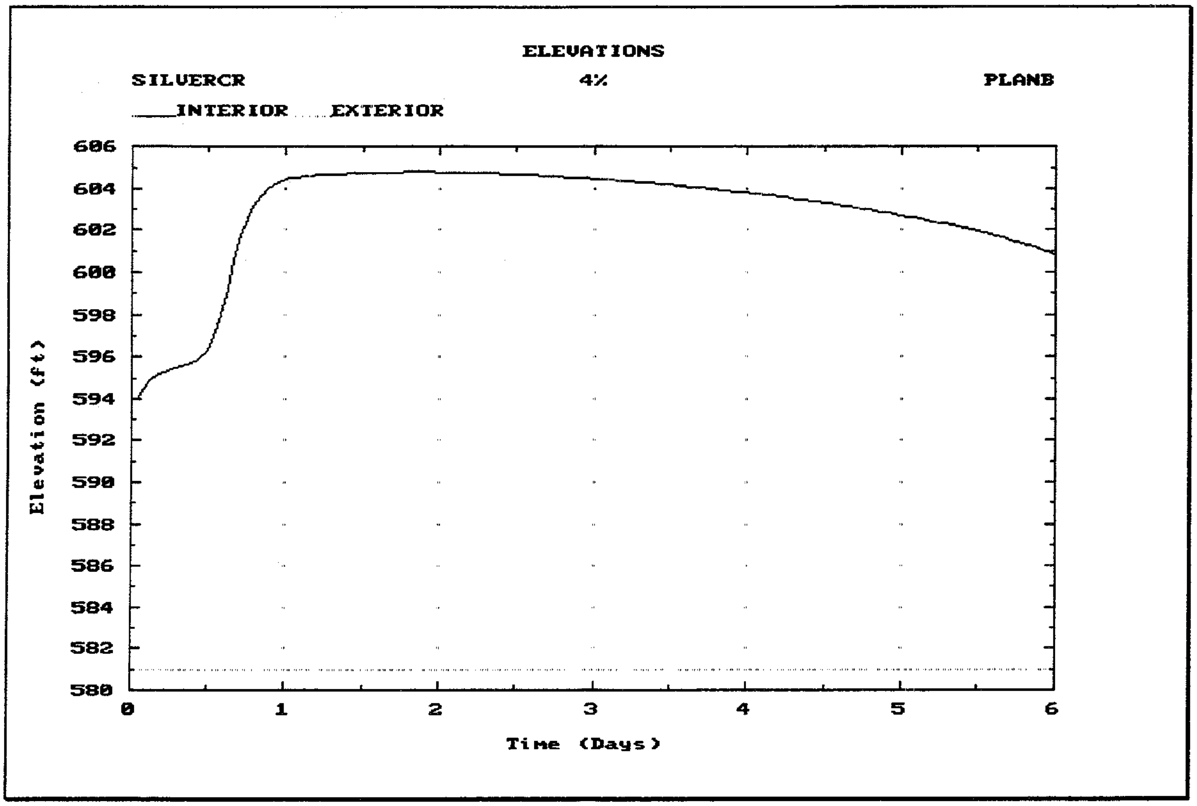


FIGURE 12.10 Plot of Interior and Exterior Elevations for Hypothetical Event

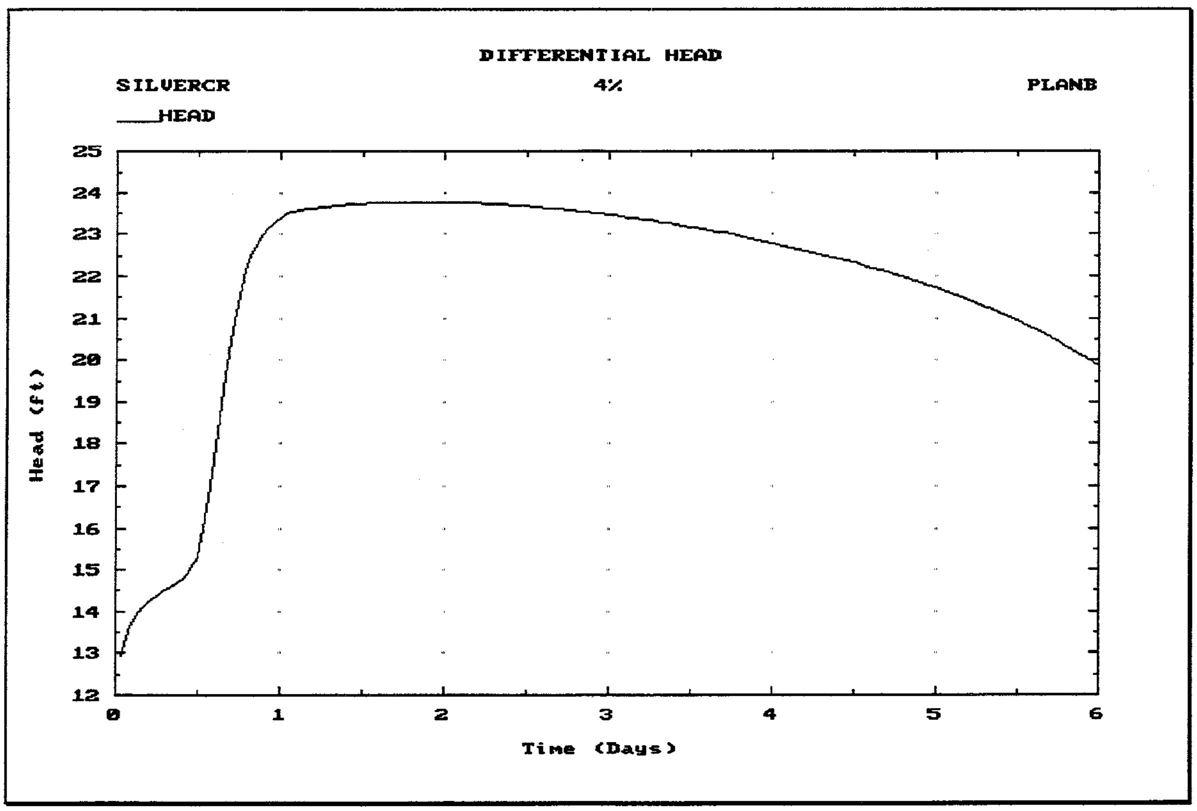


FIGURE 12.11 Plot of Differential Head for Hypothetical Event

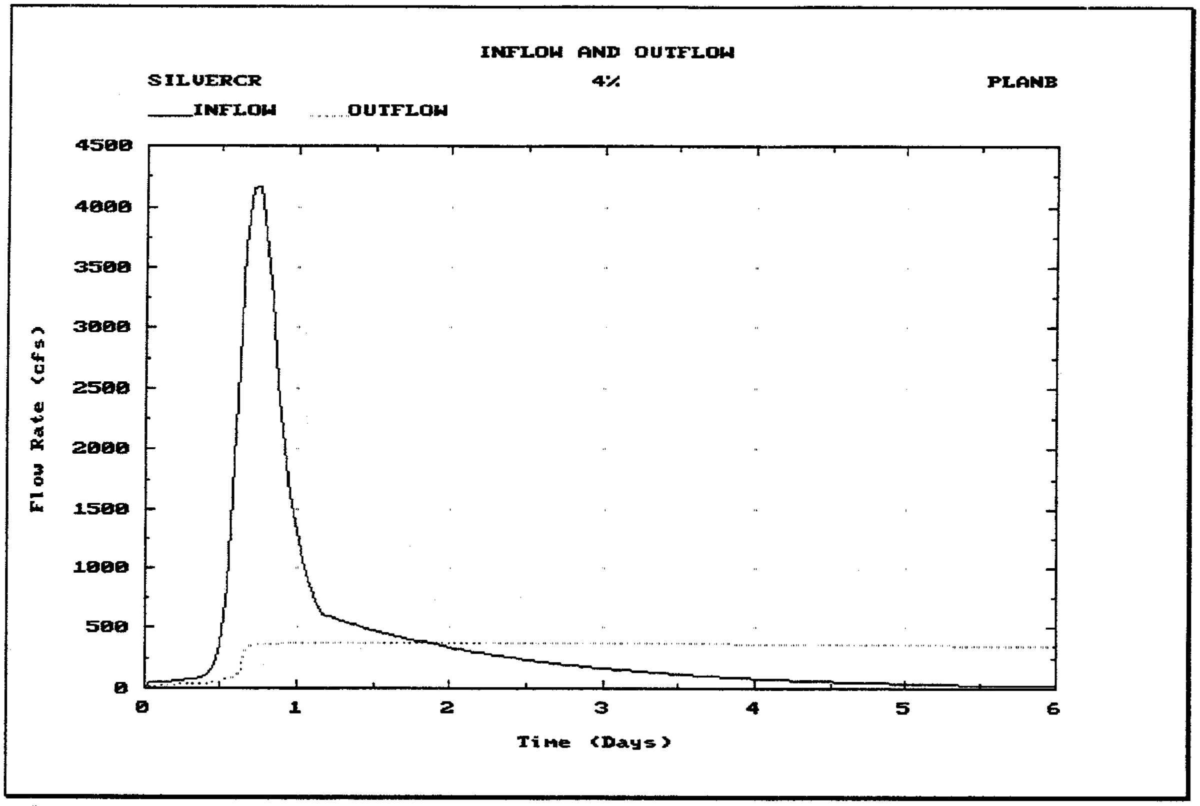


FIGURE 12.12 Plot of Inflow and Outflow for Hypothetical Event

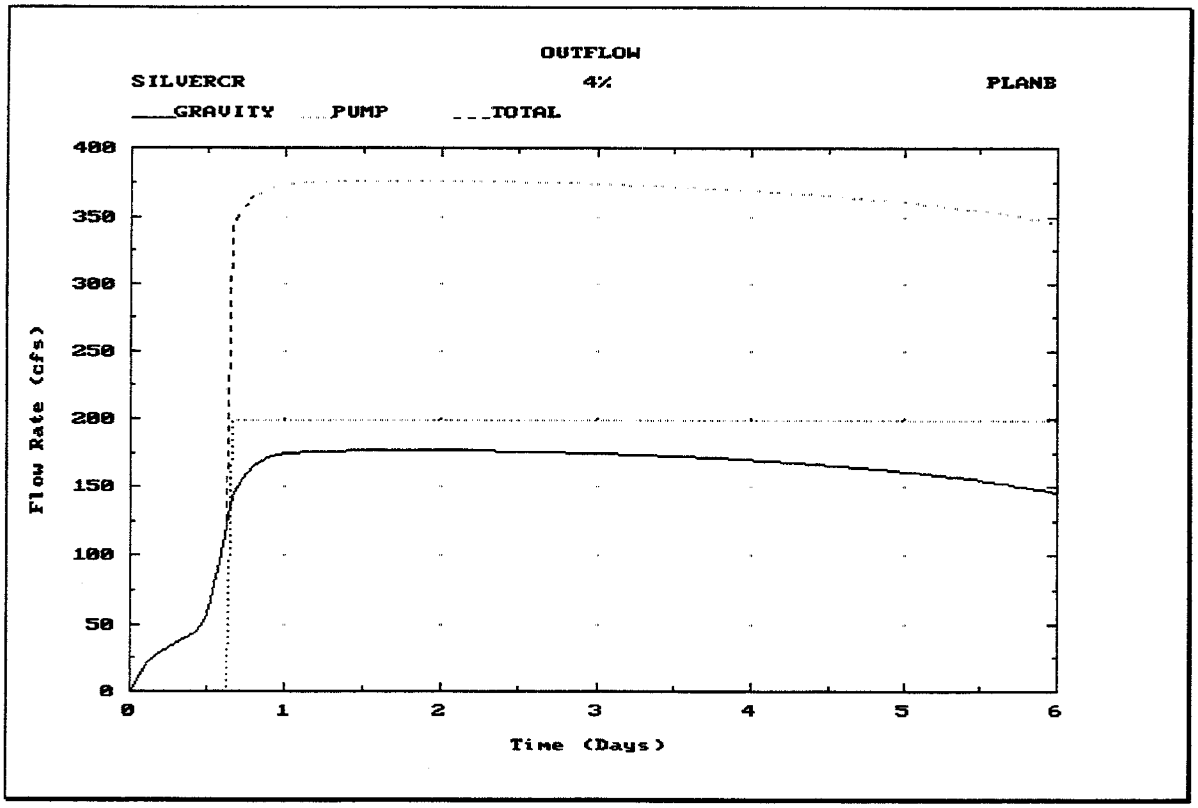


FIGURE 12.13 Plot of Outflows for Hypothetical Event

Figure 12.14 illustrates the Hypothetical Event **Detailed Inflow** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Upper Routed**: The computed flow rates of the hydrograph routed from the upper sub-basin at the end of each computation interval. See Chapter 4.
- **Lower Runoff**: The computed flow rates of the runoff hydrograph from the lower sub-basin at the end of each computation interval. Chapter 4 provides further details.
- **Auxiliary**: The computed flow rates of the auxiliary inflow hydrograph at the interior ponding area at the end of each computation interval. Auxiliary inflow is described in Chapter 9.
- **Interior Inflow**: The total computed rate of interior inflow into the interior ponding area at the end of each computation interval. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, and lower sub-basin auxiliary inflows, if applicable. Seepage inflow is from the exterior and is not included.
- **Seepage**: The total computed rate of seepage inflow into the interior ponding area at the end of each computation interval. Seepage is described in Chapter 9.
- **Total**: The total computed rate of inflow to the interior ponding area at the end of each computation interval. The total inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, auxiliary inflows, and seepage inflow, if applicable.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the [F4] Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the [F5] Report key causes the entire summary to be printed.

The [F9] Plot key causes the HEC-IFH program to display a plot of inflows, as Figure 12.15 illustrates. If the plan analysis period extends over more than 24 hours, this plot will initially display the entire duration of the plan analysis (up to 99 days). The down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. More zoom and pan plot options are described in Chapter 2.

HEA 01.01.00 SUMM28
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

G. Analysis by Events - Detailed Inflow (cfs)
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

Da/HrMn	Upper Routed	Lower Runoff	Auxiliary	Interior Inflow	Seepage	Total
1/0100	0.0	50.5	0.0	50.5	0.0	50.5
1/0200	0.0	50.5	0.0	50.5	0.0	50.5
1/0300	0.0	52.2	0.0	52.2	0.0	52.2
1/0400	0.0	55.7	0.0	55.7	0.0	55.7
1/0500	0.0	60.4	0.0	60.4	0.0	60.4
1/0600	0.0	65.8	0.0	65.8	0.0	65.8
1/0700	0.0	71.2	0.0	71.2	0.0	71.2
1/0800	0.0	76.6	0.0	76.6	0.0	76.6
1/0900	0.0	85.9	0.0	85.9	0.0	85.9
1/1000	0.0	116.3	0.0	116.3	0.0	116.3
1/1100	0.0	193.8	0.0	193.8	0.0	193.8
1/1200	0.0	363.1	0.0	363.1	0.0	363.1
1/1300	0.0	846.3	0.0	846.3	0.0	846.3

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Press SPACE to select; Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.14 Summary of Detailed Inflow Data for Hypothetical Event

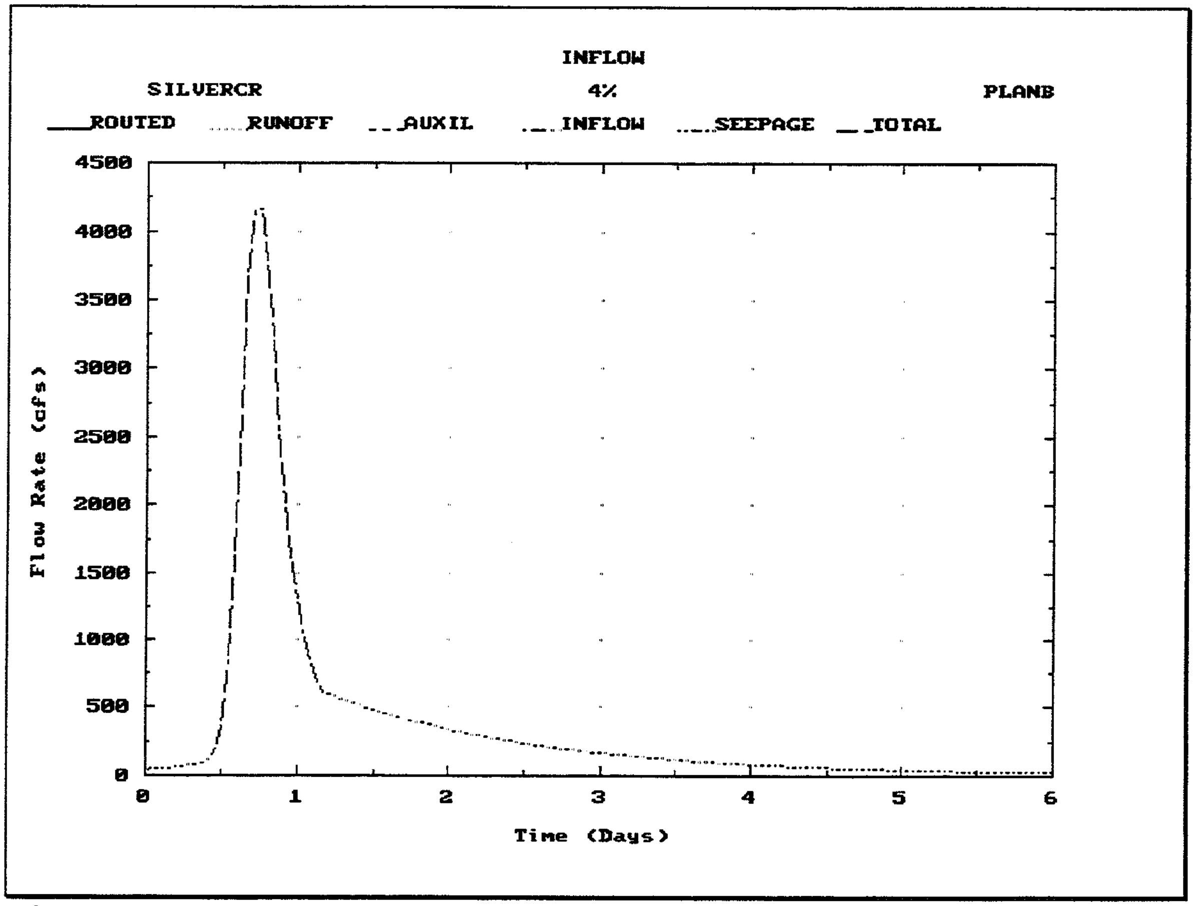


FIGURE 12.15 Plot of Detailed Inflow Data for Hypothetical Event

Figure 12.16 illustrates the Hypothetical Event **Detailed Outflow** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Total Gravity**: The total computed rate of outflow from all gravity outlets at the end of each computation interval. See Chapter 6.
- **Pump**: The total computed rate of discharge from all pumping units at the end of each computation interval. See Chapter 7.
- **Diversion**: The computed rate of discharge from diversion at the end of each computation interval. Diversions are assumed to apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area (which is in the lower interior sub-basin). See Chapter 9 for further details.
- **Overflow**: The computed rate of overflow from the interior ponding area at the end of each computation interval. See Chapter 9.
- **Total Outflow**: The total computed rate of outflow from the interior ponding area at the end of each computation interval. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the [F4] Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the [F5] Report key causes the entire summary to be printed.

The [F9] Plot key causes the HEC-IFH program to display a plot of outflows, as Figure 12.17 illustrates. If the plan analysis period extends over more than 24 hours, this plot will initially display the entire duration of the plan anslysis (up to 99 days). The down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. More zoom and pan plot options are described in Chapter 2.

HEA 01.01.00 SUMM29
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

H. Analysis by Events - Detailed Outflow (cfs)
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

Da/HrMn	Total Gravity	Pump	Diversion	Overflow	Total *
1/0100	6.9	0.0	0.0	0.0	6.9
1/0200	15.6	0.0	0.0	0.0	15.6
1/0300	21.9	0.0	0.0	0.0	21.9
1/0400	26.7	0.0	0.0	0.0	26.7
1/0500	30.1	0.0	0.0	0.0	30.1
1/0600	32.9	0.0	0.0	0.0	32.9
1/0700	35.4	0.0	0.0	0.0	35.4
1/0800	37.8	0.0	0.0	0.0	37.8
1/0900	40.3	0.0	0.0	0.0	40.3
1/1000	43.4	0.0	0.0	0.0	43.4
1/1100	48.4	0.0	0.0	0.0	48.4
1/1200	57.2	0.0	0.0	0.0	57.2

* Note: Diversion is not part of Total Pond Outflow
1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Press SPACE to select; Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.16 Summary of Detailed Outflow Data for Hypothetical Event

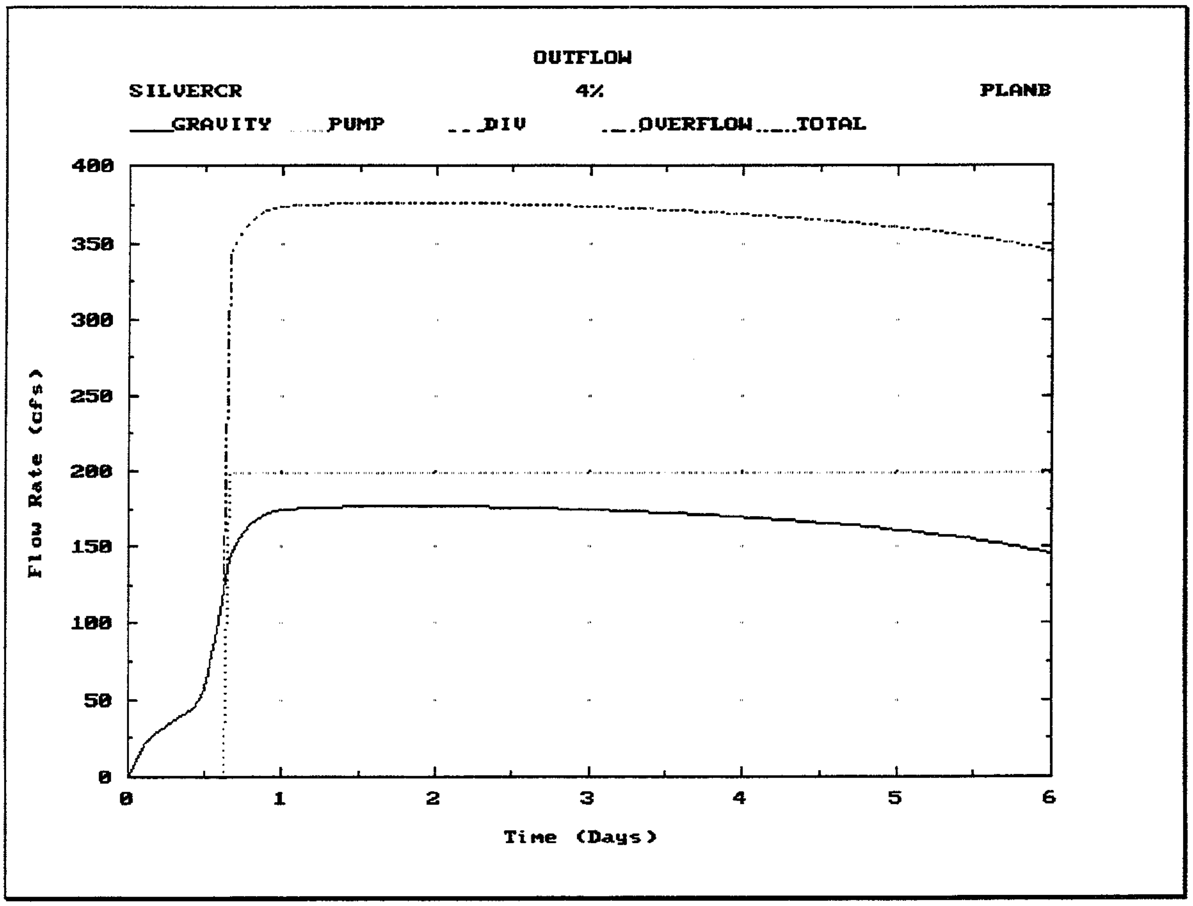


FIGURE 12.17 Plot of Detailed Outflows for Hypothetical Event

Figure 12.18 illustrates the Hypothetical Event **Detailed Gravity Outflow** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Primary**: The total computed rate of outflow from all the gravity outlets at the Primary outlet location at the end of each computation interval.
- **Sec. 1**: The total computed rate of outflow from all the gravity outlets at the Secondary 1 outlet location at the end of each computation interval.
- **Sec. 2**: The total computed rate of outflow from all the gravity outlets at the Secondary 2 outlet location at the end of each computation interval.
- **Sec. 3**: The total computed rate of outflow from all the gravity outlets at the Secondary 3 outlet location at the end of each computation interval.
- **Sec. 4**: The total computed rate of outflow from all the gravity outlets at the Secondary 4 outlet location at the end of each computation interval.
- **Total**: The total computed rate of outflow from all gravity outlets at the end of each computation interval.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the [F4] Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the [F5] Report key causes the entire summary to be printed.

The [F9] Plot key causes the HEC-IFH program to display a plot of gravity outflows, as Figure 12.17 illustrates. If the plan analysis period extends over more than 24 hours, this plot will initially display the entire duration of the plan analysis (up to 99 days). The down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. More zoom and pan plot options are described in Chapter 2.

HEA 01.01.00 SUMM30
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

I. Analysis by Events - Detailed Gravity Outflow (cfs)
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

Da/HrMn	Primary	Sec. 1	Sec. 2	Sec. 3	Sec. 4	Total
1/0100	6.9	0.0	0.0	0.0	0.0	6.9
1/0200	15.6	0.0	0.0	0.0	0.0	15.6
1/0300	21.9	0.0	0.0	0.0	0.0	21.9
1/0400	26.7	0.0	0.0	0.0	0.0	26.7
1/0500	30.1	0.0	0.0	0.0	0.0	30.1
1/0600	32.9	0.0	0.0	0.0	0.0	32.9
1/0700	35.4	0.0	0.0	0.0	0.0	35.4
1/0800	37.8	0.0	0.0	0.0	0.0	37.8
1/0900	40.3	0.0	0.0	0.0	0.0	40.3
1/1000	43.4	0.0	0.0	0.0	0.0	43.4
1/1100	48.4	0.0	0.0	0.0	0.0	48.4
1/1200	57.2	0.0	0.0	0.0	0.0	57.2
1/1300	74.1	0.0	0.0	0.0	0.0	74.1
1/1400	95.9	0.0	0.0	0.0	0.0	95.9

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Press SPACE to select; Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.18 Summary of Detailed Gravity Outflow Data for Hypothetical Event

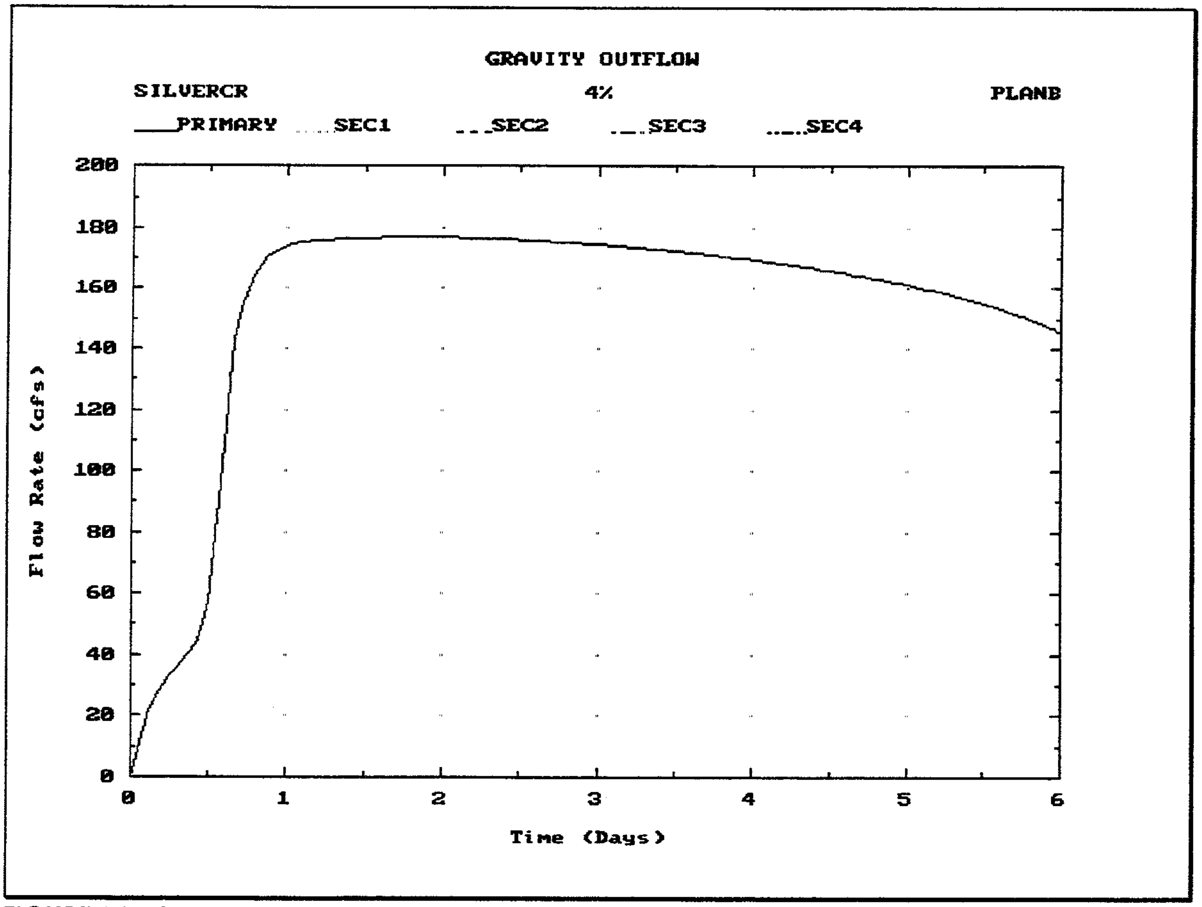


FIGURE 12.19 Plot of Detailed Gravity Outflow Data for Hypothetical Event

Figure 12.20 illustrates the Hypothetical Event **Area Flooded Data** summary for a particular event, which includes the following data values for the specified plan:

- **Da/HrMn**: The date and time at the end of each time interval during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.
- **Exterior Elevation**: The water surface elevation in the exterior channel at the end of each computation interval.
- **Interior Elevation**: The computed water surface elevation in the interior ponding area at the end of each computation interval.
- **Area Flooded**: The computed surface area of the interior ponding area at the end of each computation interval.
- **Pond Stor. Volume**: The computed storage volume of the interior ponding area at the end of each computation interval.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the entire summary to be printed.

HEA 01.01.00 — Hydrologic Analysis Summaries — SUMM31
Study ID SILVERCR
Plan ID PLANB

J. Analysis by Events - Area Flooded Data
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

Da/HrMn	Exterior Elevation (ft)	Interior Elevation (ft)	Area Flooded (ac)	Pond Stor. Volume (ac-ft)
1/0100	581.00	593.95	3.8	1.9
1/0200	581.00	594.54	7.2	5.0
1/0300	581.00	594.86	9.2	7.7
1/0400	581.00	595.09	13.7	10.1
1/0500	581.00	595.24	19.6	12.5
1/0600	581.00	595.36	24.3	15.2
1/0700	581.00	595.47	28.6	18.0
1/0800	581.00	595.57	32.7	21.1
1/0900	581.00	595.67	36.7	24.6
1/1000	581.00	595.79	41.7	29.5
1/1100	581.00	595.99	49.6	38.5
1/1200	581.00	596.33	59.9	57.2

1Help 2PrtScr 3 4Goto 5Report 6DOS 7 8 9Plot 10Exit
Press SPACE to select: Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE 12.20 Summary of Area Flooded Data for Hypothetical Event

The F9 Plot key causes the HEC-IFH program to display a plot of interior area flooded, as Figure 12.21 illustrates. If the plan analysis period extends over more than 24 hours, this plot will initially display the entire duration of the plan analysis (up to 99 days). The down-arrow key "zooms" to a one-day plot. From the one-day plot, the left-arrow and right-arrow keys "pan" to plots of different days, if available. More zoom and pan plot options are described in Chapter 2.

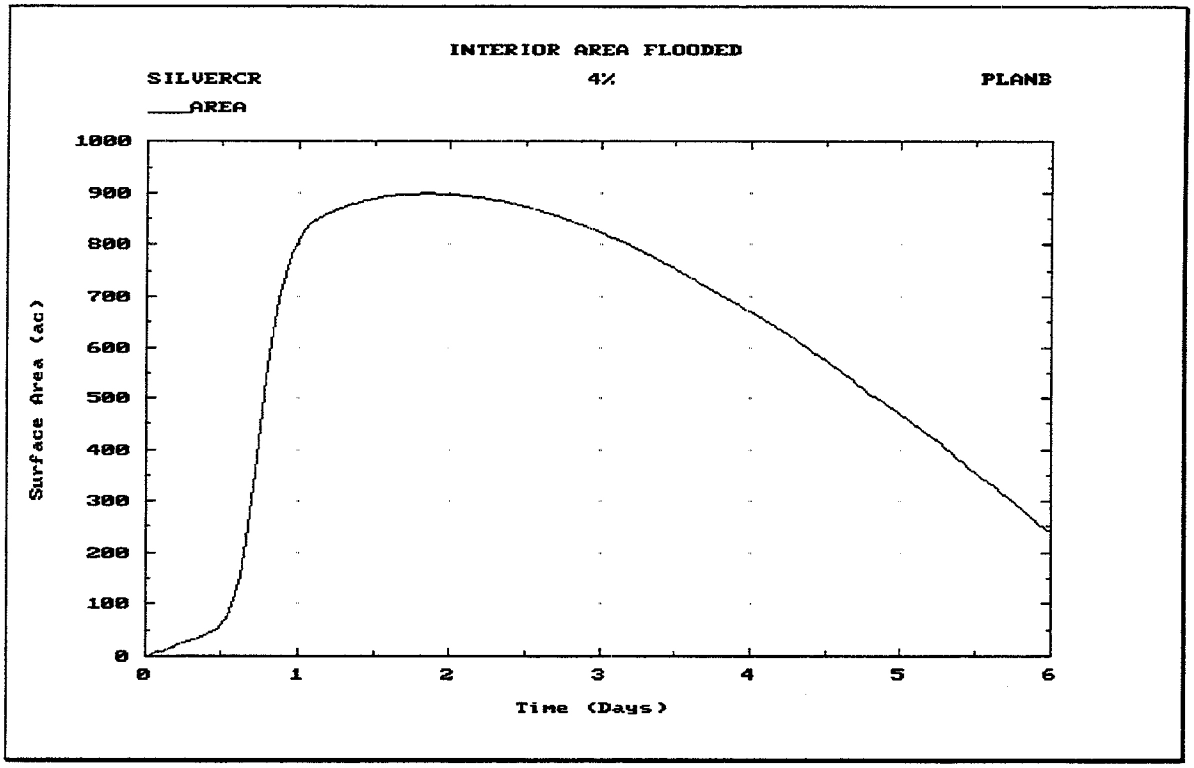


FIGURE 12.21 Plot of Area Flooded Data for Event

Figure 12.22 illustrates the Hypothetical Event **Maximum Values** summary for a particular event, which includes the following data values for the specified plan:

- **Interior Elevation**: The maximum computed water surface elevation in the interior ponding area during the analysis.
- **Interior Area Flooded**: The maximum computed surface area of the interior ponding area during the analysis.
- **Interior Storage**: The maximum computed storage volume of the interior ponding area during the analysis.
- **Exterior Elevation**: The maximum water surface elevation in the exterior channel during the analysis.
- **Positive Head**: The maximum computed positive differential head between the water surface elevations in the interior ponding area and the exterior channel, during the analysis. The differential head is positive when the interior elevation is higher.
- **Negative Head**: The maximum computed negative differential head between the water surface elevations in the interior ponding area and the exterior channel, during the analysis. The differential head is negative when the exterior elevation is higher.

- **Pump Head**: The maximum computed static pump head between the water surface elevations in the exterior channel and the interior ponding area, during a computation interval in which at least one of the pumping units operated.

For each of the maximum values listed in this table, the corresponding **Da/HrMn** value is the date and time at the end of each time interval in which the maximum conditions occurred during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the entire summary to be printed.

HEA 01.01.00 | Hydrologic Analysis Summaries | SUMM32
Study ID SILVERCR
Plan ID PLANB

K. Analysis by Events - Maximum Values
Event 50% 20% 10% [4%] 2% 1% 0.2% SPF

	Maximum Value	Da/HrMn
Interior Elevation (ft)	604.78	2/2100
Interior Area Flooded (ac)	898.3	2/2100
Interior Storage (ac-ft)	2684.8	2/2100
Exterior Elevation (ft)	581.00	1/0100
Positive Head (ft)	23.78	2/2100
Negative Head (ft)	12.00	1/0100
Pump Head (ft)	0.00	

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press SPACE to select: Press <F10> to Return

FIGURE 12.22 Summary of Maximum Values for Hypothetical Event

Figure 12.23 illustrates the Hypothetical Event **Inflows and Outflows** summary for a particular event, which includes the following data values for the specified plan:

- **Routed from Upper**: The maximum computed flow rate and total volume of the hydrograph routed from the upper sub-basin during the analysis. See Chapter 4.
- **Runoff from Lower**: The maximum computed flow rate and total volume of the runoff hydrograph from the lower sub-basin during the analysis. See Chapter 4.
- **Lower Auxiliary**: The maximum flow rate and total volume of the auxiliary inflow hydrograph at the interior ponding area during the analysis. See Chapter 9.

- **Total Interior**: The maximum total computed flow rate and total volume of interior inflow into the interior ponding area during the analysis. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, and auxiliary inflows, if applicable. Seepage inflow is from the exterior and is therefore not included.
- **Seepage**: The maximum computed rate and total volume of seepage inflow into the interior ponding area during the analysis. Seepage is described in Chapter 9.
- **Total Inflow**: The maximum total computed rate and total volume of inflow to the interior ponding area during the analysis. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, auxiliary inflows, and seepage inflow, if applicable.
- **Pump**: The maximum total computed rate of discharge and the total discharge volume from all pumping units during the analysis. See Chapter 7.
- **Gravity Outlet**: The maximum total computed rate of outflow and the total outflow volume from all gravity outlets during the analysis. See Chapter 6.
- **Diversion**: The maximum computed rate of discharge and the total discharge volume from diversion during the analysis. Diversions apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area (which is in the lower interior sub-basin). See Chapter 9 for further details.
- **Overflow**: The maximum computed rate of outflow and the total outflow volume as a result of overflows from the interior ponding area at during the analysis.
- **Total Outflow**: The maximum total computed rate of outflow and the total outflow volume from the interior ponding area during the analysis. The total outflow includes gravity outflow, pump outflow, and overflows. Diversion outflow is not included, because it does not originate from the interior ponding area.

For each of the maximum values listed in this table, the corresponding **Da/HrMn** value is the date and time at the end of each time interval in which the maximum conditions occurred during the storm event. The storm event is assumed to begin at a time of zero hours and zero minutes on Day 1 of the storm, so the first computation period ends one time interval later. For example, the first time interval would end at 1/0015 for a 15-minute computation interval, or 1/0100 for a 1-hour computation interval.

When this summary screen appears, no storm event is selected and all values are displayed as zeroes. Use the left or right arrow keys to move to the desired storm event, then press the space bar to select it. The values for the selected storm event are then displayed. Repeat this procedure to display the results for a different storm event.

Pressing the F4 Goto key instructs HEC-IFH to move directly to any specified time interval in the time series. Pressing the F5 Report key causes the entire summary to be printed.

```
HEA 01.01.00                                                        SUMM33
Study ID  SILVERCR        Hydrologic Analysis Summaries
Plan ID   PLANB
                   L. Analysis by Events - Inflows and Outflows
                   Event  50%  20%  10% [4%] 2%  1%  0.2%  SPF
```

Flows		Max. Value (cfs)	Day/HrMn	Total Volume (ac-ft)
Inflow	Routed from Upper	0.0		0.0
	Runoff from Lower	4164.1	1/1800	4624.9
	Lower Auxiliary	0.0		0.0
	Total Interior	4164.1	1/1800	4624.9
	Seepage	0.0		0.0
	Total	4164.1	1/1800	4624.9
Outflow	Pump	199.3	1/1600	2125.1
	Gravity Outlet	176.9	2/2100	1853.6
	*Diversion	0.0		0.0
	Overflow	0.0		0.0
	*Total	376.2	2/2100	3978.7

```
               * Diversion is not part of total POND outflow.
1Help  2PrtScr 3     4      5      6DOS    7      8      9      10Exit
Press SPACE to select;        Press <F10> to Return
```

FIGURE 12.23 Summary of Inflows and Outflows for Hypothetical Event

12.6. HYPOTHETICAL EVENT ANALYSIS EVENT COMPARISONS

There are six ***Event Comparisons*** which compare the results of analyses of all eight hypothetical flood events:

1. **Rainfall-Runoff Data**: The total Precipitation Depth, Losses, and Peak Runoff Rate for both sub-basins for each hypothetical flood event.
2. **Maximum Flows**: The maximum routed upper sub-basin inflow, total interior inflow, and seepage inflow rates for each hypothetical flood event. The maximum gravity, pump, diversion and overflow outflow rates are also listed.
3. **Flood Volumes**: The total routed upper sub-basin inflow, total interior inflow, and seepage inflow volumes for each hypothetical flood event. The maximum gravity, pump, diversion and overflow outflow volumes are also listed for each hypothetical flood event.
4. **Gravity Outlet Analysis**: The total outflow volume for each of the gravity outlets, along with the total days in which any of gravity outlets at the primary location were blocked during the analysis, for each hypothetical flood event.
5. **Pump Analysis**: The total pump capacity, the number of pumps, the pump start and stop elevations, the total hours pumped, and the pump energy expended during the analysis, for each hypothetical flood event.
6. **Frequency Analysis**: The maximum interior elevation, the maximum interior area flooded, and the maximum total interior inflow computed during the analysis, for each hypothetical flood event.

Figure 12.24 illustrates the Hypothetical Event **Rainfall-Runoff Data** summary, which includes the following data values for the specified plan:

- **Total Precip**: The total depth of precipitation applied to each of the sub-basins used during the analysis, for each hypothetical flood event. See Chapter 4.

- **Total Losses**: The total depth of losses subtracted from the total precipitation in each of the sub-basins used during the analysis, for each hypothetical flood event. See Chapter 4.
- **Peak Runoff**: The maximum computed flow rate of the runoff hydrograph for each of the sub-basins used during the analysis, for each hypothetical flood event. See Chapter 4.

The rainfall-runoff data summary also shows the **Type of Series**, which is an indicator of whether the interior basin precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

The F9 Plot key causes the HEC-IFH program to display a menu of available plots. Three different plots are available: one for each of the sub-basins. Figure 12.25 illustrates one of these plots. This probability-scaled plot shows the relationship between peak runoff rate and storm frequency.

The Standard Project Flood (SPF) runoff rate is depicted on each plot using a horizontal line segment, because the frequency of the SPF is not defined.

HEA 01.01.00 | Hydrologic Analysis Summaries | SUMM34
Study ID SILVERCR
Plan ID PLANB

M. Event Comparisons - Rainfall-Runoff Data

ANNUAL series | Storm Area: 15.00 (sq mi)

Event	Lower Sub-Basin Total Precip (in)	Lower Sub-Basin Total Losses (in)	Lower Sub-Basin Peak Runoff (cfs)	Upper Sub-Basin Total Precip (in)	Upper Sub-Basin Total Losses (in)	Upper Sub-Basin Peak Runoff (cfs)	Exterior Basin Total Precip (in)	Exterior Basin Total Losses (in)	Exterior Basin Peak Runoff (cfs)
50%	2.4	0.6	2240.	0.0	0.0	0.	0.0	0.0	0.
20%	3.3	0.7	2978.	0.0	0.0	0.	0.0	0.0	0.
10%	3.9	0.7	3554.	0.0	0.0	0.	0.0	0.0	0.
4%	4.5	0.7	4164.	0.0	0.0	0.	0.0	0.0	0.
2%	5.1	0.7	4657.	0.0	0.0	0.	0.0	0.0	0.
1%	5.6	0.7	5195.	0.0	0.0	0.	0.0	0.0	0.
0.2%	6.1	0.7	5804.	0.0	0.0	0.	0.0	0.0	0.
SPS	12.8	1.2	10382.	0.0	0.0	0.	0.0	0.0	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE 12.24 Summary of Rainfall-Runoff Data Event Comparison

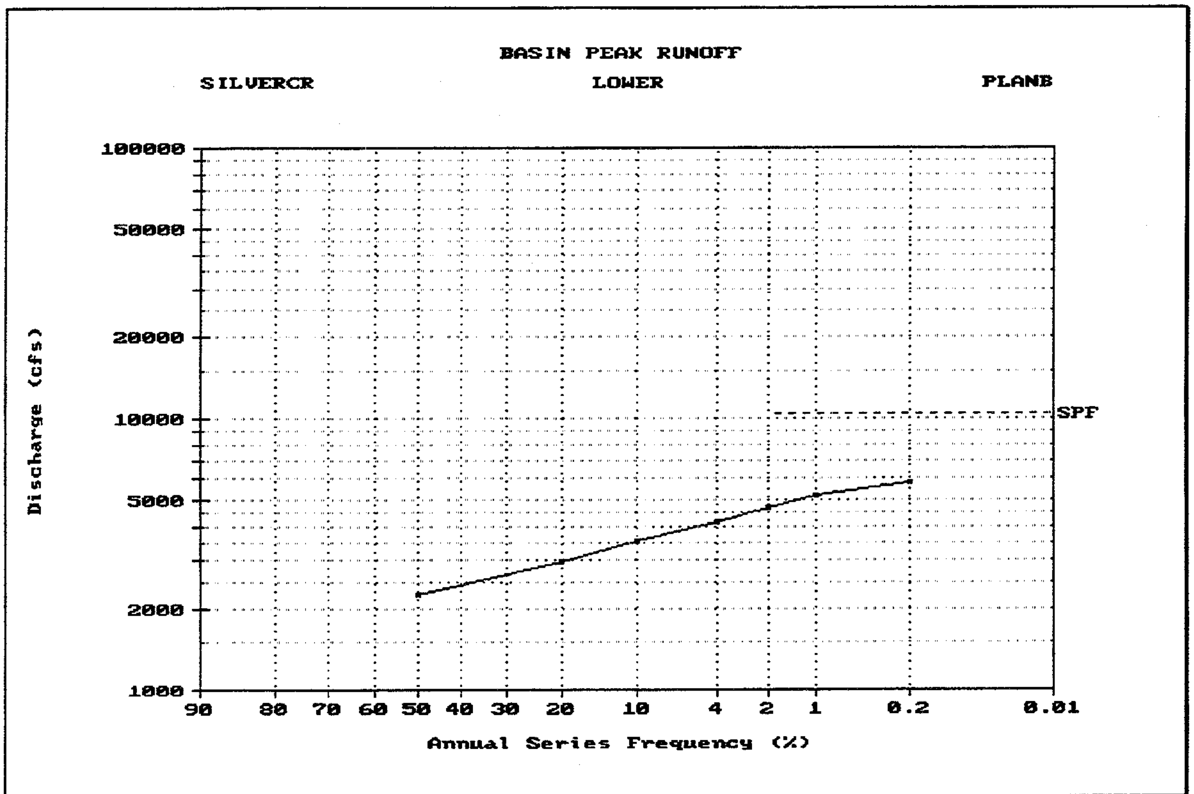


FIGURE 12.25 Plot of Rainfall-Runoff Data Event Comparison

Figure 12.26 illustrates the Hypothetical Event **Maximum Flows** summary, which includes the following data values for the specified plan:

- **Upper Routed**: The maximum computed flow rate of the hydrograph routed from the upper sub-basin during the analysis, for each hypothetical flood event. See Chapter 4.
- **Interior Total**: The maximum total computed rate of interior inflow into the interior ponding area during the analysis, for each hypothetical flood event. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, and auxiliary inflows, if applicable. Seepage inflow is from the exterior and is not included.
- **Seepage**: The maximum computed rate of seepage inflow into the interior ponding area during the analysis, for each hypothetical flood event. Seepage is described in Chapter 9.
- **Gravity**: The maximum total computed rate of outflow from all gravity outlets during the analysis, for each hypothetical flood event. See Chapter 6.
- **Pump**: The maximum total computed rate of discharge from all pumping units during the analysis, for each hypothetical flood event. See Chapter 7.
- **Diversion**: The maximum computed rate of discharge from diversion during the analysis, for each hypothetical flood event. Diversions apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area (which is in the lower interior sub-basin). See Chapter 9 for further details.

