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16. Abstract This project report, in six volumes, documents a system of computer programs for the design of drainage components: culverts, storm drains, and open channels. The system includes an input generator to estimate design rain, hyetographs, design flow, and hydrographs. Programs are facilitated with semi-expert system shells that generate input data for engineering programs. The system is expandable and designed for personal computers that operate within an MS-DOS environment. Volume I documents the control of the entire system of Pooled Fund Project (PFP) programs. The system shell is intended to support analysis and design programs and facilitate communication (data transfer) between these programs. It is also designed to provide a basis for file and disk management as well as permitting tutorial modules. Any MS-DOS file, input, output or program file can be reviewed within this shell. This volume is one of a series. The entire series is: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">FHWA No.</th> <th style="text-align: center;">Vol. No.</th> <th style="text-align: left;">Short Title</th> <th style="text-align: left;">FHWA No.</th> <th style="text-align: center;">Vol. No.</th> <th style="text-align: left;">Short Title</th> </tr> </thead> <tbody> <tr> <td>RD-88-120</td> <td style="text-align: center;">I</td> <td>HYDRAIN</td> <td>RD-88-123</td> <td style="text-align: center;">IV</td> <td>CDS</td> </tr> <tr> <td>RD-88-121</td> <td style="text-align: center;">II</td> <td>HYDRO</td> <td>RD-88-124</td> <td style="text-align: center;">V</td> <td>WSPRO</td> </tr> <tr> <td>RD-88-122</td> <td style="text-align: center;">III</td> <td>PFP-HYDRA</td> <td>RD-88-125</td> <td style="text-align: center;">VI</td> <td>HY8</td> </tr> </tbody> </table> To operate all the software, the user needs all six (6) volumes.						FHWA No.	Vol. No.	Short Title	FHWA No.	Vol. No.	Short Title	RD-88-120	I	HYDRAIN	RD-88-123	IV	CDS	RD-88-121	II	HYDRO	RD-88-124	V	WSPRO	RD-88-122	III	PFP-HYDRA	RD-88-125	VI	HY8
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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

in ²	square inches	645.2	millimetres squared	mm ²
ft ²	square feet	0.0929	metres squared	m ²
yd ²	square yards	0.836	metres squared	m ²
mi ²	square miles	2.59	kilometres squared	km ²
ac	acres	0.395	hectares	ha

MASS (weight)

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

VOLUME

fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft ³	cubic feet	0.0328	metres cubed	m ³
yd ³	cubic yards	0.0765	metres cubed	m ³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

mm ²	millimetres squared	0.0016	square inches	in ²
m ²	metres squared	10.764	square feet	ft ²
km ²	kilometres squared	0.39	square miles	mi ²
ha	hectares (10 000 m ²)	2.53	acres	ac

MASS (weight)

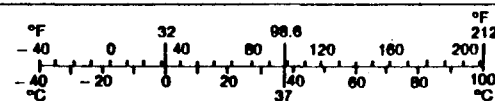
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m ³	metres cubed	35.315	cubic feet	ft ³
m ³	metres cubed	1.308	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
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These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

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Preface

This report presents documentation for the Hydrain system. HYDRO, PFP-HYDRA, CDS, WSPRO and HY8 are five nonproprietary engineering programs incorporated in the Hydrain system. The Hydrain personal computer oriented system operates the first three of these engineering programs with an interactive program shell written in the C language. The last program, HY8, also has an interactive program interspersed with the analysis code. It is written in BASIC and FORTRAN. Each program is in turn controlled by a common system shell, also in C. The system and program shells are designed with an open architecture for expansion. Hydrain is sponsored as a Pooled Fund Project (PFP) of 23 State highway departments and is managed by the Federal Highway Administration (FHWA). The latest State to join is Texas. The system and its support are expanding.

Within the Hydrain program shell concept, the HYDRO, PFP-HYDRA and CDS program shells allow the user to easily input, edit and run input data files and to scroll through output files. With these three applications, "short" (one-line) and "long" (multiple line) help is provided within the program logic.

The other two applications are incorporated into Hydrain without the high level of help and without program shells. WSPRO has the same type of batch operations as the first three but the input file has to be created with an input file generator (word processor or line editor). Hydrain system shell allows entry to this file generator, and reentry to Hydrain, but the user must rely on hard-copy documentation for help. HY8 is a stand-alone interactive BASIC program that accepts inputs during processing and produces screen outputs that the user can capture with the print screen command. All engineering programs but HY8 are batch oriented, and three steps are built into the process of using them: input file generation, programs execution, and output file screen review or listing. HY8 accepts inputs and generates outputs as the engineering program logic is executing.