- **Overflow**: The maximum computed rate of outflow as a result of overflows from the interior ponding area during the analysis, for each hypothetical flood event.

The summary also shows the **Type of Series**, which is an indicator of whether the interior basin precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

HEA 01.01.00 SUMM35
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

N. Event Comparisons - Maximum Flows (cfs)

ANNUAL series Storm Area: 15.00 (sq mi)

	Inflow			Outflow			
Event	Upper Routed	Interior Total *	Seepage	Gravity	Pump	Diversion	Overflow
50%	0.0	2240.3	0.0	157.3	199.3	0.0	0.0
20%	0.0	2978.1	0.0	166.6	199.3	0.0	0.0
10%	0.0	3554.5	0.0	172.2	199.3	0.0	0.0
4%	0.0	4164.1	0.0	176.9	199.3	0.0	0.0
2%	0.0	4657.0	0.0	180.6	199.3	0.0	0.0
1%	0.0	5194.9	0.0	183.6	199.3	0.0	0.0
		5804.1	0.0	186.5	199.3	0.0	0.0
		10381.9	0.0	204.2	199.3	0.0	0.0

Select Option
A. Plot Inflows
B. Plot Outflows

or Inflow includes Routed, Lower Runoff and Auxiliary,
include Seepage.

4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 12.26 Summary of Maximum Flows Event Comparison

The F9 Plot key causes the HEC-IFH program to display a menu of available plots. Two different plots are available: Inflows and Outflows. Figure 12.27 is a probability-scaled plot showing the relationship between peak inflow rates and storm frequency. Figure 12.28 is a similar plot showing peak outflow rates versus storm frequency. On a computer monitor with color display capabilities, each type of inflow or outflow is displayed using a different color.

The Standard Project Flood (SPF) flow rates are depicted on the plots using a horizontal line segment, because the frequency of the SPF is not defined.

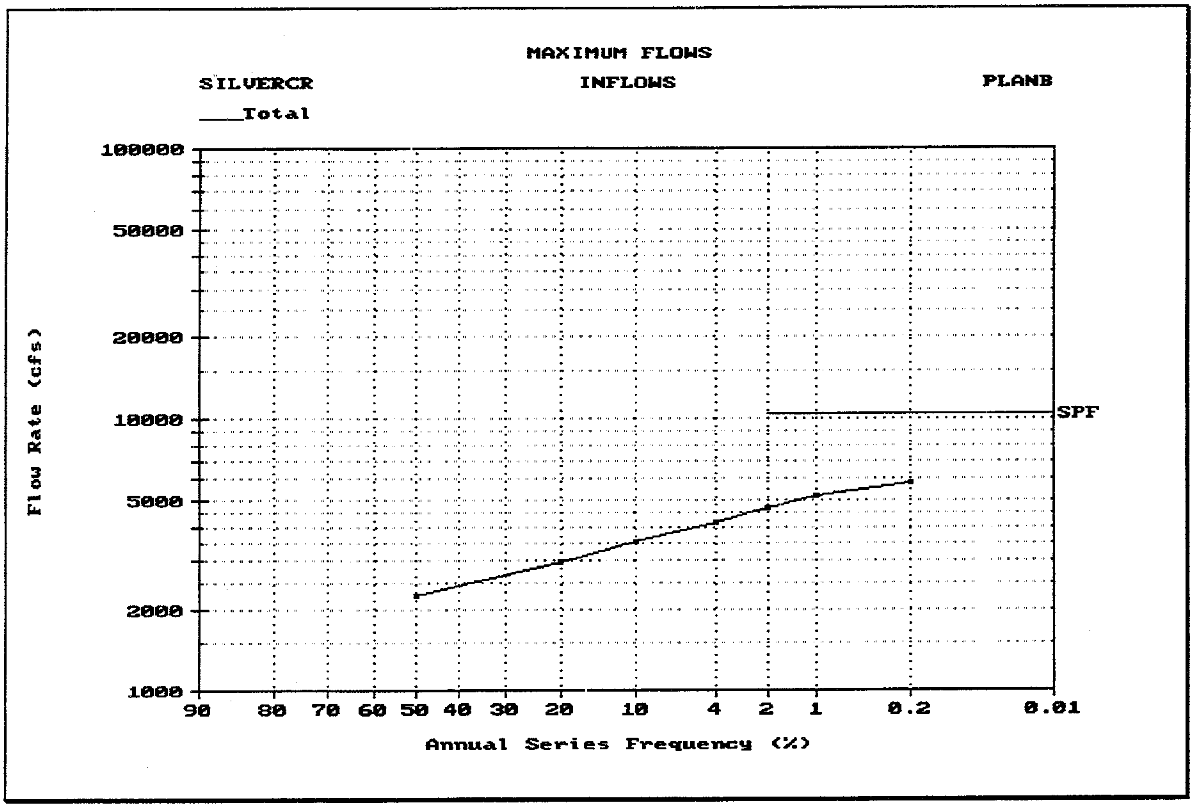


FIGURE 12.27 Plot of Maximum Inflows Event Comparison

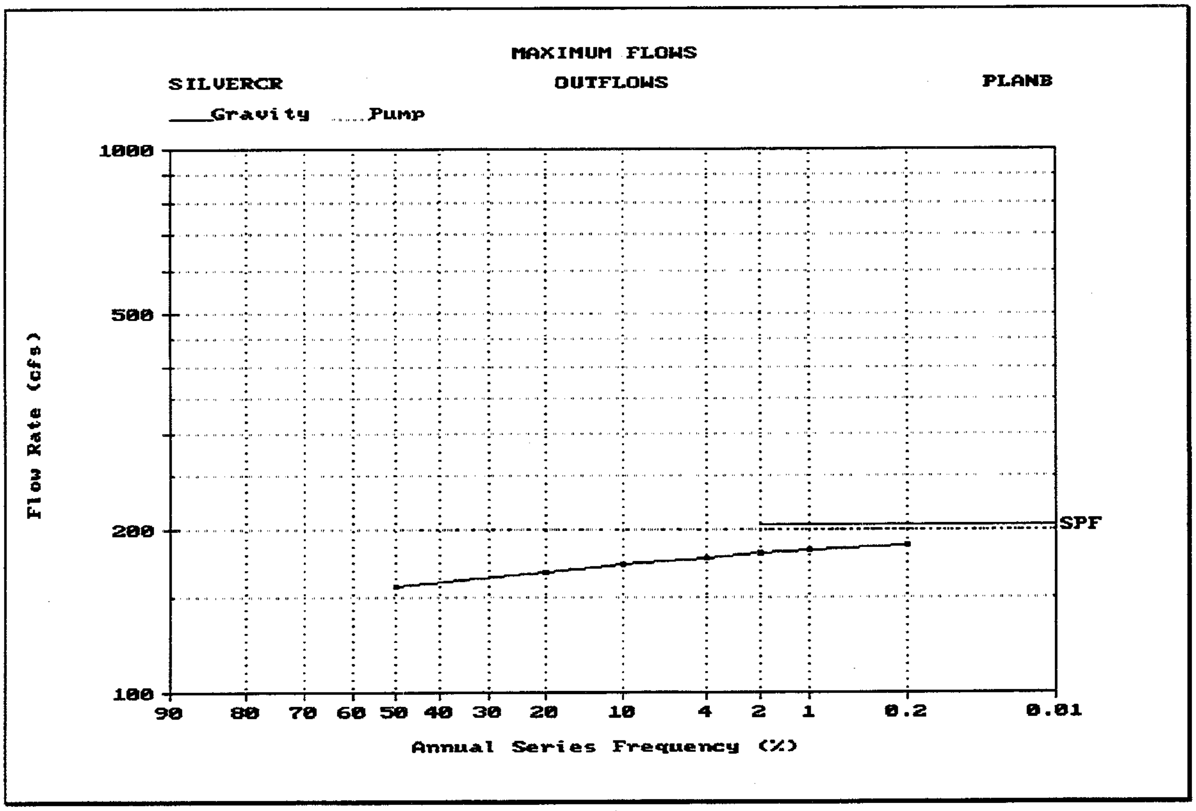


FIGURE 12.28 Plot of Maximum Outflows Event Comparison

Figure 12.29 illustrates the Hypothetical Event **Flood Volumes** summary, which includes the following data values for the specified plan:

- **Upper Routed**: The total computed volume of the hydrograph routed from the upper sub-basin during the analysis, for each hypothetical flood event. See Chapter 4.
- **Interior Total**: The total computed volume of interior inflow into the interior ponding area during the analysis, for each hypothetical flood event. The interior inflow volume includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, and auxiliary inflows, if applicable. Seepage inflow volume is from the exterior and is not included.
- **Seepage**: The total computed volume of seepage inflow into the interior ponding area during the analysis, for each hypothetical flood event. Seepage is described in Chapter 9.
- **Gravity**: The total computed volume of outflow from all gravity outlets during the analysis, for each hypothetical flood event. See Chapter 6.
- **Pump**: The total computed volume of discharge from all pumping units during the analysis, for each hypothetical flood event. See Chapter 7.
- **Diversion**: The total computed volume of discharge from diversion during the analysis, for each hypothetical flood event. Diversions apply to the upper interior sub-basin, so diversion outflows are not directly comparable to other outflows, which apply to the interior ponding area (which is in the lower interior sub-basin). See Chapter 9 for further details.
- **Overflow**: The total computed volume of outflow as a result of overflows from the interior ponding area during the analysis, for each hypothetical flood event.

The summary also shows the **Type of Series**, which is an indicator of whether the interior precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

The [F9] Plot key causes the HEC-IFH program to display a menu of available plots. Two different plots are available: Inflow Volume and Outflow Volume. Figure 12.30 is a probability-scaled plot showing the relationship between inflow volumes and storm frequency. Figure 12.31 is a similar plot showing outflow volumes versus storm frequency. On a computer monitor with color display capabilities, each type of inflow or outflow volume is displayed using a different color.

The Standard Project Flood (SPF) volumes are depicted on the plots using a horizontal line segment, because the frequency of the SPF is not defined.

HEA 01.01.00 SUMM36
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

O. Event Comparisons - Flood Volumes (ac-ft)

ANNUAL series Storm Area: 15.00 (sq mi)

Event	Inflow Volume			Outflow Volume			
	Upper Routed	Interior Total *	Seepage	Gravity	Pump	Diversion	Overflow
50%	0.0	2343.1	0.0	1222.6	1120.2	0.0	0.0
20%	0.0	3284.6	0.0	1619.6	1663.9	0.0	0.0
10%	0.0	3956.8	0.0	1930.3	2026.3	0.0	0.0
4%	0.0	4679.8	0.0	2258.2	2421.7	0.0	0.0
2%	0.0	5322.8	0.0	2571.7	2751.1	0.0	0.0
1%	0.0	5916.2	0.0	2850.5	3064.1	0.0	0.0
		9.7	0.0	3163.4	3377.1	0.0	0.0
		1.1	0.0	6429.1	6556.6	0.0	0.0

Select Option

A. Plot Inflow Volumes
B. Plot Outflow Volumes

low includes Routed, Lower Runoff and Auxiliary,
de Seepage.

5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 12.29 Summary of Flood Volumes Event Comparison

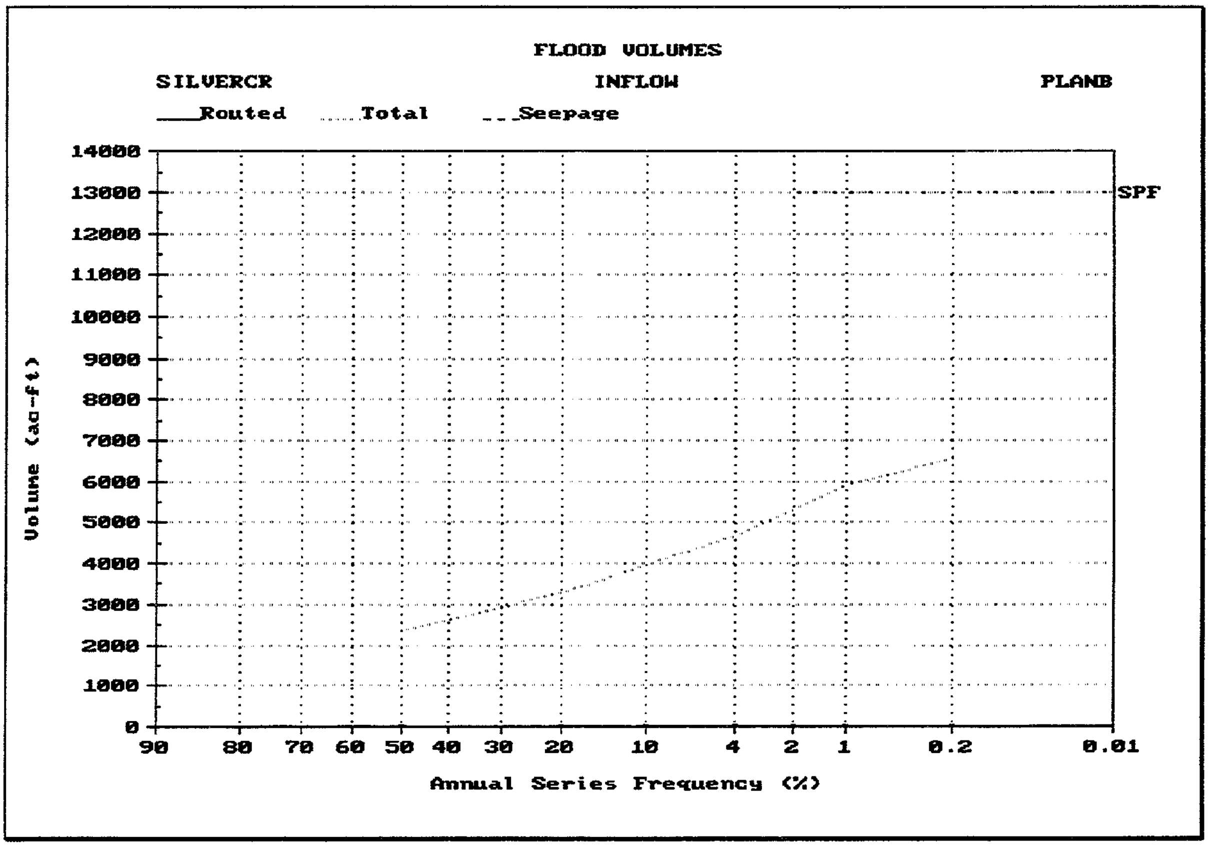


FIGURE 12.30 Plot of Inflow Volumes Event Comparison

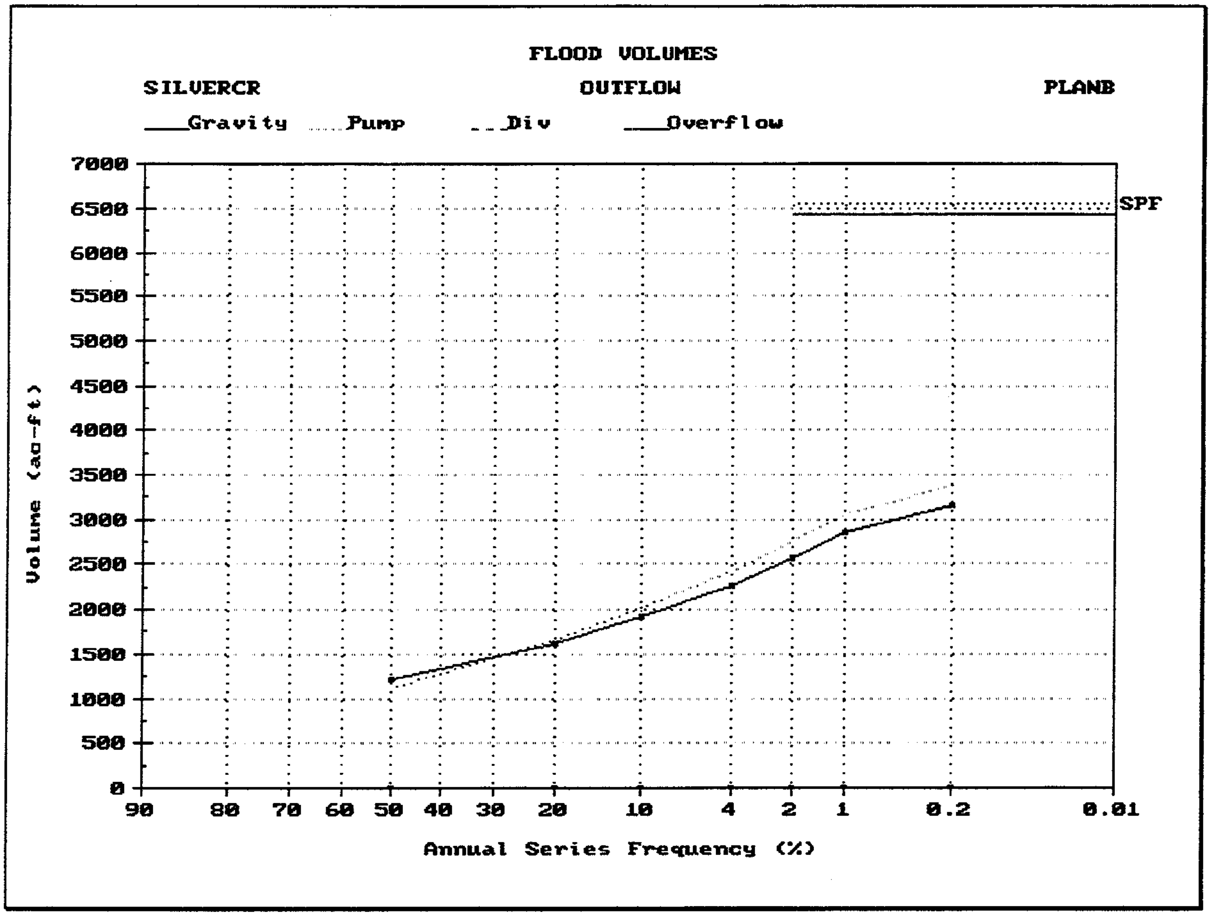


FIGURE 12.31 Summary of Outflow Volumes Event Comparison

Figure 12.32 illustrates the Hypothetical Event **Gravity Outlet Analysis** summary, which includes the following data values for the specified plan:

- **Primary Gravity Outlet Volume of Outflow**: The total computed volume of outflow from all the gravity outlets at the Primary outlet location during the analysis, for each hypothetical flood event.
- **Primary Gravity Outlet Total Hours Blocked**: The total number of hours in which the interior pond water surface elevation was higher than the lowest culvert invert elevation at the primary outlet location, but there was not discharge for the culvert. for each hypothetical flood event. The lack of discharge is attibutable to either of 2 conditions: 1) the exterior water surface elevation is greater than the gate closure elevation for the outlet; or 2) the differential head (interior - exterior) is less than the minimum head for operation of the outlet.
- **Secondary Outlet 1 Outflow Volumes**: The total computed volume of outflow from all the gravity outlets at the Secondary 1 outlet location during the analysis, for each hypothetical flood event.
- **Secondary Outlet 2 Outflow Volumes**: The total computed volume of outflow from all the gravity outlets at the Secondary 2 outlet location during the analysis, for each hypothetical flood event.

- **Secondary Outlet 3 Outflow Volumes:** The total computed volume of outflow from all the gravity outlets at the Secondary 3 outlet location during the analysis, for each hypothetical flood event.
- **Secondary Outlet 4 Outflow Volumes:** The total computed volume of outflow from all the gravity outlets at the Secondary 4 outlet location during the analysis, for each hypothetical flood event.

HEA 01.01.00 | **Hydrologic Analysis Summaries** | SUMM38

Study ID SILVERCR

Plan ID PLANB

P. Event Comparisons - Gravity Outlet Analysis

ANNUAL series | Storm Area: 15.00 (sq mi)

	Primary Gravity Outlet		Secondary Gravity Outlet Outflow Volumes (ac-ft)			
Event	Volume of Outflow (ac-ft)	Total Hours Blocked	Secondary Outlet 1	Secondary Outlet 2	Secondary Outlet 3	Secondary Outlet 4
50%	1222.6	0.	0.0	0.0	0.0	0.0
20%	1619.6	0.	0.0	0.0	0.0	0.0
10%	1930.3	0.	0.0	0.0	0.0	0.0
4%	2258.2	0.	0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0

Select Option:

A. Plot Volume at Primary Outlet
B. Plot Hours Blocked at Primary Outlet
C. Plot Volumes of Secondary Outlets

7 8 9 10Exit

Press <F10> to Return

FIGURE 12.32 Summary of Gravity Outlet Analysis Event Comparison

The summary also shows the **Type of Series**, which is an indicator of whether the interior basin precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

The [F9] Plot key causes the HEC-IFH program to display a menu of available plots. Three different plots are available:

1. **Volume at Primary Outlet**, as illustrated in Figure 12.33.
2. **Hours Blocked at Primary Outlet.**
3. **Volumes of Secondary Outlets.**

All of these are probability-scaled plots showing the relationship between the quantities described and the storm frequency. On a computer monitor with color display capabilities, the volumes of each secondary outlet are displayed using a different color.

The Standard Project Flood (SPF) results are depicted on the plots using a horizontal line segment, because the frequency of the SPF is not defined.

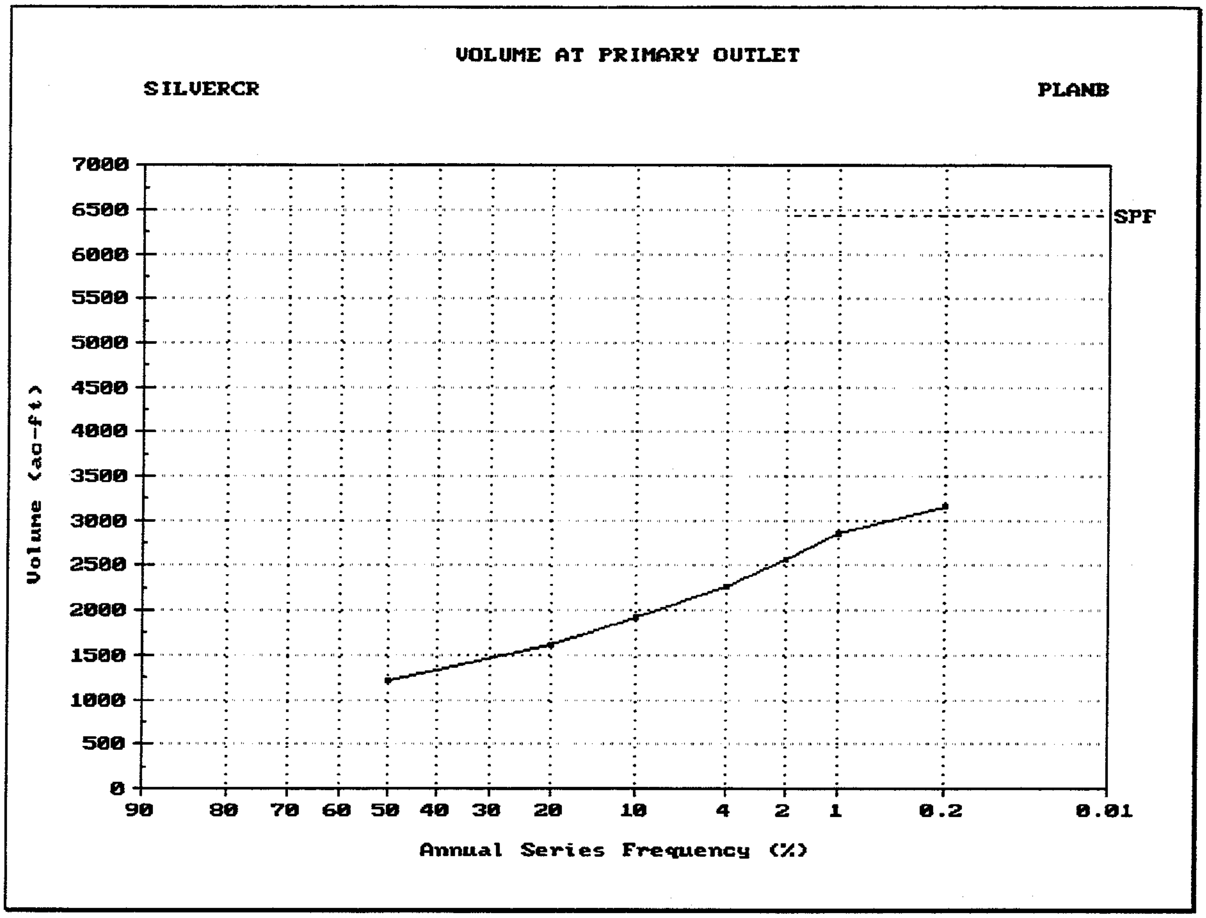


FIGURE 12.33 Plot of Volume at Primary Outlet Event Comparison

Figure 12.34 illustrates the Hypothetical Frequency **Pump Analysis** summary, which includes the following data values for the specified plan:

- **Total Pump Capacity**: The total maximum capacity of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Number of Pumps**: The total number of pumping units available for the analysis.
- **Min. Pump Start Elevation**: The lowest of all of the pump start elevations entered for each of the pumping units available for the analysis.
- **Min. Pump Stop Elevation**: The lowest of all of the pump stop elevations entered for each of the pumping unit available for the analysis.
- **Total Hours Pumped**: The total number of hours in which at least one of the pumping units discharged during the analysis, for each hypothetical flood event.
- **Pump Energy**: The total amount of energy expended in operating all of the pumping units during the analysis, for each hypothetical flood event. The pump energy is computed considering the efficiency of the pumping units.

The summary also shows the **Type of Series**, which is an indicator of whether the interior basin precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

The F9 Plot key causes the HEC-IFH program to display a menu of available plots. Two different plots are available: **Total Hours Pumped** (Figure 12.35) and **Pump Energy** . The Standard Project Flood (SPF) results are depicted on the plots using a horizontal line segment, because the frequency of the SPF is not defined.

HEA 01.01.00
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

SUMM39

Q. Event Comparisons - Pump Analysis

ANNUAL series

Storm Area: 15.00 (sq mi)

Event	Total Pump Capacity (cfs)	Number of Pumps	Min. Pump Start Elev. (ft)	Min. Pump Stop Elev. (ft)	Total Hours Pumped	Pump Energy (mW-hrs)
50%	200.0	1.	600.00	598.00	2.8	0.00
20%	200.0	1.	600.00	598.00	4.2	0.00
10%	200.0	1.	600.00	598.00	5.1	0.00
4%	200.0	1.	600.00	598.00	6.1	0.00
2%	200.0	1.	600.00	598.00	7.0	0.00
1%	200.0	1.	600.00	598.00	7.8	0.00
0.2%	200.0	1.	600.00	598.00	8.5	0.00
		1.	600.00	598.00	16.6	0.00

Select Option:

A. Plot Total Hours Pumped
B. Plot Pump Energy

5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 12.34 Summary of Pump Analysis Event Comparison

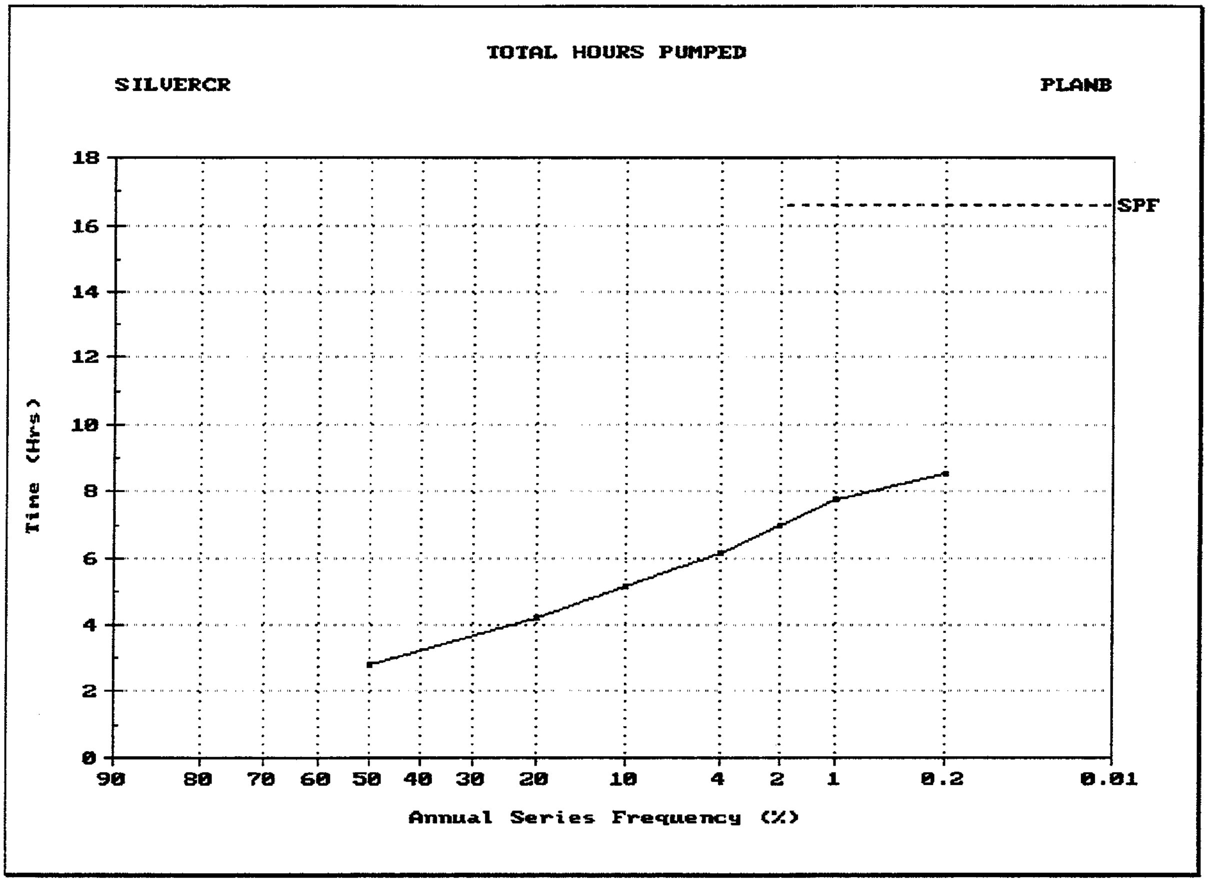


FIGURE 12.35 Plot of Total Hours Pumped Event Comparison

Figure 12.36 illustrates the Hypothetical Event **Frequency Analysis** summary, which includes the following data values for the specified plan:

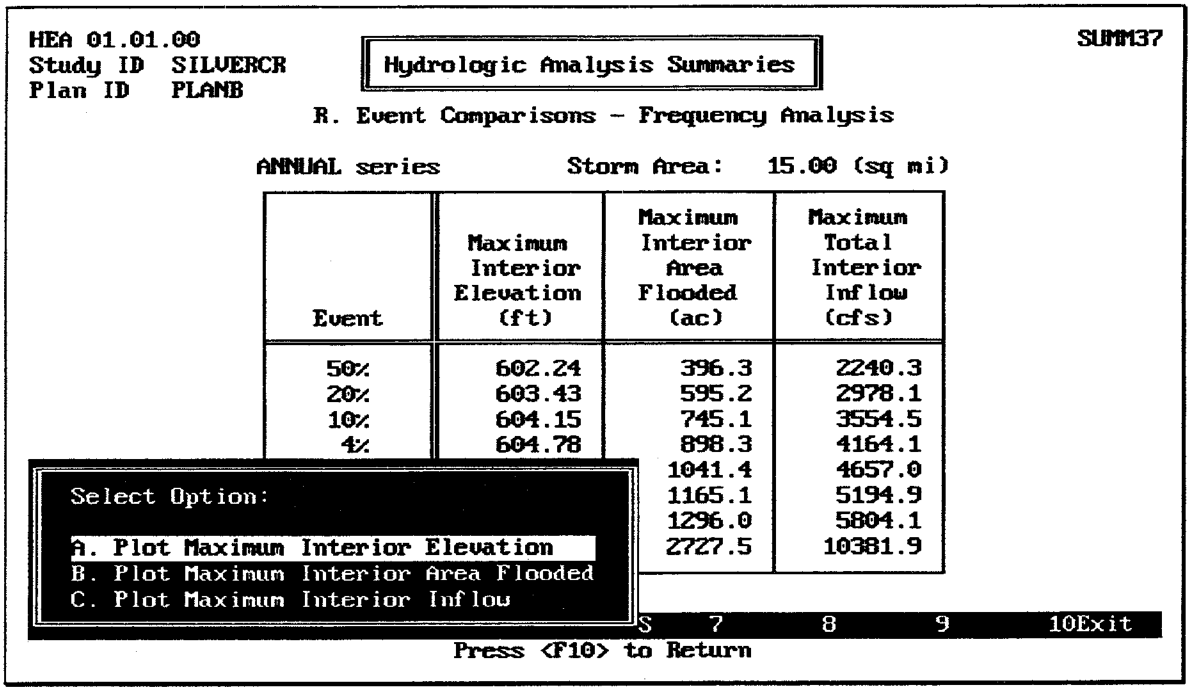
- **Maximum Interior Elevation**: The maximum computed water surface elevation in the interior ponding area during the analysis, for each hypothetical flood event.
- **Maximum Interior Area Flooded**: The maximum computed surface area of the interior ponding area during the analysis, for each hypothetical flood event.
- **Maximum Total Interior Inflow**: The maximum total computed rate of interior inflow into the interior ponding area during the analysis, for each hypothetical flood event. The interior inflow includes the direct runoff from the lower sub-basin, the routed flows from the upper sub-basin, and auxiliary inflows, if applicable.

The summary also shows the **Type of Series**, which is an indicator of whether the interior basin precipitation computations were performed on the basis of ANNUAL series or PARTIAL duration series frequency. The **Storm Area** is also displayed. This is the total area over which the interior basin storm event occurred, as specified in the Precipitation Module (Chapter 3).

The F9 Plot key causes the HEC-IFH program to display a menu of available plots:

1. **Maximum Interior Elevation**, as illustrated in Figure 12.37.
2. **Maximum Interior Area Flooded**, as illustrated in Figure 12.38.
3. **Maximum Interior Inflow**, as illustrated in Figure 12.39.

All of these are probability-scaled plots showing the relationship between the quantities described and the storm frequency. The Standard Project Flood (SPF) results are depicted on the plots using a horizontal line segment, because the SPF frequency is not defined.



HEA 01.01.00
Study ID SILVERCR
Plan ID PLANB

Hydrologic Analysis Summaries

SUMM37

R. Event Comparisons - Frequency Analysis

ANNUAL series Storm Area: 15.00 (sq mi)

Event	Maximum Interior Elevation (ft)	Maximum Interior Area Flooded (ac)	Maximum Total Interior Inflow (cfs)
50%	602.24	396.3	2240.3
20%	603.43	595.2	2978.1
10%	604.15	745.1	3554.5
4%	604.78	898.3	4164.1
		1041.4	4657.0
		1165.1	5194.9
		1296.0	5804.1
		2727.5	10381.9

Select Option:

A. Plot Maximum Interior Elevation
B. Plot Maximum Interior Area Flooded
C. Plot Maximum Interior Inflow

S 7 8 9 10Exit

Press <F10> to Return

FIGURE 12.36 Summary of Frequency Analysis Event Comparison

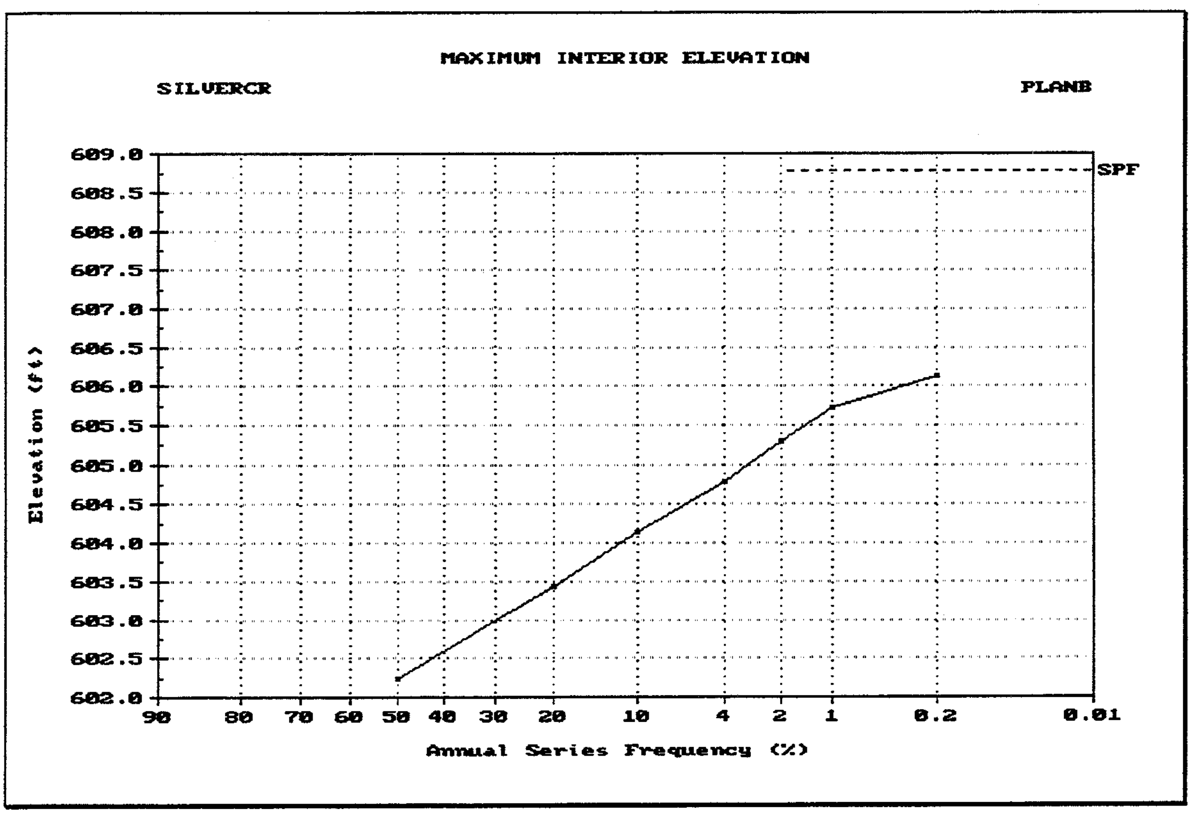


FIGURE 12.37 Plot of Maximum Interior Elevation Event Comparison

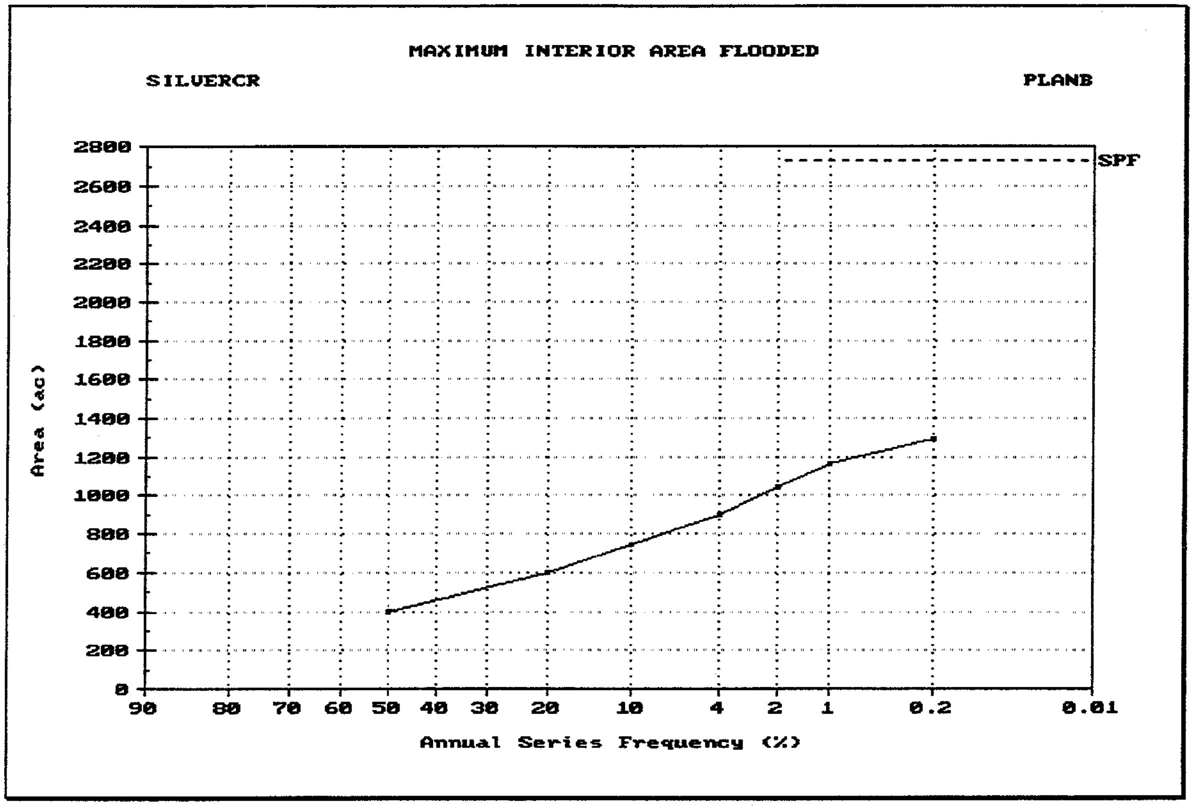


FIGURE 12.38 Plot of Maximum Interior Area Flooded Event Comparison

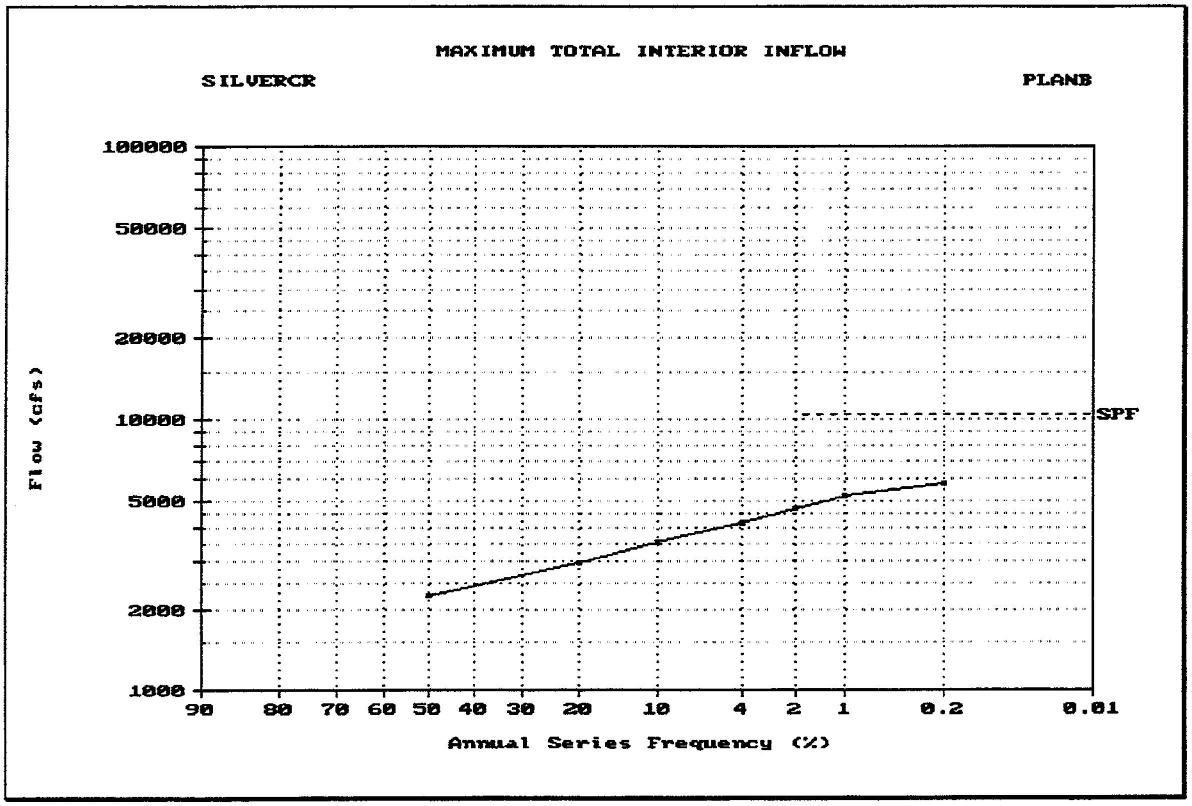


FIGURE 12.39 Plot of Maximum Total Interior Inflow Event Comparison

Figure 12.40 illustrates the **Error Messages** analysis record summary, which includes the error messages and warning messages generated by HEC-IFH during each analysis. Since these error messages may be too numerous to fit on one screen, a "file browser" or "list" utility program is used to provide access to the entire range of error and warning messages. The file browser allows the messages to be scrolled in increments of one line or one screen at a time, either up or down.

Error and warning messages are intended to be fairly self-explanatory. Appendix E of this manual provides a listing of all error and warning messages with further background information.

```
LIST       1                 02/29/92 20:25 ♦ SILVERCR\PLANB.ERR
Plan PLANB                        Errors and Warnings            29FEB1992/201803



+--------------------------------------------------------------------------------+
:   Exterior Stage Hydrograph Calculations                    29FEB1992/134553   :
+--------------------------------------------------------------------------------+
WARNING: Cannot read transfer relation.  Exterior stage not computed.


+--------------------------------------------------------------------------------+
:   Exterior Stage Hydrograph Calculations                    29FEB1992/134554   :
+--------------------------------------------------------------------------------+
WARNING: Cannot read transfer relation.  Exterior stage not computed.


+--------------------------------------------------------------------------------+
:   Exterior Stage Hydrograph Calculations                    29FEB1992/134554   :
+--------------------------------------------------------------------------------+
WARNING: Cannot read transfer relation.  Exterior stage not computed.
Command▸    *** Top-of-file ***          Keys: ↑↓→← PgUp PgDn F10=exit F1=Help
```

FIGURE 12.40 Analysis Record Summary of Error Messages

CHAPTER 13.
Comparison of Plans

13.1. INTRODUCTION

One of the most useful aspects of the IFH program is the ability to generate results for several different plans and then compare these results directly. In this way, the effects of different conditions or assumptions can be quickly evaluated.

To make it easier to compare different plans, a series of special reports called ***Plan Comparison Summaries*** are available. These reports display the results of specified plans side-by-side. Some reports include plots which allow plan results to be compared graphically.

13.2. HEC-IFH NUMERIC DISPLAY FORMATS

As noted in Chapter 11 and Chapter 12, all HEC-IFH summaries are displayed using tables formed by horizontal and vertical lines. Numeric output values displayed in such tables are generally limited to a fixed number of digits and a fixed decimal point location. The total number of digits and the position of the decimal point for each output value have been carefully selected to display a very wide range of values. However, the values may occasionally overflow the number of digits available. In such cases, HEC-IFH automatically modifies the display format to provide appropriate values within the space available, rather than simply printing the uninformative "*****.*" value which is the FORTRAN default output.

For example, assume that a particular summary displays peak runoff rate to the nearest 0.1 unit using seven total characters. The highest peak runoff rate which could normally be displayed in such a summary would be 99999.9 units. However, if a peak runoff rate of 4,189,876 units is computed, HEC-IFH automatically eliminates the decimal point and the digit right of the decimal point, and 4189876 is displayed as a seven-digit integer.

HEC-IFH will automatically use exponential notation to display output values which are too large for display even as integers. For example, if the computed runoff rate in the example above were 13,894,176 units, it could not be displayed in seven total characters, even as an integer. In such a case, HEC-IFH would automatically display the value as 13894E3, which is 13,894 times 10^3, or 13,894,000.

13.3. SELECTION OF PLAN COMPARISON SUMMARIES

Figure 13.1 illustrates the screen used to select plans for Plan Comparison Summaries. As shown, up to 7 plans may be selected by specifying the **Plan ID**. In order for a plan to be used in a Plan Comparison Summary, the plan computations described in Chapter 10 must have been completed. The [F3] Index key may be used to display a list of valid Plan IDs. As each Plan ID is specified, the corresponding Plan Description is displayed for verification.

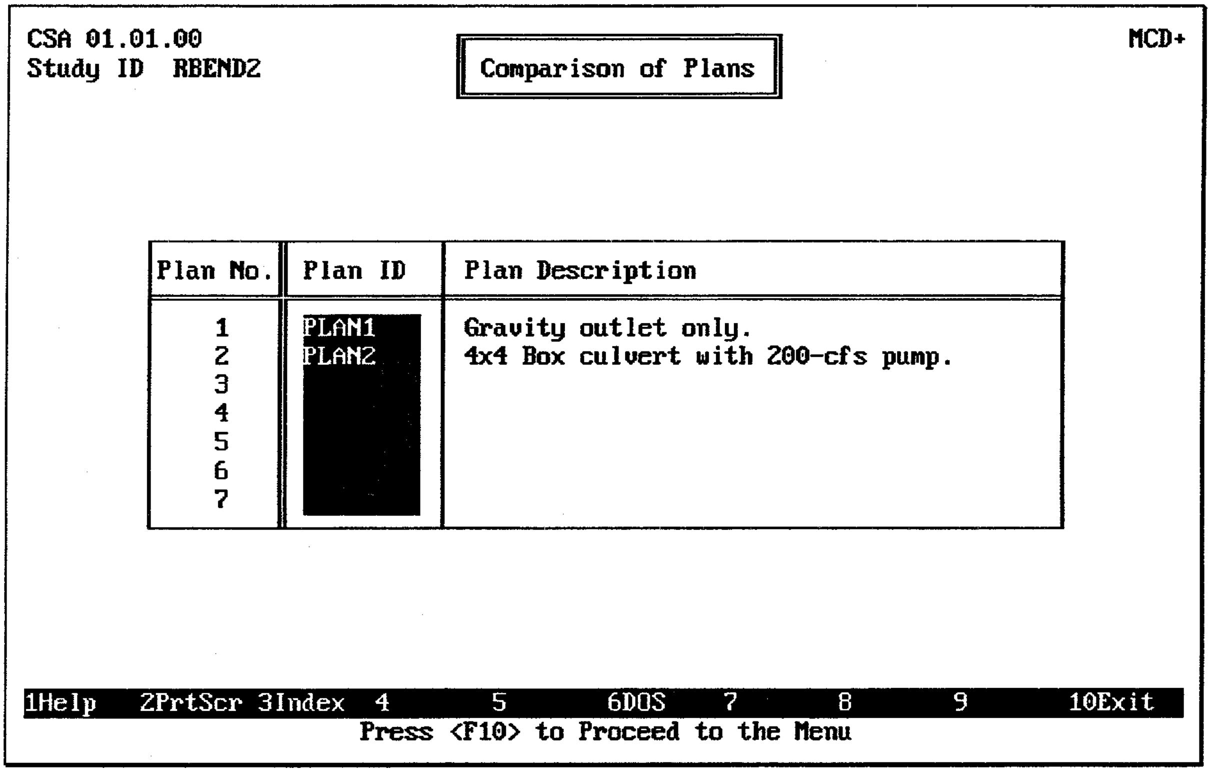


FIGURE 13.1 CSA Plan Comparison Summaries Plan Selection Screen

13.4. CSA PLAN COMPARISON SUMMARIES

Eight (8) Plan Comparison Summaries are available for Continuous Simulation Analyses. These 8 reports fall into four categories:

1. **Analysis Summaries**: Reports which compare the overall maximum or total values generated during the analysis of several plans. These include the Maximum Values Analysis Summary and the Flood Volume Analysis Summary.

2. **Gravity Outlet Analysis Summaries**: Reports which compare the gravity outflows from the interior area for several plans. These include the Gravity Outlet Outflow Volumes and the Gravity Outlet Days Blocked.

3. **Pump Analysis Summaries**: Reports which compare the pump outflows from the interior area for several plans. The Pump Capacity Summary and Days Pumped report is available in this category.

4. **Interior Analysis Summaries**: Reports which present specific comparisons of plan results for the interior ponding area. These include Maximum Interior Elevations, Duration of Interior Flooding, and Maximum Interior Area Flooded. Each of these reports are accompanied by plots.

Figure 13.2 illustrates the Plan Comparison menu which is used to select which Plan Comparison Summary to display. After each report is displayed on the screen, the F2 PrtScrn key may be used to generate a printed copy of the report. All reports fit on a single computer screen, so lengthy printed reports are not necessary.

```
CSA 01.01.00                                                        MCD
Study ID  RBEND2             Comparison of Plans

                   Analysis Summaries
                     A. Maximum Values
                     B. Flood Volume Data

                   Gravity Outlet Analysis
                     C. Outflow Volumes
                     D. Days Blocked

                   Pump Analysis
                     E. Capacity Summary and Days Pumped

                   Interior Analysis
                     F. Maximum Interior Elevations
                     G. Duration of Interior Flooding
                     H. Maximum Interior Area Flooded

1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
            Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 13.2 Continuous Simulation Plan Comparison Summary Menu

13.4.1. Plan Comparison Analysis Summaries

Two (2) Plan Comparison Analysis Summaries are available for Continuous Simulation Analyses. These reports compare the overall maximum or total values generated during the analysis of several plans:

1. Maximum Values Analysis Summary
2. Flood Volume Analysis Summary

Figure 13.3 illustrates the **Maximum Values Analysis Summary**, which includes the following data values for each plan specified for comparison:

- **Exterior Elev.**: The maximum exterior water surface elevation recorded during the analysis.
- **Interior Elev.**: The maximum interior water surface elevation recorded during the analysis.
- **Interior Area Flooded**: The maximum interior surface area flooded during the analysis.
- **Maximum Head Differential**: The maximum difference between interior and exterior water surface elevations recorded during the analysis.
- **Minimum Head Differential**: The minimum difference between interior and exterior water surface elevations recorded during the analysis. This value will be negative in most cases.
- **Pump Head**: The maximum head differential recorded while at least one pumping unit was operating during the analysis.

- **Pump Outflow**: The maximum flow rate for the combined pumping units during the analysis.

CSA 01.01.00 | Comparison of Plans | COMP02

Study ID RBEND2

A. Analysis Summaries - Maximum Values

Plan ID	Exterior Elev. (ft)	Interior Elev. (ft)	Interior Area Flooded (ac)	Head Differential Maximum (ft)	Head Differential Minimum (ft)	Pump Data Head (ft)	Pump Data Outflow (cfs)
PLAN1	613.74	602.89	1313.9	17.34	-11.00	0.00	0.0
PLAN2	613.74	602.28	1114.5	17.34	-11.53	11.53	199.3

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 13.3 Maximum Values Analysis Summary

Figure 13.4 illustrates the **Flood Volume Analysis Summary**, which includes the following data values for each plan specified for comparison:

- **Routed from Upper**: The total volume of the hydrograph which is routed from the upper sub-basin to the lower sub-basin during the analysis.
- **Runoff into Lower**: The total volume of direct runoff from the lower sub-basin during the analysis.
- **Auxiliary Inflow**: The total volume of auxiliary inflows into the lower sub-basin during the analysis.
- **Seepage Inflow**: The total volume of seepage inflows into the interior pond during the analysis.
- **Gravity Outflow**: The total volume of outflow from all gravity outlets during the analysis.
- **Pump Outflow**: The total volume of outflow from all pumping units during the analysis.
- **Diversion Outflow**: The total volume of diversion overflows from the upper interior sub-basin during the analysis.
- **Overflow Outflow**: The total volume of auxiliary overflows from the interior ponding area during the analysis.

CSA 01.01.00 COMP03
Study ID RBEND2

Comparison of Plans

B. Analysis Summaries - Flood Volume Data

	Inflow (ac-ft)				Outflow (ac-ft)			
Plan ID	Routed from Upper	Runoff into Lower	Auxil-iary	Seepage	Gravity	Pump	Diver-sion	Overflow
PLAN1	65896.	48277.	0.	0.	114377.	0.	0.	0.
PLAN2	65896.	48277.	0.	0.	105571.	8809.	0.	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 13.4 Flood Volume Analysis Summary

13.4.2. Plan Comparison Gravity Outlet Analysis Summaries

Two (2) Plan Comparison Gravity Outlet Analysis Summaries are available for Continuous Simulation Analyses. These reports compare the gravity outflows from the interior area for several plans:

1. Gravity Outlet Outflow Volumes
2. Gravity Outlet Days Blocked

Figure 13.5 illustrates the **Gravity Outlet Outflow Volumes**, which includes the following data values for each plan specified for comparison:

- **Primary Outlet Outflow Volumes**: The total outflow volumes for all of the gravity outlets located at the primary outlet location, for each of the plans specified for comparison.
- **Secondary No. 1 Outflow Volumes**: The total outflow volumes for all of the gravity outlets located at the secondary outlet location no. 1, for each of the plans specified for comparison.
- **Secondary No. 2 Outflow Volumes**: The total outflow volumes for all of the gravity outlets located at the secondary outlet location no. 2, for each of the plans specified for comparison.
- **Secondary No. 3 Outflow Volumes**: The total outflow volumes for all of the gravity outlets located at the secondary outlet location no. 3, for each of the plans specified for comparison.

- **Secondary No. 4 Outflow Volumes**: The total outflow volumes for all of the gravity outlets located at the secondary outlet location no. 4, for each of the plans specified for comparison.
- **Total Outflow Volumes**: The total outflow volumes for all of the gravity outlets at all locations, for each of the plans specified for comparison.

CSA 01.01.00 | Comparison of Plans | COMP04

Study ID RBEND2

C. Gravity Outlet Analysis - Outflow Volumes

	Outflow Volumes (ac-ft)					
Plan ID	Primary Outlet	Secondary No. 1	Secondary No. 2	Secondary No. 3	Secondary No. 4	Total
PLAN1	114377.	0.	0.	0.	0.	114377.
PLAN2	105571.	0.	0.	0.	0.	105571.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Return

FIGURE 13.5 Gravity Outlet Outflow Volumes Summary

Figure 13.6 illustrates the **Gravity Outlet Days Blocked** summary. A gravity outlet is "blocked" during a particular time period if the pond elevation is higher than the interior invert elevation of the outlet, but the outlet did not convey any discharge. There are two possible causes for a blocked outlet:

1. The exterior water surface elevation is greater than the specified elevation for gate closure for the outlet.
2. The differential head (interior - exterior) is less than the specified minimum head for gravity operation.

This summary includes the following Total Days Blocked values for each plan specified for comparison:

- **Primary Total Days Blocked**: The total number of days in which any of the gravity outlets located at the primary outlet location is blocked during the analysis, for each of the plans specified for comparison.
- **Secondary No. 1 Total Days Blocked**: The total number of days in which any of the gravity outlets located at the secondary outlet location no. 1 is blocked during the analysis, for each of the plans specified for comparison.

- **Secondary No. 2 Total Days Blocked**: The total number of days in which any of the gravity outlets located at the secondary outlet location no. 2 is blocked during the analysis, for each of the plans specified for comparison.
- **Secondary No. 3 Total Days Blocked**: The total number of days in which any of the gravity outlets located at the secondary outlet location no. 3 is blocked during the analysis, for each of the plans specified for comparison.
- **Secondary No. 4 Total Days Blocked**: The total number of days in which any of the gravity outlets located at the secondary outlet location no. 4 is blocked during the analysis, for each of the plans specified for comparison.

Each of the Total Days Blocked values are computed by taking the total number of time periods in which any of the gravity outlets at each location are blocked during the analysis, and dividing this total by the number of time periods in 24 hours. For example, if at least one of the gravity outlets at the primary location is blocked for 1800 time periods during an analysis, and if the computation time interval for the analysis is 30 minutes, then the Total Days Blocked would be 1800/48 = 37.5, which would be rounded to 38 Total Days Blocked.

CSA 01.01.00
Study ID RBEND2

Comparison of Plans

COMP05

D. Gravity Outlet Analysis - Days Blocked

	Total Days Blocked					Average Annual Days Blocked				
Plan ID	Prim.	Sec. 1	Sec. 2	Sec. 3	Sec. 4	Prim.	Sec. 1	Sec. 2	Sec. 3	Sec. 4
PLAN1	139.	0.	0.	0.	0.	14.	0.	0.	0.	0.
PLAN2	143.	0.	0.	0.	0.	14.	0.	0.	0.	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 13.6 Gravity Outlet Days Blocked Summary

The Gravity Outlet Days Blocked Summary also includes the following Annual Days Blocked values:

- **Primary Average Annual Days Blocked**: The water year average annual number of days in which any of the gravity outlets located at the primary outlet location discharged during the analysis, for each of the plans specified for comparison.
- **Secondary No. 1 Average Annual Days Blocked**: The water year average annual number of days in which any of the gravity outlets located at the secondary outlet

location no. 1 discharged during the analysis, for each of the plans specified for comparison.

- **Secondary No. 2 Average Annual Days Blocked**: The water year average annual number of days in which any of the gravity outlets located at the secondary outlet location no. 2 discharged during the analysis, for each of the plans specified for comparison.
- **Secondary No. 3 Average Annual Days Blocked**: The water year average annual number of days in which any of the gravity outlets located at the secondary outlet location no. 3 discharged during the analysis, for each of the plans specified for comparison.
- **Secondary No. 4 Average Annual Days Blocked**: The water year average annual number of days in which any of the gravity outlets located at the secondary outlet location no. 4 discharged during the analysis, for each of the plans specified for comparison.

Each of the Average Annual Days Blocked values are computed by taking the Total Days Blocked and dividing by the number of water years, including fractions, during the analysis. For example, if the Total Days Blocked is 37.5 for an analysis which includes 3.5 water years, the Average Annual Days Blocked would be 37.5/3.5 = 10.7, which would be rounded to 11 Average Annual Days Blocked.

13.4.3. Plan Comparison Pump Outlet Analysis Summaries

One (1) Plan Comparison Pump Outlet Analysis Summary is available for Continuous Simulation Analyses. This report compares the pump outflows from the interior area for several plans. The **Pump Capacity Summary and Days Pumped** report is illustrated in FIgure 13.7. It contains the following data values:

- **Total Pump Capacity**: The total maximum capacity of all of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Number of Pump Units**: The total number of pumping units available for the analysis.
- **Minimum Pump Start Elevation**: The lowest pump start elevation entered for any pumping unit, for any month of the water year.
- **Minimum Pump Stop Elevation**: The lowest pump stop elevation entered for any pumping unit, for any month of the water year.
- **Maximum Pump Head**: The highest pump head differential recorded during the analysis, for a time period in which at least one pumping unit was operating.
- **Total Days Pumped**: The total number of days in which any of the pumping units discharged during the analysis, for each of the plans specified for comparison. This value is computed by taking the total number of time periods in which any of the pumping units discharged during the analysis, and dividing this total by the number of time periods in 24 hours. For example, if at least one of the pumping units discharged for 1800 time periods during an analysis, and if the computation time interval for the analysis is 30 minutes, then the Total Days Pumped would be 1800/48 = 37.5, which would be rounded to 38 Total Days Pumped.

- **Average Annual Days Pumped**: The water year average annual number of days in which any of the pumping units discharged during the analysis, for each of the plans specified for comparison. This value is computed by taking the Total Days Pumped and dividing by the number of water years, including fractions, during the analysis. For example, if the Total Days Pumped is 37.5 for an analysis which includes 3.5 water years, the Average Annual Days Pumped would be 37.5/3.5 = 10.7, which would be rounded to 11 Average Annual Days Pumped.

CSA 01.01.00 Comparison of Plans COMP06
Study ID RBEND2

E. Pump Analysis - Capacity Summary and Days Pumped

Plan ID	Total Pump Capacity (cfs)	Number of Pump Units	Min. Pump Start Elev. (ft)	Min. Pump Stop Elev. (ft)	Maximum Pump Head (ft)	Total Days Pumped	Average Annual Days Pumped
PLAN1	0.0	0	0.00	0.00	0.00	0.	0.
PLAN2	200.0	1	600.00	598.00	11.53	22.	2.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 13.7 Pump Capacity and Days Pumped Summary

13.4.4. Plan Comparison Interior Analysis Summaries

Three (3) Plan Comparison Interior Analysis Summaries are available for Continuous Simulation Analyses. These reports present specific comparisons of plan results for the interior ponding area:

1. Maximum Interior Elevations
2. Duration of Interior Flooding
3. Maximum Interior Area Flooded

Figure 13.8 illustrates the **Maximum Interior Elevations** summary, which includes the following values for each plan specified for comparison:

- **Area Prim. Grav.**: The total cross-sectional area of all of the gravity outlets at the primary outlet location.
- **Total Pump Cap.**: The total maximum capacity of all of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.

- **Peak Elevation vs. Percent Chance Exceedance Frequency Event**: The peak interior water surface elevation for each of several standard hypothetical-frequency flood events, including the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% flood events. These elevations are computed from a frequency analysis of the interior pond elevations.

CSA 01.01.00 COMP07
Study ID RBEND2

Comparison of Plans

F. Interior Analysis - Maximum Interior Elevations

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Peak Elevation (ft) vs. Percent Chance Exceedence Frequency Event						
			50%	20%	10%	4%	2%	1%	0.2%
PLAN1	16.0	0.0	599.89	601.06	601.75	603.50	605.00	605.00	605.00
PLAN2	16.0	200.0	599.80	600.85	601.46	602.46	603.37	604.44	605.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE 13.8 Maximum Interior Elevations Summary

While the Maximum Interior Elevations summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.9. This probability-scaled plot shows the relationship between interior water surface elevation and frequency for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

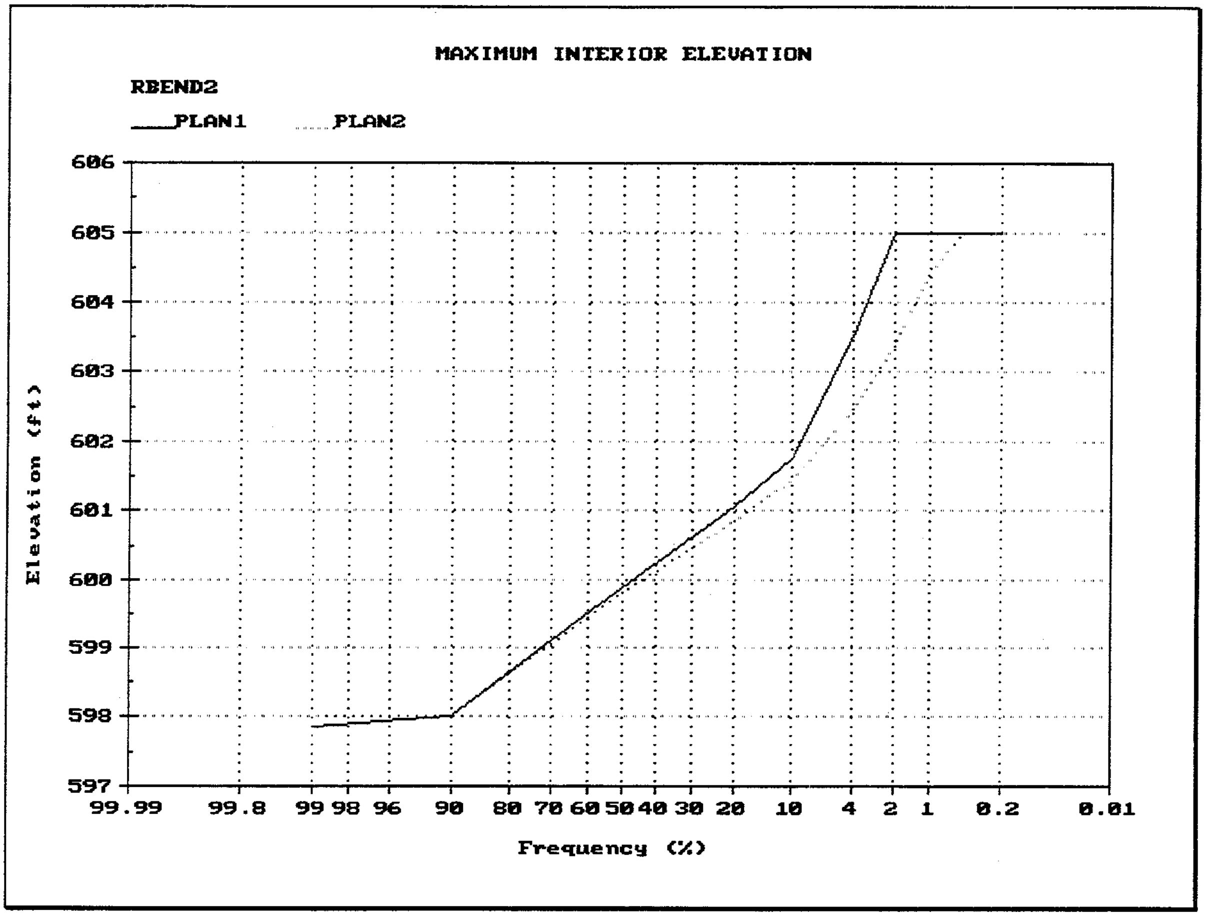


FIGURE 13.9 Maximum Interior Elevation Plot

Figure 13.10 illustrates the **Duration of Interior Flooding** summary, which includes the following values for each plan specified for comparison:

- **Area Prim. Grav.**: The total cross-sectional area of all of the gravity outlets at the primary outlet location.
- **Total Pump Cap.**: The total maximum capacity of all of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Average Annual Days Flooded**: The average Water Year annual days in which the water surface elevation exceeds each of seven user-specified elevations, for each of the plans specified for comparison.

While the Duration of Interior Area Flooding summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.11. This plot shows the relationship between interior water surface elevation and duration of interior area flooded for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

CSA 01.01.00
Study ID RBEND2

Comparison of Plans

COMP08

G. Interior Analysis - Duration of Interior Flooding

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Average Annual Days Flooded						
			591.40 Elev. 1	592.41 Elev. 2	595.14 Elev. 3	597.42 Elev. 4	598.56 Elev. 5	599.56 Elev. 6	601.93 Elev. 7
PLAN1	16.0	0.0	186.5	73.2	36.5	14.6	7.3	3.6	0.7
PLAN2	16.0	200.0	107.6	72.0	34.9	12.5	5.5	1.9	0.7

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE 13.10 Duration of Interior Flooding Summary

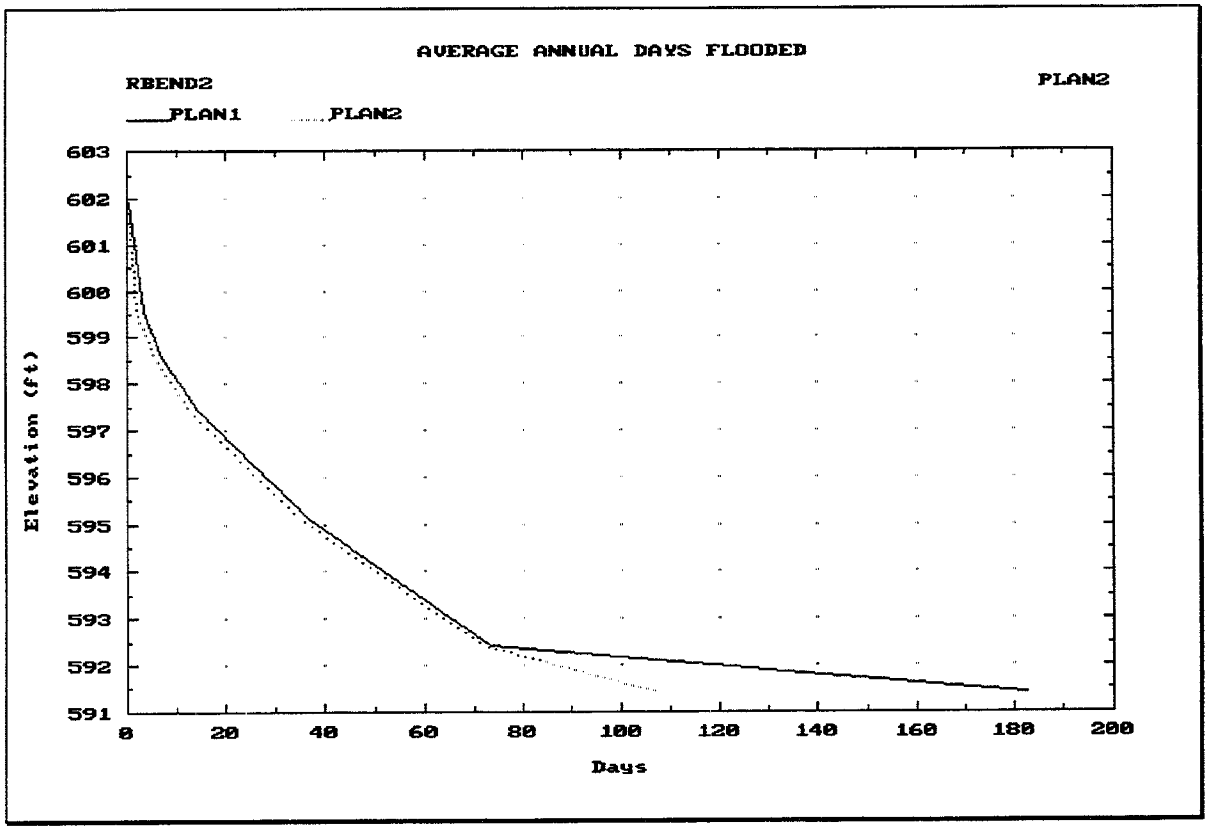


FIGURE 13.11 Duration of Interior Flooding Plot

Figure 13.12 illustrates the **Maximum Interior Area Flooded** summary, which includes the following values for each plan specified for comparison:

- **Area Prim. Grav.**: The total cross-sectional area of all of the gravity outlets at the primary outlet location.
- **Total Pump Cap.**: The total maximum capacity of all of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.
- **Maximum Interior Area Flooded**: The maximum interior area flooded for each of several standard hypothetical-frequency flood events, including the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% flood events. These areas are computed from a frequency analysis of the interior pond elevations.

CSA 01.01.00 COMP09
Study ID RBEND2

Comparison of Plans

H. Interior Analysis - Maximum Interior Area Flooded

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Maximum Interior Area Flooded (ac) vs. Percent Chance Exceedence Frequency Event						
			50%	20%	10%	4%	2%	1%	0.2%
PLAN1	16.0	0.0	1.6	6.5	82.8	231.4	345.4	469.5	1001.6
PLAN2	16.0	200.0	0.7	6.0	73.9	210.6	290.8	401.7	603.9

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE 13.12 Maximum Interior Area Flooded Summary

While the Maximum Interior Area Flooded summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.13. This probability-scaled plot shows the relationship between interior water surface elevation and frequency for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

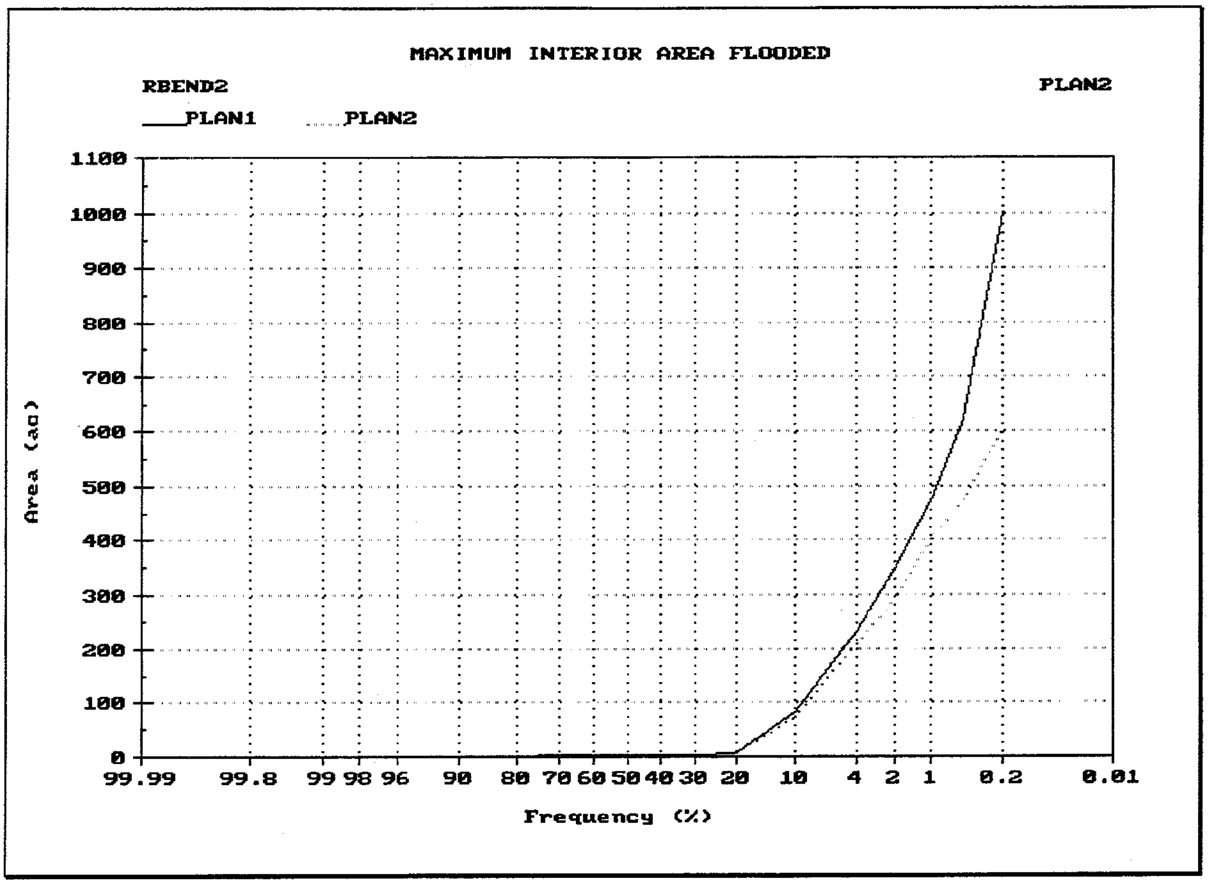


FIGURE 13.13 Maximum Interior Area Flooded Plot

13.5. HYPOTHETICAL EVENT ANALYSIS

Four (4) Plan Comparison Summaries are available for Hypothetical Event Analysis. Each Plan Comparison Summary lists results for up to seven specified plans, for a selected storm event.

Figure 13.14 illustrates the screen used to select plans for Plan Comparison Summaries. As shown, up to 7 plans may be selected by specifying the **Plan ID**. In order for a plan to be used in a Plan Comparison Summary, the plan computations described in Chapter 10 must have been completed. The F3 Index key may be used to display a list of valid Plan IDs. As each Plan ID is specified, the corresponding Plan Description is displayed for verification.

Figure 13.15 illustrates the Plan Comparison menu which is used to select which Plan Comparison Summary to display. After each report is displayed on the screen, the F2 PrtScrn key may be used to generate a printed copy of the report. All reports fit on a single computer screen, so lengthy printed reports are not produced. The following Plan Comparison Summaries are available:

1. Plan Summary
2. Maximum Interior Elevation-Frequency
3. Maximum Interior Area Flooded-Frequency
4. Maximum Total Interior Inflow-Frequency

```
HEA 01.01.00                                                        MDD+
Study ID  SILVERCR           Comparison of Plans

        | Plan No. | Plan ID | Plan Description                            |
        |    1     | PLANA   | 48-in CMP unblocked outlet conditions.       |
        |    2     | PLANB   | 48-in CMP unblocked outlet,1-200CFS PUMP     |
        |    3     |         |                                              |
        |    4     |         |                                              |
        |    5     |         |                                              |
        |    6     |         |                                              |
        |    7     |         |                                              |

1Help  2PrtScr 3Index  4     5     6DOS   7     8     9     10Exit
                  Press <F10> to Proceed to the Menu
```

FIGURE 13.14 HEA Plan Comparison Summaries Plan Selection Screen

```
HEA 01.01.00                                                        MDD
Study ID  SILVERCR           Comparison of Plans

            Select Option:

              A. Plan Summary
              B. Maximum Interior Elevation-Frequency
              C. Maximum Interior Area Flooded-Frequency
              D. Maximum Total Interior Inflow-Frequency

1Help  2PrtScr 3   4     5     6DOS   7     8     9     10Exit
          Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE 13.15 Hypothetical Event Plan Comparison Summary Menu

Figure 13.16 illustrates the **Plan Summary**, which includes the following values for each plan specified for comparison:

- **Type of Series**: As noted in Chapter 10, Hypothetical Event Analyses may be based on either Annual Series or Partial Duration Series Frequency Analysis. This column indicates the type of series used for each plan analysis.
- **Storm Area**: The total area over which the storm event occurred, as specified in the Precipitation Module (Chapter 3).
- **Area of Primary Grav. Out.**: The total cross-sectional area of all of the gravity outlets at the primary outlet location.
- **Min. Pump Start Elev.**: The lowest pump start elevation entered for any pumping unit.
- **Min. Pump Stop Elev.**: The lowest pump stop elevation entered for any pumping unit.
- **Total Pump Capacity**: The total maximum capacity of all of the pumping units available for the analysis. The maximum capacity of each pumping unit is the first capacity value entered in the pump head versus capacity table for the pumping unit.

HEA 01.01.00 COMP10
Study ID SILVERCR

Comparison of Plans

A. Plan Summary

Plan ID	Type of Series	Storm Area (sq mi)	Storm Duration (hr)	Area of Primary Grav.Out (sq ft)	Min Pump Start Elev. (ft)	Min Pump Stop Elev. (ft)	Total Pump Capacity (cfs)
PLANA	ANNUAL	15.00	24.00	12.57	0.00	0.00	0.0
PLANB	ANNUAL	15.00	24.00	12.57	600.00	598.00	200.0

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE 13.16 Plan Summary

Figure 13.17 illustrates the **Maximum Interior Elevation-Frequency** summary, which includes the following values for each plan specified for comparison:

- **Peak Elevation vs. Percent Chance Exceedance**: The peak elevation for each of several synthetic storm events, including the 50%, 20%, 10%, 4%, 2%, 1%, 0.2% and Standard Project Flood (SPF) flood events. If a particular storm event was not included in the analysis, the peak elevation for that storm event will be zero (0.00).

HEA 01.01.00 COMP13
Study ID SILVERCR

Comparison of Plans

B. Maximum Interior Elevation-Frequency

Plan ID	Peak Elevation (ft) vs. Percent Chance Exceedance							
	50%	20%	10%	4%	2%	1%	0.2%	SPF
PLANA	602.89	604.12	604.81	605.44	605.92	606.33	606.72	609.27
PLANB	602.24	603.43	604.15	604.78	605.30	605.72	606.13	608.78

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE 13.17 Maximum Interior Elevation-Frequency Summary

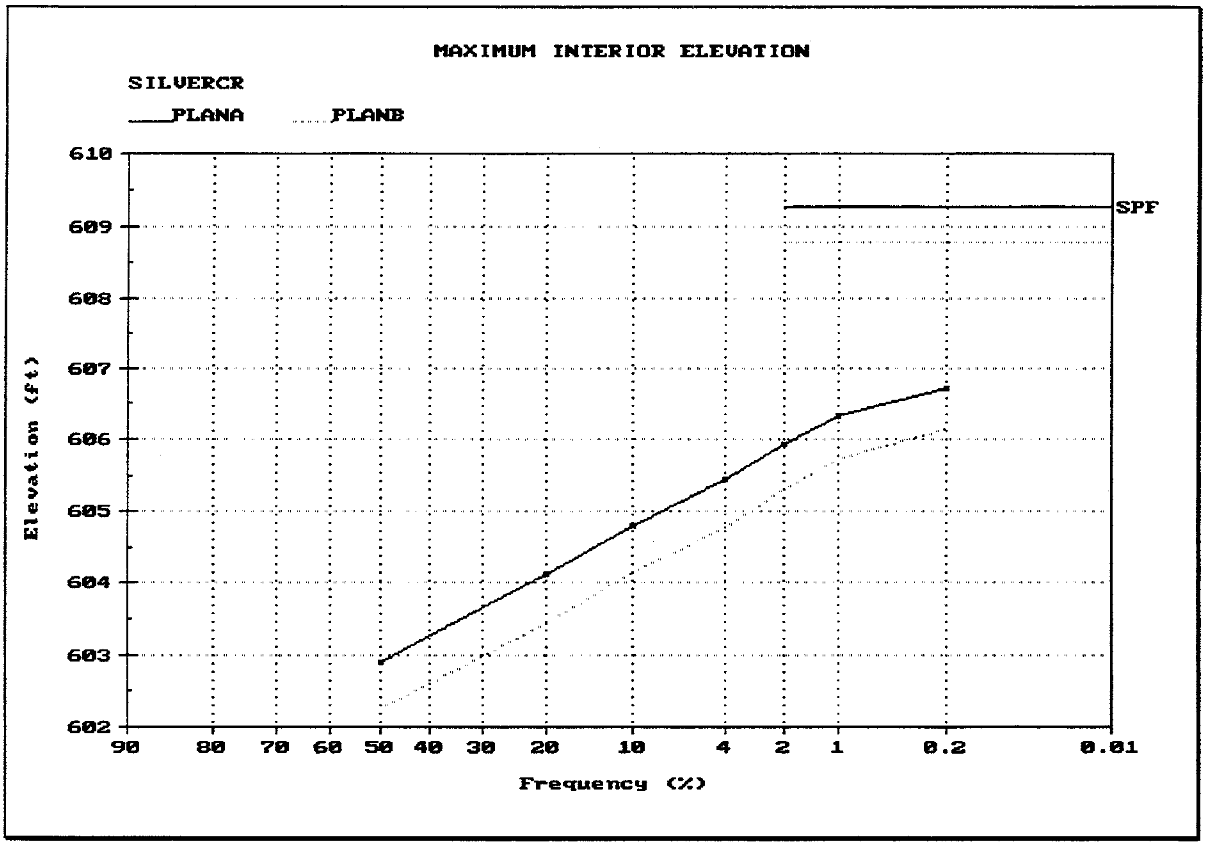


FIGURE 13.18 Maximum Interior Elevation-Frequency Plot

While the Maximum Interior Elevation-Frequency summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.18. This probability-scaled plot shows the relationship between interior water surface elevation and storm frequency for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

The Standard Project Flood (SPF) elevation is depicted on the plot using a horizontal line segment, because the frequency of the SPF is not defined.

Figure 13.19 illustrates the **Maximum Interior Area Flooded-Frequency** summary, which includes the following values for each plan specified for comparison:

- **Maximum Interior Area Flooded vs Percent Chance Exceedance**: The maximum interior area flooded for each of several synthetic storm events, including the 50%, 20%, 10%, 4%, 2%, 1%, 0.2%, and SPS flood events. If a particular storm event was not included in the analysis, the maximum interior area flooded for that storm event will be zero (0.00).

HEA 01.01.00
Study ID SILVERCR

Comparison of Plans

COMP14

C. Maximum Interior Area Flooded-Frequency

Plan ID	Maximum Interior Area Flooded (ac) vs. Percent Chance Exceedance							
	50%	20%	10%	4%	2%	1%	0.2%	SPF
PLANA	493.4	738.9	904.2	1080.7	1226.9	1364.5	1501.0	3034.8
PLANB	396.3	595.2	745.1	898.3	1041.4	1165.1	1296.0	2727.5

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE 13.19 Maximum Interior Area Flooded-Frequency Summary

While the Maximum Interior Area Flooded-Frequency summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.20. This probability-scaled plot shows the relationship between interior area flooded and storm frequency for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

The Standard Project Flood (SPF) elevation is depicted on the plot using a horizontal line segment, because the frequency of the SPF is not defined.

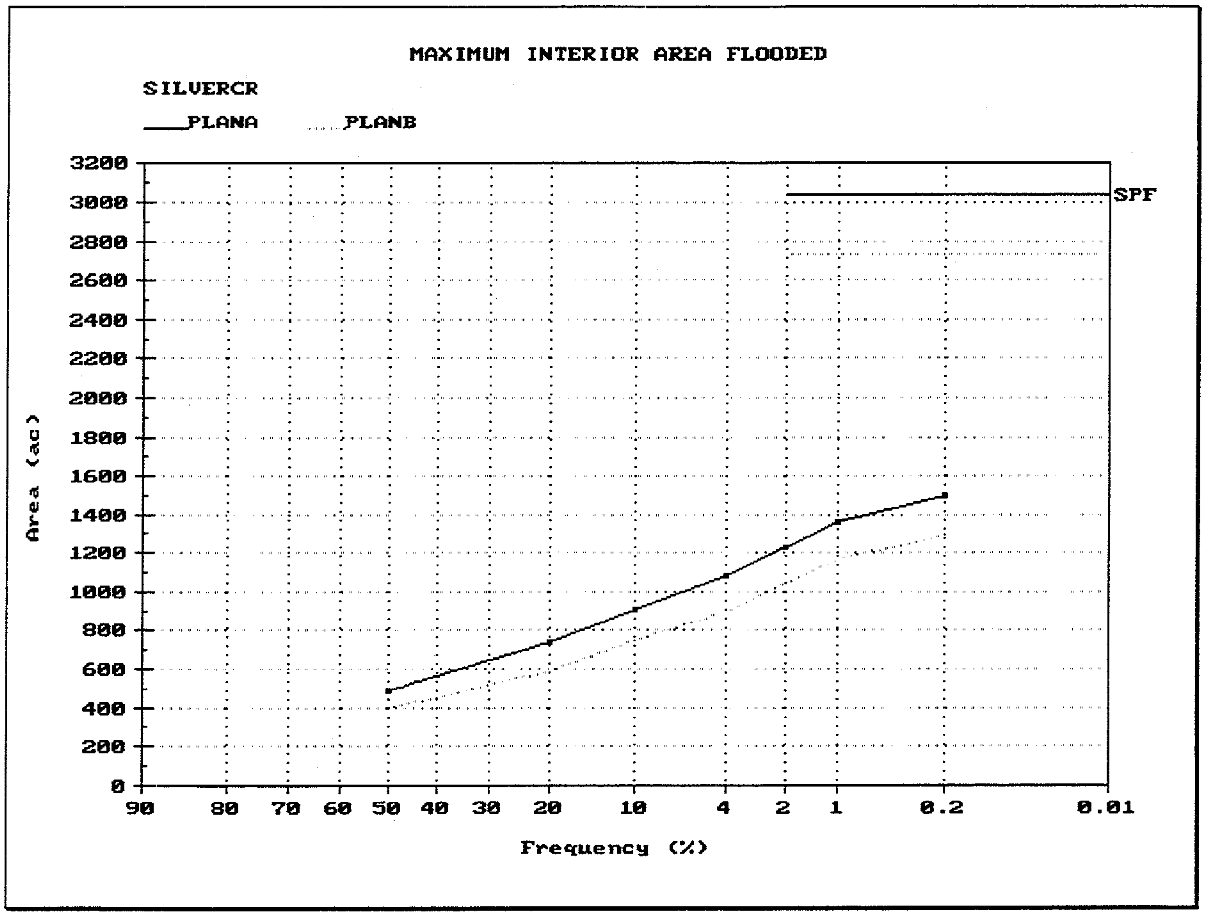


FIGURE 13.20 Maximum Interior Area Flooded-Frequency Plot

Figure 13.21 illustrates the **Maximum Total Interior Inflow-Frequency** summary, which includes the following values for each plan specified for comparison:

- **Maximum Total Interior Inflow vs Percent Chance Exceedance:** The peak rate of inflow to the interior ponding area for each of several synthetic storm events, including the 50%, 20%, 10%, 4%, 2%, 1%, 0.2%, and Standard Project Flood (SPF) flood events. If a particular storm event was not included in the analysis, the maximum total interior inflow rate for that storm event will be zero (0.00).

While the Maximum Interior Inflow-Frequency summary is displayed, pressing the F9 plot key displays the plot illustrated in Figure 13.22. This probability-scaled plot shows the relationship between peak interior inflow rate and storm frequency for each plan. On a computer monitor with color display capabilities, each plan is displayed using a different color.

The Standard Project Flood (SPF) elevation is depicted on the plot using a horizontal line segment, because the frequency of the SPF is not defined.

HEA 01.01.00 COMP15
Study ID SILVERCR

Comparison of Plans

D. Maximum Total Interior Inflow-Frequency

Plan ID	Maximum Total Interior Inflow (cfs) vs. Percent Chance Exceedance							
	50%	20%	10%	4%	2%	1%	0.2%	SPF
PLANA	2240.3	2978.1	3554.5	4164.1	4657.0	5194.9	5804.1	10381.9
PLANB	2240.3	2978.1	3554.5	4164.1	4657.0	5194.9	5804.1	10381.9

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE 13.21 Maximum Total Interior Inflow-Frequency Summary

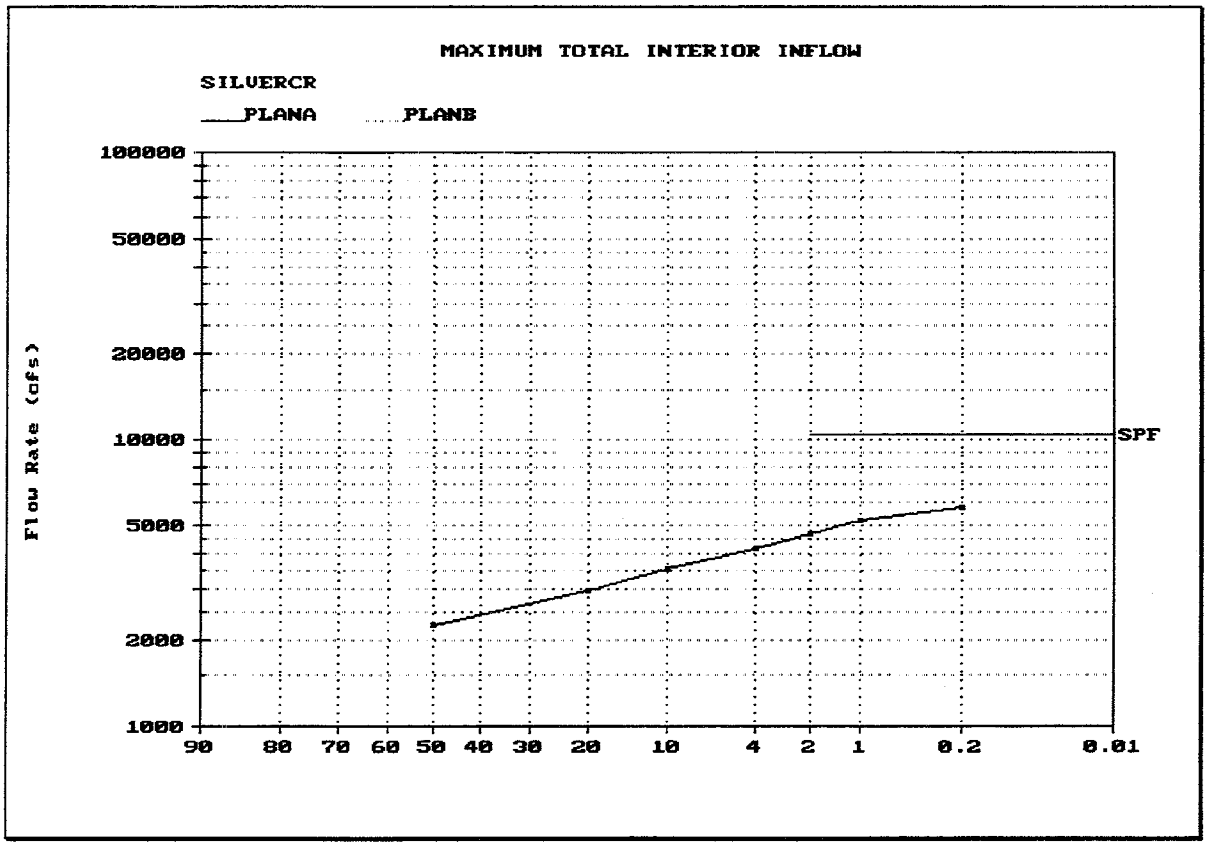


FIGURE 13.22 Maximum Total Interior Inflow-Frequency Plot

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APPENDIX B.
Installing and Configuring HEC- IFH

This appendix contains instructions on how to install the HEC-IFH program on your computer. It also describes how to adjust the configuration of the HEC-IFH program to improve performance.