HYDRO Program

FORTRAN code for HYDRO was developed to combine existing approaches for rainfall and runoff analyses into one computerized program. Within the Hydrain system, it can be used independently or to generate input data for other engineering programs within the system.

HYDRO offers many hydrologic analysis options to the engineer. Each is site specific based on user-defined coordinates.

- Design Rain Using Digitized NWS Information - Calculates the rainfall intensity for a specific return period, duration, and site.
- Design Hyetograph using Yen and Chow's method - Calculates the rain versus time plot for a return period, duration and site.

- Intensity-Duration-Frequency Curve - Analyzes a specific site and creates two graphs: a plot of points for durations up to 24 hours, and a detail graph of the first 2 hours.
- Design Flow by Rational Method - Uses a specific return period, duration and intensity to determine the peak flow for the site.
- Design Flow by USGS Regression Method - Uses USGS three or seven parameter regression equations or user supplied equations to determine design flow.
- Design Flow by log Pearson type III - Calculates the peak flow for given data.
- Design Hydrograph by Rational Method and Snyder's Unit Graph - The rainfall intensity for a return period is used to calculate the peak flow. A hydrograph is created using Constant's modification of Snyder's method.
- Design Hydrograph by USGS Regression and Snyder's Unit Graph - Develops a hydrograph for a site based on peak flow and a unit hydrograph.
- Design Hydrograph by log Pearson type III and Snyder's Unit Graph - Develops a hydrograph for a site based on peak flow and a unit hydrograph.
- Hydrograph - Develops a hydrograph for a site based on its unit graph for a given flow.

PFP-HYDRA Program

FORTTRAN code for PFP-HYDRA previously existed and the Pooled Fund work effort included substantial improvements. PFP-HYDRA is a storm and sanitary sewer system analysis and design program. It is used either to model an existing sewer system or to design a new system.

PFP-HYDRA generates storm flows by using either the Rational Method technique, hydrologic simulation techniques, or accepting a hydrograph generated by a HYDRO analysis. It can be used to design or analyze storm, sanitary or combined collection systems. PFP-HYDRA can handle up to 1,000 contributing drainage areas and 2,000 pipes. Additionally, PFP-HYDRA can be used for cost estimating. The Rational Method approximates the peak rate of runoff from a basin resulting from storms of a given return period. PFP-HYDRA's hydrologic simulation models the natural rainfall-runoff process. In the simulation, runoff hydrographs are generated, merged together and routed through the collection system. Inlet limitations can be analyzed: inlet overflow can be passed down a gutter system, while inlets in sumps can store water in ponds.

In the PFP-HYDRA design process, the program will select the pipe size, slope and invert elevations given certain design criteria. Additionally, PFP-HYDRA will perform analyses on an existing system of pipes (and/or ditches). When an existing system of pipes is overloaded, PFP-HYDRA will show suggested flow removal quantities as well as an increased pipe diameter size as an alternative remedy.

PFP-HYDRA requires the forming of an input file of commands to describe the sewer system. The program shell facilitates this activity. The commands are placed in a logical sequence usually from upper to lower elevation. It is possible that several command sequences can produce the same result. An input file is established for a particular collection system by the engineer and then the PFP-HYDRA program is executed. To change the characteristics of the collection system, the input file can be edited using the program shell. The input file, in itself, is a line by line command language that identifies the computation and provides the required data. Each line of data is preceded with a three-letter command. A typical command is **PDA**, indicating the line contains the design parameters for pipe analysis (**PIPE DATA**). PFP-HYDRA reads the command line one line (command) at a time and executes each command individually. However, PFP-HYDRA maintains a memory of information, including prior command information and results. Error checking is performed on each command.

The PFP-HYDRA program requires design criteria for the pipes: friction factor (Manning's "n"), minimum diameter, ideal depth, minimum ground cover, minimum velocity (full flow), minimum slope, and maximum diameter. The friction factor is necessary for both analysis and design, while the remaining values are needed only for design. For design, the program selects invert elevations and slope as well as the physical sizing of each link given certain design criteria. In the analysis mode, pipe alignment and sizing are predetermined and the impact of proposed flows are analyzed. Design criteria can be changed for each pipe if so desired. PFP-HYDRA is not an optimization program, thus individual case studies need to be run and analyzed by the engineer.

CDS Program

The Culvert Design System provides the user with two broad options for investigating culvert characteristics. CDS can either (1) hydraulically design a culvert or (2) analyze an existing or proposed culvert. CDS has capabilities for investigating a variety of hydrograph relationships, culvert shapes, materials, and inlet types. With CDS, the engineer can request any of six culvert types: round concrete, round metal, arch concrete, arch metal, oval concrete, and concrete box. CDS routes hydrographs and considers ponding.