B.1. HEC-IFH PROGRAM DISKS AND FILES

The Interior Flood Hydrology computer program is supplied on two (2) high-density 5.25" (1.2MB) or 3.5" (1.44MB) program disks:

1. The **HEC-IFH Package Diskette 1** includes the following files:
   - README.TXT: a file containing installation instructions.
   - IFH01Z.EXE: a self-extracting archive (zip) file containing the following files:
     a. HECIFH.EXE: The HEC-IFH program file.
     b. HECIFHDM.BAT: The HEC-IFH data management batch file.
     c. HECIFH.SCR: The HEC-IFH screen image file.
     d. HECIFH.SDR: The HEC-IFH screen support file.
     e. HECIFH.FLD: The HEC-IFH data entry support file.
     f. F77L3.EER: The Lahey FORTRAN error message file.
     g. LIST.COM: A file viewing (list) utility program written by Vernon Buerg and licensed by HEC for distribution with HEC-IFH.
2. The **HEC-IFH Package Diskette 2** includes IFHDTAZ.EXE, a self-extracting archive (zip) file which contains program data files as follows:
   - A HEC-DSS file (IFHTEST.DSS) which contains the precipitation and stage time series data for the Continuous Simulation Analysis (CSA) example study described in Appendix C.
   - The input data files for the example CSA study described in Appendix C (RBEND1). These files are listed below:

4X4BOX.GRT	Gravity outlet data file.
EXSTAGE.EMC	Exterior stage module control file.
GAGE1.PDS	Precipitation data file.
GAGE2.PDS	Precipitation data file.
INTPOND1.OMC	Interior pond module control file.
LOWER.BRD	Sub-Basin runoff data file.
OUTLET1.GMC	Gravity outlet module control file.
PLAN1.DSS	Plan 1 output HEC-DSS file.
PLAN1.ERR	Plan 1 message file.
PLAN1.PCF	Plan 1 plan control file.
POND1.ODS	nterior pond elevation-area data.
PRECIP1.PMC	Precipitation module control file.
PUMP1.PUD	Pump unit data file.
PUMPMOD1.UMC	Pump station module control file.
RBEND1.DSS	River Bend example study input HEC-DSS file.
RBEND1.SID	River Bend study ID file.

ROUTE1.CRD	Channel routing data file.
RUNOFF1.RMC	Basin runoff module control file.
UPPER.BRD	Sub-Basin runoff data file.
UPPER.PDS	Precipitation data file.

- The input data files for the example Hypothetical Event Analysis (HEA) study (SILVER) described in Appendix D. These files are listed below:

1-48CMP.GRT	Gravity outlet data file.
EXSTAGE.EMC	Exterior stage module control file.
OUTLET1.GMC	Gravity outlet module control file.
PLANA.DSS	Plan A output HEC-DSS file.
PLANA.ERR	Plan A message file.
PLANA.PCF	Plan A plan control file.
POND.ODS	Interior pond elevation-area data.
PONDMOD. OMC	Pond module control file.
ROMOD1.RMC	Basin runoff module control file.
SILVER.BRD	Sub-Basin runoff data file.
SILVER.DSS	Silver Creek example study input HEC-DSS file.
SILVER.SID	Silver Creek study ID file.
STORM1.PDS	Precipitation data file.
STORM1.PMC	Precipitation module control file.

In addition to the files listed above, the HEC-IFH program may create other files as it executes.

B.2. INSTALLING HEC-IFH ON YOUR COMPUTER

The HEC-IFH computer program requires the following computer system:

1. An IBM PC compatible computer based on an 80386 or higher microprocessor.
2. MS-DOS, Windows 3.1, 95, 98, or NT 3.51 or higher operating system.
3. At least 4MB of RAM memory, with at least 3MB configured as extended memory. No extended memory manager is required to run HEC-IFH because extended memory management is "bundled" (Included) in the HEC-IFH program executable file. If EMM386.SYS expanded memory manager is loaded, use "NOEMS" as one of the parameters. HEC-IFH is compatible with the HIMEM.SYS driver.
4. At least 3.5 MB of storage capacity is required to install the HEC-IFH program files. An additional 2.5 MB is required to install the example CSA and HEA study data y files used for Appendix C and D. Much more storage space is often required for actual study data, especially if a long-term continuous simulation analysis is required. A minimum of 10 MB of free space is suggested for any plan analysis.

B.2.1. Making Backup Copies of the Program Disks

You should make a back-up copy of the program disks immediately, and then put the original program disks in a safe place. Replacement copies of each program disk are available if the original becomes damaged. However, your own efforts to protect your original program disks are your best protection.

B.2.2. Using HEC-IFH on a Computer with a Hard Disk

Installation of the program is accomplished through execution of self extracting WinZip files. The program files require about 3.5 MB of storage. To install HEC-IFH program files, do the following:

1. Windows
   - Place the DISKETTE 1 into the A: or B: drive and open a window to the drive to display the files.
   - Double click the self-extracting WinZip file ifh02z.exe and specify the drve path (e.g., C:\ or D;\) where you would like to install the program.
2. DOS
   - Start your computer in DOS and go to the drive (e.g., C:\ or D:\) in which you would like to install this software.
   - Place the DISKETTE 1 into the A: or B: drive as appropriate for your system
   - Type **A:IFH02Z** (or **B: IFH02Z**) press the [Enter] key and specify the drve path (e.g., C:\ or D;\) where you would like to install the program.
3. The following actions will occur when the files are extracted:
   - The HECIFH.EXE and HECIFHDM.BAT files will be copied to the \HECEXE directory.
   - The supplementary files, HECIFH.SCR, HECIFH.SDR, and HECIFH.FLD, will be copied to the \HECEXE\SUP directory.
   - The F77L3.ERR file will be copied to the \HECIFH directory. If these directories do not exist, they will be created automatically.
4. To allow access of the executable programs from any directory, it will be necessary to edit the AUTOEXEC.BAT file to include a path to the \HECEXE directory. The AUTOEXEC.BAT file should be in the root (C:\) directory. The following is an example PATH command that would allow access to the \HECEXE directory as well as the root (C:\) directory:

   ```
   PATH C:\;C:\HECEXE
   ```

   The PATH may also include other directories on the system. If so, just add the names of the directories to this command. For more information on the PATH command and the AUTOEXEC.BAT file, consult a DOS manual.
5. The final step is to modify the CONFIG.SYS file. Many HEC programs require the capability to open more than eight (8) files at any one time. Because eight is the system default for some older operating systems, it may be necessary to modify the CONFIG.SYS to include the following lines:

   ```
   FILES=20
   BUFFERS=15
   ```

   For more information concerning the CONFIG.SYS file, consult your operating system manual. Use a text editor to make these changes. **AFTER THESE CHANGES ARE MADE, THE SYSTEM MUST BE REBOOTED.**

6. HEC-IFH test data installation is accomplished by the execution of the the self-extracting WinZip file ifhdtaz.exe. Installing the test data is optional but suggested in order to follow through the example applications in Appendix C and Appendix D. To install the HEC-IFH program test data files, do the following:

   a. Windows

      - Place the DISKETTE 2 into the A: or B: drive and open a window to the drive to display the files.
      - Double click the self-extracting WinZip file ifhdtaz.exe and specify the drve path (e.g., C:\ or D;\) where you would like to install the program.

   b. DOS

      - Go to the drive (e.g., C: or D:) where you would like to install the test data.
      - Place the DISKETTE 2 into the A: or B: drive, as appropriate for your system.
      - Type **A:IFHDTAZ** (or **B: IFHDTAZ**) press the [Enter] key and specify the drve path (e.g., C:\ or D;\) where you would like to install the program.

   c. The IFHTEST.DSS file will be copied to the directory \HECIFH. The CSA (River Bend) study data files will be copied to the directory \HECIFH\RBEND1 and all the HEA (Silver Creek) study data will be copied to the directory \HECIFH\SILVER.

      NOTE: If these directories do not exist, they will be created for you. These files MUST reside in the indicated directories in order for the program to access the study files.

7. HEC-IFH Program Execution:

   a. Go to the directory containing the HEC-IFH data files (e.g., CD \HECIFH).

   b. Type **HEC-IFH** and press the [Enter] key. This will start the HEC-IFH program.

   c. Proceed through the Program Configuration Options in the following section to configure HEC-IFH properly for screen graphics adapter, printer, and other options.

B.3. HEC-IFH PROGRAM CONFIGURATION OPTIONS

The HEC-IFH program allows several configuration options to be set. These options control the appearance of program screens, plots, and printed reports. In addition, the units of measurement used in the program can be configured.

Figure B.1 shows the structure of the HEC-IFH program user interface which deal with program configuration options. As this figure indicates, the various configuration options are controlled from a single main menu, with a subsidiary menu to control screen characteristics. Figure B.2 shows the program configuration main menu screen.

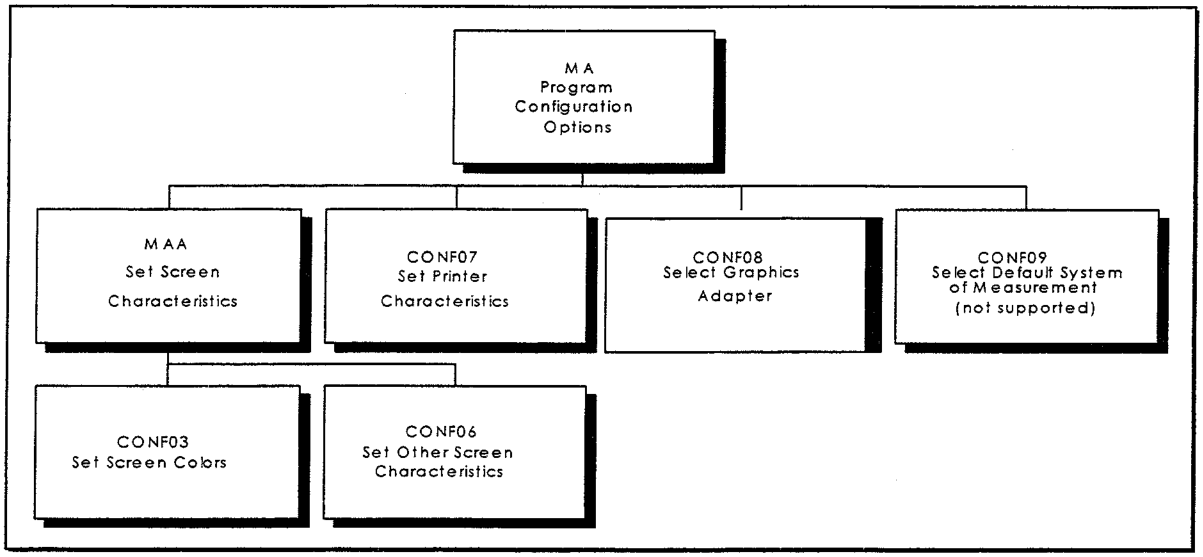

FIGURE B.1 HEC-IFH Program Configuration Options

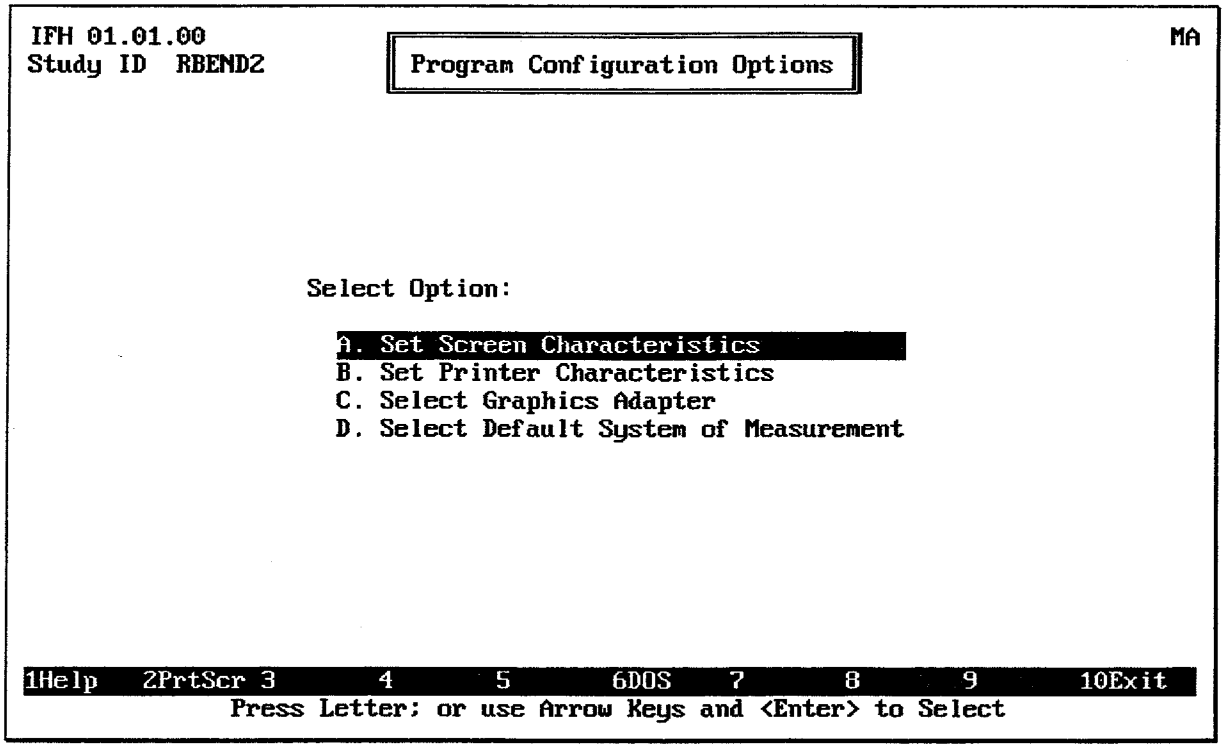

FIGURE B.2 HEC-IFH Program Configuration Options Menu

B.3.1. Setting Screen Characteristics

If the user selects option A: Set Screen Characteristics from the program configuration main menu (Figure B.2), another menu screen appears listing the following options:

A. Set Screen Colors

B. Set Other Screen Characteristics

Figure B.3 illustrates the screen used to set the colors used for screen displays. On computer systems with color displays, HEC-IFH provides a great deal of flexibility for specification of desired colors. Color combinations can be individually specified for all the following screen areas:

- **Main**: The primary portion of each screen, including the overall background of the screen and most of the text contained on the screen.
- **Main 2**: A contrasting area on the primary portion of each screen. This contrasting area would be used to highlight the current data entry field or menu selection. Setting Main 2 to the same colors as Main would make the HEC-IFH program almost impossible to use.
- **Inset**: The "windows" which appear during certain program operations, such as when the F3 Index key, the F4 Goto key, the F5 Report key, the F7 Import key, or the F9 Plot key are pressed.
- **Inset 2**: A contrasting area on the each inset window. This contrasting area would be used to highlight the current data entry field or menu selection. Setting Inset 2 to the same colors as Inset would make many HEC-IFH program options almost impossible to use.
- **Help Window**: The help "windows" which appear when the F1 Help key is pressed.
- **Error Messages**: The "windows" which appear when an error condition occurs during program operation.

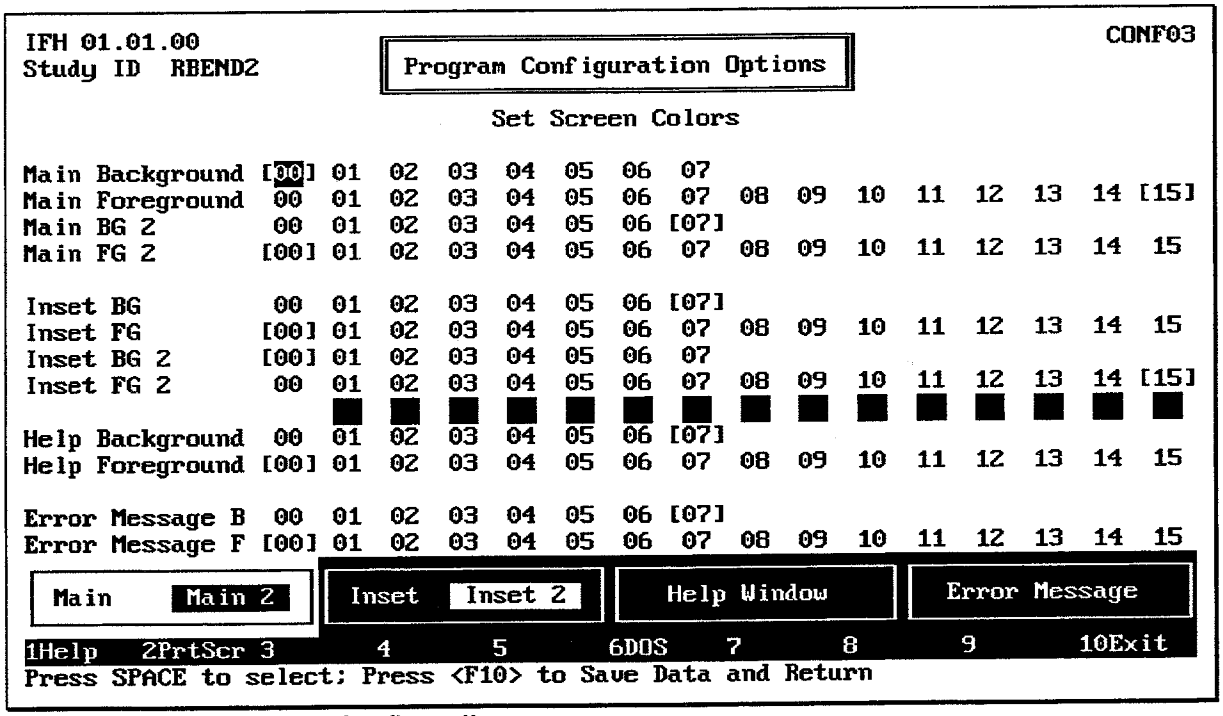

FIGURE B.3 Screen Colors Configuration

For each screen area, the Background (BG) and Foreground (FG) colors are set separately using horizontal menus, as illustrated in Figure B.3. To set a certain color, use the up-arrow and down-arrow keys to move to the appropriate line. Then use the left-arrow and right-arrow keys to highlight the desired color. Pressing the space bar selects the highlighted color. The selected color is bracketed. A sample of each screen area is provided near the bottom of the data entry screen, so that the current color settings may be viewed immediately.

As the menus indicate, eight background colors and sixteen foreground colors are available for color display systems. Sample blocks of each color are shown between the Inset and Help menu areas of the screen. Table B.2 lists the colors available.

TABLE B.1 Text Screen Colors Available

Number	Background Color	Foreground Color
00	Black	Black
01	Blue	Blue
02	Green	Green
03	Cyan	Cyan
04	Red	Red
05	Magenta	Magenta
06	Brown	Brown
07	Light Gray	Light Gray
08	N/A	Dark Gray
09	N/A	Light Blue
10	N/A	Light Green
11	N/A	Light Cyan
12	N/A	Light Red
13	N/A	Light Magenta
14	N/A	Yellow
15	N/A	White

Figure B.4 illustrates the screen used to set other screen characteristics, including program sounds and line types for plots.

The HEC-IFH program can sound the computer "bell" (actually a small speaker) after errors in data entry, and after lengthy computations. This capability is very useful for notifying the user of program operations. However, these sounds may not be desirable in all circumstances. To turn these sounds off, use the up-arrow or down-arrow key to move to the appropriate line. Use the left-arrow and right-arrow keys to highlight the desired response (Yes or No). Pressing the space bar selects the highlighted response, which is then bracketed.

The HEC-IFH program offers many plot screens, which display input and output data in graphical form. Many of these plots present multiple data sets. On EGA and VGA displays, each data set appears in a different color, which allows the data sets to be readily identified. However, when the plot is printed, all data sets are printed as black solid lines.

To allow different data sets to be distinguished on printed plots, different line types or styles may be specified for each data set. The selected line types are used for screen displays as well as printed plots. Table B.2 lists the line types available. Since only six different line types are available for plots, which may contain up to eight different data sets, it is not possible to provide a unique line type for all data sets on all plots.

Line types are selected using the same operations used in other horizontal pick lists within the HEC-IFH program:

1. Use the up-arrow or down-arrow key to move to the appropriate line.
2. Use the left-arrow and right-arrow keys to highlight the desired line type.
3. Press the space bar to select the highlighted line type. The selected line type is then bracketed.

TABLE B.2 Plot Line Types Available

Number	Line Type
0	Solid
1	Dots
2	Short Dashes
3	Long Dashes
4	Dash-Dot
5	Dash-Dot-Dot

```
IFH 01.01.00                                                   CONF06
Study ID  RBEND2         Program Configuration Options

                       Set Other Screen Characteristics

        Sound bell upon data entry error?           [Yes] No
        Sound bell after lengthy computations?      [Yes] No

        Screen plots line type for line 1          [0] 1  2  3  4  5
        Screen plots line type for line 2           0 [1] 2  3  4  5
        Screen plots line type for line 3           0  1 [2] 3  4  5
        Screen plots line type for line 4           0  1  2 [3] 4  5
        Screen plots line type for line 5           0  1  2  3 [4] 5
        Screen plots line type for line 6           0  1  2  3  4 [5]
        Screen plots line type for line 7          [0] 1  2  3  4  5

        Note:  Line type 0 is solid           ____________
               Line type 1 is dots            . . . . . . .
               Line type 2 is short dashes    - - - - - -
               Line type 3 is long dashes     — — — —
               Line type 4 is dash-dot        -.-.-.-.-.
               Line type 5 is dash-dot-dot    -..-..-..-..

1Help  2PrtScr 3    4     5     6DOS    7     8     9      10Exit
Press SPACE to select; Press <F10> to Save Data and Return
```

FIGURE B.4 Screen Characteristics Configuration

B.3.2. Printer Characteristics

The HEC-IFH program allows the following printer characteristics to be configured:

- **Printer Setup String**: A series of characters, which are sent to the printer before each printed report or screen. The printer setup string may include "printable" characters (such as letters, digits, or punctuation marks) as well as "non-printable" characters (such as the "escape" character). Printable characters are entered by simply typing the corresponding key. Non-printable characters are entered using their three-digit ASCII code number after a backslash (\) character. For example, the "escape" character (ASCII code number 27) would be entered as "\027" as shown in Figure B.5. Printer manuals generally provide the ASCII code numbers for non-printable characters recognized as part of printer commands. The default string is blank.

- **Screen Box Characters**: Indicates whether the program should substitute other characters for those used to create boxes on the screen, for printed reports or screens. Most IBM-compatible personal computers have special characters built in to draw boxes on the screen. HEC-IFH makes extensive use of these characters for screen displays as well as printed reports. Unfortunately, not all printers recognize these characters, so HEC-IFH printed reports and screens will not have the correct appearance on some printers. If this is the case, HEC-IFH can be configured to use the "|", "+", and "-" characters when printing reports or screens. These characters provide an acceptable printed output even on printers, which are not fully compatible with the IBM PC extended character set. To use these alternate box characters, type "Y" in the data entry field available, as illustrated in Figure B.5. The default value is "N".

- **Maximum Printable Lines Per Page**: Controls the number of lines on each page of printed reports. The default value is 56 lines per page. If printed reports run past the end of each page, the lines per page should be reduced. If, however, the printer is capable of printing more lines per page, the setting can be increased and the total pages of printout will be reduced.
- **Printer Type**: The brand and model of printer available for printing plot screens. This selection does not affect printed text. The default printer type is Epson.

Figure B.5 illustrates the screen used to set printer characteristics.

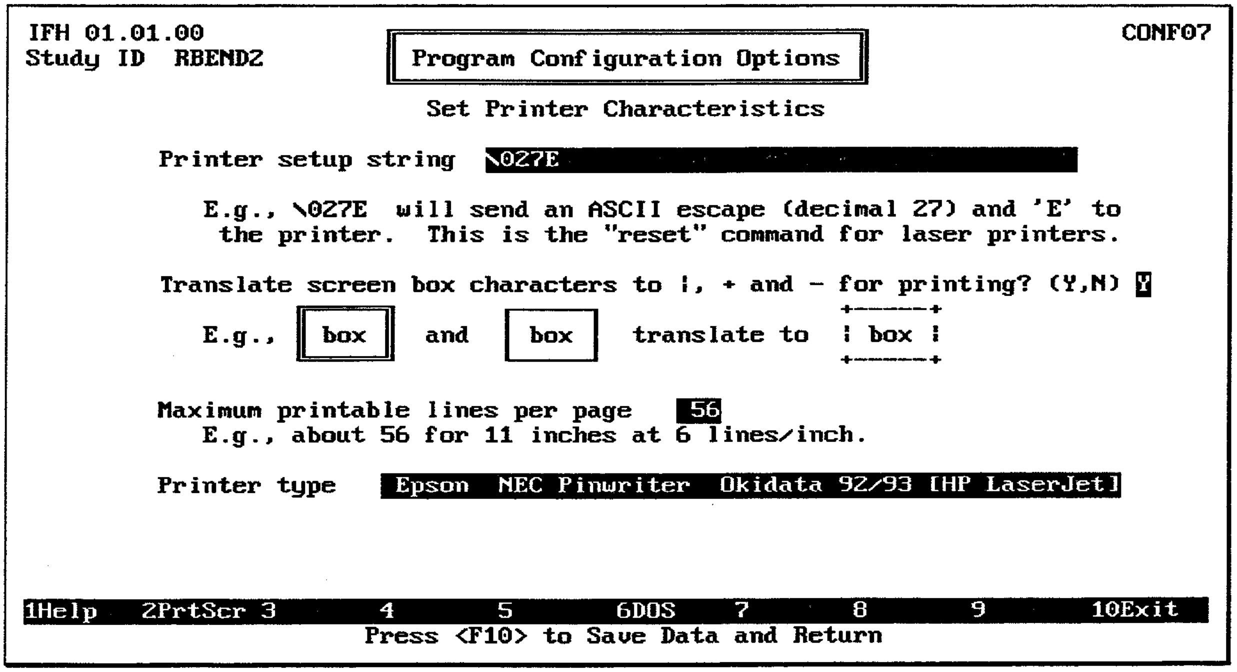

FIGURE B.5 Printer Characteristics Configuration

HEC-IFH supports direct printing of plot screens to several types of popular printers, including Epson, NEC Pinwriter, Okidata 92/03, and HP LaserJet. A horizontal pick list is used to select the appropriate type of printer. Use the left-arrow and right-arrow keys to highlight the desired printer. Pressing the space bar selects the highlighted printer, which is then bracketed.

If in doubt about the appropriate type of printer, select Epson for dot-matrix printers and HP LaserJet for laser printers. Most dot-matrix printers emulate Epson graphics capability, and most laser printers are compatible with HP LaserJet graphics.

B.3.3. Graphics Adapter

The HEC-IFH program supports the following types of graphics adapters:

- **Monochrome (MON)**: Displays with only one color (generally green, amber, or white on a black background). HEC-IFH does not support graphics output for Monochrome displays.

- **IBM Color Graphics Adapter (CGA)**: Displays with color text capabilities and 640 x 200 monochrome graphics. CGA graphics may not provide acceptable quality graphic output.
- **IBM Enhanced Graphics Adapter (EGA)**: Displays with color text capabilities and 640 x 350 color graphics. All HEC-IFH program capabilities are available when an EGA display is used.
- **IBM Virtual Graphics Array (VGA)**: Displays with color text capabilities and 640 x 480 color graphics. All HEC-IFH program capabilities are available when a VGA display is used, and VGA graphics provide the best quality graphic output.

To select a particular adapter, use the up-arrow and down-arrow keys to highlight the desired adapter. Press the space bar to selected the highlighted adapter. The selected adapter will then be bracketed to confirm the selection.

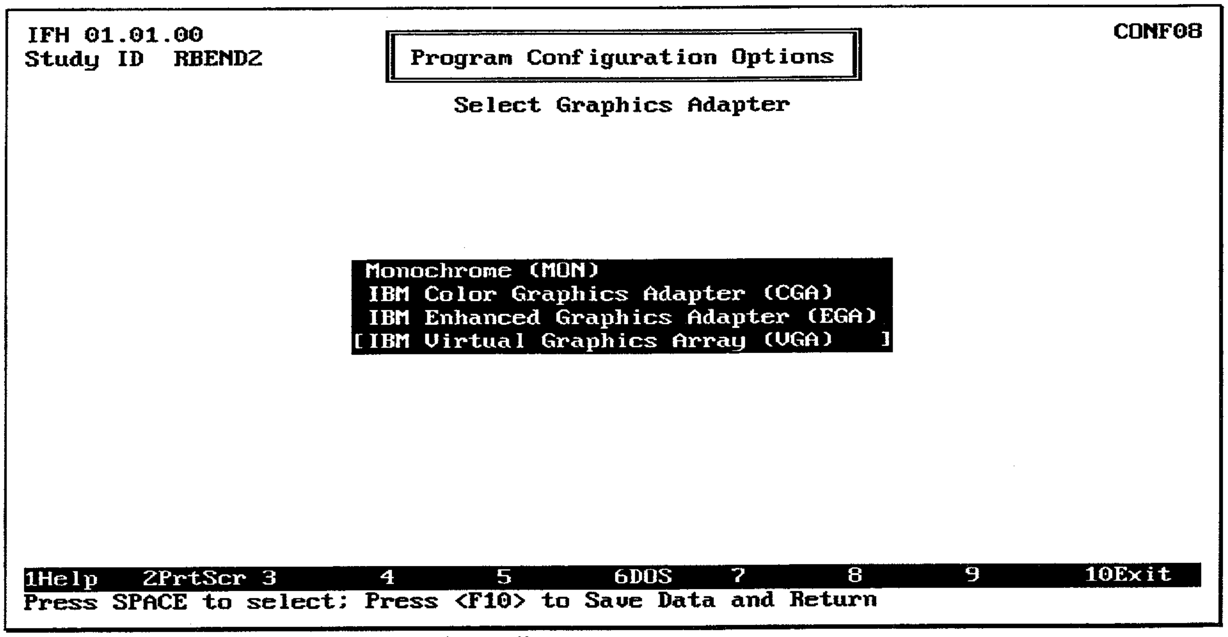

FIGURE B.6 Graphics Adapter Configuration

B.3.4. Default System of Measurement

The default system of measurement for the HEC-IFH program is the English system. Metric units are not supported. Table B.3 lists the categories of data used in the HEC-IFH program, English units used, and corresponding Metric conversion factors.

TABLE B.3 Categories of Data, English Units, and Corresponding Metric Conversion Factors

Category of Data	English Units	Metric Units	Conversion Factor
Precipitation Depth	in	mm	1 in = 25.4 mm
Infiltration Loss Volume	in	mm	1 in = 25.4 mm
Infiltration Loss Rate	in/hr	mm/hr	1 in/hr = 25.4 mm/hr
Elevation	ft	m	1 ft = 0.3048 m
Flow Rate	cfs	m^3/s	1 cfs = 0.0283 m^3/s
Flow Volume	ac-ft	m^3	1 ac-ft = 1,232.748 m^3
Pond Surface Area	ac	m^2	1 ac = 4,046.87 m^2
Drainage Area	mi^2	km^2	1 mi^2 = 2.5889 km^2
Outlet Cross-Sectional Area	ft^2	m^2	1 ft^2 = 0.0929034 m^2
Pump Energy	kW-hrs	kW-hrs	(none)
Time	hr	hr	(none)

APPENDIX C.
HEC-IFH CSA Example Application

This appendix demonstrates the application of the Interior Flood Hydrology (HEC-IFH) computer program to a simple example of an interior flood analysis problem using Continuous Simulation Analysis. Appendix D provides an example of a Hypothetical Event Analysis. Gravity outlets and pumps will be evaluated by determining interior area runoff from recorded rainfall, routing the runoff to and through the line-of-protection, and developing interior area elevation-frequency relationships. Note: the procedures described in this Appendix are based on the assumption that the HEC-IFH program and data files have been installed as described in Appendix B.

C.1. BACKGROUND INFORMATION

The Corps of Engineers is to implement a levee system that will protect the community of River Bend from direct flooding from the Green River. The analysis requires the investigation of the feasibility of implementing flood damage reduction measures for the interior area. These measures will include gravity outlets and pumping stations.

The River Bend interior area consists of distinct upper and lower basins connected by a main channel. Figure C.1 illustrates the River Bend Interior Area.

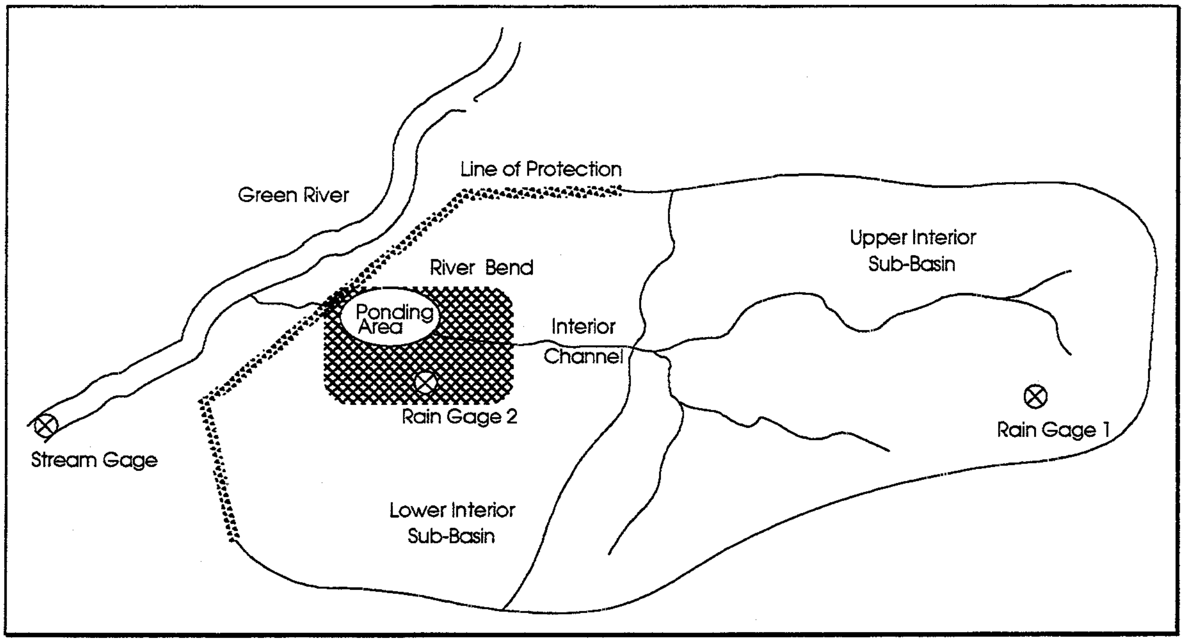

FIGURE C.1 River Bend Interior Area

The procedures specified in Appendix B of this manual create a sub-directory called "RBEND1" within the HECIFH directory on the hard disk. This sub-directory contains the correct input data for the example problem described in this appendix. *Do not modify the data stored in the RBEND1 sub-directory.* It should be preserved in its original condition for comparison with data developed in this appendix. To view the RBEND1 input data and results, specify RBEND1 as the Study ID for HEC-IFH, as described in Chapter 2 of this manual. To begin working through the example problem described in this chapter, specify a new HEC-IFH Study ID called RBEND2.

During the installation process described in Appendix B, a file called IFHTEST.DSS is stored in the HECIFH directory. This file contains hourly precipitation records and daily exterior stage data for the period from Water Year 1951 through Water Year 1960. Other data, including runoff parameters, channel routing characteristics, and interior pond data, will be described as necessary as the example problem is presented.

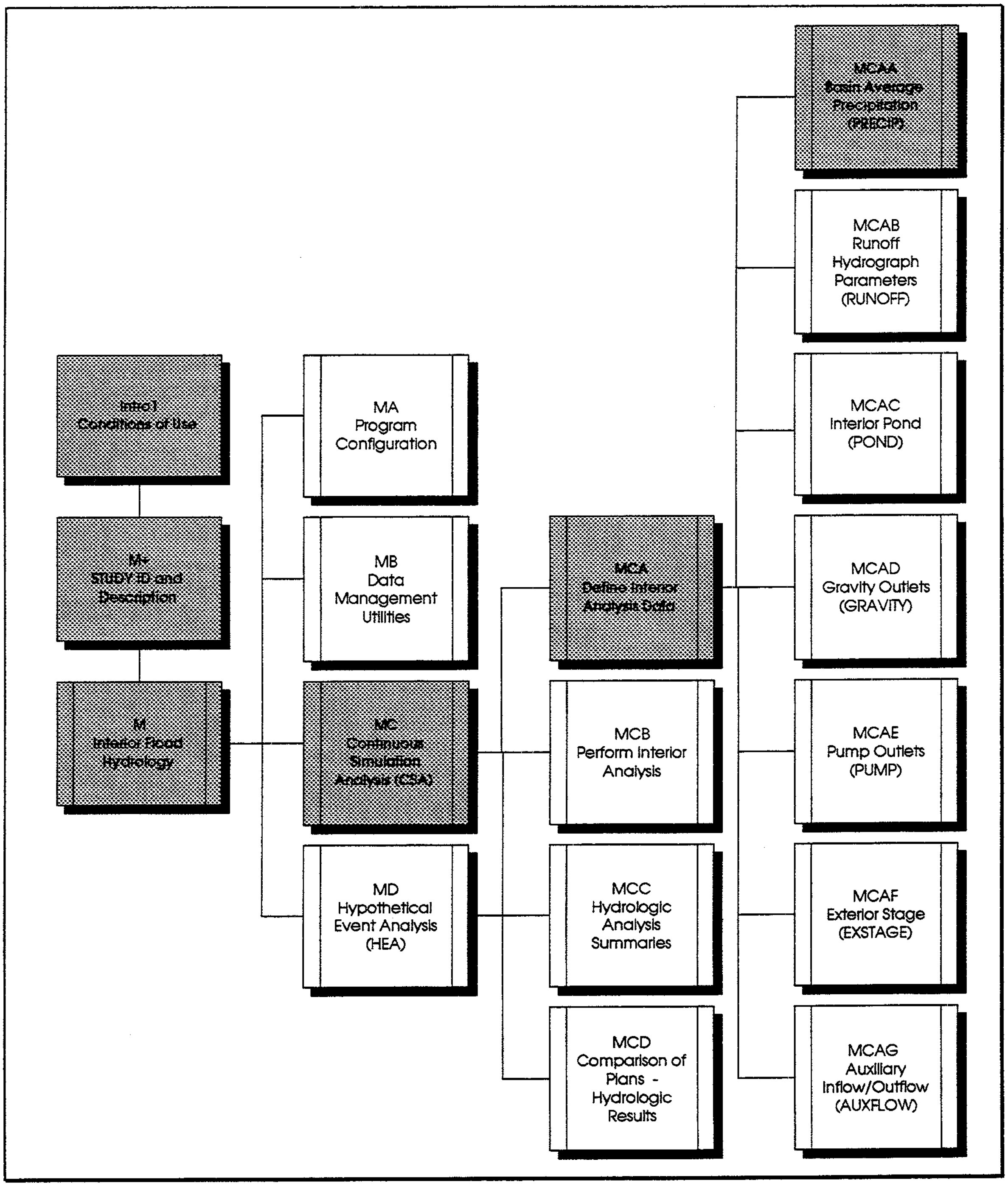

FIGURE C.2 HEC-IFH Program Menu Hierarchy

C.2. "MINIMUM FACILITY" ANALYSIS

The River Bend interior area will be analyzed for several different conditions. Each of these conditions will form a different HEC-IFH Plan. The first plan will analyze the performance of the interior system with a "minimum" gravity outlet in place.

C.2.1. Precipitation Data Import

Before the HEC-IFH program can analyze the River Bend interior area, the precipitation records must be transferred from the IFHTEST.DSS file. The IFHTEST.DSS file is called an "external" HEC-DSS file because it was not created by the HEC-IFH program for use in this study. As described in Chapter 2, HEC-IFH can import data from an external HEC-DSS file for use in an HEC-IFH analysis. (Note: the "external" HEC-DSS data file could have been created by HEC-IFH to store input data or output results during a previous study.)

As indicated in Figure C.1, two rainfall gages provide records for the River Bend interior area. Figure C.2 highlights the path through the HEC-IFH menu system required to reach the *Basin Average Precipitation (PRECIP)* menu screen.

To start the HEC-IFH program and prepare to enter precipitation data, follow these steps:

1. Use the DOS command **CD \HECIFH** and press [Enter] to change to the HECIFH directory on the hard disk.
2. Type **HECIFH** and press [Enter] to start the HEC-IFH program.
3. Press any key to proceed to the Study ID screen.
4. Specify RBEND2 as the current **Study ID**.
5. Select *Continuous Simulation Analysis* from the HEC-IFH main menu.
6. Select *Define Interior Analysis Data* from the HEC-IFH Continuous Simulation Analysis menu.
7. Select *Basin Average Precipitation (PRECIP)* from the Define Interior Analysis Data menu.
8. Select *Enter/Import Precipitation Station Data* from the Basin Average Precipitation menu screen. The data entry screen illustrated in Figure C.3 will appear.

To import the GAGE1 precipitation record for the analysis, follow these steps:

1. Use GAGE1 as the **Precipitation Station ID**, and enter an appropriate 40-character description on the Precipitation Record Data Entry Screen.
2. Enter a **Starting Period** of 01OCT1950/0100 for the GAGE1 precipitation record. This is the end of the first 1-hour time increment in Water Year 1951.
3. Enter an **Ending Period** of 30SEP1960/2400 for the GAGE1 precipitation record. This is the end of Water Year 1960.
4. Specify a **Time Increment** of 1HOUR for the GAGE1 data.
5. After entering the time increment and pressing the [Enter] key, the cursor moves to the top of the Precipitation column. Press the [F7] key to specify that the data will be imported. Use the file name and HEC-DSS path name information from Table C.1 for the external HEC-DSS file. Press the [F10] key to begin data import.

6. After the data import procedure is complete, press the [F4] key to locate the values listed in Table C.2 and ensure that they are correct. These are the maximum hourly rainfall totals for each gage.
7. Press the [F9] plot key to plot the data. Use the HEC-IFH plotting capabilities to review the computed data. Figure C.4 illustrates the plot of maximum annual values which should appear when the [F9] plot key is pressed. Press the down-arrow key to "zoom" to a plot of monthly totals for Water Year 1951. Press the right-arrow key repeatedly or press 6 plus the right-arrow key (to skip 6 years) to "pan" to a plot of monthly totals for Water Year 1957. Press the down-arrow key again to zoom to plot of actual values for October 1956. Press the right-arrow repeatedly or press 9 plus the right-arrow key (to skip 9 months) again to pan to a plot of actual values for July 1957. The peak rainfall value for Gage 1 occurs during this month, as shown in Table C.2. Press the [Esc] key until the data entry screen reappears.
8. Press the [F10] key to store the GAGE1 precipitation data and return to the Basin Average Precipitation menu screen.
9. Repeat all the steps listed above for Gage 2. The Gage 2 data should be stored using a **Precipitation Station ID** of GAGE2.

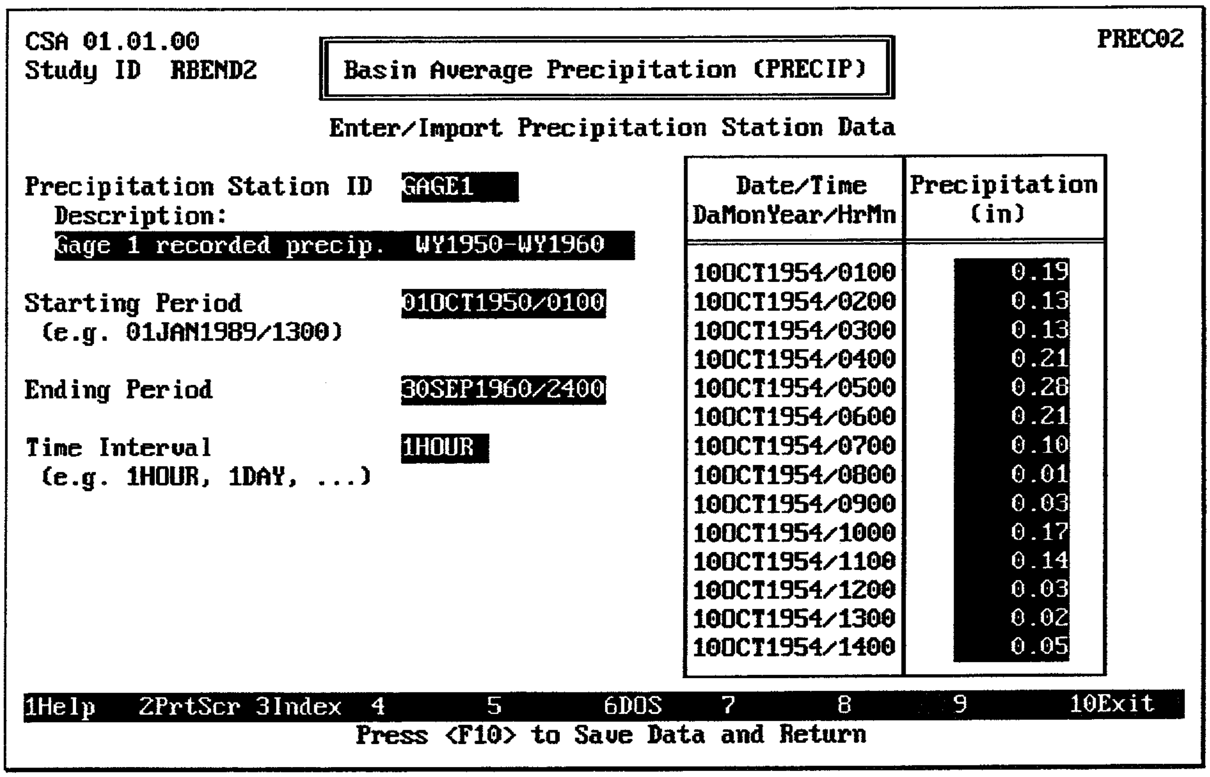

FIGURE C.3 Precipitation Record Data Entry Screen

TABLE C.1 External HEC-DSS Data for Precipitation Gages

Data Item	Gage 1	Gage 2	Note
HEC-DSS File Name	IFHTEST.DSS	IFHTEST.DSS	1
HEC-DSS Path Name Part A	INTERIOR	INTERIOR	–
HEC-DSS Path Name Part B	GAGE1	GAGE2	–
HEC-DSS Path Name Part C	PRECIP-INC	PRECIP-INC	–
HEC-DSS Path Name Part D	01JAN1900	01JAN1900	2
HEC-DSS Path Name Part E	1HOUR	1HOUR	–
HEC-DSS Path Name Part F	OBSERVED	OBSERVED	–

Note 1: The current directory is the default installation location of the IFHTEST.DSS file. Use a complete DOS path name if you have installed the IFHTEST.DSS file in a different location.
Note 2: For Import, Part D is not used. Any valid date may be entered, including the default date of 01JAN1900.

TABLE C.2 Maximum Hourly Rainfall Values

Rainfall Gage or Record	Date and Time	Hourly Rainfall Total (inches)
Gage 1	12JUL1957/1900	1.93
Gage 2	10OCT1954/0100	1.13
UPPER Composite	12JUL1957/1900	2.00

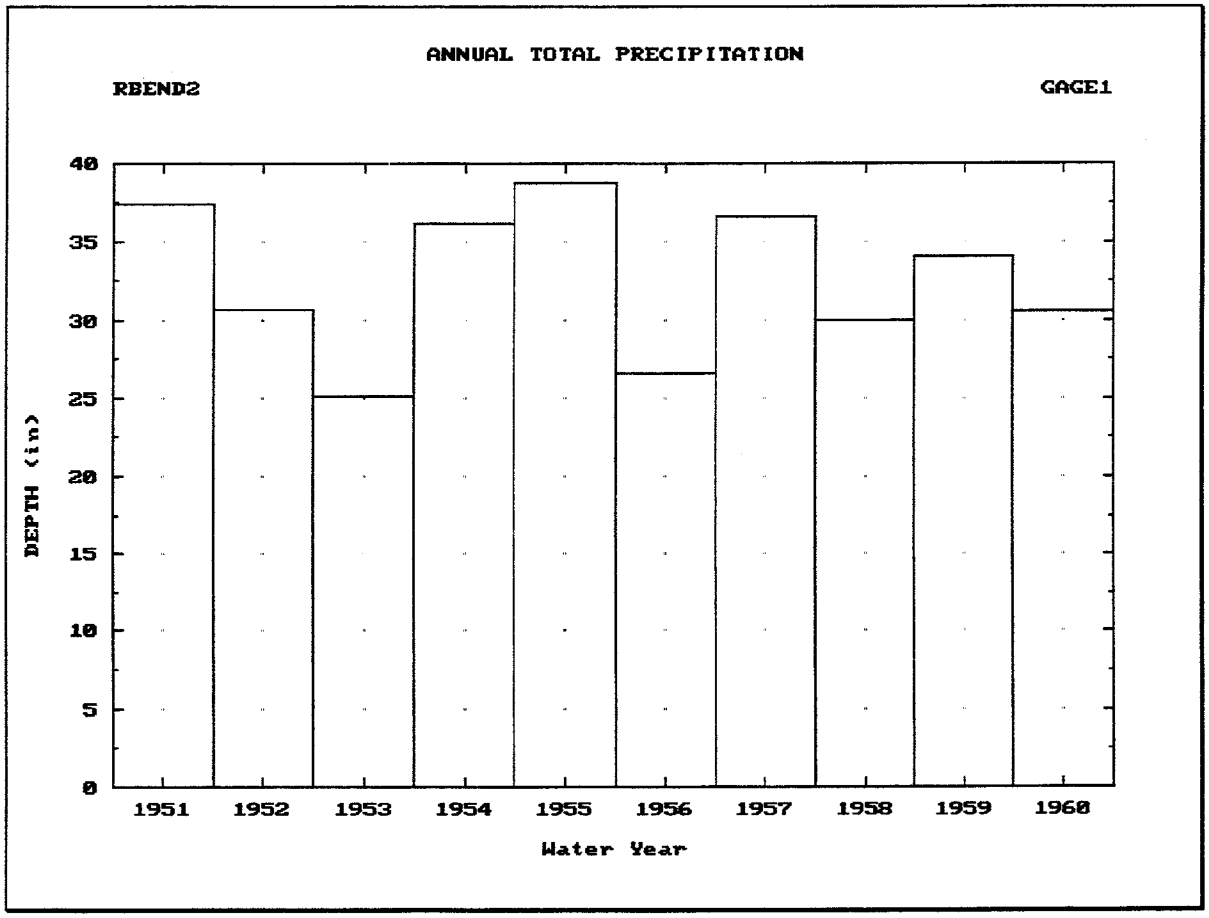

FIGURE C.4 Plot of Annual Precipitation Totals

C.2.2. Composite Precipitation Computations

As illustrated in Figure C.1, Gage 2 appears to be located near the centroid of the lower interior sub-basin for the River Bend interior area. However, the upper interior sub-basin is positioned between Gage 1 and Gage 2. Therefore, the most representative precipitation record for the upper interior sub-basin will be a composite of the Gage 1 and Gage 2 records. To compute this composite distribution, use the following steps.

1. Select *Specify Composite Precipitation Weights* from the Basin Average Precipitation menu screen. Figure C.5 shows the data entry screen used to specify the Composite Precipitation Weights.
2. Use UPPER as the **Composite Precipitation Record ID**, and enter an appropriate 40-character **Description.**
3. List the GAGE1 and GAGE2 **Precipitation Station IDs**, along with the **Total Precipitation Weight** and **Distribution Weight** values listed in Table C.3. Press the F10 key to exit the composite precipitation data entry screen.

TABLE C.3 Gage Weights for Upper Interior Sub-Basin Composite Precipitation

Rainfall Gage	Total Precipitation Weight	Distribution Weight
Gage 1	60%	100%
Gage 2	40%	0%

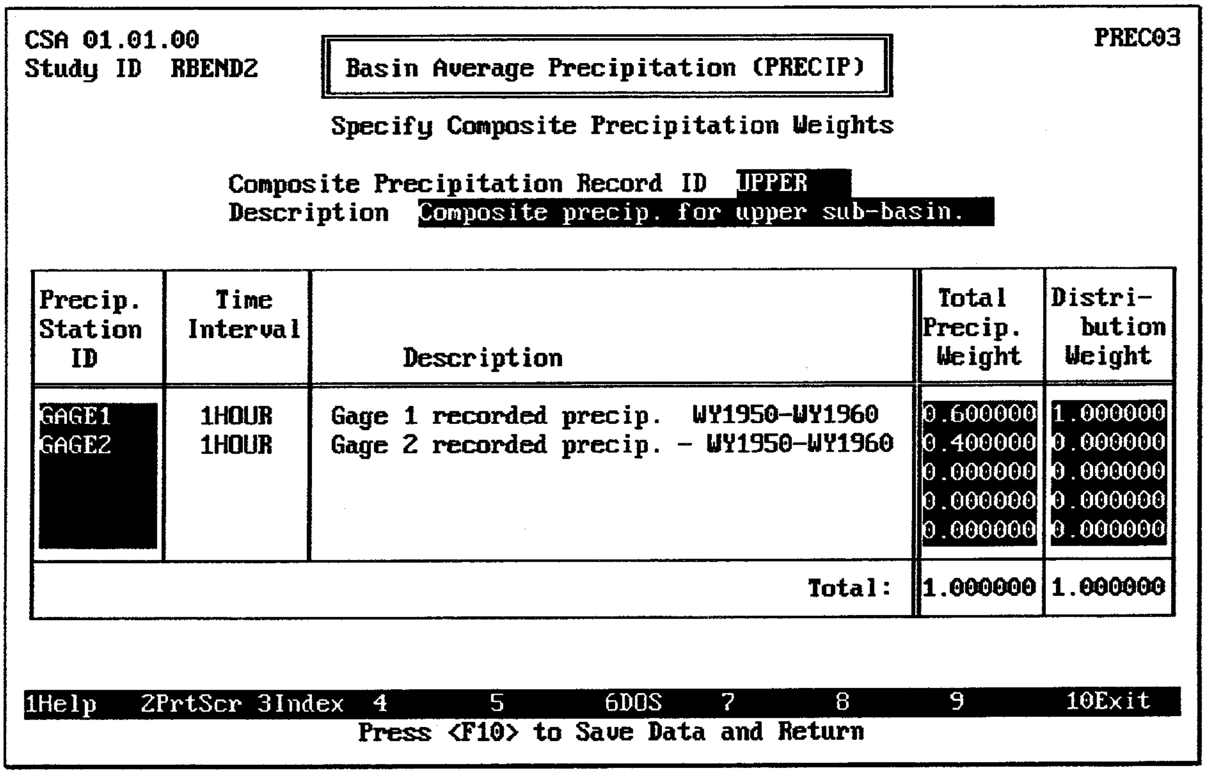

FIGURE C.5 Composite Basin Average Precipitation Data Entry Screen

After the Composite Precipitation Weights have been entered, follow these steps to view the composite precipitation pattern:

1. Select *View Composite Precipitation Patterns* from the Basin Average Precipitation menu screen. Figure C.6 shows the screen used to view a computed composite precipitation pattern.

2. Press the [F3] key and select the UPPER **Composite Precipitation Record ID.** Press [Enter] and the HEC-IFH program will compute the UPPER composite rainfall record.

3. After the composite precipitation computation is complete, press the [F4] key to locate the values listed in Table C.2. These are the maximum hourly rainfall totals for each gage.

4. Press the [F9] key to plot the data. Use the HEC-IFH plotting capabilities to review the computed data. Figure C.7 illustrates the annual composite precipitation hyetograph. On a color computer monitor, the composite precipitation and each of the individual gage records would be plotted in a different color.

5. Press the [F10] key to return to the Basin Average Precipitation menu screen.

CSA 01.01.00
Study ID RBEND2

Basin Average Precipitation (PRECIP)

PREC04

View Composite Precipitation Pattern

Composite Precipitation Record ID: UPPER **Units: (in)**

Date/Time DaMonYear/HrMn	Station GAGE1	Station GAGE2	Station	Station	Station	Basin Average
10OCT1954/0100	0.19	1.13				0.20
10OCT1954/0200	0.13	0.38				0.14
10OCT1954/0300	0.13	0.28				0.14
10OCT1954/0400	0.21	0.12				0.22
10OCT1954/0500	0.28	0.23				0.29
10OCT1954/0600	0.21	0.17				0.22
10OCT1954/0700	0.10	0.22				0.10
10OCT1954/0800	0.01	0.02				0.01
10OCT1954/0900	0.03	0.02				0.03
10OCT1954/1000	0.17	0.06				0.18
10OCT1954/1100	0.14	0.05				0.14
10OCT1954/1200	0.03	0.00				0.03

1Help 2PrtScr 3Index 4Goto 5Report 6DOS 7 8 9Plot 10Exit

Press <PgDn>, <PgUp> or <F4> for more; <F10> to Return

FIGURE C.6 Composite Storm Table

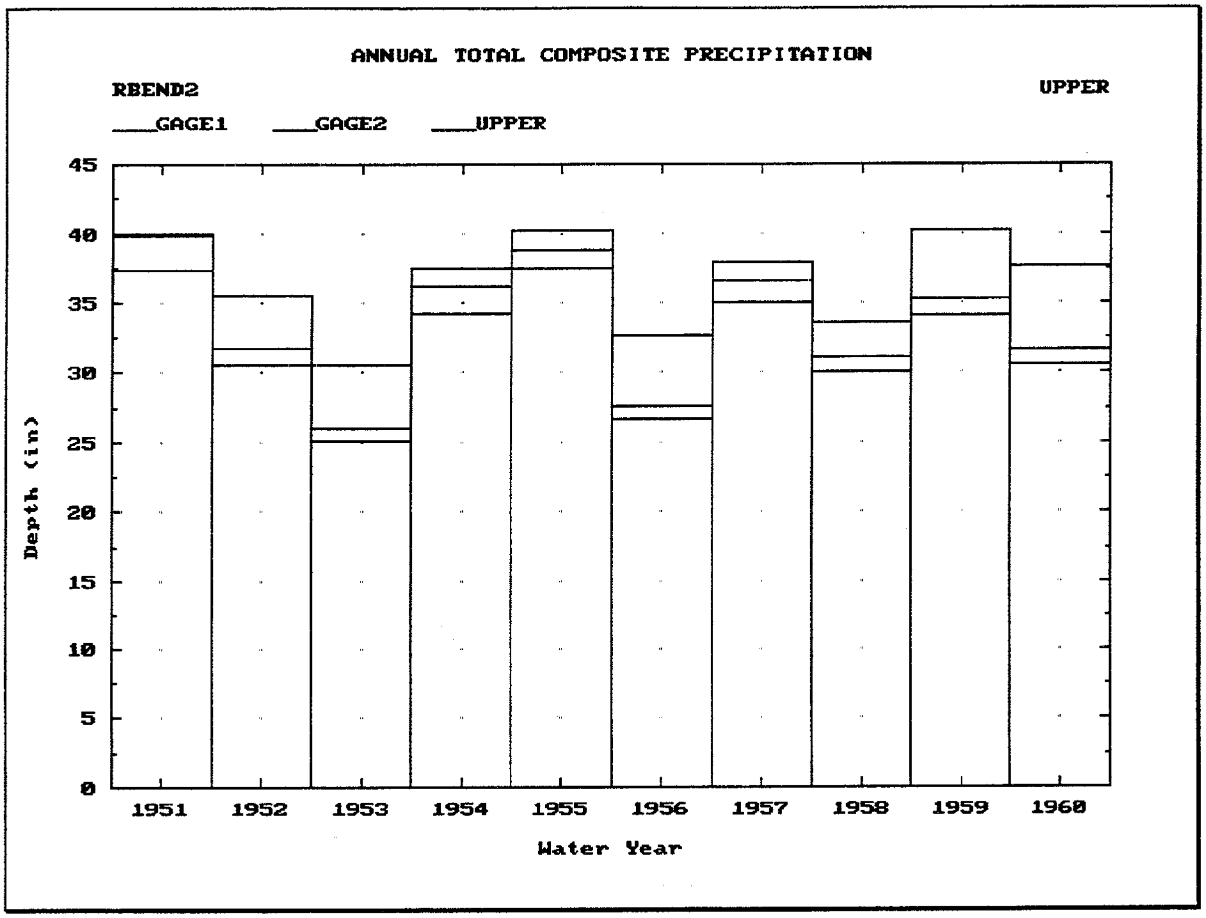

FIGURE C.7 Plot of Composite Precipitation Annual Totals

C.2.3. Specify PRECIP Module

After the rainfall gage records are imported, and composite precipitation records are computed, they are combined into a single "module" of precipitation data. This module is identified by a Module ID. The precipitation data already entered could be combined with other data entered later (perhaps a different composite precipitation computation, for example) to form different modules. To specify the PRECIP module, the following steps are required:

1. Select *Assign Precipitation Record for Each Sub-Basin* from the Basin Average Precipitation menu screen. Figure 3.8 illustrates the data entry screen which should appear.
2. Use PRECIP1 as the **Module ID**, and enter an appropriate 40-character **Description**.
3. Enter GAGE2 as the **Precipitation Station ID** for the lower interior sub-basin. Confirm that the description matches what you entered earlier when this rainfall gage record was imported.
4. Enter UPPER as the **Precipitation Station ID** for the upper interior sub-basin. Confirm that the description matches what you entered earlier when this composite precipitation record was computed.

5. Press the [F10] key to store the PRECIP1 PRECIP module data and return to the Basin Average Precipitation menu Screen. The PRECIP1 PRECIP module is ready to be used in a plan analysis.

```
CSA 01.01.00                                                     PREC05
Study ID  RBEND2      Basin Average Precipitation (PRECIP)

              Assign Precipitation Record for Each Sub-Basin

           Module ID     PRECIP1
           Description   Precip. data for App. C.

 Sub-Basin        Precipitation        Description
                   Station ID
 Lower Interior    GAGE2        Gage 2 recorded precip. - WY1950-WY1960
 Upper Interior    UPPER        Composite precip. for upper sub-basin.

1Help  2PrtScr 3Index  4     5     6DOS    7     8     9     10Exit
                  Press <F10> to Save Data and Return
```

FIGURE C.8 Continuous Simulation Precipitation Data Specification Screen

C.2.4. Basin Runoff Data

Runoff from each of the two River Bend interior sub-basins will be computed using available data. Assume that the following information is available:

1. Neither of the interior sub-basins has any significant base flow in any month.
2. The infiltration losses for each sub-basin can be estimated using the Initial-Uniform-Recovery method, with the loss parameters listed in Table C.4.
3. The runoff characteristics of each sub-basin can be modeled using the SCS Dimensionless unit hydrograph, with the unit hydrograph parameters listed in Table C.4.

TABLE C.4 Runoff Parameters for Interior Sub-Basins

Parameter	Upper Sub-Basin	Lower Sub-Basin
Basin Drainage Area	7.5 square miles	5.0 square miles
Initial Loss	0.50 inches	0.50 inches
Uniform Loss Rate	0.02 inches/hour	0.02 inches/hour
Initial Loss Recovery Rate	0.1 inches/day (all months)	0.1 inches/day (all months)
% of Drainage Area Impervious	15%	20%
SCS Lag	4.2 hours	3.5 hours

The HEC-IFH RUNOFF data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Runoff Hydrograph Parameters (RUNOFF)* from the Define Interior Analysis Data Menu.
2. Select *Enter Basin Runoff Data* from the Runoff Hydrograph Parameters menu screen.
3. Use UPPER as the Basin ID, and enter an appropriate 40-character description.
4. Enter the runoff data parameters listed in Table C.4 as follows:
   a. First enter the **Basin Drainage Area** and **Percent of Drainage Area Impervious**.
   b. Specify no base flow by pressing the space bar to select 'No' for Enter Monthly Base Flow Rates.
   c. Specify the appropriate Basin Infiltration Loss Data by first highlighting Initial-Uniform-Recovery Method and pressing the space bar. A window will appear, containing data entry fields for monthly **Loss Recovery Rate**, **Initial Loss**, and **Uniform Loss Rate**. Enter these values. Figure C.9 illustrates the data entry window for the Initial-Uniform-Recovery loss method.
   d. Select the appropriate Basin Unit Hydrograph Data by first highlighting SCS Dimensionless Unit Graph and pressing the space bar. A window will appear, containing a data entry field for **SCS Lag**. Enter this value. Figure C.10 shows the data entry window for the SCS Dimensionless Unit Hydrograph Method.
   e. After entering the **SCS Lag** value, select 'yes' to display (tabulate) the unit hydrograph. Another window will appear for tabulating the unit hydrograph. Specify a 1HOUR unit hydrograph duration. The SCS Unit Hydrograph will be computed and displayed. (See Figure C.11). Locate the peak flow value. Confirm that the value listed in Table C.5 is correct.
   f. Press the [F9] key to plot the computed unit hydrograph. Press [Esc] to exit the plot and press the [F10] key to exit the unit hydrograph window.
5. Press the [F10] key again to store the UPPER sub-basin runoff data and return to the Runoff Hydrograph Parameters menu screen.
6. Repeat Steps 2 through 5 for the lower sub-basin. The lower interior sub-basin data should be stored using a Basin ID of LOWER.

TABLE C.5 Peak Flow Rates of 1-Hour Unit Hydrograph

Sub-Basin	Hour	Peak Flow Rate (cfs)
Upper Sub-Basin	5	766.7
Lower Sub-Basin	4	605.0

```
CSA 01.01.00                                                        RUN004
Study ID  RBENDZ       Runoff Hydrograph Parameters (RUNOFF)

                              Enter Basin Runoff Data
Basin ID     UPPER                                    Month  Initial Loss Recovery
   Upper Sub-basin for App. C example.
                                                       Oct        0.10    (in/day)
Basin Drainage Area (sq mi)             7.50           Nov        0.10
Percent of Drainage Area Impervious     15.0           Dec        0.10
                                                       Jan        0.10
Enter Monthly Base Flow Rates       Yes  No            Feb        0.10
                                                       Mar        0.10
Basin Infiltration Loss Data                           Apr        0.10
  Generalized Runoff Coefficients                      May        0.10
 [Initial-Uniform-Recovery Method]                     Jun        0.10
  No Losses Computed                                   Jul        0.10
                                                       Aug        0.10
Basin Unit Hydrograph Data                             Sep        0.10
  Clark's Unit Hydrograph
  Snyder's Unit Hydrograph                             Initial Loss (in)      0.50
 [SCS Dimensionless Unit Graph]                        Uniform Loss (in/hr)   0.02
  Enter Unit Hydrograph

1Help  2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                      Press <F10> to Save Data and Return
```

FIGURE C.9 Initial-Uniform-Recovery Data Entry Window

```
CSA 01.01.00                                                        RUN007
Study ID  RBENDZ       Runoff Hydrograph Parameters (RUNOFF)

                              Enter Basin Runoff Data
Basin ID     UPPER
   Upper Sub-basin for App. C example.

Basin Drainage Area (sq mi)             7.50
Percent of Drainage Area Impervious     15.0

Enter Monthly Base Flow Rates       Yes  No

Basin Infiltration Loss Data
  Generalized Runoff Coefficients
 [Initial-Uniform-Recovery Method]
  No Losses Computed

Basin Unit Hydrograph Data              SCS Dimensionless Unit Hydrograph
  Clark's Unit Hydrograph
  Snyder's Unit Hydrograph             SCS Lag (hr)                  4.20
 [SCS Dimensionless Unit Graph]        Display (Tabulate) U. Hyd.?   yes [no]
  Enter Unit Hydrograph

1Help  2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                      Press <F10> to Save Data and Return
```

FIGURE C.10 SCS Dimensionless Unit Hydrograph Data Entry Window

CSA 01.01.00
Study ID RBEND2

Runoff Hydrograph Parameters (RUNOFF)

RUN025

Enter Basin Runoff Data

Basin ID UPPER
Upper Sub-basin for App. C example.

Basin Drainage Area (sq mi) 7.50
Percent of Drainage Area Impervious 15.0

Enter Monthly Base Flow Rates Yes No

Basin Infiltration Loss Data
Generalized Runoff Coefficients
[Initial-Uniform-Recovery Method]
No Losses Computed

Basin Unit Hydrograph Data
Clark's Unit Hydrograph
Snyder's Unit Hydrograph
[SCS Dimensionless Unit Graph]
Enter Unit Hydrograph

Unit Hydro. Duration 1HOUR

Time (HOUR)	Unit Hydrograph Ordinates (cfs)
1	86.0
2	270.7
3	556.6
4	741.3
5	766.7
6	676.2
7	532.9
8	353.8
9	248.9
10	180.1
11	127.2
12	89.8

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Save Data and Return

FIGURE C.11 Unit Hydrograph Tabulation

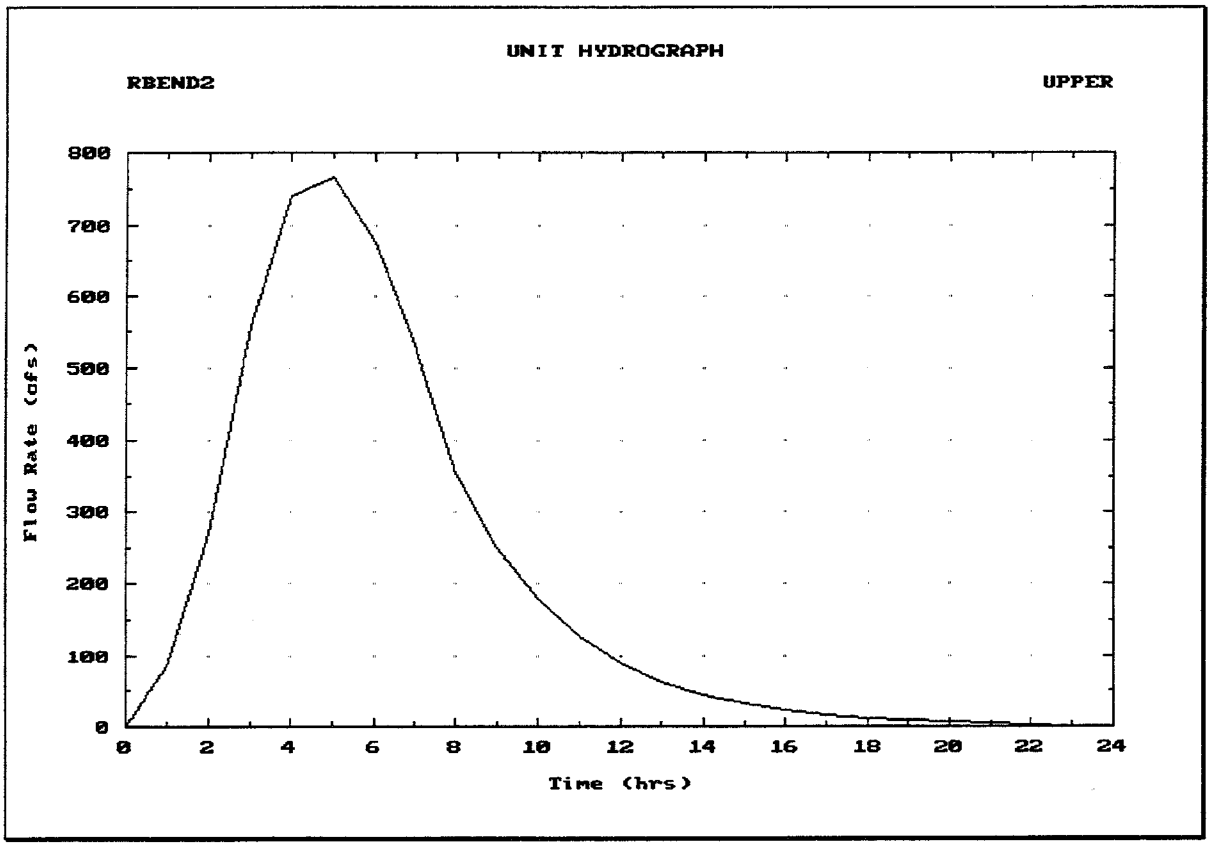

FIGURE C.12 Unit Hydrograph Plot

C.2.5. Channel Routing Data

As noted previously, a channel connects the upper interior sub-basin of the River Bend interior area to the interior pond. Assume that the channel can be modelled using the Muskingum method of channel routing. Table C.6 lists the Muskingum routing parameters for the channel.

TABLE C.6 Channel Routing Parameters for Upper Interior Sub-Basin

Parameter	Value
Number of Routing Steps	5
Muskingum K Coefficient	5 hours
Muskingum x Coefficient	0.4

The HEC-IFH RUNOFF data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Enter Channel Routing Data for Upper Sub-Basin* from the Runoff Hydrograph Parameters (RUNOFF) menu.
2. Use ROUTE1 as the **Channel Routing ID**, and enter an appropriate 40-character **Description**.
3. Enter the channel routing parameters listed in Table C.6. Figure C.13 shows the data entry screen for the Muskingum routing parameters.
4. Press the F10 key to store the ROUTE1 channel routing data and return to the Runoff Menu Screen.

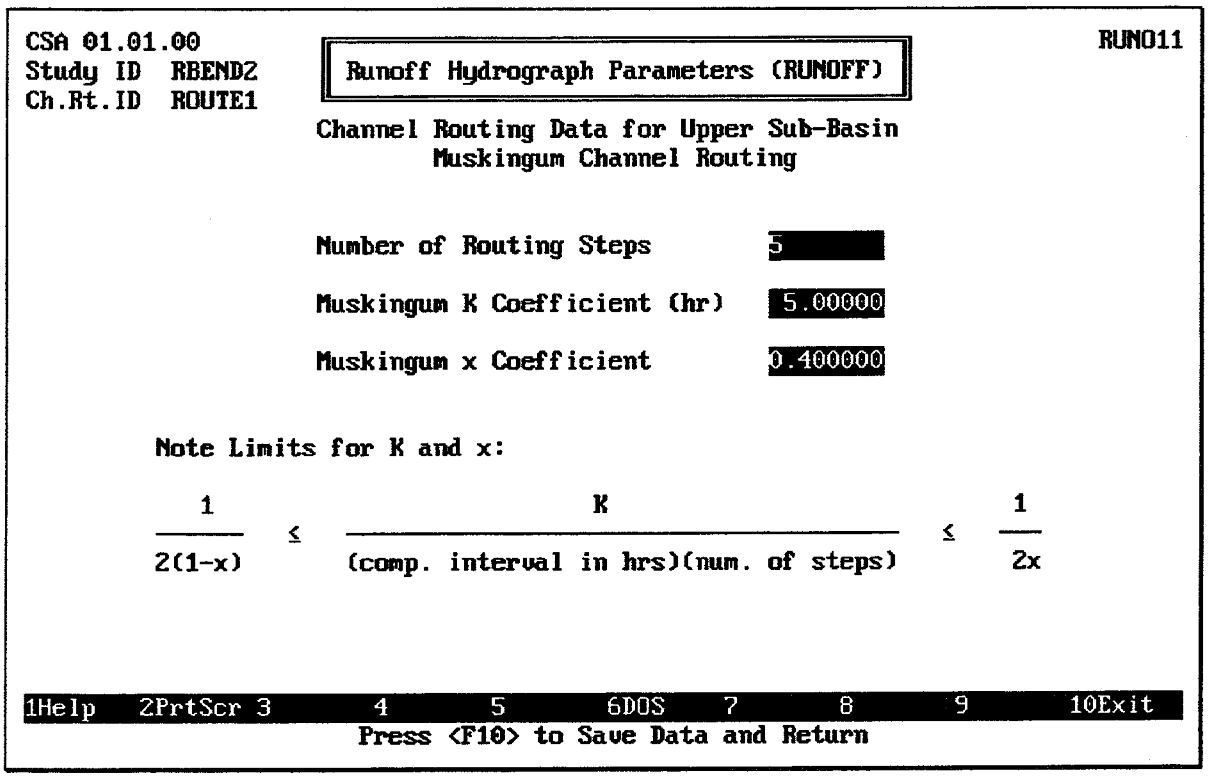

FIGURE C.13 Muskingum Routing Data Entry Screen

C.2.6. Specify RUNOFF Module

After the runoff parameters and channel routing data are entered, they are combined into a single "module" of runoff data. This module is identified by a Module ID. The sub-basin runoff and channel routing data already entered could be combined with other data entered later (perhaps a different channel routing method, for example) to form different modules. To specify the runoff module, the following steps are required:

1. Select *Assign Basin Runoff Data Set for Each Sub-Basin* from the Runoff Hydrographs Parameters (RUNOFF) Screen.
2. Use RUNOFF1 as the **Module ID**, and enter an appropriate 40-character **Description**.
3. Press the [F3] key and select LOWER as the **Basin ID** for the lower interior sub-basin. Confirm that the description and drainage area match those entered earlier.
4. Press the [F3] key and select UPPER as the **Basin ID** for the upper interior sub-basin. Confirm that the description and drainage area match those entered earlier.
5. Press the [F3] key and select ROUTE1 as the **Upper Sub-Basin Channel Routing ID**. Confirm that the description matches that entered earlier.
6. Press the [F10] key to store the RUNOFF1 runoff module data and return to the Runoff Menu Screen. The RUNOFF1 RUNOFF module is ready to be used in a plan analysis.

```
CSA 01.01.00                                                          RUN017
Study ID  RBEND2     Runoff Hydrograph Parameters (RUNOFF)

              Assign Basin Runoff Data Set for Each Sub-Basin

          Module ID     RUNOFF1

          Description   Runoff data for App. C. example.
```

Sub-Basin	Basin ID	Description	Drainage Area (sq mi)
Lower Interior	LOWER	Lower sub-basin for App. C example.	5.00
Upper Interior	UPPER	Upper Sub-basin for App. C example.	7.50

```
 Upper Sub-Basin Channel Routing ID  ROUTE1
                                     Channel routing data for App. C example.

1Help  2PrtScr 3Index  4     5     6DOS   7     8     9     10Exit
                 Press <F10> to Save Data and Return
```

FIGURE C.14 Runoff Data Specification Screen

C.2.7. Interior Pond Data

The River Bend interior area has an interior pond with the following characteristics:

1. The elevation versus surface area relationship of the ponding area is described using the data in Table C.7.
2. The interior pond is directly adjacent to the proposed line-of-protection. No interior ditch is required to convey discharges from the interior pond to the line of protection.

TABLE C.7 Elevation versus Surface Area Relationship for Interior Ponding Area

Elevation (feet, NGVD)	Surface Area (acres)	Storage Volume (ac-ft)
591	0	0.0
592	4	2.0
593	10	9.0
594	15	21.5
595	75	66.5
596	130	169.0
597	200	334.0
598	275	571.5
599	400	909.0
600	525	1371.5
601	700	1984.0
605	2000	7384.0

The HEC-IFH POND data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Interior Pond (POND)* from the HEC-IFH Define Interior Analysis Data Menu.
2. Select *Enter Surface Areas for Computing Volumes* from the Interior Pond Menu Screen.
3. Use POND1 as the **Storage Table ID**, and enter an appropriate 40-character **Description**.
4. Enter the **Pond Elevation** and **Surface Area** values listed in Table C.7. The data entry screen should match the illustration in Figure C.15.
5. Press the [F9] key to plot the surface areas and computed pond storage volumes. Confirm that the computed pond storage volumes listed in Table C.7 are correct. The plot is illustrated in Figure C.16.
6. Press the [F10] key to store the POND1 interior pond storage data and return to the Interior Pond Menu Screen.

CSA 01.01.00 POND03
Study ID RBEND2

Interior Pond (POND)

Enter Surface Areas for Computing Volumes

Storage Table ID POND1

Description
Interior pond for App. C example.

Pond Elevation (ft)	Surface Area (ac)	Storage Volume (ac-ft)
591.00	0.0	0.0
592.00	4.0	2.0
593.00	10.0	9.0
594.00	15.0	21.5
595.00	75.0	66.5
596.00	130.0	169.0
597.00	200.0	334.0
598.00	275.0	571.5
599.00	400.0	909.0
600.00	525.0	1371.5
601.00	700.0	1984.0
605.00	2000.0	7384.0
0.00	0.0	0.0

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE C.15 Pond Surface Area Data Entry Screen

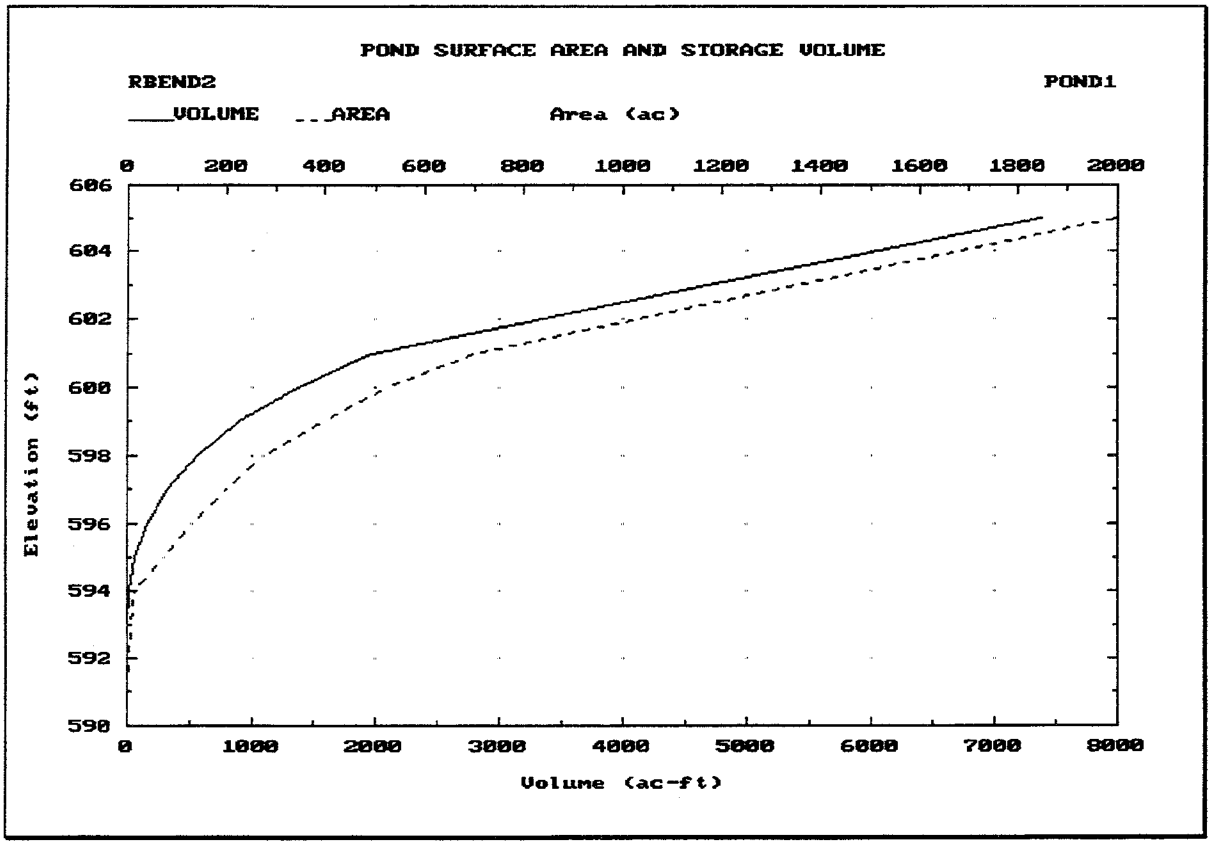

FIGURE C.16 Pond Surface Area and Storage Volume Plot

C.2.8. Specify POND Module

After the interior storage data and interior ditch rating curve are entered, they are combined into a single "module" of pond data. This module is identified by a Module ID. The interior storage data and interior ditch data already entered could be combined with other data entered later (perhaps a larger pond, for example) to form different modules. To specify the POND module, the following steps are required:

1. Select *Specify Module Data* from the Interior Pond Menu Screen.
2. Use INTPOND1 as the **Module ID**, and enter an appropriate 40-character **Description**.
3. Enter POND1 as the **Storage Table ID** for the interior ponding area. Confirm that the description matches what you entered earlier.
4. Do not enter a **Ditch Table ID**. Since this interior ponding area is directly connected to the outlets at the line-of-protection, there is no need to specify the capacity of the channel connecting the interior ponding area with the outlets.
6. Press the F10 key to store the INTPOND1 POND module data and return to the Interior Pond Menu Screen. The INTPOND1 POND module is ready to be used in a plan analysis.
7. Press the F10 key again to return to the Define Interior Analysis data menu.

```
CSA 01.01.00                                                       POND05
Study ID  RBEND2          Interior Pond (POND)

                          Specify Module Data

      Module ID          INTPOND1

      Description        Interior pond module data for App. C.

      Storage Table ID   POND1     Interior pond for App. C example.
      Ditch Table ID

1Help  2PrtScr 3    4     5     6DOS    7     8     9     10Exit
                 Press <F10> to Save Data and Return
```

FIGURE C.17 Pond Data Specification Screen

C.2.9. Exterior Stage Data

Before the HEC-IFH program can analyze the River Bend interior area, the exterior stage records for the Green River must be transferred from the IFHTEST.DSS file. To import the Green River stage record, follow these steps:

1. Select *Exterior Stage (EXSTAGE)* from the HEC-IFH Define Interior Analysis Data Menu.
2. Use EXSTAGE1 as the **Module ID**, and enter an appropriate 40-character **Description**. Press the F10 key to continue to the Exterior Stage Menu screen.
3. Select [*A. Specify Exterior Stage*] from the Exterior Stage Menu screen.
4. Use the space bar to select [Main River] as the **Primary Outlet Location**, since the stream gage location is close enough to the primary gravity outlet location so that no transfer relationship is necessary.
5. Select [*Use Index Stage Hydrograph for all Outlet Locations*] as the appropritate **Transfer Relation**.
6. Select [*Enter/Import*] Index Stage Hydrograph. The Enter/Import Screen will then appear. (See Figure C.18.)

```
CSA 01.01.00                                                        EXST04
Study ID  RBEND2         | Exterior Stage (EXSTAGE) |   Primary Outlet Location
Module ID EXSTAGE
                     Enter/Import Exterior Stage Hydrograph

Starting Period              01OCT1950/2400      Date/Time         Elevation
 (e.g. 01JAN1989/1300)                           DaMonYear/HrMn    (ft)

Ending Period                30SEP1960/2400      10OCT1954/2400    605.20
                                                 11OCT1954/2400    613.74
Time Interval                1DAY                12OCT1954/2400    608.30
 (e.g. 1HOUR, 1DAY, ...)                         13OCT1954/2400    601.36
                                                 14OCT1954/2400    599.58
                                                 15OCT1954/2400    598.81
                                                 16OCT1954/2400    597.57
                                                 17OCT1954/2400    590.79
                                                 18OCT1954/2400    590.40
                                                 19OCT1954/2400    590.17
                                                 20OCT1954/2400    589.40
                                                 21OCT1954/2400    587.70
                                                 22OCT1954/2400    587.27
                                                 23OCT1954/2400    586.27

1Help   2PrtScr 3     4     5     6DOS   7     8     9     10Exit
                     Press <F10> to Save Data and Exit
```

FIGURE C.18 Exterior Stage Data Entry Screen

1. Enter a **Starting Period** of 01OCT1950/2400 for the exterior stage hydrograph. This is the end of the first 1-day period in Water Year 1951.
2. Enter an **Ending Period** of 30SEP1960/2400 for the exterior stage hydrograph. This is the end of Water Year 1960.
3. Specify a **Time Interval** of 1DAY for the exterior stage hydrograph.

4. After the HEC-IFH program moves the cursor to the top of the **Elevation** column, press the [F7] key to specify that the data will be imported. Use the file name and HEC-DSS path name information from Table C.8 for the external HEC-DSS file. Press the [F10] key to begin data import.

5. After the data import procedure is complete, press the [F4] key to locate the value for 11OCT1954/2400. Confirm that the value is 613.74 feet NGVD. This is the maximum exterior stage value.

6. Press the [F9] key to plot the data. Use the HEC-IFH plotting capabilities to review the imported data.

7. Press the [F10] key 3 times until the Exterior Stage Menu Screen reappears. Press the [Esc] key twice to return to the Define Interior Analysis Data menu screen.

TABLE C.8 External HEC-DSS Data for Exterior Stages

Data Item	Value	Note
HEC-DSS File Name	IFHTEST.DSS	1
HEC-DSS Path Name Part A	EXTERIOR	–
HEC-DSS Path Name Part B	L-O-P	–
HEC-DSS Path Name Part C	STAGE	–
HEC-DSS Path Name Part D	01JAN1900	2
HEC-DSS Path Name Part E	1DAY	–
HEC-DSS Path Name Part F	COMPUTED	–

Note 1: The current directory is the default installation location of the IFHTEST.DSS file. Use a complete DOS path name if the IFHTEST.DSS file is installed in a different location.
Note 2: For Import, Part D is not used. Any valid date may be entered, including the default date of 01JAN1900.

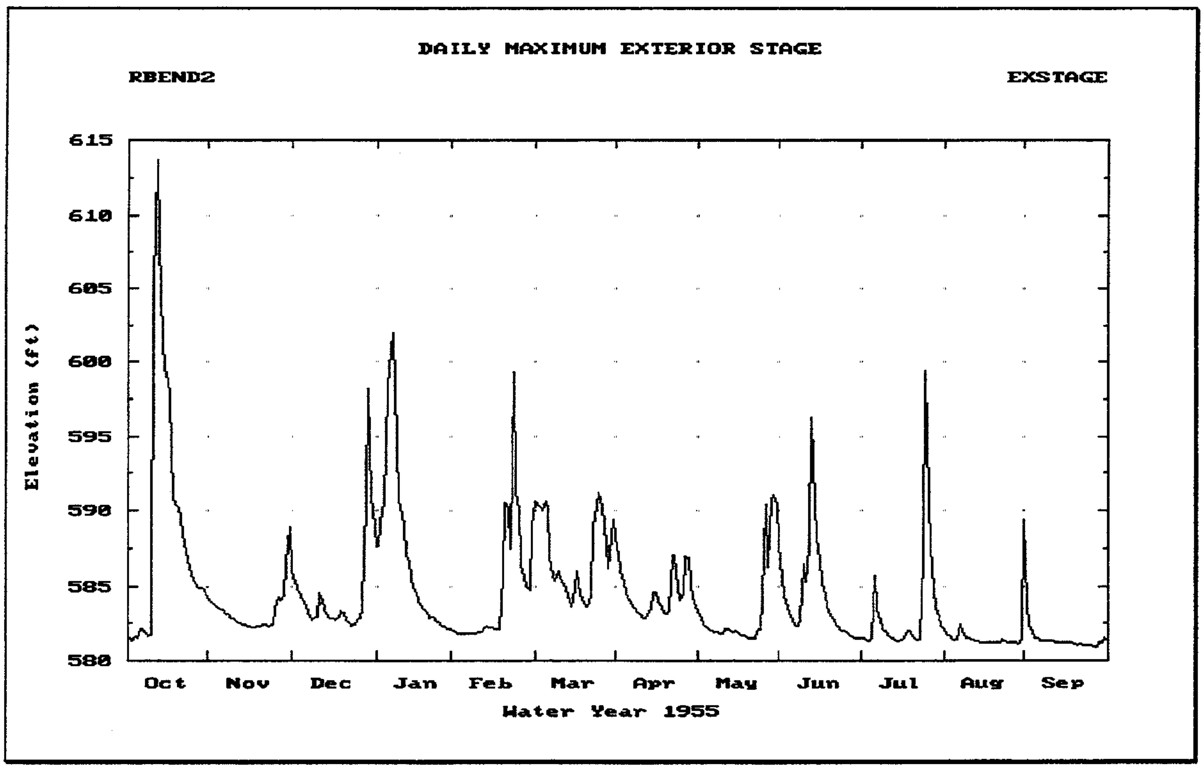

FIGURE C.19 One-Year Plot of Daily Maximum Exterior Stage Hydrograph

C.2.10. Gravity Outlet Data

For the "minimum" plan, the River Bend interior area is assumed to have a single 4x4 box culvert draining the interior ponding area. The characteristics of this gravity outlet are listed in Table C.9.