The Design option selects a culvert size and number of barrels that are compatible with engineering data, environmental constraints, and site geometry. In this option, hydraulic performance data are calculated for each new culvert system design. The Review option provides hydraulic performance data for any preselected combination of culvert type and size, inlet type, slope, and number of barrels. The initial design and analysis options may be followed by up to five additional culvert types or flow frequencies so a full spectrum of risk scenarios or economic considerations can be simulated at the same time.

Two possible flow scenario methods can be selected: (1) constant flow through the culvert (steady state or irrigation), or (2) time variable drainage flow conditions (dynamic). The dynamic option can route a hydrograph through the culvert system using three hydrograph alternatives: a user input hydrograph for a given discharge, a hydrograph produced by the HYDRO program, or the use of an internally produced default hydrograph (simulating semi-arid, high plains conditions). Additionally, the dynamic flow scenario can accommodate upstream pond storage.

CDS will determine culvert size based on the design headwater, headwater/diameter ratio, inundation, outlet velocity, cover limitations, or any combination of these parameters. The program will automatically increase the number of barrels when the maximum culvert size is exceeded. There is a limit of six barrels for commercial size culverts and five for concrete box culverts. The program can also be used to assess flood hazards, environmental assessments of upstream pond coverage, downstream flooding, channel impact, inlet type and beveled inlet evaluations, and reservoir facilities which use a culvert type structure for the spillway. Based on these data the program will proceed to identify the flow type and the outlet conditions for velocity, Froude number, and brink depth.

WSPRO Program

The Water Surface Profile Computation Model Microcomputer Program has been designed to provide a water-surface profile for six major types of open channel flow situations:

- Unconstricted flow.
- Single opening bridge.
- Bridge opening(s) with spur dikes.
- Single opening embankment overflow.
- Multiple alternatives for a single job.
- Multiple openings.

The United States Geologic Survey (USGS) originally developed WSPRO for the Federal Highway Administration. The model was a batch mode mainframe program, written in FORTRAN. The members of the Pooled Fund Project decided to use WSPRO as the bridge waterways analysis element of the Integrated Computerized Drainage Design System. WSPRO was downloaded to the microcomputer by the USGS and FHWA. The microcomputer version of WSPRO, is dated August 1987. As yet, WSPRO does not have a user friendly, interactive shell to aid in data input and manipulation, although this is planned as a future Hydrain enhancement. The result is that the user must create or edit an input file on a line editor or word processor.

The input file forms a logical description of the physical characteristics of a waterway. Once the user is comfortable with this method of data setup, the program will provide a simple method for determining water surface profiles. The scheme is similar to the Corps of Engineers HEC-2 program. Both WSPRO and HEC-2 are acceptable to the Federal Emergency Management Agency. WSPRO has the advantage that it uses more recent approximation techniques for the backwater effects associated with bridge constrictions.

HY8 Program

HY8 is an interactive culvert analysis program that uses the FHWA analysis methods and information published by pipe manufacturers. The program includes modules to allow the user to interactively enter, save, and edit data. HY8 will compute the culvert hydraulics for circular, rectangular, elliptical, arch and user defined geometry. Additionally, improved inlets can be specified and the user can: analyze inlet and outlet control for full and partially full culverts, analyze the tailwater in trapezoidal and coordinate defined downstream channels, analyze flow over the roadway embankment, and balance flows through multiple parallel culverts.

The initial logic involves calculating the inlet control and outlet control headwater elevations for the given flow. These elevations are compared and the larger of the two is used as the controlling headwater elevation. Tailwater effects are taken into consideration when calculating these elevations. If the controlling headwater elevation overtops the roadway embankment, an overtopping analysis is done in which flow is balanced between the culvert discharge and the surcharge over the roadway. A balancing technique is also used for multiple barrels. If the culvert is less than full for all or part of its length, open channel computations are performed.

A series of data menus, data screens, summary screens, and output screens guides the user through the program. Each menu contains several options to match the desired culvert configuration, while the data screens prompt the user for specific dimensions and coordinates. Summary screens allow the user to edit entered data or change menu selections. Output screens display the output as calculations proceed; hard copy is only obtained using the "print screen" key.

There are three main groups of data to be entered into the program: initial culvert data, downstream channel data, and roadway data. Within the program, the user is sequentially led from one group to the next. From these sets of data, the program develops culvert performance data with or without overtopping. A performance curve can be plotted on a computer with graphics capabilities by typing a V for view. In addition to developing performance curves, the program generates rating curves for uniform flow, velocity, and maximum shear for the downstream channel. Culvert outlet velocities, inlet control head, and outlet control head are also calculated.

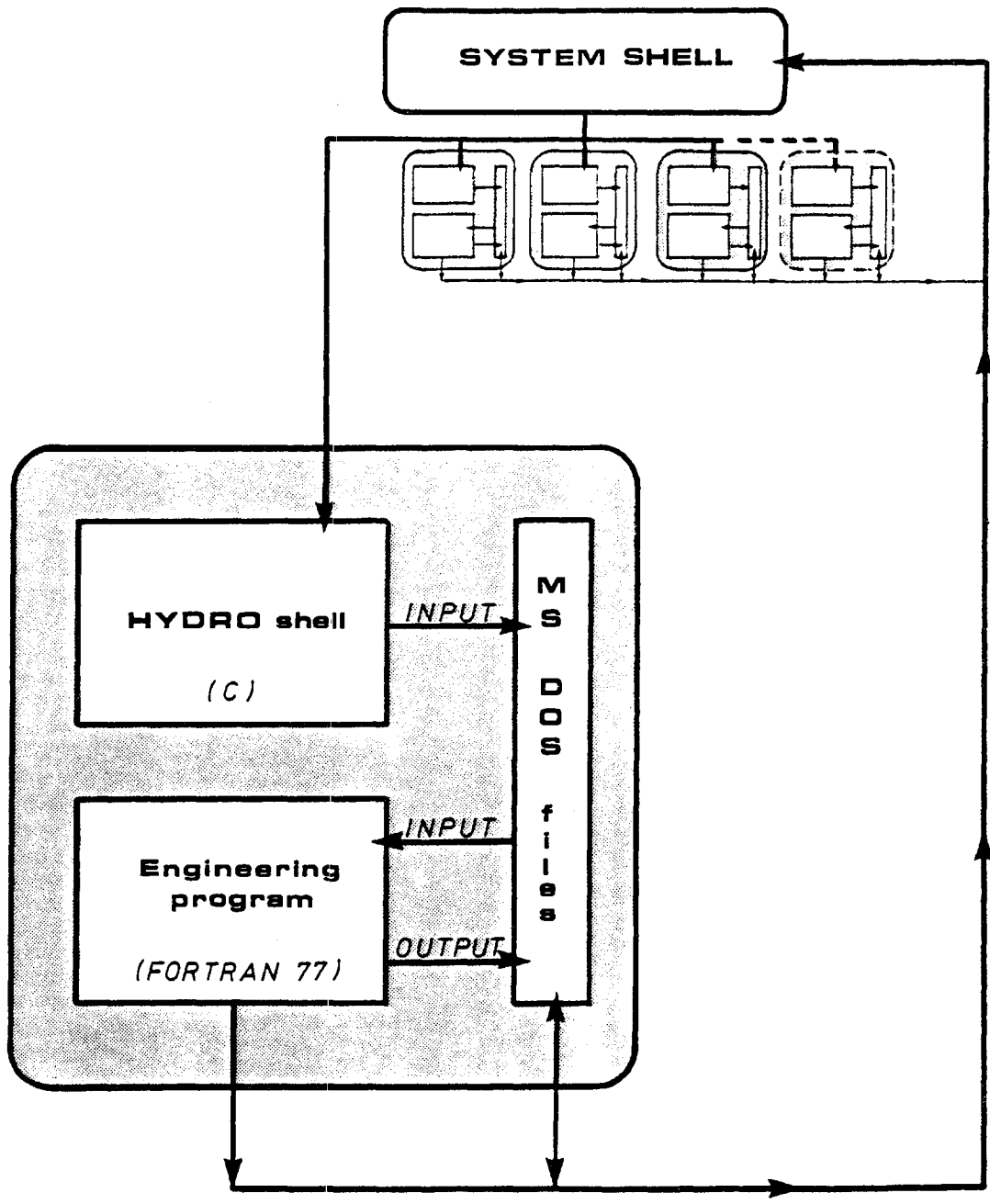


Figure 1. Conceptualized program module.

The engineering programs, input programs and other modules controlled by the system shell are as follows:

- HYDRO - Design Event versus Return Period.
- CDS - Culvert Design System.
- PFP-HYDRA - Storm and Sanitary Sewer Analysis.
- WSPRO - Open Channel Water Surface Analysis.
- HY8 - Penn State Culvert Review.
- (Future PFP Programs).
- Support System Modules.
 - DOS Shell (go back and forth to DOS without leaving Hydrain).
 - System Maintenance (File Housekeeping).
 - System Help.
- Quit (leave Hydrain programs).