TABLE C.9 Gravity Outlet Characteristics

Characteristic	Value
Width	4 feet
Height	4 feet
FHWA Chart Number	8 (Flared Wingwalls)
FHWA Scale Number	1 (Wingwalls Flared 30-75 degrees)
Number of Identical Outlets	1
Length	200 feet
Manning's n	0.012
Entrance Loss Coefficient	0.4
Exterior Invert Elevation	589 feet NGVD
Interior Invert Elevation	591 feet NGVD

The HEC-IFH GRAVITY data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Gravity Outlets (GRAVITY)* from the Define Interior Analysis Data Menu.
2. Select *Compute Gravity Outlet Rating Table for Culvert* from the Gravity Outlet Menu Screen. The screen illustrated in Figure C.20 will appear.
3. Use 4x4BOX as the **Outlet Structure ID**, and enter an appropriate 40-character **Description**.
4. Use the space bar to select [BOX] as the **Culvert Type**. The Box Culvert data entry screen will appear (Figure C.21). Enter the first 4 values listed in Table C.9 describing the box culvert. Press the [F10] key to return to the previous data entry screen.
5. Enter the **Number of Identical Outlets**, **Length**, **Manning's n**, and **Entrance Loss Coefficient** values from Table C.9.
5. Enter a value of 4 feet for the **Tailwater Tabulation Interval**. This provides a range of 6 x 4 = 24 feet for tailwater values, from the exterior invert elevation of 589 feet NGVD up to 613 feet NGVD.
6. Enter a value of 20 cfs for the **Flow Capacity Tabulation Interval**. This provides a range of 20 x 20 = 400 cfs for flow values. The intervals are used to compute a gravity outlet table to view or plot. Internally, the program uses a 50 x 50 inverted gravity outlet trating table for pond routing.
7. Specify a value of 605 for the **Exterior Elevation for Gate Closure**. The gravity outlets will be closed whenever the exterior stage exceeds this value.
8. Press the [F10] key to store the 4x4BOX gravity outlet data and compute the gravity outlet rating table (See Figure C.22).
9. Press the [F9] key to plot the gravity outlet rating table (See Figure C.23).
10. Press the [F10] key to store the 4x4BOX gravity outlet rating table and return to the Gravity Outlet Menu Screen.

```
CSA 01.01.00                                                      GRAV04
Study ID  RBEND2          Gravity Outlets (GRAVITY)

              Compute Gravity Outlet Rating Table for Culvert

            Outlet Structure ID  4X4BOX
            Description          Single 4x4 Box culvert.

            Culvert Type:                              [Box] Circular

            Number of Identical Outlets                       1
            Length (ft)                                  200.00
            Manning's n                                0.012000
            Entrance Loss Coefficient                  0.400000

          * Tailwater Tabulation Interval (ft)             4.00
         ** Flow Capacity Tabulation Interval (cfs)        20.0

            Exterior Outlet Invert Elevation (ft)        589.00
            Interior Outlet Invert Elevation (ft)        591.00
            Exterior Elevation for Gate Closure (ft)     605.00

* 1/7th the expected elevation range        ** 1/20th the expected flow range
1Help  2PrtScr 3Index  4      5      6DOS   7      8      9      10Exit
                     Press <F10> to Save Data and Return
```

FIGURE C.20 Data Entry Screen for Culvert Computations

```
CSA 01.01.00                                                      GRAV05
Study ID  RBEND2          Gravity Outlets (GRAVITY)
Struc.ID  4X4BOX
             Compute Gravity Outlet Rating Table for Box Culvert

 Outlet Dimensions :
   Width (ft)          4.00
   Height (ft)         4.00

 FHWA Chart          8
   08 Flared Wingwalls
   09 Flared Wingwall and Inlet Top Edge Bevel
   10 90-degree Headwall; Chamfered or Beveled Inlet Edges
   11 Skewed Headwall; Chamfered or Beveled Inlet Edges
   12 Non-offset Flared Wingwalls; 3/4-inch Chamfer at Top of Inlet
   13 Offset Flared Wingwalls; Beveled Edge at Top of Inlet

 FHWA Scale         1
  1 Wingwalls flared 30 to 75 degrees
  2 Wingwalls flared 90 or 15 degrees
  3 Wingwalls flared 0 degrees (sides extended straight)

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
                     Press <F10> to Save Data and Return
```

FIGURE C.21 Box Culvert Data Entry Screen

CSA 01.01.00 GRAV09
Study ID RBEND2
Struc.ID 4X4BOX

Gravity Outlets (GRAVITY)

View Computed Gravity Outlet Rating Table

Flow Capacity (cfs)	Headwater Elevation (ft) No TailWater	TailWater Elev. 1 593.00	TailWater Elev. 2 597.00	TailWater Elev. 3 601.00	TailWater Elev. 4 605.00	TailWater Elev. 5 609.00	TailWater Elev. 6 613.00
0.0	591.00	593.00	597.00	601.00	605.00	609.00	613.00
20.0	* 592.42	593.05	597.05	601.05	605.05	609.05	613.05
40.0	* 593.30	* 593.30	597.22	601.22	605.22	609.22	613.22
60.0	* 594.04	* 594.04	597.49	601.49	605.49	609.49	613.49
80.0	* 594.71	* 594.71	597.87	601.87	605.87	609.87	613.87
100.0	* 595.34	* 595.34	598.36	602.36	606.36	610.36	614.36
120.0	* 596.29	* 596.29	598.96	602.96	606.96	610.96	614.96
140.0	* 597.17	* 597.17	599.66	603.66	607.66	611.66	615.66
160.0	* 598.07	* 598.07	600.48	604.48	608.48	612.48	616.48
180.0	* 599.09	* 599.09	601.40	605.40	609.40	613.40	617.40
200.0	* 600.24	* 600.24	602.44	606.44	610.44	614.44	618.44

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
* Inlet Control Press <PgDn>, <PgUp> or <F10>

FIGURE C.22 Computed Gravity Outlet Rating Table

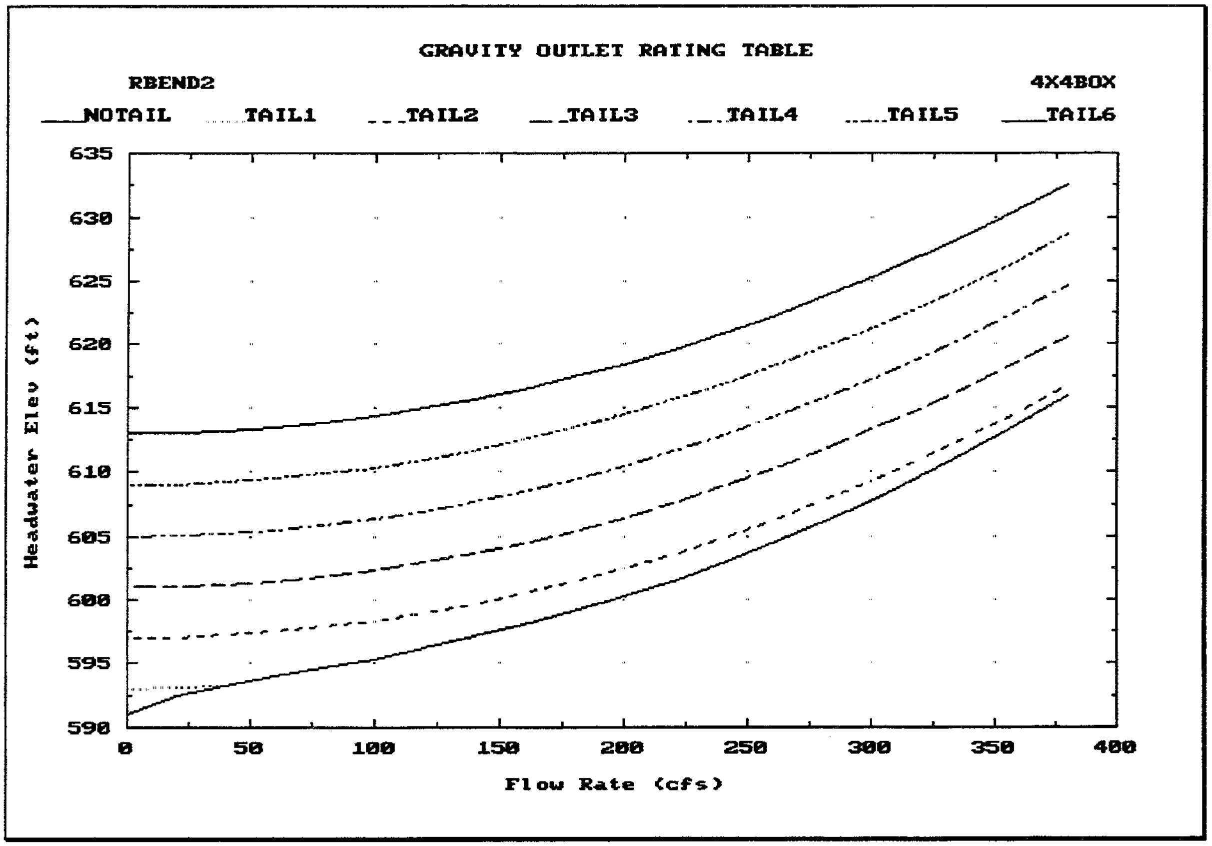

FIGURE C.23 Computed Gravity Outlet Rating Table Plot

C.2.11. Specify GRAVITY Module

After the gravity outlet rating tables are entered or computed, they are combined into a single "module" of gravity outlet data. This module is identified by a Module ID. The gravity outlet rating table already computed could be combined with other data entered later (perhaps an additional outlet, for example) to form different modules. To specify the GRAVITY module, the following steps are required:

1. Select *Assign Location for Each Outlet Structure ID* from the Gravity Outlets (GRAVITY) Menu Screen (see Figure C.24).
2. Use OUTLET1 as the **Module ID**, and enter an appropriate 40-character description.
3. Enter 4x4BOX as the first **Structure ID** for the Primary Location. Other Structure IDs can be left blank, since there are no other primary or secondary gravity outlets for this analysis. Also, the the **River/Levee Station** values are optional and can be left blank.
6. Press the F10 key to store the OUTLET1 module data and return to the Gravity Outlets (GRAVITY) Menu Screen. The OUTLET1 module is ready to be used in a plan analysis.

```
CSA 01.01.00                                                  GRAV08
Study ID  RBEND2          Gravity Outlets (GRAVITY)

              Assign Location for Each Outlet Structure ID

         Module ID     OUTLET1
         Description   1 - 4x4 box at the primary location.
```

	Primary Location	Secondary 1 Location	Secondary 2 Location	Secondary 3 Location	Secondary 4 Location
Structure ID Structure ID Structure ID Structure ID Structure ID	4X4BOX				
River/Levee Station (mi)	0.00	0.00	0.00	0.00	0.00

```
1Help  2PrtScr 3Index  4     5     6DOS    7     8     9     10Exit
              Press <F10> to Save Data and Return
```

FIGURE C.24 Screen to Specify GRAVITY Module Data

C.2.12. Specify PLAN and Compute Upper and Lower Sub-Basin Runoff

Each of the building blocks have been completed from which to build a PLAN. Use the Esc key to back up to the Continuous Simulation Analysis screen and select the *Perform Interior Analysis* option. Figure C.26 illustrates the Plan Specification screen.

1. Specify PLAN1 as the **Plan ID** and answer "Yes" to create a new Plan ID. Enter an appropriate 40-character description, such as "Gravity Outlet Only".

2. Use F3 to recall the available PRECIP Modules; highlight PRECIP1 (which should be the only one listed) and press Enter. Press Enter again to accept PRECIP1 as the correct PRECIP module; the short description will appear; verify that this is the correct module.

3. Use the F3 key to recall the available **Module IDs** and select RUNOFF (RUNOFF1), POND (INTPOND1), and GRAVITY (OUTLET1) Module IDs. Press Enter or use the down-arrow key to skip the PUMP module. Use the F3 key to choose the EXSTAGE module (EXSTAGE1).

4. Skip to the **Beginning Date for Analysis** box and enter 01OCT1950/0100 for beginning and 30SEP1960/2400 for the **Ending Date for Analysis**. Use 1HOUR for the **Computation Time Interval**.

5. Press F10 to advance to the next screen and select *Perform Lower Sub-Basin Analysis (+ Upper as Needed)*. HEC-IFH computes the runoff hydrograph and routes the flow to the interior pond. A running report of the progress of each step is displayed during computations. (Note: The analysis of this 10 years of hourly data will require about 7 megabytes of free storage space for the PLAN1.DSS output file. On a 25-MHz 80486 computer, about 7 minutes is required to analyze each basin.)

6. Use the Esc key to back up to the Continuous Simulation Analysis screen. Choose *Hydrologic Analysis Summaries* from this screen and press F10. The Hydrologic Analysis Summaries menu screen shown in Figure C.26 will be displayed.

7. Select *Rainfall-Runoff Data* from the Calculation Period Summaries portion of the menu (See Figure C.27). Use the F4 key to go to 10OCT1954/0100. Observe the precipitation and runoff from the upper and lower sub-basins during the October 1954 storm event. Press the F9 key and choose option A. to plot the lower sub-basin rainfall and runoff (See Figure C.28).

```
CSA 01.01.00                  Perform Interior Analysis                    MCB+
Study ID  RBEND2

  Plan ID  PLAN1      Description  Gravity outlet only.

                                  Module
            Module                  ID                  Description

Basin Average Precipitation     PRECIP1   Precip. data for App. C.
Runoff Hydrograph Parameters    RUNOFF1   Runoff data for App. C. example.
Interior Pond                   INTPOND1  Interior pond module data for App. C.
Gravity Outlets                 OUTLET1   1 - 4x4 box at the primary location.
Pump Data
Exterior Stage                  EXSTAGE   Exterior stage data for App. C example.
Auxiliary Flow

    Beginning Date for Analysis (DaMonYear/HrMn)            01OCT1950/0100
    Ending Date for Analysis (DaMonYear/HrMn)               30SEP1960/2400
    Computation Time Interval (e.g. 1HOUR, 1DAY, ...)       1HOUR

1Help  2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                        Press <F10> to Proceed to the Menu
```

FIGURE C.25 Plan Specification Screen

```
CSA 01.01.00                                                    MCC
Study ID  RBEND2     | Hydrologic Analysis Summaries |   Begin 01OCT1950/0100
Plan ID   PLAN1                                          End   30SEP1960/2400

Analysis Input Summaries                  Water Year Annual Summaries
   A. Data Management Summary                N. Rainfall-Runoff Data
   B. Rainfall-Runoff Summary                O. Interior/Exterior/Pump Data
   C. Gravity Outlet Data                    P. Maximum Area Flooded
   D. Pump Station Data

Calculation Period Summaries              Analysis Record Summaries
   E. Rainfall-Runoff Data                   Q. Maximum Values
   F. Interior/Exterior Data                 R. Inflows and Outflows
   G. Detailed Inflow Data                   S. Exceedance Duration Table
   H. Detailed Outflow Data                  T. Plotting Position Table
   I. Detailed Grav. Outflow Data            U. Stage-Frequency Table
   J. Area Flooded Data                      V. Pump Operation

Monthly Summaries                         Analysis Error Messages
   K. Average Monthly Rainfall               W. List Warning/Error Messages
   L. Interior/Exterior Data
   M. Pump Operation

1Help   2PrtScr 3      4       5       6DOS    7       8       9      10Exit
              Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE C.26 Hydrologic Analysis Summaries Menu Screen

```
CSA 01.01.00                                                  SUMM07
Study ID  RBEND2     | Hydrologic Analysis Summaries |   Begin 01OCT1950/0100
Plan ID   PLAN1                                          End   30SEP1960/2400
           E. Calculation Period Summaries - Rainfall-Runoff Data
```

	Lower Sub-Basin			Upper Sub-Basin			Exterior Basin		
Date/Time DaMonYear/HrMn	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)	Precip (in)	Losses (in)	Runoff (cfs)
10OCT1954/0100	1.13	0.02	479	0.20	0.02	2057	0.00	0.00	0
10OCT1954/0200	0.38	0.02	757	0.14	0.02	1949	0.00	0.00	0
10OCT1954/0300	0.28	0.02	1072	0.14	0.02	1698	0.00	0.00	0
10OCT1954/0400	0.12	0.02	1214	0.22	0.02	1388	0.00	0.00	0
10OCT1954/0500	0.23	0.02	1186	0.29	0.02	1202	0.00	0.00	0
10OCT1954/0600	0.17	0.02	1059	0.22	0.02	1106	0.00	0.00	0
10OCT1954/0700	0.22	0.02	894	0.10	0.02	1052	0.00	0.00	0
					01	997	0.00	0.00	0
					02	905	0.00	0.00	0
					02	781	0.00	0.00	0
					02	661	0.00	0.00	0
					02	575	0.00	0.00	0

```
Select Option:

 A. Plot Lower Sub-Basin Rainfall-Runoff
 B. Plot Upper Sub-Basin Rainfall-Runoff
 C. Plot Exterior Sub-Basin Rainfall-Runoff
                                              7       8       9      10Exit
     Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End> or <F4>
```

FIGURE C.27 Calculation Period Summary of Rainfall-Runoff Data

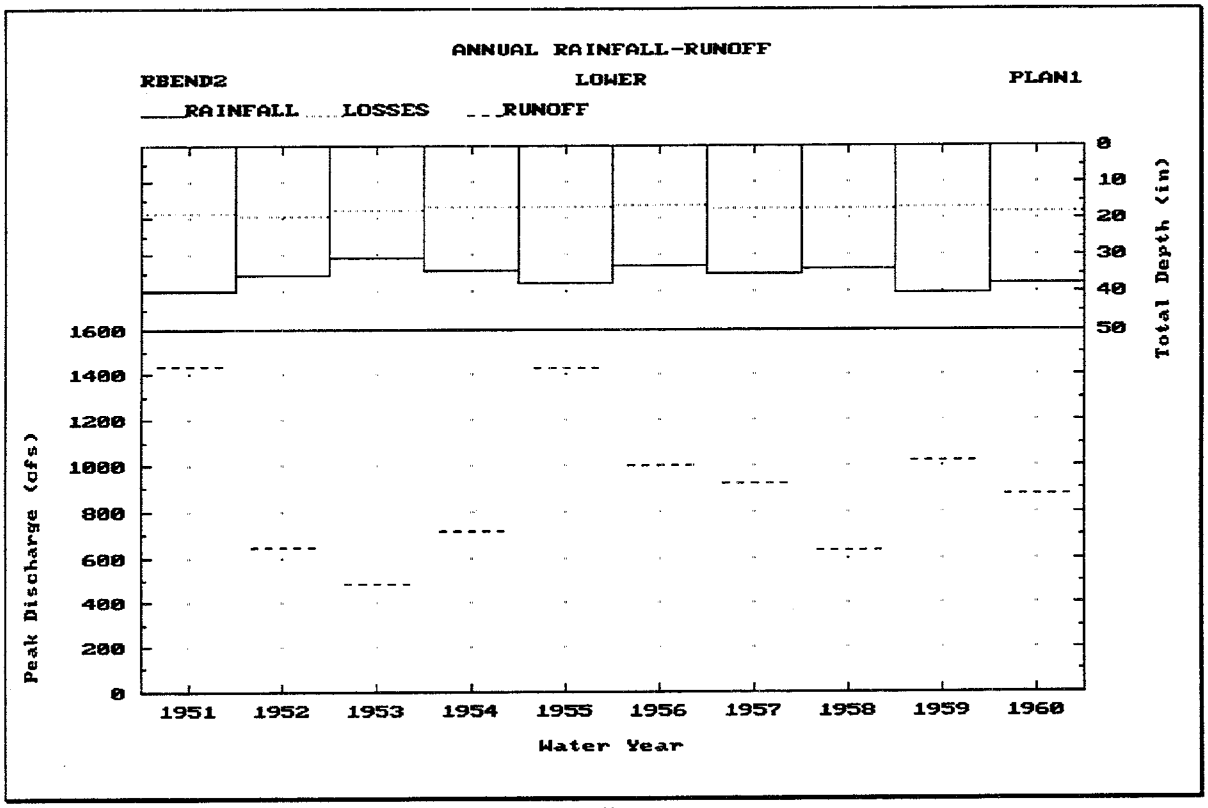

FIGURE C.28 Plot of Annual Total Rainfall-Runoff

C.2.13. Perform Pond Routing and Frequency Analysis

1. Press the [Esc] key to back up to the Continuous Simulation Analysis screen and select *Perform Interior Analysis* again. Press the [F10] key to exit the Plan Specification screen.
2. Next choose *Perform Frequency Analysis (Plus Pond Routing As Needed)*. Note that this choice will also perform any needed upstream calculations; none are required if you are following this set of instructions. Use a value of 591.1 for the **Starting Pond Elevation** and 0.1 for the **Minimum Head for Gravity Outlet Operation**. Since there are no pumps in this plan, skip **Operate Pumps, Gravity Outlets Simultaneously**. Select "Annual" for the **Type of Frequency Analysis** (see Figure C.29).
3. Press [F10] to perform the calculations. Again the program displays a computation progress report. The flow is routed through the interior pond and the interior area stage-frequncy relationship is determined. These steps require about 26 minutes on a 25MHz 80486 PC. The program performs several passes to arrive at various totals. Be sure to press the [F10] key after the analysis is completed to save the computed data.
4. Press the [Esc] key twice to back up to the Continuous Simulation Analysis menu screen. Choose *Hydrologic Analysis Summaries* to view the results of this plan.

From this menu screen, choose Stage-Frequency Table to view the interior area stage-fequency relationship based on 10 years of record (Figure C.30).

```
CSA 01.01.00                                                         CALC02
Study ID  RBENDZ          Perform Interior Analysis

           Perform Frequency Analysis (Plus Pond Routing as Needed)

  For New Pond Routing Analysis, enter or change:

    Starting Pond Elevation (ft)                              591.10
    Minimum Head for Gravity Outlet Operation (ft)              0.10
    Operate Pumps, Gravity Outlets Simultaneously?         Yes [No]

  For Frequency Analysis, set:

    Generate Annual Series or Partial Series?          [Annual] Partial
    For Partial Series:
      Threshold Elevation for events (ft)                       0.00
      Minimum days between events                                  0

1Help  2PrtScr 3     4      5      6DOS   7      8      9      10Exit
Press SPACE to select;   Press <F10> to Perform Analysis
```

FIGURE C.29 Pond Starting Conditions Screen

```
CSA 01.01.00                                                     SUMM25
Study ID  RBENDZ        Hydrologic Analysis Summaries   Begin 01OCT1950/0100
Plan ID   PLAN1                                         End   30SEP1960/2400
              U. Analysis Record Summaries - Stage-Frequency Table

                                Annual Series
```

% Chance Exceeded	Method of Computation	Computed Storage (ac-ft)	Computed Interior Stage (ft)	Adjusted Interior Stage (ft)
99%	Extrapolation	540.3	597.87	597.87
90%	Interpolation	572.5	598.00	598.00
50%	Interpolation	1319.9	599.89	599.89
20%	Interpolation	2061.7	601.06	601.06
10%	Interpolation	2996.7	601.75	601.75
4%	Extrapolation	5362.7	603.50	603.50
2%	Extrapolation	7868.7	605.00	605.00
1%	Extrapolation	11109.2	605.00	605.00
0.5%	Extrapolation	15232.1	605.00	605.00
0.2%	Extrapolation	22329.3	605.00	605.00

```
1Help  2PrtScr 3     4      5      6DOS   7      8      9Plot  10Exit
                         Press <F10> to Return
```

FIGURE C.30 Stage-Frequency Table

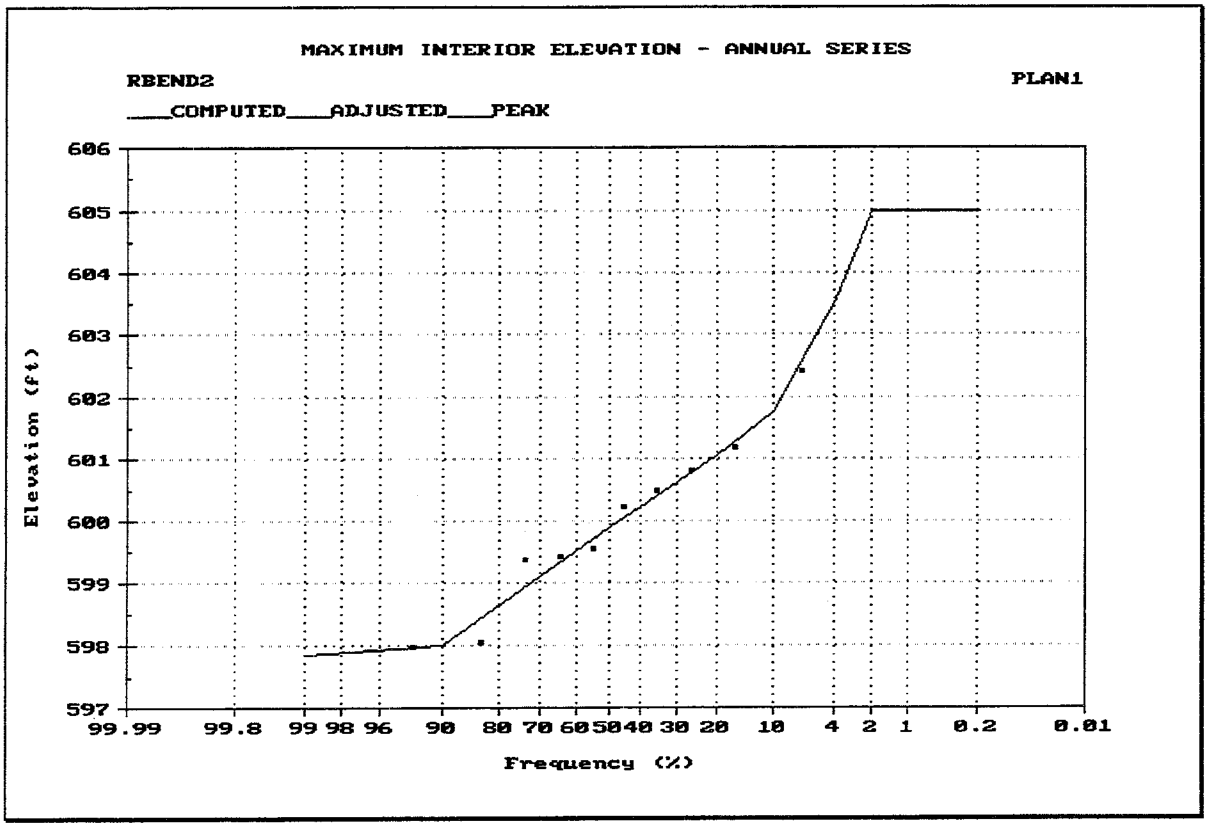

FIGURE C.31 Stage-Frequency Plot

C.3. "ADD A PUMP" ANALYSIS

A second plan will be formulated which uses a pump in addition to the 4 x 4 box culvert. Formulation of a second plan will allow a comparison of the plans.

The new plan, which will be named PLAN2, is still part of the RBEND2 study. The PRECIP, RUNOFF, EXSTAGE modules prepared as part of PLAN1 will also be a part of PLAN2. These data values do not have to be entered again. A new PUMP module must be prepared.

C.3.1 Prepare PUMP Module

1. From the Define Interior Analysis Data menu screen, choose *Pump Outlets (PUMP)*. Choose *Enter Pump Unit Data.* Figure C.32 illustrates the data entry screen which will appear.
2. Use PUMP1 for a **Pump Unit ID**. Supply an appropriate 40-character description.
3. The **Estimated Head Loss** (friction, etc.) is 1 foot. The **Total Head-Capacity-Efficiency** values for the pumping unit are listed in Table C.10.
4. Use elevation 600 as the **Pump Start Elevation** and elevation 598 as the **Pump Stop Elevation** for all months. For quicker data entry, type (*) or ditto (") on the second through twelfth rows to copy the data values from the row above.
5. After completing the data entry, press the F9 key to plot the Total Head versus Capacity curve and start/stop elevations for the pumping unit (Figures C.33 and C.34).

6. Use [F10] to save the data and choose *Assign Pump Unit for Each Pump Station* in order to name the PUMP module.
7. Name the PUMP module PUMPMOD1. Add an appropriate 40 character description. Use the [F3] key to select the Pump Unit (PUMP1 should appear in the list of available pumps.)
8. Use [F10] to save the data and [Esc] to back up to the Continuous Simulation Analysis menu screen.

TABLE C.10 Total Head-Capacity-Efficiency Characteristics of Pumping Unit

Total Head (feet)	Capacity (cfs)	Efficiency (%)
0	200	50
15	190	68
18	185	72
20	175	77
23	150	86
25	120	80
28	50	70
30	0	0

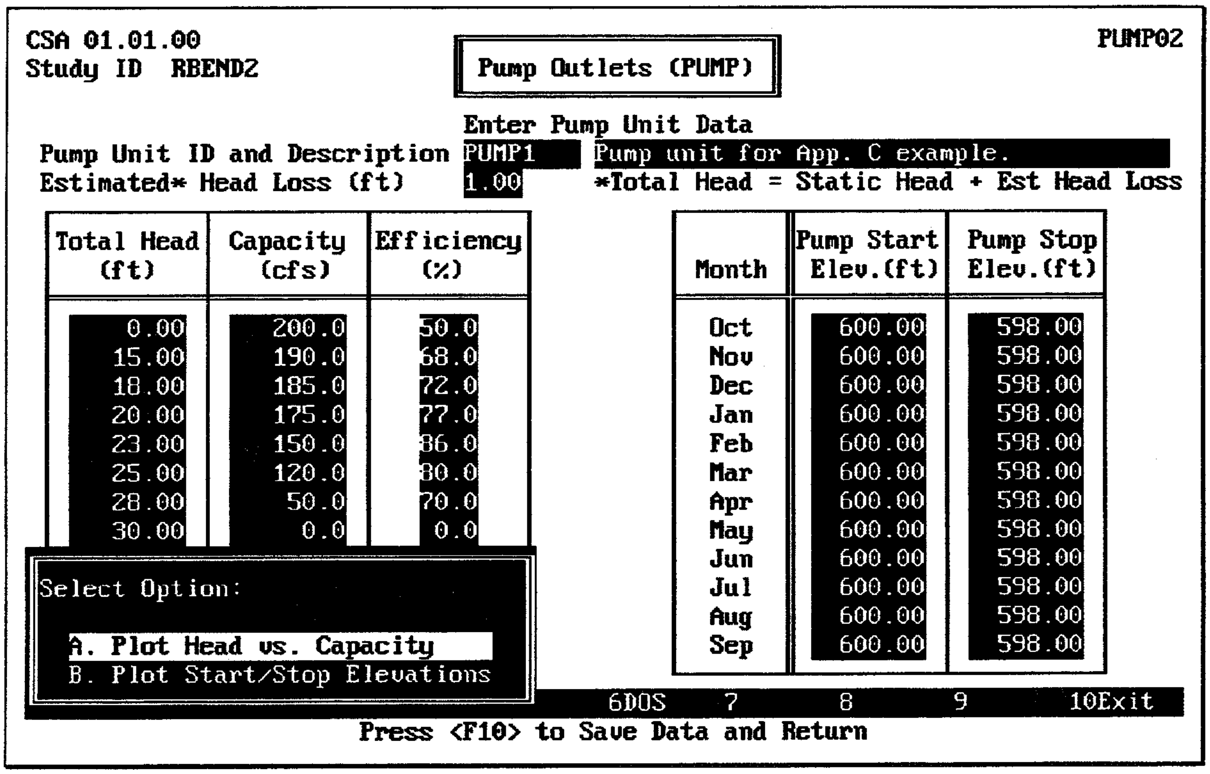

FIGURE C.32 Pump Unit Data Entry Screen

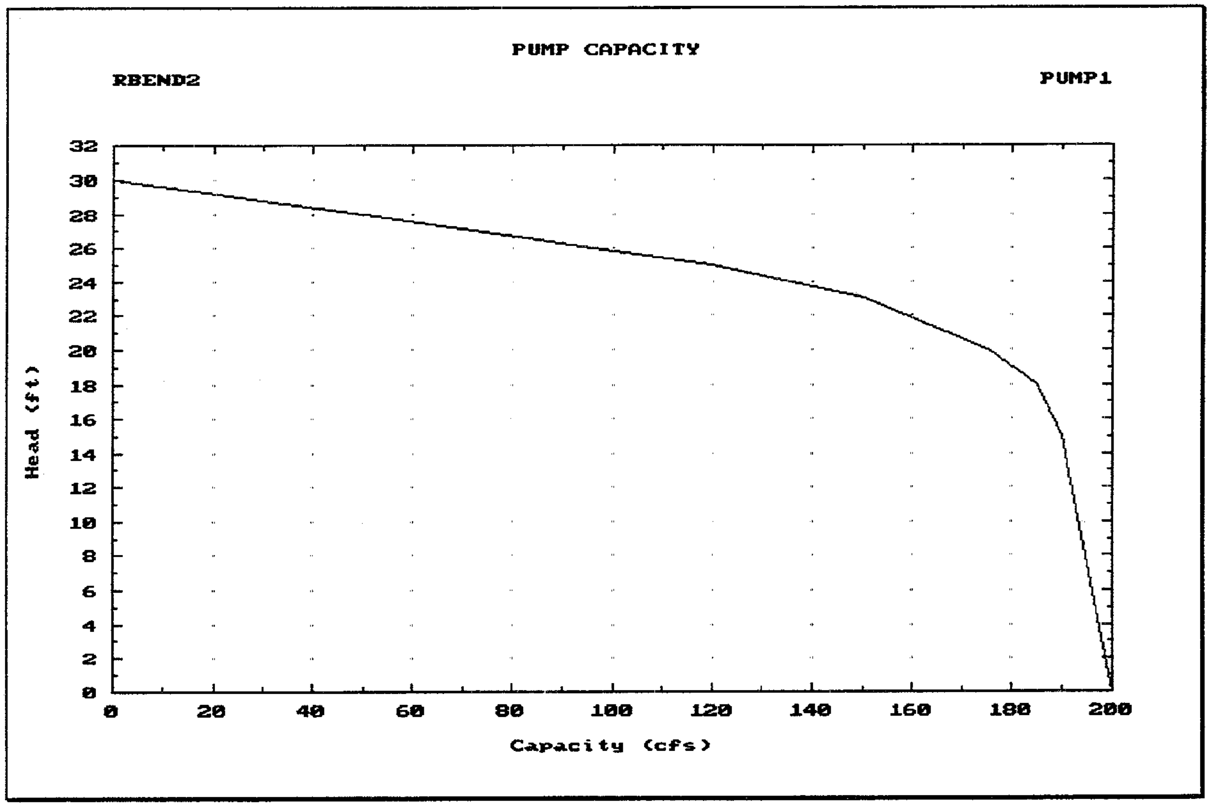

FIGURE C.33 Plot of Pump Capacity Versus Head and Efficiency

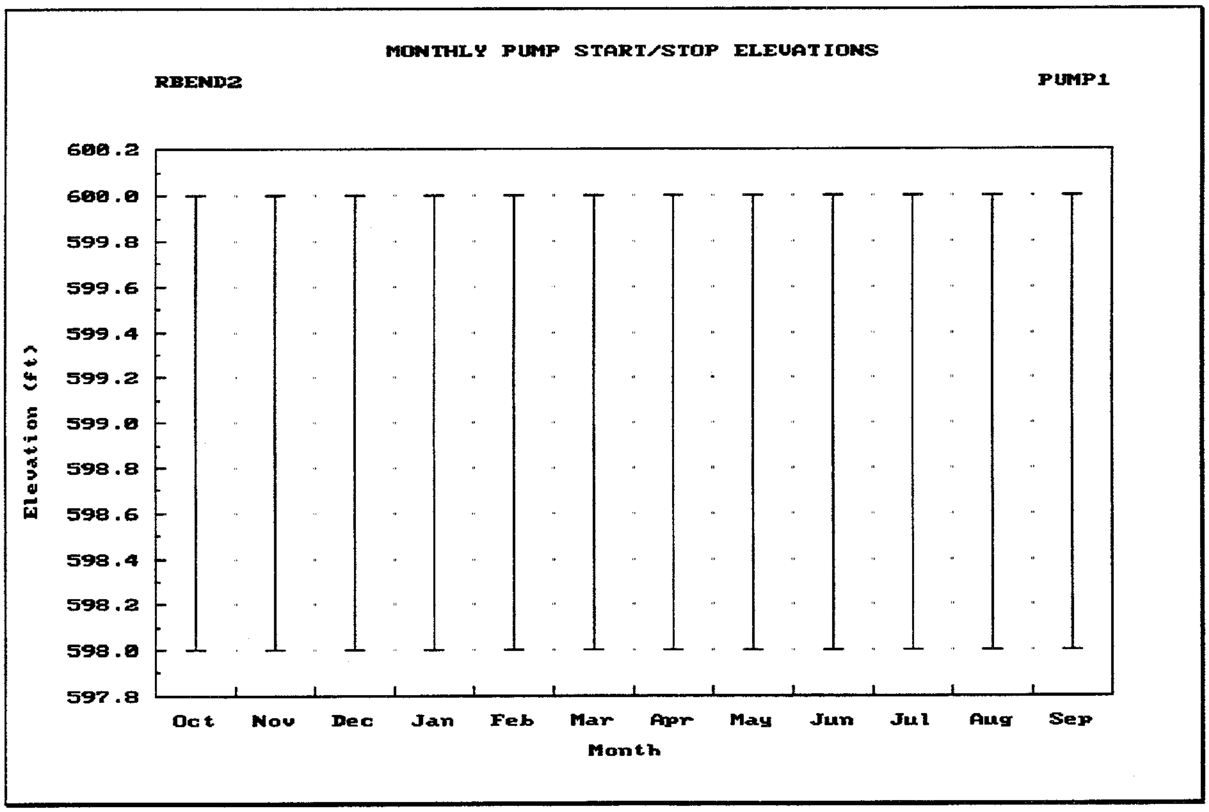

FIGURE C.34 Plot of Monthly Pump Start/Stop Elevations

CSA 01.01.00
Study ID RBEND2

Pump Outlets (PUMP)

PUMP03

Assign Pump Unit for Each Pump Station

Module ID PUMPMOD1
Description Pump module for App. C example.

Pump Number	Pump Unit ID	Description
1.	PUMP1	Pump unit for App. C example.
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE C.35 Screen to Specify PUMP Module Data

C.3.2 Prepare PLAN2

1. Choose *Perform Interior Analysis* from the Continuous Simulation Analysis menu screen.

2. Use PLAN2 as a **Plan ID** and insert an appropriate 40 character **Description**. Use the F3 key to choose the **Module ID** for Basin Average Precipitation, Runoff Hydrograph Parameters, Interior Pond, Gravity Outlet, Pump Data, and Exterior Stage. Note that only the PUMPMOD1 module is new to this Plan; all the others are also part of PLAN1.

3. As before, the **Beginning Date for Analysis** is 01OCT1950/0100, the **Ending Date for Analysis** is 30SEP1960/2400 and the **Computation Time Interval** is 1HOUR.

4. Use F10 to save the data; choose *Perform Pond Routing Analysis (+ Upper, Lower, Ext, as needed)* from the menu. Use a starting pond elevation of 591.1 and a minimum head for gravity outlet operation of 0.10 (same values as in PLAN1). Use YES to operate pumps, gravity outlets simultaneously.

5. As before, you will be notified of the progress of the computations. Note that you have selected to do the complete analysis (except for the frequency analysis) in one operation for this plan.

6. Choose *Perform Frequency Analysis* to complete the analysis for PLAN2. To compare plans 1 and 2, press the Esc key twice to return to the Continuous Simulation Analysis menu screen. Select *Comparison of Plans*. Use the F3 Index key to select the plans to compare. Figures C.37 through C.44 show the plan comparison screens. Results may vary in later versions of the program.

```
CSA 01.01.00                                                      MCD+
Study ID  RBENDZ              Comparison of Plans
```

Plan No.	Plan ID	Plan Description
1	PLAN1	Gravity outlet only.
2	PLAN2	4x4 Box culvert with 200-cfs pump.
3		
4		
5		
6		
7		

```
1Help  2PrtScr 3Index  4    5    6DOS   7    8    9    10Exit
              Press <F10> to Proceed to the Menu
```

FIGURE C.36 CSA Plan Comparison Summaries Plan Selection Screen

```
CSA 01.01.00                                                      COMP02
Study ID  RBENDZ              Comparison of Plans

                A. Analysis Summaries - Maximum Values
```

Plan ID	Exterior Elev. (ft)	Interior		Head Differential		Pump Data	
		Elev. (ft)	Area Flooded (ac)	Positive (ft)	Negative (ft)	Head (ft)	Outflow (cfs)
PLAN1	613.74	602.89	1313.9	17.34	-11.00	0.00	0.0
PLAN2	613.74	602.28	1114.5	17.34	-11.53	11.53	199.3

```
1Help  2PrtScr 3    4    5    6DOS   7    8    9    10Exit
                    Press <F10> to Return
```

FIGURE C.37 Maximum Values Analysis Summary

CSA 01.01.00 COMP03
Study ID RBEND2

Comparison of Plans

B. Analysis Summaries - Flood Volume Data

Plan ID	Inflow (ac-ft) Routed from Upper	Runoff into Lower	Auxil-iary	Seepage	Outflow (ac-ft) Gravity	Pump	Diver-sion	Overflow
PLAN1	65896.	48277.	0.	0.	114377.	0.	0.	0.
PLAN2	65896.	48277.	0.	0.	105571.	8809.	0.	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE C.38 Flood Volume Analysis Summary

CSA 01.01.00 COMP05
Study ID RBEND2

Comparison of Plans

D. Gravity Outlet Analysis - Days Blocked

Plan ID	Total Days Blocked Prim.	Sec. 1	Sec. 2	Sec. 3	Sec. 4	Average Annual Days Blocked Prim.	Sec. 1	Sec. 2	Sec. 3	Sec. 4
PLAN1	139.	0.	0.	0.	0.	14.	0.	0.	0.	0.
PLAN2	143.	0.	0.	0.	0.	14.	0.	0.	0.	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Return

FIGURE C.39 Gravity Outlet Days Blocked Summary

CSA 01.01.00 | Comparison of Plans | COMP07

Study ID RBEND2

F. Interior Analysis - Maximum Interior Elevations

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Peak Elevation (ft) vs. Percent Chance Exceedence Frequency Event						
			50%	20%	10%	4%	2%	1%	0.2%
PLAN1	16.0	0.0	599.89	601.06	601.75	603.50	605.00	605.00	605.00
PLAN2	16.0	200.0	599.80	600.85	601.46	602.46	603.37	604.44	605.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE C.40 Maximum Interior Elevations Summary

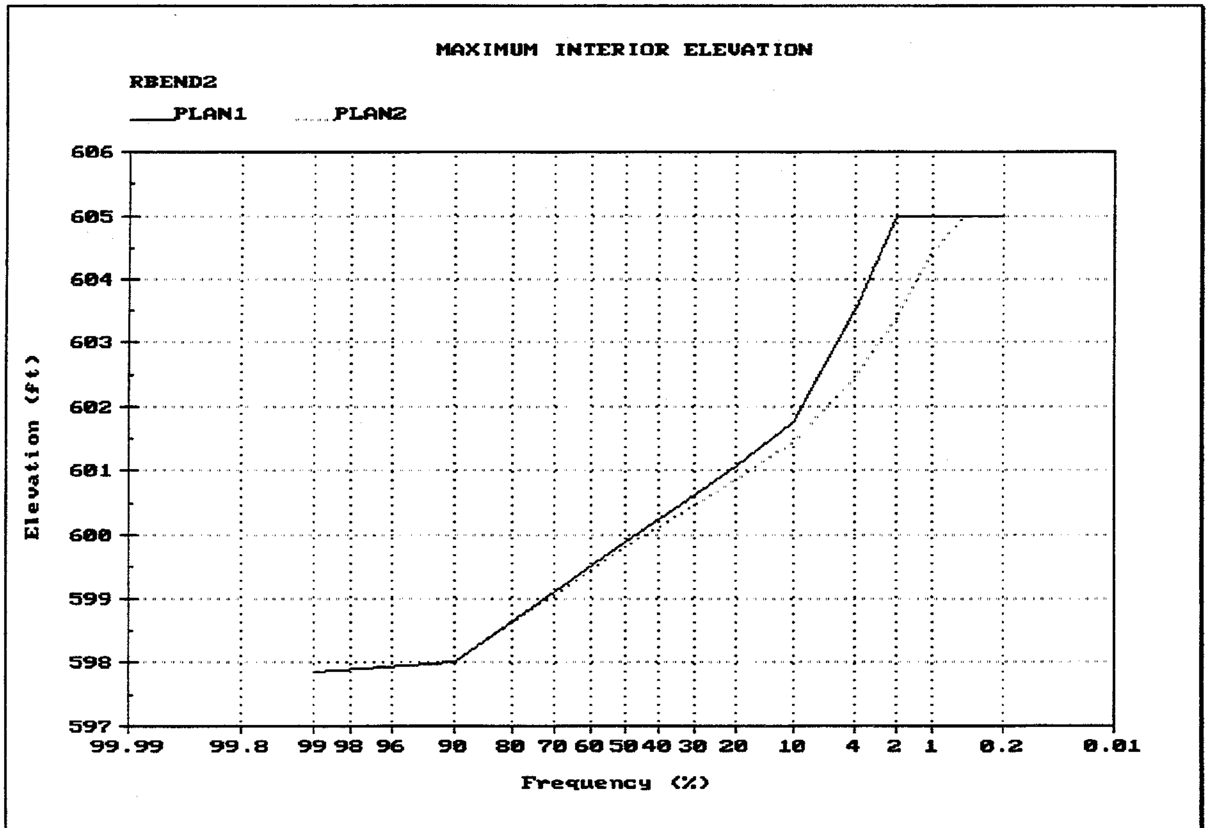

FIGURE C.41 Maximum Interior Elevation Plot

CSA 01.01.00
Study ID RBEND2

Comparison of Plans

COMP08

G. Interior Analysis - Duration of Interior Flooding

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Average Annual Days Flooded						
			591.40 Elev. 1	592.41 Elev. 2	595.14 Elev. 3	597.42 Elev. 4	598.56 Elev. 5	599.56 Elev. 6	601.93 Elev. 7
PLAN1	16.0	0.0	186.5	73.2	36.5	14.6	7.3	3.6	0.7
PLAN2	16.0	200.0	107.6	72.0	34.9	12.5	5.5	1.9	0.7

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE C.42 Duration of Interior Flooding Summary

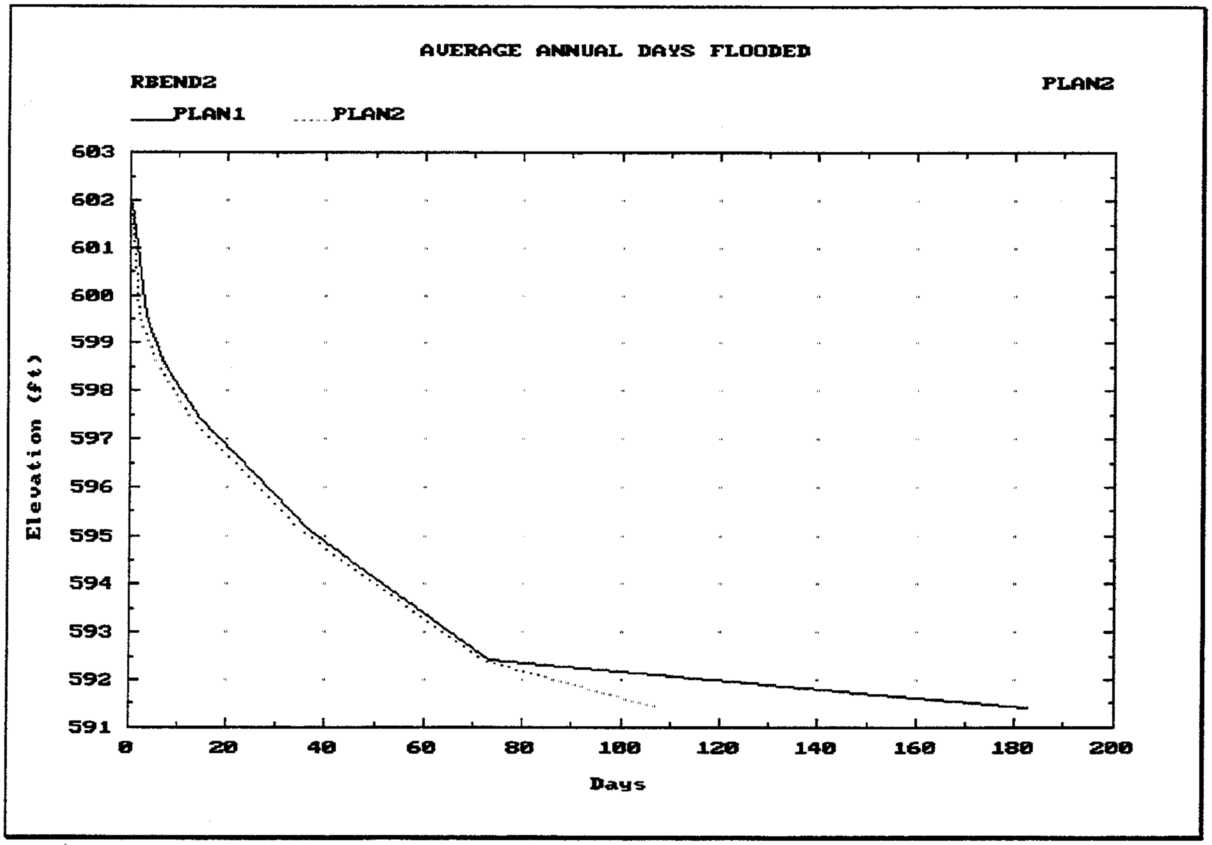

FIGURE C.43 Duration of Interior Flooding Plot

CSA 01.01.00
Study ID RBEND2

Comparison of Plans

COMP09

H. Interior Analysis - Maximum Interior Area Flooded

Plan ID	Area Prim. Grav. (sqft)	Total Pump Cap. (cfs)	Maximum Interior Area Flooded (ac) vs. Percent Chance Exceedence Frequency Event						
			50%	20%	10%	4%	2%	1%	0.2%
PLAN1	16.0	0.0	1.6	6.5	82.8	231.4	345.4	469.5	1001.6
PLAN2	16.0	200.0	0.7	6.0	73.9	210.6	290.8	401.7	603.9

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE C.44 Maximum Interior Area Flooded Summary

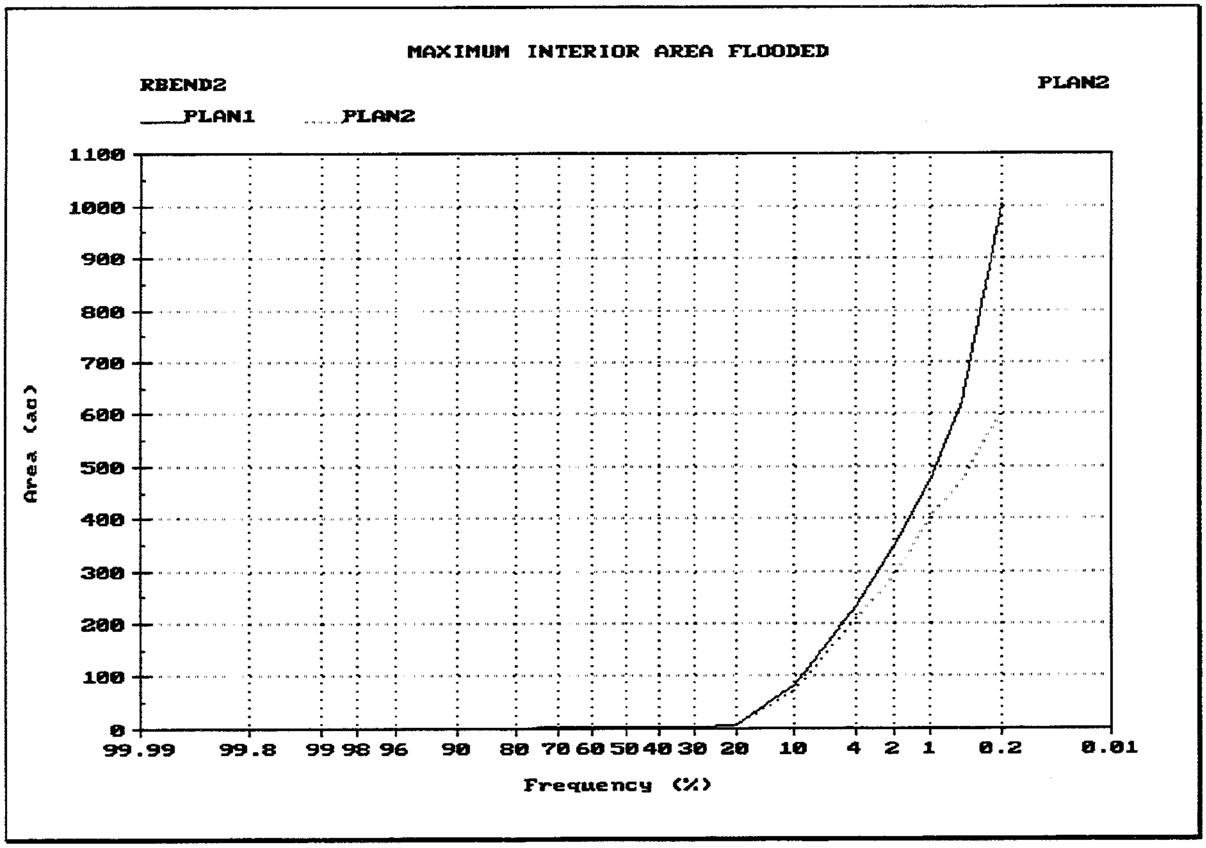

FIGURE C.45 Maximum Interior Area Flooded Plot

APPENDIX D. HEC-IFH HEA Example Application

This appendix demonstrates the application of the Interior Flood Hydrology (HEC-IFH) computer program to a simple example of a detention system analysis problem using Hypothetical Event Analysis. Appendix C provides an example of a Continuous Simulation Analysis. A gravity outlet and ponding area will be evaluated by determining basin area runoff from a wide range of hypothetical storm events and routing the runoff through the ponding area and line-of-protection to the point of discharge.

D.1. BACKGROUND INFORMATION

The community of Silver Creek is is served by a flood protection system which utilizes an existing levee and ponding area. The storage area discharges into the Big River through a 48-inch corrugated metal pipe culvert. The Silver Creek watershed consists of one basin, with 15 square miles of drainage area. Figure D.1 illustrates the Silver Creek watershed.

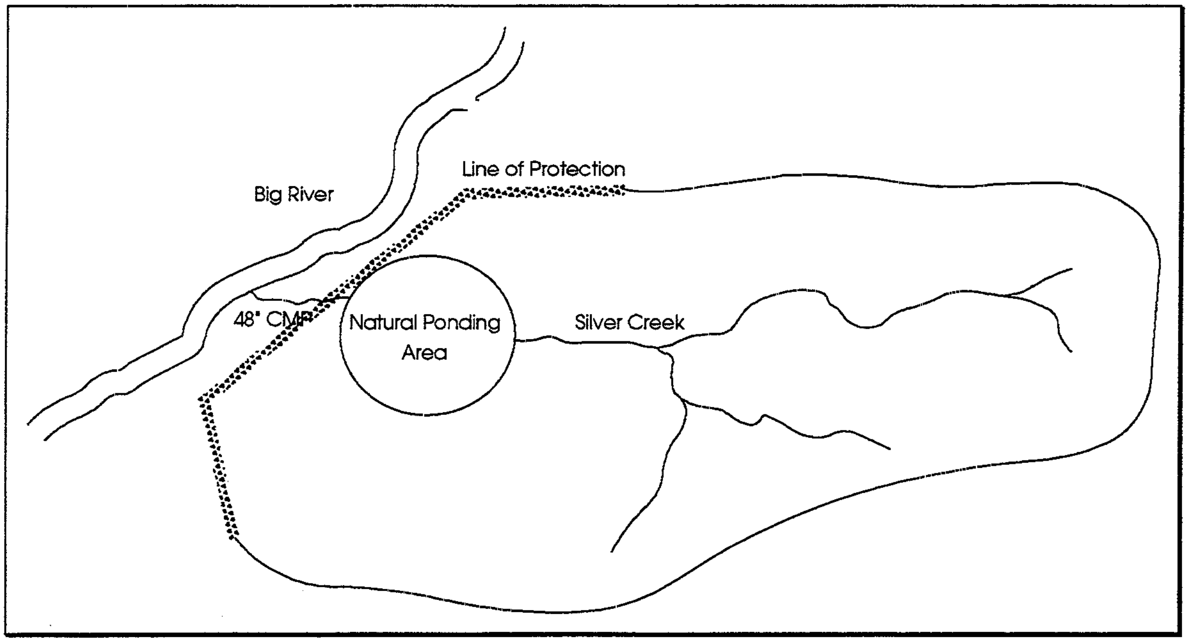

FIGURE D.1 Silver Creek Interior Area

The existing Silver Creek flood protection system has worked adequately during historical storm events. However, because of development within the watershed, the citizens of the Silver Creek community are concerned about the ability of the existing facilities to accommodate large storm events. Therefore, the focus of this analysis will be on "design storm" events — hypothetical storms which represent standardized rainfall depths and distributions. Rainfall data for hypothetical frequency storms will be taken from TP-40 [Hershfield, 1961]. The Standard Project Flood will also be analyzed.

Because the watershed of Silver Creek is very small in comparison with the watershed of Big River, it is not reasonable to expect that the two streams would be affected simultaneously by the same design storm events. Therefore, this analysis will concerned with design storms which occur over the Silver Creek watershed only. The elevation in Big River will be assumed to be at its normal low level throughout the analysis, so the 48-inch culvert outlet will be unblocked.

The procedures specified in Appendix B of this manual create a sub-directory called "SILVER" within the HECIFH directory on the hard disk. This sub-directory contains the correct input data for the example problem described in this appendix. *Do not modify the data stored in the SILVER sub-directory.* It should be preserved in its original condition for comparison with data developed in this appendix. To view the SILVER input data and results, specify SILVER as the Study ID for HEC-IFH, as described in Chapter 2 of this manual. To begin working through the example problem described in this chapter, specify a new HEC-IFH Study ID called SILVERCR.

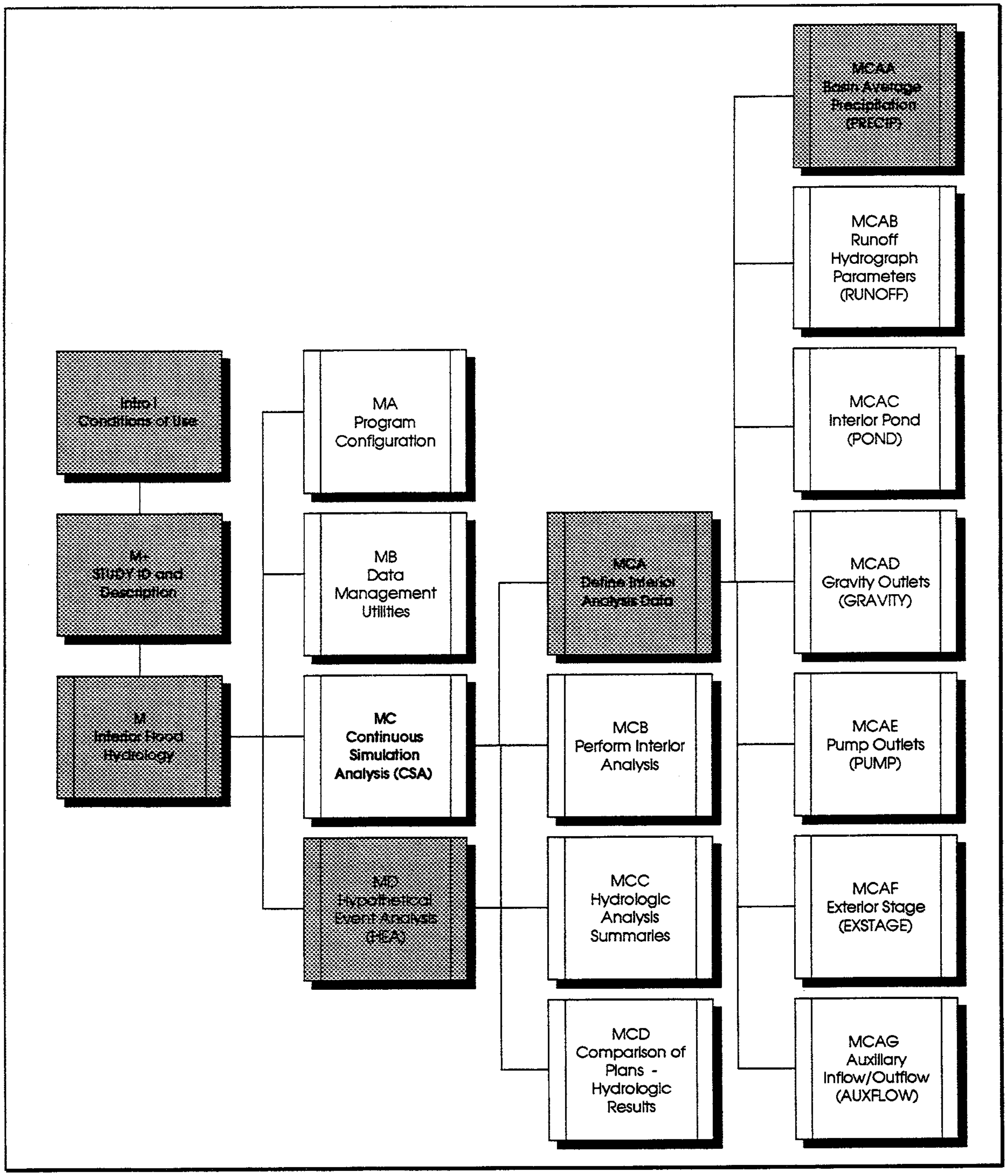

FIGURE D.2 HEC-IFH Program Menu Hierarchy

D.2. PRECIPITATION DATA

To start the HEC-IFH program and prepare to enter precipitation data, follow these steps:

1. Use the DOS command **CD \HECIFH** and press [Enter] to change to the HECIFH directory on the hard disk.
2. Type **HECIFH** and press [Enter] to start the HEC-IFH program.
3. Press any key to proceed to the Study ID screen.
4. Specify SILVERCR as the current **Study ID**.
5. Select *Hypothetical Event Analysis* from the HEC-IFH main menu.
6. Select *Define Interior Analysis Data* from the Hypothetical Event Analysis menu.
7. Select *Basin Average Precipitation* from the Define Interior Analysis Data menu. The screen shown in Figure D.3 will appear.