Currently, the HYDRO, CDS, PFP-HYDRA, WSPRO, and HY8 engineering modules, and support system modules are operational. Space has been allotted for the addition of future programs.

The engineering modules provide access to their corresponding design and/or analysis programs by parallel branching to the design and analysis modules. Once an engineering program is selected the system shell allows the engineer to create/edit a data file, run the program using an existing data file or review an input or output data file. The system shell assists the user by ensuring that proper naming conventions are used and providing online help upon request. Figure 2 illustrates the current layout of the engineering modules.

The DOS option allows the user to temporarily return to the operating system, possibly for using a word processor or the editor, and return to the system shell, without ever actually "leaving" the Hydrain program.

The file maintenance system module allows the user to perform many file management functions. This includes the DOS equivalent activities of reviewing directories as well as copying, deleting, renaming, printing or looking at files. All of these activities are performed without leaving the System Shell.

The other system module provides for online help - a feature provided throughout the PFP system - for further explanation of a requested option as well as providing "how to" information and selected references.

This chapter will review the capabilities of the Hydrain System Shell, providing a technical reference and discussing user instructions. The goal will be to allow the user to understand and use the System Shell, and by extension, the remaining elements of the Pooled Fund Project.

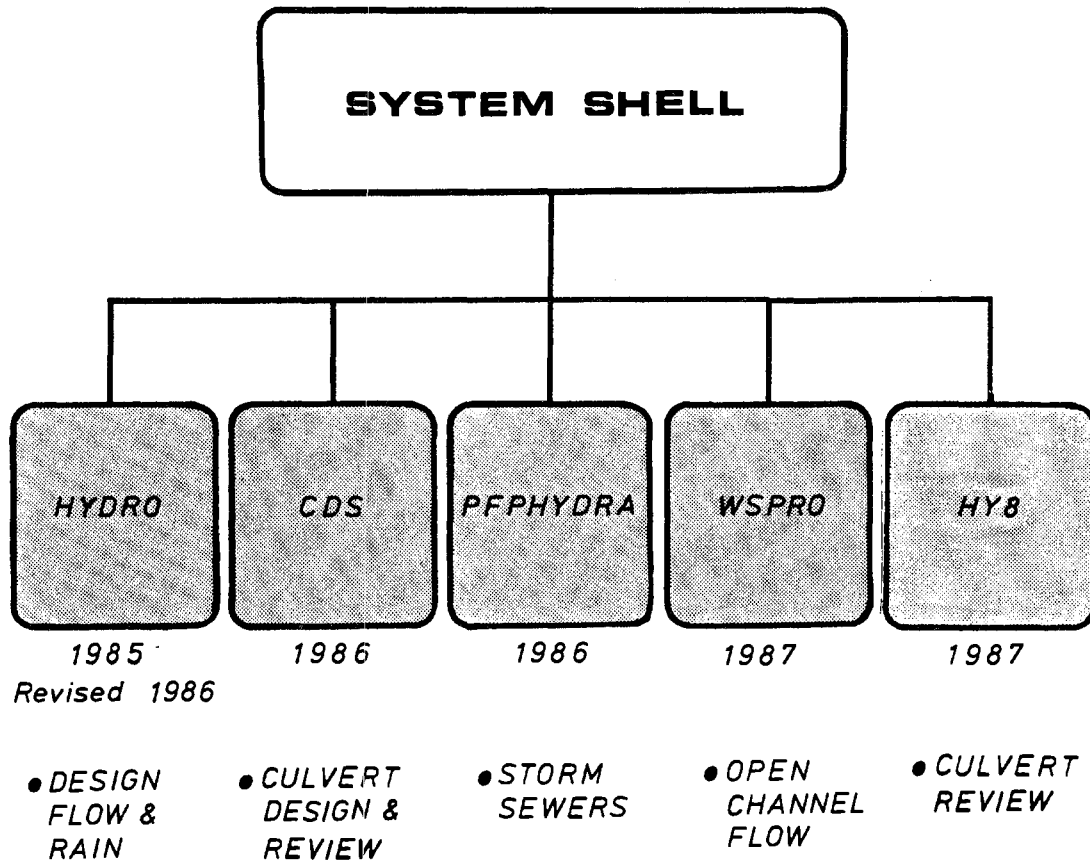


Figure 2. Hydrain layout.

2. Technical Reference

Summary of Features

The Hydrain System Shell is designed to run on MS-DOS version 3.1 (or higher) on IBM-XT/PC or compatible microcomputers. It has the following capabilities:

- Linkages to PFP Engineering Modules - There are five engineering programs: HYDRO, CDS, PFP-HYDRA, WSPRO, and HY8. Four of the five have a program shell to assist in inputting/editing data (currently WSPRO does not).
- Open Architecture - This allows the number of modules and programs included in the system to grow as the user community wishes. By planning for the addition of future programs, the Hydrain System Shell ensures flexibility, allowing such modules to be easily "plugged in".
- Active Short Help Messages - The System Shell (as well as other program shells) has an active, one line help message that appears automatically when the cursor is on an appropriate field. The help message provides the user with a short concise description of the operation of the field. When the cursor is moved to another file, the short help message is updated.
- Long Help on Request - Longer help messages are available to the user at any time within the Hydrain system by simply pressing the function key F10 (denoted as <F10> in the documentation). These messages can range from a short paragraph to several pages in length.
- DOS "Shell" Capabilities - This allows the user to temporarily "leave" the Hydrain System Shell and enter DOS. Typing EXIT at the DOS prompt returns the user to the primary menu. An obvious use of this feature may be to "leave" the System Shell to enter a word processor or text editor, or to execute a spreadsheet program such as Lotus 1-2-3. When this option is selected, Hydrain will remain resident in memory. For this reason it is important to always return to the System Shell (by typing EXIT) and leave Hydrain in a normal manner (through the QUIT option).
- Screen Capture of Inputs - The primary advantage of a shell is its ability to use the full terminal screen as an input device. Data is entered in a consistent manner so that the concerns of placing a variable in a proper row or column is dispensed with. That operation is achieved by the Input Program.
- Error and Range Checking - A shell can also provide facilities to check the appropriate range and default variables for a given parameter. This error checking includes providing default values of a parameter where appropriate.
- File Review Program - A file review program providing data displaying capabilities is used by many modules in the system shell. The program allows the user to view all the input, output and other files that are

found in the Hydrain system. The program allows the use of the ↑ and ↓ arrows, PgUp, PgDn, Home and End keys to move vertically (ie. top to bottom) through a file, and the use of the ← and → arrow keys to move horizontally in a file. This horizontal scrolling ability is useful for viewing documents wider than the computers display screen. In this way, a 132 character output, such as produced by CDS, can be easily reviewed.

- System Maintenance - One file module available to the user consists of system upkeep capabilities. This system maintenance module provides the user with the DOS equivalent commands of Renaming, Copying, Erasing, and Printing files. The user can either enter a filename, or choose from files contained in the Hydrain directories. Additionally, a directory feature allows the user to scan the files in the Hydrain directories.
- Ring Menus - The decision screens in the system and program shells consist of a series of fields linked by a ring menu. This means the user can select the option they wish to investigate by simply using the cursor keys to move to the field and striking carriage control or enter (denoted as <CR> in the documentation). In the Hydrain System Shell and the HYDRO Input program, the user can also choose an option by simply pressing a letter highlighted in the field.

File Management Structure

The overall file management structure is designed to be operated on a hard-disk drive using MS-DOS 3.1 (or higher) as the operating system.

The hard disk file structure is set up as shown below in figure 3. The "primary" directory will be **HYDRAIN**. This primary directory will itself have subdirectories that will contain the data files for the individual analysis programs. This will be transparent to the user when running the Hydrain package. A description of the composition of files contained under the subdirectories are found in appendix A.

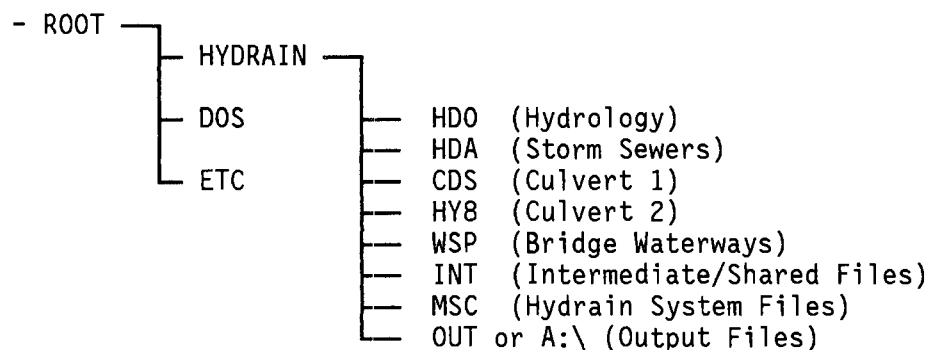


Figure 3. Hydrain directory structure.