```
HEA 01.01.00                                                       MDAA+
Study ID  SILVERCR    Basin Average Precipitation (PRECIP)



             Module Id    STORM1

             Description  Precip. depth-duration data.

             Storm Area (sq mi)                    15.00

             Type of Series *                  [Annual] Partial

             Time Interval (e.g., 1HOUR, 1DAY)   1HOUR


    * NOTE:  ANNUAL  - Convert Rainfall from Partial to Annual
             PARTIAL - No Conversion

1Help  2PrtScr 3Index  4      5      6DOS    7      8      9      10Exit
                    Press <F10> to Proceed to the Menu
```

FIGURE D.3 Hypothetical Event Analysis Data Specification Screen

To specify the PRECIP module, the following steps are required:

1. Use STORM1 as the PRECIP **Module ID**, and enter an appropriate 40-character **Description**.
2. Enter a **Storm Area** of 15 square miles (equal to the Silver Creek watershed area).
3. Highlight "Annual" and press the space bar to select the **Type of Series**. Since the rainfall depth data taken from TP-40 represent partial series data, the program will convert the data to annual series for the analysis.
4. Enter a **Time Interval** of 1HOUR.

5. Press the [F10] key to proceed to the Basin Average Precipitation menu screen.

6. Select *Enter Data to Compute Hypothetical Storms* from the Basin Average Precipitation menu screen to proceed to the Rainfall Depth-Duration-Frequency data entry screen. Figure D.4 shows this screen.

7. Enter the values listed in Table D.1.

8. Press the [F10] key to proceed to the Standard Project Storm data entry screen. Figure D.5 shows this screen. Enter a **Standard Project Index Precipitation** of 9.0 inches and a **STORM Reduction Coefficient (Shape Factor)** of 1.00.

9. Press the [F10] key to return to the Basin Average Precipitation menu screen. The necessary precipitation data have been entered.

TABLE D.1 Rainfall Depth-Duration-Frequency Data for Silver Creek Watershed

	Rainfall Depths (inches) for each Hypothetical Storm Frequency (%)						
Duration	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**
1 hour	1.50	1.65	1.95	2.30	2.50	2.75	3.20
2 hours	1.80	2.00	2.30	2.70	2.90	3.25	3.60
3 hours	2.20	2.40	2.60	2.90	3.25	3.60	4.00
6 hours	2.40	2.60	3.00	3.50	3.80	4.25	4.70
12 hours	2.60	3.00	3.50	4.00	4.50	5.00	5.60
24 hours	2.80	3.50	4.00	4.60	5.20	5.70	6.20

HEA 01.01.00
Study ID SILVERCR
Module ID STORM1

Basin Average Precipitation (PRECIP)

PREC06

Enter Partial-Duration Rainfall Depth-Duration-Frequency Data

	Rainfall Depth (in) for each Hypothetical Event						
Duration	50%	20%	10%	4%	2%	1%	0.2%
5 minutes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 minutes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 hour	1.50	1.65	1.95	2.30	2.50	2.75	3.20
2 hours	1.80	2.00	2.30	2.70	2.90	3.25	3.60
3 hours	2.20	2.40	2.60	2.90	3.25	3.60	4.00
6 hours	2.40	2.60	3.00	3.50	3.80	4.25	4.70
12 hours	2.60	3.00	3.50	4.00	4.50	5.00	5.60
24 hours	2.80	3.50	4.00	4.60	5.20	5.70	6.20
2 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 days	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Save Data and Continue

FIGURE D.4 Rainfall Depth-Duration-Frequency Data Entry Screen

```
HEA 01.01.00                                                        PREC08
Study ID  SILVERCR    Basin Average Precipitation (PRECIP)
Module ID STORM1
                Enter Standard Project Storm (SPS) Rainfall Data




      Standard Project Index Precipitation (in)             9.00

      STORM Reduction Coefficent (Shape Factor)             1.000000







1Help  2PrtScr 3      4      5      6DOS    7      8      9     10Exit
                   Press <F10> to Save Data and Return
```

FIGURE D.5 Standard Project Storm Data Entry Screen

After the hypothetical frequency rainfall depths and Standard Project Storm data have been entered, follow these steps to view the computed precipitation:

1. Select *View Table of Storm Distribution* from the Basin Average Precipitation menu screen. Figure D.6 shows the screen used to view a computed storm distribution.

2. Press the F9 key to display the window used to select flood events for plotting. Plot a mass rainfall curve including all flood events. Figure D.7 illustrates the appearance of the plot. As indicated, the SPF is a 4-day (96-hour) event while the other storms are 1-day (24-hour) events. On a color computer monitor, each of the individual storm events would be plotted in color. Press the Esc key to exit the plot screen.

5. Press the F10 key twice to return to the Define Interior Analysis Data menu screen.

HEA 01.01.00
Study ID SILVERCR
Module ID STORM1

Basin Average Precipitation (PRECIP)

PREC01

View Table of Storm Distribution

ANNUAL series

Storm Area: 15.00 (sq mi)

Da/HrMn	Precipitation (in) for each Hypothetical Frequency and SPS							
	50%	20%	10%	4%	2%	1%	0.2%	SPS
1/0100	0.01	0.03	0.03	0.04	0.05	0.05	0.04	0.00
1/0200	0.01	0.03	0.04	0.04	0.05	0.05	0.04	0.00
1/0300	0.01	0.04	0.04	0.05	0.05	0.05	0.05	0.00
1/0400	0.02	0.04	0.04	0.05	0.06	0.06	0.05	0.00
1/0500	0.02	0.04	0.05	0.06	0.07	0.07	0.06	0.00
1/0600	0.02	0.05	0.05	0.06	0.07	0.07	0.06	0.00
1/0700	0.02	0.05	0.07	0.07	0.10	0.10	0.13	0.01
1/0800	0.03	0.06	0.08	0.08	0.11	0.12	0.14	0.01
				.10	0.13	0.14	0.17	0.01
				.17	0.16	0.19	0.20	0.01
				.24	0.22	0.26	0.28	0.01
				.42	0.42	0.52	0.44	0.01

Select Flood Events

50% 20% 10% 4% 2% 1% 0.2% SPF
Y Y Y Y Y Y Y Y

6DOS 7 8 9 10Exit

Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>

FIGURE D.6 Storm Distribution Table

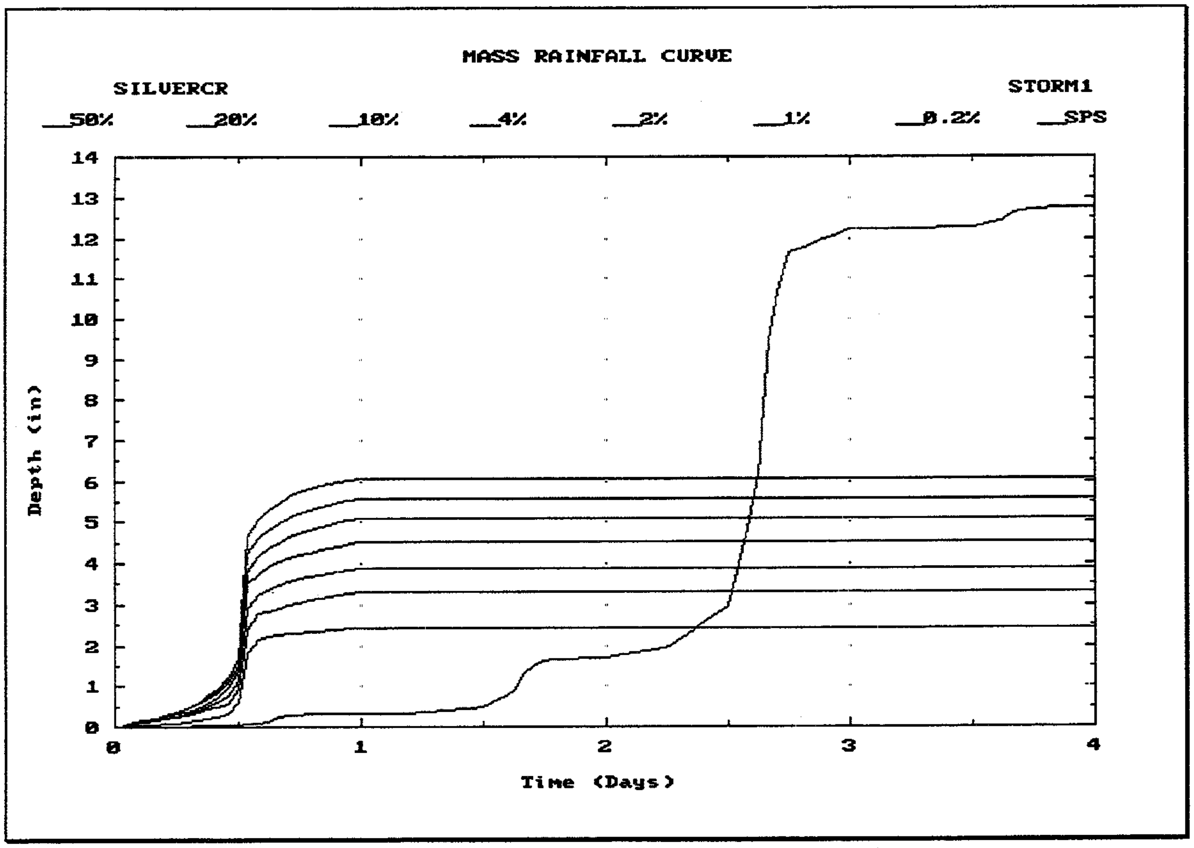

FIGURE D.7 Plot of Mass Rainfall Curves for Hypothetical Storm Events

D.3 BASIN RUNOFF DATA

Runoff from the Silver Creek watershed will be computed using available data:

1. **Base Flow**: The Silver Creek watershed carries a base flow, which is estimated according to the parameters listed in Table D.2.
2. **Infiltration Losses**: The infiltration losses for the watershed can be estimated using the Initial-Uniform method, with the loss parameters listed in Table D.2.
3. **Runoff Characteristics**: The runoff characteristics of the watershed can be modeled using the SCS Dimensionless unit hydrograph, with the unit hydrograph parameters listed in Table D.2.

TABLE D.2 Runoff Parameters for Silver Creek Watershed

Parameter	Value
Basin Drainage Area	15 square miles
Base Flow at Start of Storm	50 cfs
Ratio to Peak Below which Base Flow Starts	0.15
Ratio of Recession Flow One Hour Later	1.03
Initial Loss	0.50 inches
Uniform Loss Rate	0.02 inches/hour
% of Drainage Area Impervious	10%
SCS Lag	5 hours

The HEC-IFH RUNOFF data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Runoff Hydrograph Parameters (RUNOFF)* from the Define Interior Analysis Data Menu.
2. Select *Enter Basin Runoff Data* from the Runoff Hydrograph Parameters menu screen.
3. Use SILVER as the **Basin ID**, and enter an appropriate 40-character **Description**.
4. Enter the runoff data parameters listed in Table D.2 as follows:
   a. First enter the **Basin Drainage Area** and **Percent of Drainage Area Impervious**.
   b. Specify base flow and recession data by first highlighting Yes for Enter Base Flow and Recession and pressing the space bar. A window will appear, containing data entry fields for **Flow at Start of Storm**, **Ratio to Peak**, and **Ratio of Recession Flow One Hour Later**. Enter these values. Figure D.9 illustrates the data entry window for Base Flow and Recession Parameters.
   c. Specify the appropriate Basin Infiltration Loss Data by first highlighting Initial-Uniform Method and pressing the space bar. A window will appear, containing data entry fields for **Initial Loss** and **Uniform Loss**. Enter these values. Figure D.10 illustrates the data entry window for the Initial-Uniform loss method.
   d. Select the appropriate Basin Unit Hydrograph Data by first highlighting SCS Dimensionless Unit Graph and pressing the space bar. A window will appear, containing a data entry field for **SCS Lag**. Enter this value. Figure D.11 shows the data entry window for the SCS Dimensionless Unit Hydrograph Method.
   e. After entering the **SCS Lag** value, select 'yes' to display (tabulate) the unit hydrograph. Another window will appear for tabulating the unit hydrograph.

Specify a 1HOUR unit hydrograph duration. The SCS Unit Hydrograph will be computed and displayed. (See Figure D.12).

f. Press the [F10] key to exit the unit hydrograph window.

5. Press the [F10] key again to store the SILVER basin runoff data and return to the Runoff Hydrograph Parameters menu screen.

```
HEA 01.01.00                                                          RUN018
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                          Enter Basin Runoff Data
Basin ID      SILVER     Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                        15.00
Percent of Drainage Area Impervious           10.0

Enter Base Flow Data and Recession [Yes] No

Infiltration Loss Data              Unit Hydrograph Data
  SCS Curve Number Method             Clark's Unit Hydrograph
  Holtan Method                       Snyder's Unit Hydrograph
  Green-Ampt Method                  [SCS Dimensionless Unit Graph]
 [Initial-Uniform Method ]            Enter Unit Hydrograph
  No Losses Computed



1Help  2PrtScr 3Index  4      5      6DOS    7      8      9      10Exit
                     Press <F10> to Save Data and Return
```

FIGURE D.8 HEA Basin Runoff Data Screen

```
HEA 01.01.00                                                           RUN019
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                                 Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                    15.00
Percent of Drainage Area Impervious       10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data          Unit Hydrograph Data
  SCS Curve Number Method         Clark's Unit Hydrograph
  Holtan Method                   Snyder's Unit Hydrograph
  Green-Ampt Method              [SCS Dimensionless Unit Graph]
 [Initial-Uniform Method ]        Enter Unit Hydrograph
  No Losses Computed
                              ---------Base Flow and Recession Parameters-------
                               Flow at Start of Storm (cfs)               50.0
                               Flow Below which Base Flow Starts (cfs)     0.0
                                 or Ratio to Peak                     0.150000
                               Ratio of Recession Flow One Hour Later 1.030000
1Help  2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                        Press <F10> to Save Data and Return
```

FIGURE D.9 Base Flow and Recession Data Entry Window

```
HEA 01.01.00                                                           RUN023
Study ID  SILVERCR    Runoff Hydrograph Parameters (RUNOFF)

                                 Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                    15.00
Percent of Drainage Area Impervious       10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data          Unit Hydrograph Data
  SCS Curve Number Method         Clark's Unit Hydrograph
  Holtan Method                   Snyder's Unit Hydrograph
  Green-Ampt Method              [SCS Dimensionless Unit Graph]
 [Initial-Uniform Method ]        Enter Unit Hydrograph
  No Losses Computed

                                    ---------Initial-Uniform Method-----
                                        Initial Loss (in)          0.500

                                        Uniform Loss (in/hr)       0.020
1Help  2PrtScr 3      4      5      6DOS    7      8      9      10Exit
                        Press <F10> to Save Data and Return
```

FIGURE D.10 Initial-Uniform Data Entry Window

```
HEA 01.01.00                                                          RUN028
Study ID  SILVERCR   Runoff Hydrograph Parameters (RUNOFF)

                        Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                  15.00
Percent of Drainage Area Impervious     10.0

Enter Base Flow Data and Recession  Yes  No

Infiltration Loss Data            Unit Hydrograph Data
  SCS Curve Number Method           Clark's Unit Hydrograph
  Holtan Method                     Snyder's Unit Hydrograph
  Green-Ampt Method                [SCS Dimensionless Unit Graph]
 [Initial-Uniform Method ]          Enter Unit Hydrograph
  No Losses Computed

                                  SCS Dimensionless Unit Hydrograph
                                  SCS Lag (hr)                   5.000
                                  Display (Tabulate) U. Hyd.?  yes [no]

1Help  2PrtScr 3     4     5     6DOS   7     8     9      10Exit
                   Press <F10> to Save Data and Return
```

FIGURE D.11 SCS Dimensionless Unit Hydrograph Data Entry Window

```
HEA 01.01.00                                                          RUN029
Study ID  SILVERCR   Runoff Hydrograph Parameters (RUNOFF)

                        Enter Basin Runoff Data
Basin ID     SILVER    Silver Creek using SCS UHG & I/U loss

Drainage Area (sq mi)                  15.00   Unit Hydro. Duration 1HOUR
Percent of Drainage Area Impervious     10.0
                                                  Time   Unit Hydrograph
Enter Base Flow Data and Recession  Yes  No      (HOUR)  Ordinates (cfs)

Infiltration Loss Data          Unit Hydrograph      1        114.9
  SCS Curve Number Method         Clark's Unit       2        350.7
  Holtan Method                   Snyder's Unit      3        732.6
  Green-Ampt Method               SCS Dimension      4       1119.2
 [Initial-Uniform Method ]        Enter Unit Hy      5       1304.7
  No Losses Computed                                 6       1304.7
                                                     7       1157.5
                                                     8        955.2
                                                     9        689.5
                                                    10        499.2
                                                    11        368.7

1Help  2PrtScr 3     4     5     6DOS   7     8     9Plot  10Exit
                   Press <F10> to Save Data and Return
```

FIGURE D.12 Unit Hydrograph Tabulation

D.3.1. Specify RUNOFF Module

After the runoff parameters and channel routing data (if present) are entered, they are combined into a single "module" of runoff data. This module is identified by a Module ID. To specify the runoff module, the following steps are required:

1. Select *Assign Basin Runoff Data Set for Each Sub-Basin* from the Runoff Hydrographs Parameters (RUNOFF) Screen. The screen illustrated in Figure D.13 will appear.
2. Use ROMOD1 as the **Module ID**, and enter an appropriate 40-character **Description**.
3. Press the [F3] key and select SILVER as the **Basin ID** for the lower interior sub-basin, for each hypothetical storm frequency event and SPF.
6. Press the [F10] key to store the ROMOD1 runoff module data and return to the Runoff Menu Screen. The RUNOFF module is ready to be used in a plan analysis.

HEA 01.01.00 RUN032
Study ID SILVERCR

Runoff Hydrograph Parameters (RUNOFF)

Assign Basin Runoff Data Set for Each Sub-Basin

Module ID ROMOD1

Description One area- same rainfall-runoff for each.

Sub Basin	Basin ID for each Hypothetical Frequency Event and SPF							
	50%	20%	10%	4%	2%	1%	0.2%	SPF
Lower	SILVER	SILVER	SILVER	SILVER	SILVER	SILVER	SILVER	SILVER
Upper								

Upper Sub-Basin Channel Routing ID

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <F10> to Save Data and Return

FIGURE D.13 Runoff Data Specification Screen

D.4 INTERIOR POND DATA

The Silver Creek pond and wetland area has the following characteristics:

1. The elevation versus surface area relationship of the ponding area is described using the data in Table D.3.
2. The ponding area is directly connected to the outlet. No interior ditch is required to convey discharges from the pond to the outlet.

TABLE D.3 Elevation versus Surface Area Relationship for Ponding Area

Elevation (feet, NGVD)	Surface Area (acres)	Storage Volume (ac-ft)	Elevation (feet, NGVD)	Surface Area (acres)	Storage Volume (ac-ft)
593	0	0	601	250	704
594	4	2	602	360	1,009
595	10	9	603	510	1,444
596	50	39	604	710	2,054
597	80	104	605	950	2.884
598	110	199	606	1,250	3,984
599	145	326.5	607	1,600	5,409
600	180	489	610	3,500	13,059

The HEC-IFH POND data entry module is used to enter these data values, as follows:

1. Select *Interior Pond (POND)* from the Define Interior Analysis Data Menu.
2. Select *Enter Surface Areas for Computing Volumes* from the Interior Pond menu.
3. Use POND as the **Storage Table ID**, and enter a 40-character **Description**.
4. Enter the **Pond Elevation** and **Surface Area** values listed in Table D.3. The data entry screen should match the illustrations in Figures D.14 and D.15. Confirm that the computed pond storage volumes listed in Table D.3 are correct.
5. Press the F10 key to store the POND pond storage data and return to the Interior Pond Menu Screen.

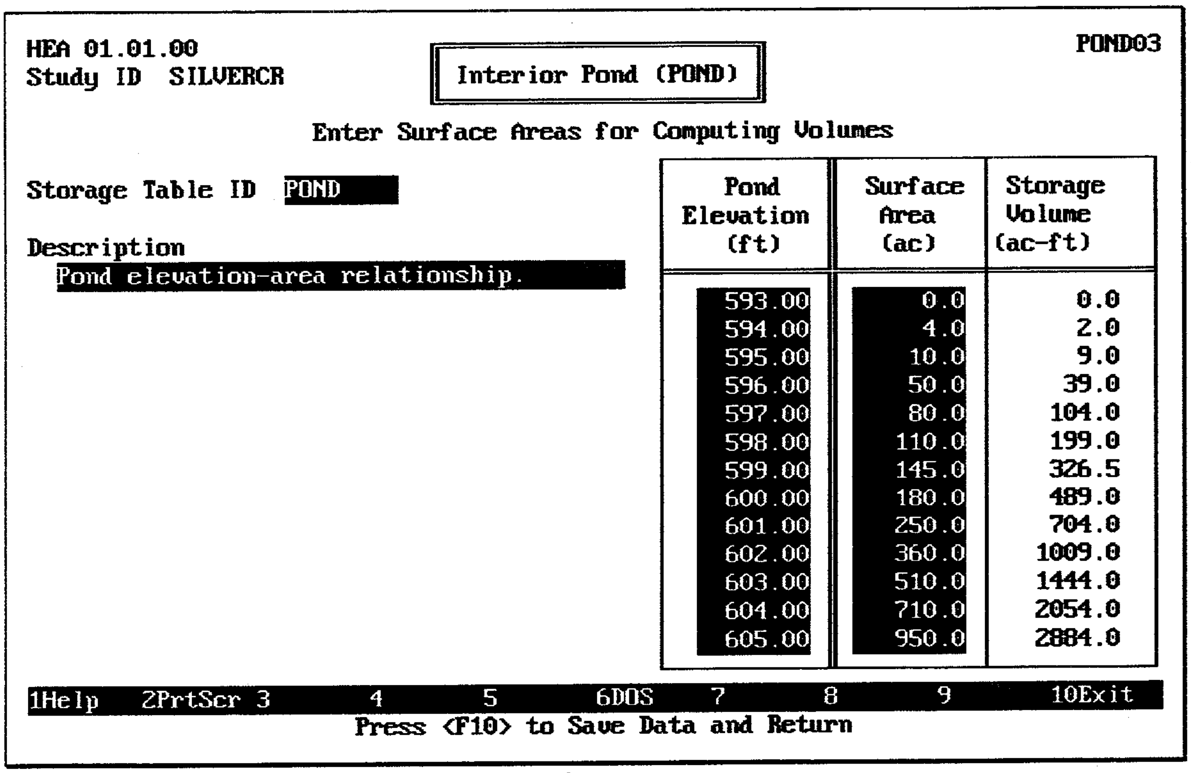

FIGURE D.14 Pond Surface Area Data Entry Screen

```
HEA 01.01.00                                                   POND03
Study ID  SILVERCR          Interior Pond (POND)

                 Enter Surface Areas for Computing Volumes

Storage Table ID  POND               Pond       Surface    Storage
                                     Elevation  Area       Volume
Description                          (ft)       (ac)       (ac-ft)
  Pond elevation-area relationship.
                                     606.00     1250.0      3984.0
                                     607.00     1600.0      5409.0
                                     610.00     3500.0     13059.0
                                       0.00        0.0         0.0
                                       0.00        0.0         0.0
                                       0.00        0.0         0.0
                                       0.00        0.0         0.0

1Help  2PrtScr 3    4    5    6DOS   7    8    9Plot   10Exit
              Press <F10> to Save Data and Return
```

FIGURE D.15 Pond Surface Area Data Entry Screen (continued)

D.4.1. Specify POND Module

After the interior storage data and interior ditch rating curve (if present) are entered, they are combined into a single "module" of pond data. This module is identified by a Module ID. To specify the POND module, the following steps are required:

1. Select *Specify Module Data* from the Interior Pond Menu Screen.
2. Use PONDMOD as the **Module ID**, and enter an appropriate 40-character **Description**.
3. Enter POND as the **Storage Table ID** for the ponding area. Confirm that the description match what you entered earlier.
4. Do not enter a **Ditch Table ID**. Since this ponding area is directly connected to the outlet, there is no need to specify the capacity of the channel connecting the ponding area with the outlet.
6. Press the [F10] key to store the PONDMOD POND module data and return to the Interior Pond Menu Screen. The PONDMOD POND module is ready to be used in a plan analysis.
7. Press the [F10] key again to return to the Define Interior Analysis data menu.

```
HEA 01.01.00                                                        POND05
Study ID  SILVERCR          Interior Pond (POND)

                            Specify Module Data

        Module ID          PONDMOD

        Description        Natural ponding area at the primary loc.

        Storage Table ID   POND       Pond elevation-area relationship.
        Ditch Table ID

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
                    Press <F10> to Save Data and Return
```

FIGURE D.16 Pond Data Specification Screen

D.5 EXTERIOR STAGE DATA

For the Silver Creek analysis, a very simple exterior stage condition is assumed: Big River is assumed to be at a constant level of 581.0 throughout the analysis. To define this exterior stage condition, do the following:

1. Select *Exterior Stage (EXSTAGE)* from the Define Interior Analysis Data Menu.
2. Use EXSTAGE as the **Module ID**, and enter an appropriate 40-character **Description**. Press the F10 key to continue to the Exterior Stage Menu screen.
3. Select *Specify Exterior Stage* from the Exterior Stage menu. Select *Main River* as the Primary Outlet Location and then select *Use Index Stage Hydrogrpahs at All Outlet Locations.*
4. Select *Enter/Import Index Stage Hydrograph* from the Index Stage Options Menu. The Exterior Stage Data Entry Screen illustrated in Figure D.17 is displayed.
5. Specify a Time Interval of 1HOUR to match the time interval used for computed precipitation.
6. Use the option to **Initially set all elevation to:** 581.0.
7. Specify 480 as the **Number of Intervals.** As observed during the preparation of the precipitation data, the SPF is a 96-hour storm. By continuing the analysis many days past the end of the SPF rainfall, it is possible to avoid the problems which arise when a discharge hydrograph is "cut off" or the interior pond is not allowed to empty. The HEC-IFH program will compute more accurate total volumes of inflow and outflow when an adequate number of intervals is specified.

8. Press the [F10] key twice until the Exterior Stage Menu Screen reappears. Press the [Esc] key twice to return to the Define Interior Analysis Data menu screen.

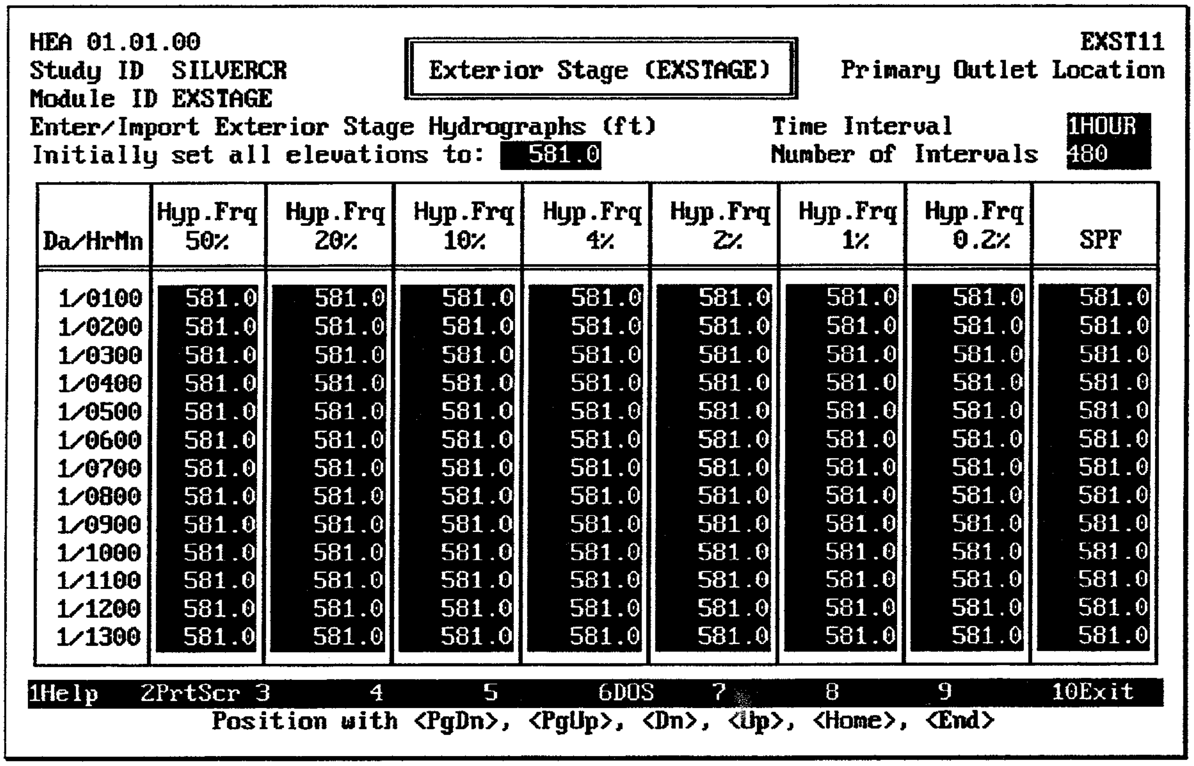

FIGURE D.17 Exterior Stage Data Entry Screen

D.6 GRAVITY OUTLET DATA

As already stated, the Silver Creek ponding area discharge through a single 48-inchd Corrugated Metal Pipe culvert (CMP). The characteristics of this gravity outlet are listed in Table D.4.

TABLE D.4 Gravity Outlet Characteristics

Characteristic	Value
Diameter	4 feet
FHWA Chart Number	2 (Corrugated Metal)
FHWA Scale Number	1 (Headwall)
Number of Identical Outlets	1
Length	200 feet
Manning's n	0.024
Entrance Loss Coefficient	0.5
Exterior Invert Elevation	589 feet NGVD
Interior Invert Elevation	593 feet NGVD

The HEC-IFH GRAVITY data entry module is used to enter these data values, according to the following sequence of steps:

1. Select *Gravity Outlets (GRAVITY)* from the Define Interior Analysis Data Menu.
2. Select *Compute Gravity Outlet Rating Table for Culvert* from the Gravity Outlet Menu Screen. The screen illustrated in Figure D.18 will appear.

3. Use 1-48CMP as the **Outlet Structure ID**, and enter an appropriate 40-character **Description**.
4. Use the space bar to select [Circular] as the type of culvert. The Circular Culvert data entry screen will appear (Figure D.19). Enter the first three values listed in Table D.4 describing the culvert. Press the F10 key to return to the previous data entry screen.
5. Enter the **Number of Identical Outlets**, **Length**, **Manning's n**, and **Entrance Loss Coefficient** values from Table D.4.
5. Enter a value of 3 feet for the **Tailwater Tabulation Interval.** This provides a range of 6 x 3 = 18 feet for tailwater values, from the exterior invert elevation of 589 feet NGVD up to 607 feet NGVD.
6. Enter a value of 12 cfs for the **Flow Capacity Tabulation Interval**. This provides a range of 20 x 12 = 240 cfs for flow values. The intervals are used to compute a gravity outlet table to view or plot. Internally, the program uses a 50 x 50 inverted gravity outlet trating table for pond routing.
7. Specify a value of 0 for the **Exterior Elevation for Gate Closure**. This culvert is not gated, and will remain open under all conditions.
8. Press the F10 key to store the 1-48CMP gravity outlet data and compute the gravity outlet rating table.
9. Press the F10 key to store the 4x4BOX gravity outlet rating table and return to the Gravity Outlet Menu Screen.

```
HEA 01.01.00                                                          GRAV04
Study ID  SILVERCR          Gravity Outlets (GRAVITY)

                 Compute Gravity Outlet Rating Table for Culvert

             Outlet Structure ID   1-48CMP
             Description           1-48 in CMP 200 ft long.

             Culvert Type:                            Box [Circular]

             Number of Identical Outlets                        1
             Length (ft)                                   200.00
             Manning's n                                 0.024000
             Entrance Loss Coefficient                   0.500000

          *  Tailwater Tabulation Interval (ft)              3.00
          ** Flow Capacity Tabulation Interval (cfs)         12.0

             Exterior Outlet Invert Elevation (ft)         589.00
             Interior Outlet Invert Elevation (ft)         593.00
             Exterior Elevation for Gate Closure (ft)        0.00

* 1/7th the expected elevation range          ** 1/20th the expected flow range
1Help  2PrtScr 3    4     5     6DOS    7     8     9     10Exit
                  Press <F10> to Save Data and Return
```

FIGURE D.18 Data Entry Screen for Culvert Computations

```
HEA 01.01.00                                                              GRAV06
Study ID  SILVERCR          Gravity Outlets (GRAVITY)
Struc.ID  1-48CMP
             Compute Gravity Outlet Rating Table for Circular Culvert


 Outlet Dimensions :
   Diameter (in)  48.00

 FHWA Chart        2
   1 Concrete
   2 Corrugated Metal
   3 Concrete: Beveled Ring Entrance

 FHWA Scale        1
  1 Headwall
  2 Mitered to conform to slope
  3 Pipe projecting form fill


1Help  2PrtScr 3     4      5      6DOS    7      8      9Plot   10Exit
                     Press <F10> to Save Data and Return
```

FIGURE D.19 Circular Culvert Data Entry Screen

D.6.1. Specify GRAVITY Module

After the gravity outlet rating tables are entered or computed, they are combined into a single "module" of gravity outlet data. This module is identified by a Module ID. The gravity outlet rating table already computed could be combined with other data entered later (perhaps an additional outlet, for example) to form different modules. To specify the GRAVITY module, the following steps are required:

1. Select *Assign Location for Each Outlet Structure ID* from the Gravity Outlets (GRAVITY) Menu Screen (see Figure D.20).

2. Use OUTLET1 as the **Module ID**, and enter an appropriate 40-character **Description**.

3. Enter 1-48CMP as the first **Structure ID** for the Primary Location. Other Structure IDs can be left blank, since there are no other primary or secondary gravity outlets for this analysis. Also, the the **River/Levee Station** values are optional and can be left blank.

6. Press the F10 key to store the OUTLET1 module data and return to the Gravity Outlets (GRAVITY) Menu Screen. The OUTLET1 module is ready to be used in a plan analysis.

HEA 01.01.00 | Gravity Outlets (GRAVITY) | GRAV08
Study ID SILVERCR

Assign Location for Each Outlet Structure ID

Module ID OUTLET1
Description 1-48 in CMP at the primary location.

	Primary Location	Secondary 1 Location	Secondary 2 Location	Secondary 3 Location	Secondary 4 Location
Structure ID Structure ID Structure ID Structure ID Structure ID	1-48CMP				
River/Levee Station (mi)	0.00	0.00	0.00	0.00	0.00

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <F10> to Save Data and Return

FIGURE D.20 Screen to Specify GRAVITY Module Data

D.7 PLAN SPECIFICATION AND ANALYSIS

Each of the building blocks have been completed from which to build a PLAN. Use the [Esc] key to back up to the Hypothetical Event Analysis screen and select the *Perform Interior Analysis* option. Figure D.21 illustrates the Plan Specification screen.

1. Specify PLANA as the **Plan ID** and answer "Yes" to create a new Plan ID. Enter an appropriate 40-character description, such as "48 in CMP unblocked outlet condition".

2. Use [F3] to recall the available PRECIP Modules; highlight STORM1 (which should be the only one listed) and press [Enter]. Press [Enter] again to accept STORM1 as the correct PRECIP module; the short description will appear; verify that this is the correct module.

3. Use the [F3] key to recall the available **Module IDs** and select RUNOFF (ROMOD1), POND (PONDMOD), and GRAVITY (OUTLET1) Module IDs. Press [Enter] or use the down-arrow key to skip the PUMP module. Use the [F3] key to choose the EXSTAGE module (EXSTAGE).

4. Skip to the **Computation Time Interval** and enter 1HOUR. Specify 480 as the Number of Time Intervals. As discussed in connection with the exterior stage data, the number of time intervals should normally extend considerably beyond the end of the storm event, to allow the HEC-IFH program to account for the stored runoff which usually discharges slowly over a long period of time after the storm.

5. Next choose *Perform Pond Routing Analysis.* Note that this choice will also perform any needed upstream calculations; none are required if you are following this set of instructions. Use a value of 593 for the **Starting Pond Elevation** and 0.0 for the **Minimum Head for Gravity Outlet Operation**. Since there are no pumps in this plan, skip **Operate Pumps, Gravity Outlets Simultaneously.**

6. Press [F10] to perform the calculations. The program displays a computation progress report as computations are performed. Be sure to press the [F10] key after the analysis is completed to save the computed data.

7. Press the [Esc] key twice to back up to the Hypothetical Frequency Analysis menu screen.

```
HEA 01.01.00                                                        MDB+
Study ID  SILVERCR        Perform Interior Analysis

  Plan ID  PLANA      Description  48-in CMP unblocked outlet conditions.

 Module                          Module   Description
                                 ID
 Basin Average Precipitation     STORM1   Precip. depth-duration data.
 Runoff Hydrograph Parameters    ROMOD1   One area- same rainfall-runoff for each.
 Interior Pond                   PONDMOD  Natural ponding area at the primary loc.
 Gravity Outlets                 OUTLET1  1-48 in CMP at the primary location.
 Pump Data
 Exterior Stage                  EXSTAGE  Constant stage = 581.00 (unblocked)
 Auxiliary Flow

     ANNUAL series
     Computation Time Interval (e.g. 1HOUR, 1DAY, ...)    1HOUR
     Number of Time Intervals                               480

1Help  2PrtScr 3Index  4     5     6DOS   7     8     9     10Exit
                  Press <F10> to Proceed to the Menu
```

FIGURE D.21 Plan Specification Screen

D.8 HYDROLOGIC ANALYSIS SUMMARIES

From the Hypothetical Frequency Analysis menu, choose *Hydrologic Analysis Summaries* to view the results of this plan. The following figures illustrate the results of the analysis for the 1% storm (100-year event), a comparions of rainfall-runoff data for all storm events, and a stage frequency analysis for the ponding area.

```
HEA 01.01.00                                                        CALC01
Study ID  SILVERCR          Perform Interior Analysis

                          Perform Pond Routing Analysis


    Starting Pond Elevation (ft)                                   593.00
    Minimum Head for Gravity Outlet Operation (ft)                   0.00
    Operate Pumps, Gravity Outlets Simultaneously?               Yes [No]


1Help  2PrtScr 3     4     5     6DOS    7     8     9     10Exit
                     Press <F10> to Perform Analysis
```

FIGURE D.22 Pond Starting Conditions Screen

```
HEA 01.01.00                                                        SUMM02
Study ID  SILVERCR          Hydrologic Analysis Summaries
Plan ID   PLANA
                  E. Analysis by Events - Rainfall-Runoff Data
                  Event  50%  20%  10%  4%  2% [1%] 0.2%  SPF
```

Da/HrMn	Lower Sub-basin Precip (in)	Lower Sub-basin Losses (in)	Lower Sub-basin Runoff (cfs)	Upper Sub-basin Precip (in)	Upper Sub-basin Losses (in)	Upper Sub-basin Runoff (cfs)	Exterior Basin Precip (in)	Exterior Basin Losses (in)	Exterior Basin Runoff (cfs)
1/0100	0.05	0.04	51.	0.00	0.00	0.	0.00	0.00	0.
1/0200	0.05	0.05	51.	0.00	0.00	0.	0.00	0.00	0.
1/0300	0.05	0.05	53.	0.00	0.00	0.	0.00	0.00	0.
1/0400	0.06	0.05	57.	0.00	0.00	0.	0.00	0.00	0.
1/0500	0.07	0.06	63.	0.00	0.00	0.	0.00	0.00	0.
1/0600	0.07	0.07	70.	0.00	0.00	0.	0.00	0.00	0.
					0	0.	0.00	0.00	0.
					0	0.	0.00	0.00	0.
					0	0.	0.00	0.00	0.
					0	0.	0.00	0.00	0.
					0	0.	0.00	0.00	0.