The Hydrain System shell uses this structure when it passes information to an input program, engineering program, or output review program. For example, when the system shell uses a "child" process to call and execute the PFP-Hydra Input Program, it takes the user supplied filename, appends the appropriate drive and path, and passes this information to the program. How this is accomplished for the other programs depends on whether the "child" program is input, output, or analysis.

This structure is initialized at Hydrain installation by creating an "environment" that is set up every time the microcomputer boots up. For more advanced users, this structure can be changed to support most other configurations.

File Naming Conventions

Standardization of input and output file extensions is used to further ensure compatibility and to prevent the passing of incorrect files.

All PFP files must follow the convention **xxxxxxx.yyy**. The file name node or prefix (ie: xxxxxxx) may have up to eight characters (conforming to DOS file naming conventions). An extension (ie: yyy) of up to three characters is also required.

Engineering Program File Name Extensions

- The Hydrology program (HYDRO) uses an **HDO** extension for inputting/editing data and executing the HYDRO analysis program.
- The Culvert Design System (CDS) uses one of four extensions to designate a work deck file. These extensions are:
 - SD** = "STAGE DISCHARGE" - This deck contains the tailwater stage discharge or downstream channel cross-section tables.
 - SS** = "STAGE STORAGE" - This deck contains a table of stage versus storage or a table describing the upstream cross section.
 - CD** = "CULVERT DESIGN" - This deck contains data to select culvert types and characteristics, and peak flows. The user can also determine whether to review an existing culvert or to design a culvert.
 - FD** = "FLOW DISTRIBUTION" - This deck is included to obtain the flow-distribution for a channel.

The user generates these work decks in the CDS Input Program and then combines them into an input dataset that will be used by the CDS analysis program. The extension used with the input file is **CDS**. See the CDS documentation for more details.

- The Storm and Sanitary Sewer Analysis and Design program (PFP-HYDRA) uses an **HDA** extension for inputting/editing data and executing the program.
- The Bridge Waterways (and Open Channel) Analysis program (WSPRO) uses a **WSP** extension for inputting/editing data and executing the program.

Output File Name Conventions

- All output files will retain the input file name prefix (i.e. **xxxxxxxx**), but they will have a **LST** extension.

Other File Name Conventions

- **QT** - This extension contains the ordinates of a hydrograph (ie: flow (Q) versus time (T)). The file is generated by HYDRO and, at user option, can be incorporated into the other PFP Engineering programs (ie: into CDS using the **xxxxxxxx.CD** work deck, and into PFP-HYDRA using the **UHY** Command).
- **HYE** - This extension contains the ordinates of a hyetograph (ie: rainfall intensity (I) versus time (T)). The file is generated by HYDRO and, at user option, can be incorporated into the other PFP Engineering programs (ie: into PFP-HYDRA using the **UHY** Command).
- **IDF** - This extension contains the ordinates of an Intensity-Duration-Frequency (IDF) curve (for a duration from 5 minutes to 24 hours). The file is generated by HYDRO and, at user option, can be incorporated into PFP-HYDRA using the **RAI** Command.
- **HLP** - This extension indicates the file contains either short or long help for the different shells. There will be at least two help files for each program.
- **DFN** - This extension contains the engineering shell data definitions, default values, range checks, and variable types. Currently, only the HYDRO input shell uses these files.
- **ERR** - This extension contains any system error messages. The standard error output (if any) is captured by the system shell and may be viewed to assist in debugging.

The file convention, when combined with the file management structure discussed earlier, provides the user with a strategy and method of organizing files within the MS-DOS environment. Input files would only be found within their designated subdirectory. This avoids the confusing proliferation of many different input files within a single DOS directory. For example, HYDRO input files will be found in the **HDO** subdirectory, WSPRO input files will be found in **WSP** subdirectory, and so forth. Files that are used by differing programs (such as files with **IDF**, **QT**, and **HYE** extensions) are also placed in a common subdirectory, **INT**, where they too can be easily accessed by the engineering modules.

Keyboard Usage

Function Keys

Hydrain includes a series of specially defined function keys which are used throughout the system shell and each of the program shells. **The function keys currently active in the module that the user is in will be displayed on the bottom of the screen.** They are used as follows:

- F1 - Back up one field.
- F2 - Move forward one field.
- F3 - Back up one screen.
- F4 - Move forward one screen (similar to carriage return).
- F5 - Delete all data in the field on which the cursor is positioned.
- F6 - Return to the principal menu in the current session, saving the data if appropriate.
- F7 - Abort the current session and do not save the data.
- F8 - Undefined.
- F9 - Undefined.
- F10 - **HELP** - strike for additional long help. The help message corresponds to the field the cursor is on when F10 is pressed.