```
Select Option:

A. Plot Lower Sub-Basin Rainfall-Runoff
B. Plot Upper Sub-Basin Rainfall-Runoff
C. Plot Exterior Basin Rainfall-Runoff

                                   7     8     9     10Exit
          Position with <PgDn>, <PgUp>, <Dn>, <Up>, <Home>, <End>
```

FIGURE D.23 Rainfall-Runoff Data for 1% Storm Event

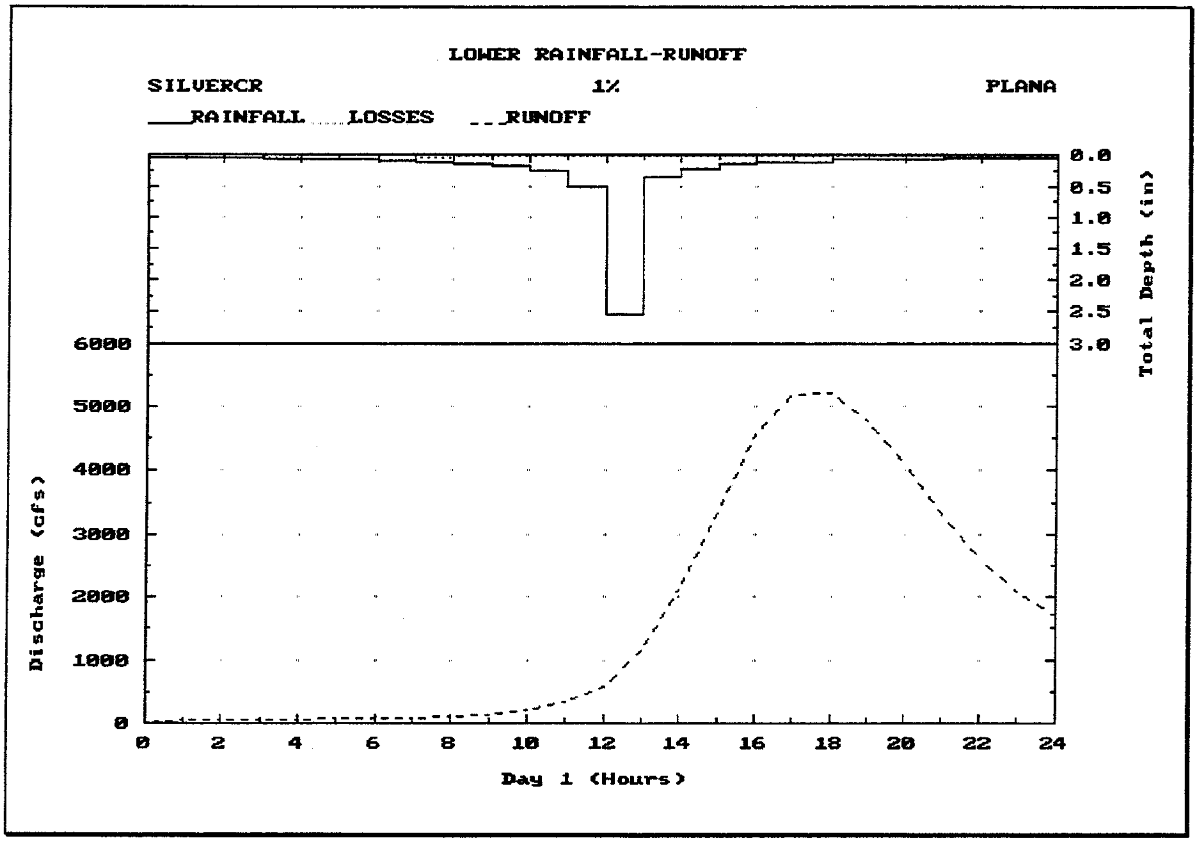

FIGURE D.24 Plot of Rainfall-Runoff for 1% Storm Event

HEA 01.01.00
Study ID SILVERCR
Plan ID PLANA

Hydrologic Analysis Summaries

SUMM34

M. Event Comparisons - Rainfall-Runoff Data

ANNUAL series Storm Area: 15.00 (sq mi)

	Lower Sub-Basin			Upper Sub-Basin			Exterior Basin		
Event	Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)	Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)	Total Precip (in)	Total Losses (in)	Peak Runoff (cfs)
50%	2.4	0.6	2240.	0.0	0.0	0.	0.0	0.0	0.
20%	3.3	0.7	2978.	0.0	0.0	0.	0.0	0.0	0.
10%	3.9	0.7	3554.	0.0	0.0	0.	0.0	0.0	0.
4%	4.5	0.7	4164.	0.0	0.0	0.	0.0	0.0	0.
2%	5.1	0.7	4657.	0.0	0.0	0.	0.0	0.0	0.
1%	5.6	0.7	5195.	0.0	0.0	0.	0.0	0.0	0.
0.2%	6.1	0.7	5804.	0.0	0.0	0.	0.0	0.0	0.
SPS	12.8	1.2	10382.	0.0	0.0	0.	0.0	0.0	0.

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit
Press <F10> to Return

FIGURE D.25 Comparison of Rainfall-Runoff Data for All Storm Events

HEA 01.01.00
Study ID SILVERCR
Plan ID PLANA

SUMM37

Hydrologic Analysis Summaries

R. Event Comparisons - Frequency Analysis

ANNUAL series Storm Area: 15.00 (sq mi)

Event	Maximum Interior Elevation (ft)	Maximum Interior Area Flooded (ac)	Maximum Total Interior Inflow (cfs)
50%	602.89	493.4	2240.3
20%	604.12	738.9	2978.1
10%	604.81	904.2	3554.5
4%	605.44	1080.7	4164.1
2%	605.92	1226.9	4657.0
1%	606.33	1364.5	5194.9
0.2%	606.72	1501.0	5804.1
SPF	609.27	3034.9	10381.9

1Help 2PrtScr 3 4 5 6DOS 7 8 9Plot 10Exit

Press <F10> to Return

FIGURE D.26 Frequency Analysis Screen

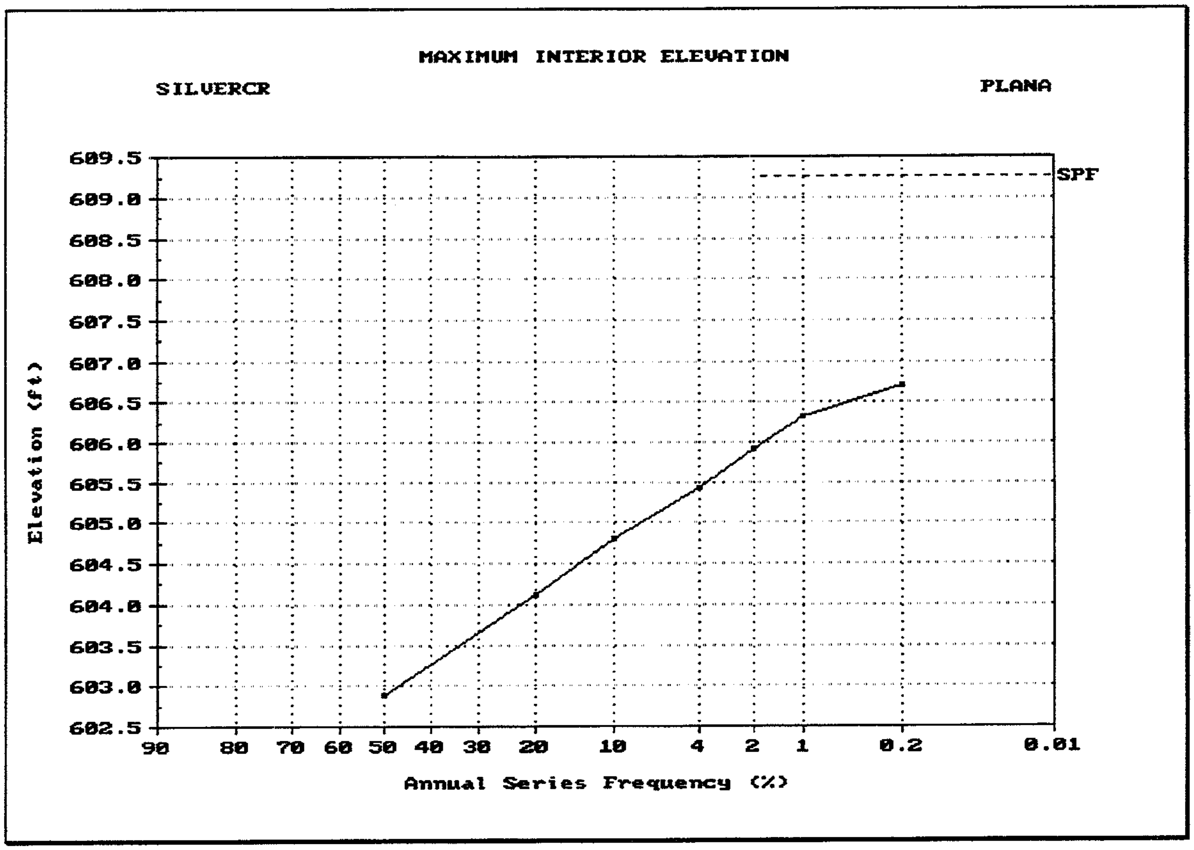

FIGURE D.27 Plot of Frequency Analysis

APPENDIX E.
HEC-IFH Data Management

This appendix describes the data management options provided by the HEC-IFH program. To more easily deal with large volumes of data, the HEC-IFH program contains features for viewing, storing, retrieving, and deleting selected input data and output. Figure E.1 illustrates the HEC-IFH Data Management Menu screen.

```
IFH 01.01.00                                                        MB
Study ID  RBEND2            Data Management Utilities

                 List Studies or Plans
                   A. List Studies
                   B. List Plans of Present Study
                   C. List Master Directory for Present Study

                 Store Archival Copy of Study or Plan
                   D. Store Archival Copy of Specified Study
                   E. Store Archival Copy of Specified Plan

                 Retrieve Archival Copy of Study or Plan
                   F. Retrieve Archival Copy of Specified Study
                   G. Retrieve Archival Copy of Specified Plan

                 Delete Studies or Plans
                   H. Delete Specified Study (Input and Output)
                   I. Delete Specified Study (Output only)
                   J. Delete Specified Plan

1Help  2PrtScr 3      4      5      6DOS   7      8      9      10Exit
              Press Letter; or use Arrow Keys and <Enter> to Select
```

FIGURE E.1 HEC-IFH Data Management Menu

E.1. LISTING HEC-IFH INPUT AND OUTPUT

As described in Chapter 2, HEC-IFH deals with Studies and Plans. A ***study*** is an analysis of a particular interior system. The purpose of the study is generally to propose changes to the interior system to improve performance under existing or future conditions. During the course of the study, several different ***plans*** will be formulated for analysis. Each plan represents a unique combination of precipitation, runoff, pond storage, and outflow conditions. HEC-IFH provides three types of screens which list the data available:

- **List Studies**: A list of all of the studies currently residing in the HEC-IFH directory on the computer system. (See Figure E.2.) Each study contains at least some input data. However, the input data may not be complete, and no output data are necessarily available for any study.

- **List Plans of Present Study**: A list of all of the plans currently residing in the HECIFH\STUDYID directory on the computer system, for the specified study. (See Figure E.3.) Each plan contains at least some input data. However, the input data may not be complete, and no output data are necessarily available for any study.

- **List Master Directory for Present Study**: A comprehensive list of all of the data files currently residing in the HECIFH\STUDYID directory on the computer system, for the specified plan. (See Figure E.4.)

IFH 01.01.00
Study ID RBEND2

Data Management Utilities

DATA02

List Studies

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes) Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	739	9362
SILVERCR	Silver Creek Interior Area Analysis	23AUG1991/0754	53	496
STUDY0	Study for general testing of CSA and HEA	25FEB1992/1252	20	0

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <Esc> or <F10> to Exit to the Menu, or <Enter> to Continue

FIGURE E.2 List Studies

IFH 01.01.00
Study ID RBEND2

Data Management Utilities

DATA04

List Plans of Present Study

ID	Description	DaMonYear/HrMn	Num. Bytes
PLAN1	Gravity outlet only.	03MAR1992/1838	3051938
PLAN2	4x4 Box culvert with 200-cfs pump.	02MAR1992/1914	3111330
PLAN3	Stage-Freq test. 3month,1day,Partial ser	29FEB1992/1642	86946
PLANP	4x4 Box culv. with 200-cfs pump. PARTIAL	02MAR1992/2009	3111842

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit
Press <Esc> or <F10> to Exit to the Menu, or <Enter> to Continue

FIGURE E.3 List Plans of Present Study

IFH 01.01.00 DATA04
Study ID RBEND2

Data Management Utilities

List Master Directory for Present Study

ID	Description	DaMonYear/HrMn	Num. Bytes
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	1886
.DSS		03MAR1992/1531	667136
PRECIP1	Precip. data for App. C.	20FEB1992/1347	738
GAGE1	Gage 1 recorded precip. WY1950-WY1960	21FEB1992/1241	3444
GAGE2	Gage 2 recorded precip. - WY1950-WY1960	20FEB1992/1315	3444
UPPER	Composite precip. for upper sub-basin.	20FEB1992/1317	3444
RUNOFF1	Runoff data for App. C. example.	21FEB1992/1247	2132
LOWER	Lower sub-basin for App. C example.	21FEB1992/1245	3444
MAINRIV	Main River Runoff Parameters	28FEB1992/1011	3444
TRIBRUN	Tributary Runoff parameters	28FEB1992/1011	3444
UPPER	Upper Sub-basin for App. C example.	20FEB1992/1350	3444
ROUTE1	Channel routing data for App. C example.	20FEB1992/1352	2132
INTPOND1	Interior pond module data for App. C.	21FEB1992/1252	738
POND1	Interior pond for App. C example.	21FEB1992/1250	902
DITCH1	Interior Ditch (Pond to Outlets)	27FEB1992/0938	738

1Help 2PrtScr 3 4 5 6DOS 7 8 9 10Exit

Press <Esc> or <F10> to Exit to the Menu, or <Enter> to Continue

FIGURE E.4 List Master Directory for Present Study

E.2. STORING ARCHIVAL DATA

HEC-IFH can use the DOS Backup utility to store a copy of a specified study or plan. A sufficient quantity of formatted diskettes should be on hand before these commands are issued.

Figure E.5 illustrates the screen used to specify a study for archival storage. When the cursor is on the Study ID field, the F3 key displays a list of previously-defined IDs. Any of these Study IDs may be selected, and the corresponding study data will be selected for archival. All input and output data for the specified study will be copied to the archival device. The study data will not be deleted from the hard disk. A separate delete command is described later in this appendix.

Figure E.6 illustrates the screen used to specify a plan for archival storage. As indicated, this screen is identical to the previous screen, except that an additional data entry field is available for the Plan ID. When the cursor is on the Plan ID field, the F3 key displays a list of previously-defined IDs. Any of these Plan IDs may be selected, and the corresponding plan data will be selected for archival. All input and output data for the specified plan will be copied to the archival device. The plan data will not be deleted from the hard disk. A separate delete command is described later in this appendix.

IFH 01.01.00 DATA03
Study ID RBEND2

Data Management Utilities

Store Archival Copy of Specified Study

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes) Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	732	9362

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to begin processing, or <Esc> to Return to the Menu

FIGURE E.5 Store Archival Copy of Specified Study

IFH 01.01.00 DATA05
Study ID RBEND2

Data Management Utilities

Store Archival Copy of Specified Plan

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes) Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	732	9362

Plan ID	Description	Last modified DaMonYear/HrMn	Size (bytes)
PLAN1	Gravity outlet only.	03MAR1992/1838	3051938

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to begin processing, or <Esc> to Return to the Menu

FIGURE E.6 Store Archival Copy of Specified Plan

E.3. RETRIEVING ARCHIVAL DATA

HEC-IFH can use the DOS Restore utility to retrieve a copy of a specified study or plan. Sufficient capacity should be available on the hard disk before these commands are issued.

Figure E.7 illustrates the screen used to specify a study for retrieval. The [F3] Index key is NOT available to list archived Study IDs. The user must type the Study ID. All available data for the specified study will be retrieved from the archival device.

Figure E.8 illustrates the screen used to specify a plan for retrieval. The [F3] Index key is NOT available to list archived Plan IDs. The user must type the Plan ID. All available data for the specified plan will be retrieved from the archival device.

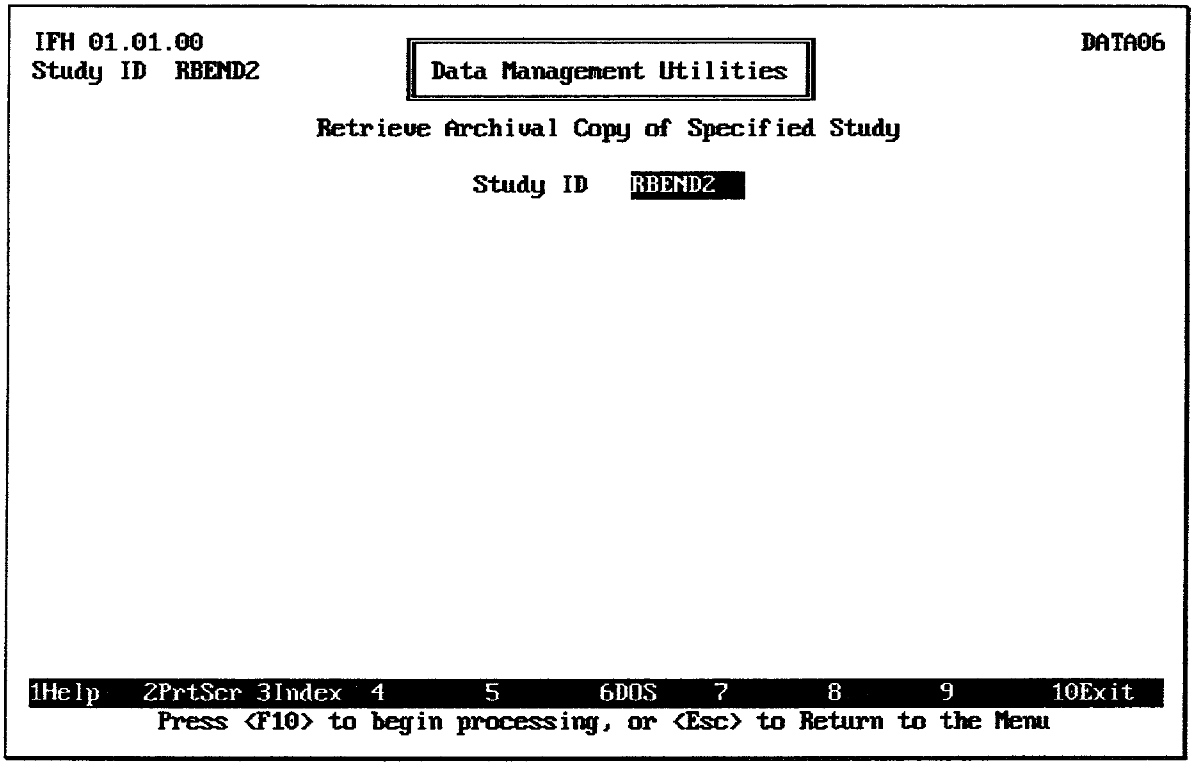

FIGURE E.7 Retrieve Archival Copy of Specified Study

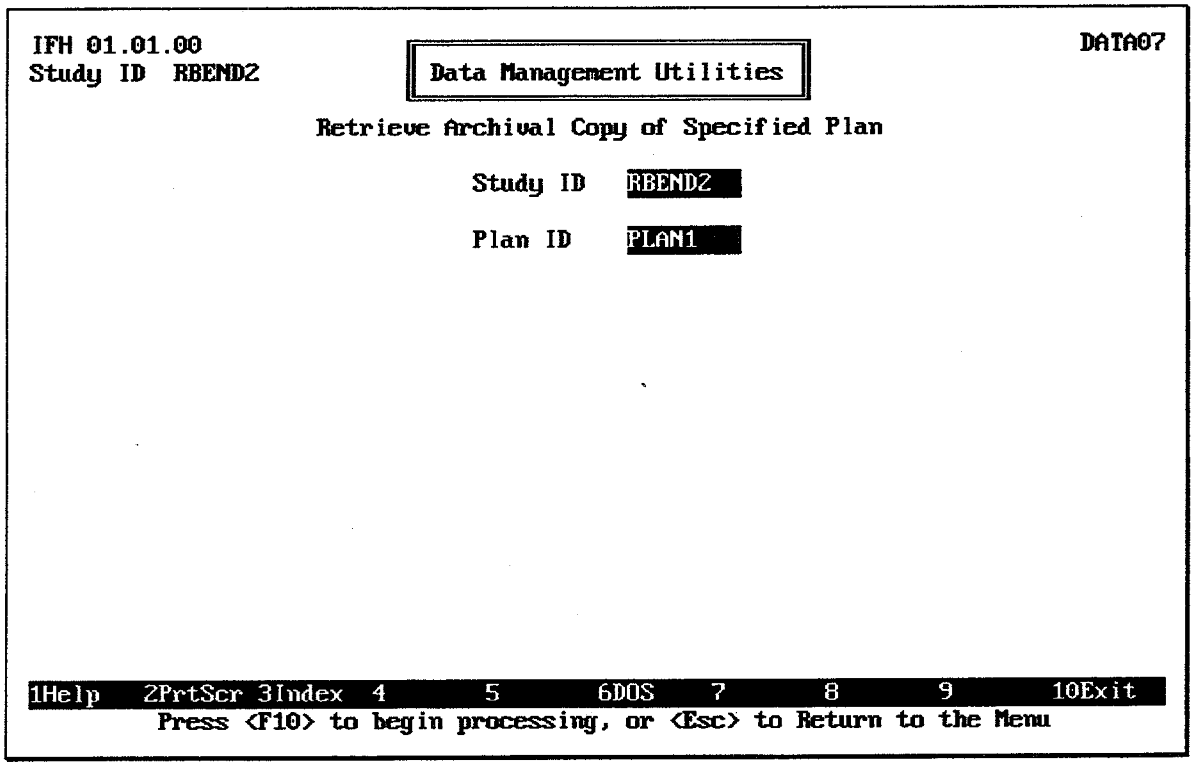

FIGURE E.8 Retrieve Archival Copy of Specified Plan

E.4. DELETING DATA

HEC-IFH can delete all or part of a specified study or plan. For studies, HEC-IFH can delete the entire study data, including input as well as output, or the output data only can be deleted. The option of deleting the output only is convenient because it reduces storage requirements significantly, but allows the user to reproduce the study results by simply executing each plan analysis again. This avoids having to restore plan results from the archival device.

Figure E.9 illustrates the screen used to specify a study for deletion. When the cursor is on the Study ID field, the [F3] key displays a list of previously-defined IDs. Any of these Study IDs may be selected, and the corresponding study data will be selected for deletion. All input and output data for the specified study will be deleted. Figure E.10 shows a similar screen which is used to delete the study output data only. All input data for the study remains intact on the hard disk.

Figure E.11 illustrates the screen used to specify a plan for deletion. As indicated, this screen is identical to the previous screen, except that an additional data entry field is available for the Plan ID. When the cursor is on the Plan ID field, the [F3] key displays a list of previously-defined IDs. Any of these Plan IDs may be selected, and the corresponding plan data will be selected for deletion. All input and output data for the specified plan will be deleted.

IFH 01.01.00
Study ID RBEND2

Data Management Utilities

DATA08

Delete Specified Study (Input and Output)

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes)	
			Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	732	9362

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to begin processing, or <Esc> to Return to the Menu

FIGURE E.9 Delete Specified Study (Input and Output)

IFH 01.01.00
Study ID RBEND2

Data Management Utilities

DATA09

Delete Specified Study (Output Only)

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes)	
			Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	732	9362

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to begin processing, or <Esc> to Return to the Menu

FIGURE E.10 Delete Specified Study (Output Only)

IFH 01.01.00   DATA10
Study ID RBEND2

Data Management Utilities

Delete Specified Plan

Study ID	Description	Last modified DaMonYear/HrMn	Size (Kbytes)	
			Input	Output
RBEND2	Analysis of River Bend Interior Area	28FEB1992/1626	732	9362

Plan ID	Description	Last modified DaMonYear/HrMn	Size (bytes)
PLAN1	Gravity outlet only.	03MAR1992/1838	3051938

1Help 2PrtScr 3Index 4 5 6DOS 7 8 9 10Exit

Press <F10> to begin processing, or <Esc> to Return to the Menu

FIGURE E.11 Delete Specified Plan

APPENDIX F.
HEC-IFH Error Messages

This appendix lists the messages which may be generated by the HEC-IFH program during plan analysis. A brief explanation is provided for each message. The messages are grouped into categories which correspond to Chapters 3 through 10 of this manual.

Error Message summaries are available from the Hydrologic Analysis Summary menu for both Continuous Simulation Analysis and Hypothetical Event Analysis.

F.1. MESSAGES RELATING TO BASIN AVERAGE PRECIPITATION

The following warning messages relate to the specification of basin average precipitation. See Chapter 3 for information concerning precipitation input data.

WARNING: PRECIP station not specified for this basin. Runoff not computed.

No precipitation station ID has been specified for the drainage basin. HEC-IFH cannot compute runoff for the basin if no precipitation has been specified.

WARNING: Analysis starts or ends outside PRECIP data range.

Precipitation has been specified, but the available time series of precipitation does not extend throughout the entire duration of the analysis. No precipitation is available for a portion of the analysis.

WARNING: PRECIP values are interpolated for analysis time interval.

The time increment of the specified precipitation time series is longer than the time increment of the interior analysis. The analysis will proceed by interpolating the precipitation from the available data. However, the quality of the results may be improved by repeating the analysis using more detailed precipitation data.

F.2. MESSAGES RELATING TO RUNOFF HYDROGRAPHS

The following warning messages relate to the specification of runoff hydrograph data. See Chapter 4 for information concerning runoff hydrograph input data.

F.2.1. Messages Relating to Basin Infiltration Loss Data

WARNING: SCS curve number not specified. Using 100 (no infiltration losses).

No value for the curve number has been specified when using the SCS Curve Number infiltration function. The computations will proceed with 100% runoff (no infiltration). Repeat the analysis after specifying a value for the SCS Curve Number.

WARNING: Green-Ampt Mass balance error. Total loss volume=999.99 excess volume=999.99 total volume=999.99

The program is unable to stabilize the relationship between rainfall, infiltration, and rainfall excess while using the Green and Ampt infiltration function. Check Green and Ampt input parameters.

F.2.2. Messages Relating to Basin Unit Hydrograph Data

F.2.2.1. Messages Relating to Clark Unit Hydrograph Computation

WARNING: Clark unit hydrograph TC increased to computation time interval

The specified computation time interval is greater than the time of concentration specified for a Clark unit hydrograph. The time interval may need to be reduced.

WARNING: Clark unit hydrograph R increased to half of computation time interval

The specified watershed storage coefficient is greater than one-half the time of concentration specified for a Clark unit hydrograph. The time interval may need to be reduced.

WARNING: Clark unit hydrograph truncated to 150 intervals.

The computed Clark unit hydrograph extends beyond the allowable 150 ordinates. Some runoff volume will be lost if the truncated unit hydrograph is used. The computation time interval may need to be increased.

F.2.2.2. Messages Relating to Snyder Unit Hydrograph Computation

WARNING: Clark unit hydrograph did not converge to given Snyder coefficients.

HEC-IFH was not able to produce a complete unit hydrograph matching the specified Snyder unit hydrograph coefficients. Check the input data.

F.2.2.3. Messages Relating to SCS Dimensionless Unitgraph Computation

WARNING: Computation time interval is greater than 0.29*TLAG. A smaller interval is recommended for computing SCS unit hydrograph.

The time increment of the analysis is so large that it seriously reduces the proper definition of an SCS dimensionless unit graph for the basin. The time increment should be reduced.

WARNING: SCS unit hydrograph truncated to 150 intervals

The computed SCS unit hydrograph extends beyond the allowable 150 ordinates. Some runoff volume will be lost if the truncated unit hydrograph is used. The computation time interval may need to be increased.

F.2.2.4. Messages Relating to Entered Unit Hydrograph

WARNING: Time interval for input unit hydrograph not equal to computation interval. Runoff not computed.

The user has specified unit hydrograph ordinates. However, the specified duration of the unit hydrograph does match the time increment of the interior analysis. Since HEC-IFH runoff computations are based on the assumption that the unit hydrograph duration equals the time increment of the analysis, no runoff can be computed.

F.2.3. Messages Relating to Channel Routing Data for Upper Sub-Basin

WARNING: Channel Routing Data missing or not readable. ID: CRDIDxxx No routing done.

The channel routing data file for the specified ID is missing or corrupted.

WARNING: Negative routed flow rates changed to zero xxxxxxx times.

During channel routing computations, negative flow rates were computed. These have been changed to zero (0) values. The HEC-IFH program records the number of times these negative flow rates are computed.

F.2.3.1. Messages Relating to Modified Puls Routing

WARNING: Modified Puls table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The flow rates listed on the Modified Puls table were lower than some of the flow rates computed during the analysis. The table was not extrapolated. Better results may be obtained if the analysis is repeated using an extended table.

F.2.3.2. Messages Relating to Muskingum Routing

WARNING: Specified Muskingum routing values fail stability test:
1/(2(1-x)) <= K/(NumSteps*Hours) <= 1/(2x)

The Muskingum routing computations may not be stable because the specified coefficients do not lie within the prescribed range. The computation time interval may have to be reduced.

F.2.3.3. Messages Relating to Lag Routing

WARNING: Channel routing lagged 0 time steps (= LagTime / StepTime).

The Lag method of channel routing was specified. However, the specified lag time was so short that it rounded to zero (0) time steps. Therefore, no routing computations were performed. The computation time increment may need to be reduced.

F.2.3.4. Messages Relating to Muskingum-Cunge Routing

WARNING: Muskingum-Cunge Channel Routing data invalid. Channel length not positive. No routing done.

The channel length value specified for Muskingum-Cunge routing computations is not valid. The upper sub-basin hydrograph has been transferred directly through the channel routing reach with no lagging or attenuation. To obtain better results, enter a positive channel length and repeat the computations.

WARNING: Muskingum-Cunge Channel Routing data invalid. Channel invert slope not positive. No routing done.

The channel invert slope value specified for Muskingum-Cunge routing computations is not valid. The upper sub-basin hydrograph has been transferred directly through the channel routing reach with no lagging or attenuation. To obtain better results, enter a positive channel invert slope and repeat the computations.

WARNING: Muskingum-Cunge Channel Routing data invalid. Channel roughness coefficient not positive. No routing done.

The channel roughness (Manning n) value specified for Muskingum-Cunge routing computations is not valid. The upper sub-basin hydrograph has been transferred directly through the channel routing reach with no lagging or attenuation. To obtain better results, enter a positive channel roughness coefficient and repeat the computations.

WARNING: Muskingum-Cunge Channel Routing data invalid. Circular channel diameter not positive. No routing done.

The circular channel diameter specified for Muskingum-Cunge routing computations is not valid. The upper sub-basin hydrograph has been transferred directly through the channel routing reach with no lagging or attenuation. To obtain better results, enter a positive channel diameter and repeat the computations.

WARNING: Muskingum-Cunge Channel Routing data invalid. Left or right overbank roughness coeff. is zero. No routing done.

One or both of the overbank roughness coefficient (Manning n) values specified for Muskingum-Cunge routing computations is not valid. The upper sub-basin hydrograph has been transferred directly through the channel routing reach with no lagging or attenuation. To obtain better results, enter positive overbank roughness coefficients and repeat the computations.

WARNING: Muskingum-Cunge channel routing array limits exceeded. Zeros are used for routed flow rates beyond limit. Avoid this with fewer number or longer duration intervals.

The Muskingum-Cunge routing computations extend beyond the allowable number of intervals (10,000 intervals for the current original release version of the program). Within the HEC-IFH program, a smaller computation time interval may be used internally during Muskingum-Cunge routing computations. The program automatically uses the shortest of the following three intervals: 1) The user-specified computation interval; 2) 1/20 of the hydrograph time to rise; or 3) the travel time of the channel reach. The user should determine which of these three intervals is controlling, and determine if the controlling interval can be increased.

F.2.4. Messages Relating to Specifying Runoff Data

WARNING: RUNOFF data not specified for this basin. Runoff not computed.

No runoff basin ID has been specified for the drainage basin. HEC-IFH cannot compute runoff for the basin if no runoff parameters have been specified.

F.3. MESSAGES RELATING TO INTERIOR POND DATA

The following warning messages relate to the specification of interior pond data. See Chapter 5 for information concerning interior pond input data.

WARNING: Ditch lower than minimum elevation (from pond elevation table). Results may be unstable.

The specified invert elevation for the interior ditch is below the minimum elevation specified in the pond elevation table. The pond elevation table should be extended down to the ditch invert elevation.

F.4. MESSAGES RELATING TO GRAVITY OUTLETS

The following warning messages relate to the specification of gravity outlet data. See Chapter 6 for information concerning gravity outlet data.

WARNING: Culvert inlet invert below minimum interior elevation (from pond elevation table). Results may be unstable. ID: xxxxxxxx

The specified interior invert elevation for a gravity outlet is below the minimum elevation specified in the pond elevation table. The gravity outlet is identified. The pond elevation table should be extended down to the culvert invert elevation.

F.5. MESSAGES RELATING TO PUMP OUTLETS

The following warning messages relate to the specification of pump outlets. See Chapter 7 for information concerning pump outlet data.

WARNING: Pump stop elevation(s) are below minimum interior elevation (from pond elevation table). Results may be unstable. ID: PUDIDxxx

The specified stop elevation for a pumping unit is below the minimum elevation specified in the pond elevation table. The pumping unit is identified. The pond elevation table should be extended down to the pump stop elevation.

WARNING: Pump start elevation(s) are above maximum interior elevation (from pond elevation table). Results may be unstable. ID: PUDIDxxx

The specified start elevation for a pumping unit is above the maximum elevation specified in the pond elevation table. The pumping unit is identified. The pond elevation table should be extended up to the pump start elevation.

F.6. MESSAGES RELATING TO EXTERIOR STAGE

The following warning messages relate to the specification of exterior stages. See Chapter 8 for information concerning exterior stage input data.

F.6.1. Messages Relating to Index Stage Hydrograph Options

WARNING: Missing exterior stage value(s). HEC-IFH extended last known value for pond routing computations.

The available time-series of exterior stages contains missing values, or does not extend throughout the entire period of analysis. The program has used the most recent known value for all missing values. These missing values are shown as zero values in Calculated Period Summaries. The missing values should be provided and the pond routing analysis should be repeated.

WARNING: Analysis starts or ends outside EXSTAGE data range.

Exterior stage data have been specified, but the available time series of exterior stages does not extend throughout the entire duration of the analysis. No exterior stage is available for a portion of the analysis.

F.6.2. Messages Relating to Primary Outlet on Main River

WARNING: Exterior stage spec for MAIN RIVER TRANSFER is incomplete.

All of the input data necessary for the program to apply a main river transfer relationship is not available. Check the main river transfer data.

WARNING: Cannot read transfer relation. Exterior stage not computed.

The program is unable to read the main river transfer relationship relationship. Check this table.

WARNING: Cannot read main river rating curve. Exterior stage not computed.

The program is unable to read the rating table for the main river when computing the exterior stage hydrograph from an entered or computed exterior discharge hydrograph. Check the rating table data.

WARNING: Exterior stage spec for PRIMARY OUTLET LOCATION is incomplete.

Neither [Main River] nor [Tributary] is specified for the "Primary Outlet Location".

WARNING: Exterior stage spec for MAIN RIVER STAGE SOURCE is incomplete.

The program is not able to identify the source of the main river stage hydrograph (index hydrograph). Check the selection on the Index Stage Hydrograph menu (Figure F.1).

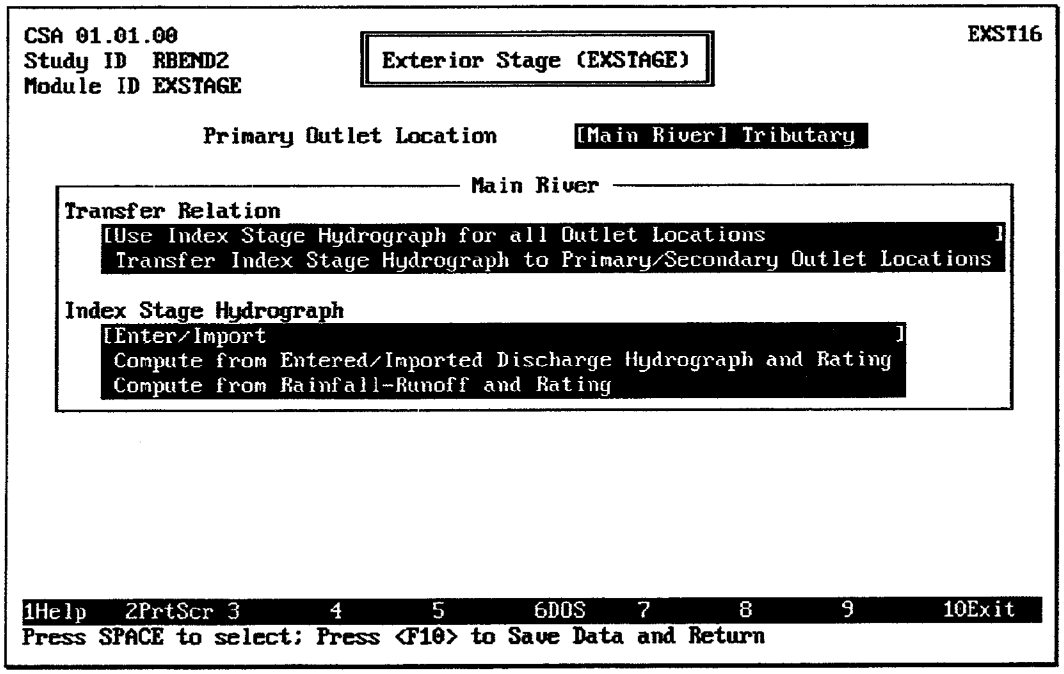

FIGURE F.1 Menu Screen for Primary Outlet Location on Main River

WARNING: Exterior discharge-to-stage rating table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The exterior basin discharge rates listed on the rating table are lower than some of the discharge rates computed during the analysis. The rating table was not extrapolated. Better results may be obtained if the analysis is repeated using an extended rating table.

F.6.3. Messages Relating to Primary Outlet Location on Tributary

WARNING: Cannot read tributary rating curve. Exterior stage not computed.

The program is unable to read the rating table for the tributary stream when transferring the main river stage hydrograph from the confluence to the outlet location on the tributary. Check the tributary rating table data.

WARNING: Cannot read transfer relation. Exterior stage not computed.

The program is unable to read the tributary transfer relationship. Check this table.

WARNING: Exterior stage spec TRIBUTARY DISCHARGE SOURCE is incomplete.

The program is not able to identify the source of the tributary discharge hydrograph. Check the selection on the Tributary menu (Figure F.3).

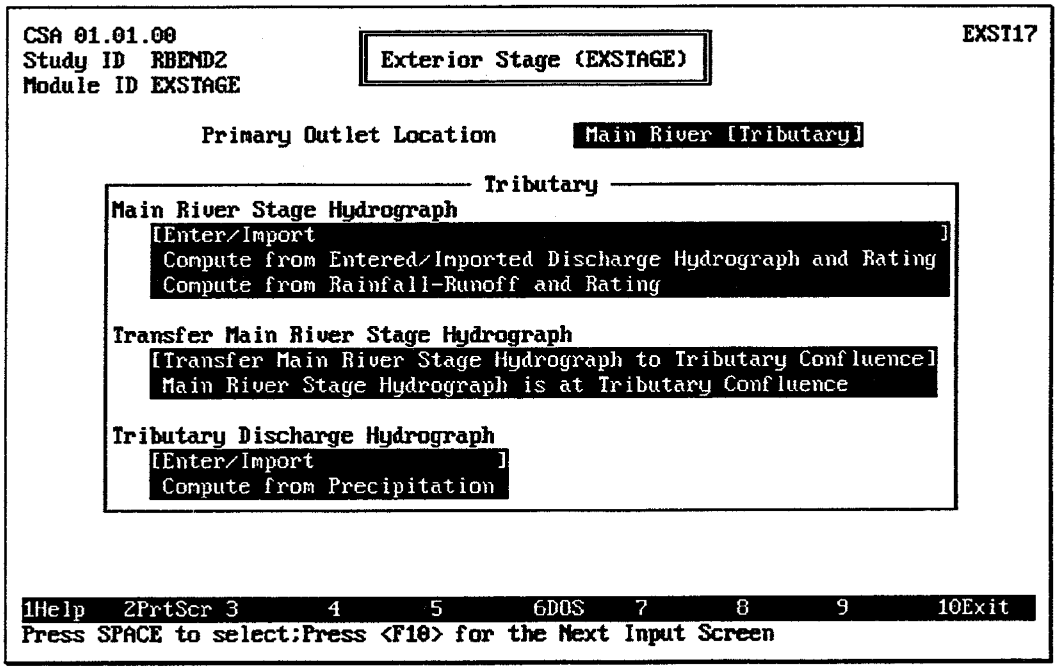

FIGURE F.3 Menu Screen for Primary Outlet Location on Tributary

WARNING: Tributary rating table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The main river stage or the tributary flow rate during the analysis is above the maxima specified in the tributary rating table. Better results may be obtained by repeating the analysis using an extended tributary rating table.

F.7. MESSAGES RELATING TO AUXILIARY INFLOW/OUTFLOW

The following warning messages relate to the specification of auxiliary inflows and outflows. See Chapter 9 for information concerning auxiliary inflow/outflow input data.

F.7.1. Messages Relating to Auxiliary Inflows for Interior Sub-Basins

WARNING: Analysis starts or ends outside AUXFLOW data range.

Auxiliary inflow has been specified, but the available time series of auxiliary inflow does not extend throughout the entire duration of the analysis. No auxiliary inflow is available for a portion of the analysis.

F.7.2. Messages Relating to Diverion for Upper Sub-Basin

WARNING: Diversion Data missing or not readable. ID: xxxxxxxx No diversion done.

The diversion data file xxxxxxxx.DFD was not found or is corrupted.

WARNING: Diversion table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The upper basin discharge rates listed on the diversion table were lower than some of the discharge rates computed during the analysis. The diversion table was not extrapolated. Better results may be obtained if the analysis is repeated using an extended diversion table.

F.7.3. Messages Relating to Overflow for Lower Sub-Basin

WARNING: Overflow table starts below minimum interior elevation (from pond elevation table). Results may be unstable.

The lowest elevation appearing on an overflow table is below the minimum elevation specified in the pond elevation table. The pond elevation table should be extended down to the minimum overflow elevation.

F.8. MESSAGES RELATING TO INTERIOR ANALYSIS

The following warning messages relate to the interior analysis parameters and computations. See Chapter 10 for information concerning the interior analysis input parameters and computations.

WARNING: Starting pond elevation is below minimum interior elevation (from pond elevation table). The minimum was used.

The specified starting pond elevation for the analysis is below the minimum elevation specified in the pond elevation-area table. Starting pond elevation should be equal to or greater than the minimum elevation in the table.

WARNING: Starting pond elevation is above maximum interior elevation (from pond elevation table). The maximum was used.

The specified starting pond elevation for the analysis is above the maximum elevation specified in the pond elevation-area table. Starting pond elevation should be equal to or less than the maximum elevation in the table.

F.8.1. Messages Relating to Interior Pond Routing Analysis

WARNING: Pond elevation-area table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The computed pond elevation during the analysis is above the maximum elevation specified in the pond elevation table. Better results may be obtained by repeating the analysis using an extended pond elevation-are table.

WARNING: Input Gravity rating table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The exterior stage or computed pond elevation during the analysis is above the maximum elevation specified in a gravity rating table. Better results may be obtained by repeating the analysis using an extended gravity rating table.

WARNING: Main river transfer table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The exterior stage during the analysis is above the maximum elevation specified in the main river transfer table. Better results may be obtained by repeating the analysis using an extended main river transfer table.

WARNING: Overflow table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The computed pond elevation during the analysis is above the maximum elevation specified in the overflow table. Better results may be obtained by repeating the analysis using an extended overflow table.

WARNING: Seepage table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The computed differential head during the analysis is above the maximum head specified in the seepage inflow table. Better results may be obtained by repeating the analysis using an extended seepage inflow table.

WARNING: Ditch table exceeded. Data not extrapolated beyond maximum value. Results may be incorrect.

The computed pond elevation during the analysis is above the maximum elevation specified in the interior ditch table. Better results may be obtained by repeating the analysis using an extended interior ditch table.

WARNING: Significant difference in inflow and outflow volume indicating possible instability. May need to shorten computation time interval.

The pond routing computation procedure is unable to achieve an acceptable balance of inflow, outflow, and storage volume. Check the input data for pond surface area, and the input data for all gravity outlets, pump outlets, and auxiliary outflows. If all data appear correct, then the analysis should be repeated with a shorter computation interval, if possible.

F.8.2. Messages Relating to Frequency Analysis

WARNING: Threshold elevation is below minimum interior elevation (from pond elevation table). No Frequency analysis done.

For a partial series analysis, the specified threshold elevation is below the minimum elevation specified in the pond elevation table. The frequency analysis must be repeated using a higher threshold elevation.

WARNING: Threshold elevation is above maximum interior elevation (from pond elevation table). No Frequency analysis done.

For a partial series analysis, the specified threshold elevation is above the maximum elevation specified in the pond elevation table. The frequency analysis must be repeated using a lower threshold elevation.

WARNING: Less than 10 years of complete water years were available for frequency analysis. A longer period is recommended.

The duration of the analysis is less than 10 years, which may be insufficient for reliable frequency analysis results. Better results may be obtained by repeating the analysis using a longer period of analysis, if possible.

WARNING: Number of partial series events above the specified threshold elevation was less than the number or years in the analysis period. A lower threshold elevation may be necessary.

When the program processed the exterior stage data to identify all events above the specified threshold elevation, the number of events was less than the duration of the analysis period in years. This is insufficient for reliable frequency analysis results. Better results may be obtained by repeating the analysis by lowering the threshold elevation.

WARNING: Number of events specified threshold elevation for partial-duration analysis exceeds frequency table limit of 200. Only the highest 200 events are included in the results.

When the program processed the exterior stage data to identify all events above the specified threshold elevation, the number of events was greater than 200 but less than 300. The computed results are valid, but the frequency analysis is based on only the largest 200 events.

WARNING: Number of events above specified threshold elevation for partial-duration analysis exceeds limit of 300. Results are invalid and are not saved or presented. Increase threshold elevation and repeat analysis.

When the program processed the exterior stage data to identify all events above the specified threshold elevation, the number of events was greater than 300. Since the program can store only 300 events, any subsequent events cannot be stored. Therefore, the frequency analysis was terminated without results. The threshold elevation must be increased to a value which will result in 300 or fewer events.

F.8.3. HEC STATLIB Error Messages

The following error messages are related to frequency analysis program (HEC STATLIB) routines. Additional messages are written to an external file IFHMSG.ERR in the default directory. Please contact HEC if these errors occur.

ERROR 1 computing stage frequency. See IFHMSG.ERR file.

ERROR 2 computing stage frequency. Fatal error in DSSPNP output path.

ERROR 3 computing stage frequency. Fatal error in DSSRPF.

ERROR 4 computing stage frequency. Fatal error in DSSPNP input pathname

ERROR 5 computing stage frequency. Fatal error in DSSRTS.

ERROR 6 computing stage frequency. Fatal error in YRMAX.

ERROR 7 computing stage frequency. Fatal error in PARDUR.

ERROR 8 computing stage frequency. Fatal error in IFHORD.

ERROR 9 computing stage frequency. Fatal error in PLTPOS.

ERROR 10 computing stage frequency. Fatal error in FRQFIT.

ERROR 11 computing stage frequency. Fatal error in DSSWPF stage-freq.

ERROR 12 computing stage frequency. Fatal error in DSSWPF plot positions

ERROR 13 computing stage frequency. Too short a period to analyze.

ERROR 14 computing stage frequency. Fatal: Missing data.

APPENDIX G: Index to HEC-IFH User's Manual

A

B

C

E

F

G

H

I

M

P

S

T