Cursor Keys

- ← Left arrow - moves the cursor to the left one field or space.
- Right arrow - moves the cursor to the right one field or space.
- ↑ Up Arrow - moves the cursor up one field.
- ↓ Down Arrow - moves the cursor down one field.

Other Keys

- <CR> - Enter/Carriage Return - Continue to the next screen.
- Esc - Operates as F3 function key.
- PgDn - Moves screen display forward one page.
- PgUp - Moves screen display backwards one page.
- Home - Moves to beginning of display.
- End - Moves to end of display.

Backspace Deletes spaces in a field one at a time.

Minimum Equipment Configuration

Hardware

- IBM XT/PC or compatible with 640K RAM.
- 360K Floppy Diskette Drive.
- Hard Disk Drive (10MB minimum capacity).
- Math Coprocessor (8087, 82087, 83087).
- Monochrome Monitor and Adapter (24 X 80).
- Dot Matrix Printer.
- Surge/Spike Protector.

Note: A Color Graphics Adapter (CGA) card is required to use the graphical capabilities of the HY8 program. The program can also run without a CGA card.

Software

- MS-DOS (version 3.1 or higher).
- FORTRAN compiler and linker.
- "C" compiler.

Note: The FORTRAN and C compilers are not required to run the Hydrain programs as supplied, but may be useful for programmers.

3. User Documentation

Installation of the Hydrain System

Before installing the Hydrain System on a microcomputer, the following criteria must be satisfied:

- The minimum equipment configuration (MEC) is present.
- The operating system must be MS-DOS 3.1 (or higher)
- Backup copies of the Hydrain diskettes have been made to prevent accidental loss of data.

To install the Hydrain System on a microcomputer, place the diskette labeled **PFM Distribution Disk - I (Hydrain)** into the disk drive. At the disk drive prompt type:

INSTALL (and strike <CR>)

The program will create the directories and subdirectories described earlier and begin to transfer Hydrain System Shell programs, files and data. The Users **AUTOEXEC.BAT** file will have a file, **HYDRAIN.DFN**, concatenated to the end. The **CONFIG.SYS** will also be modified. The changes to these files will allow the microcomputer to support the file management structure discussed earlier.

Soon, the user will receive a prompt:

**Place PFM distribution disk 2 (Hydro Input Program) into disk drive
Strike any key when ready...**

This second diskette contains the HYDRO programs and files. The program checks if the microcomputer has a math coprocessor chip, and transfers the appropriate executable files. If the microcomputer does not have a math coprocessor, executables compiled to run without a coprocessor are substituted for the "normal" programs.

Note: If the user does not have a math coprocessor, it is strongly recommended that one should be purchased (price ≈ \$100). Otherwise it can take (in some cases) substantially longer to run an engineering program.

Again, the user will receive a prompt:

**Place PFM distribution disk 3 (PFM-Hydra Input Program) into disk drive
Strike any key when ready...**

In this manner, the user will be prompted for additional diskettes until the entire series of diskettes (there are a total of 9 diskettes) have been placed onto the hard drive. When the installation procedure is finished, a message will appear on the screen stating so, and the user will be returned to DOS.

To test the installation, warm boot the microcomputer (this is achieved by holding down the **Ctrl**, **Alt**, and **Del** keys at the same time). The computer will boot up, reading the modified **AUTOEXEC.BAT** and **CONFIG.SYS** files and setting an environment that Hydrain can use.

To try out Hydrain, use the MS-DOS **CHDIR** (or **CD**) command to go to the **HYDRAIN** directory, and type:

HYDRAIN (and strike <CR>)

The first Hydrain System Shell screen should appear...

This concludes the installation procedure. The next section discusses how to use the features in the Hydrain System Shell.

Using the Hydrain System Shell

To enter the Hydrain system, use the MS-DOS **CHDIR** (or **CD**) command to go to the HYDRAIN directory, and at the DOS prompt, type:

HYDRAIN

and strike enter/carriage return, denoted as <CR>

The first Hydrain System Shell screen, depicted below in figure 4, will appear on the monitor. This screen provides the user with the names of the 23 sponsoring States in the Pooled Fund Project and the FHWA.

At the top of the screen, below the program title, is the current version of the software. The version should be **712.A**. This indicates that this version of the Hydrain system was released in 1987, month 12, and this is the A or first variant in that month.

The screen also provides a telephone number of the prime contractor, GKY and Associates, Inc., if user assistance is required.

To continue, press any key...

HYDRAIN - DRAINAGE DESIGN SYSTEM Version 712.A

sponsored by:

Arizona	Arkansas	California	Colorado	Connecticut
Florida	Iowa	Kansas	Louisiana	Maryland
Minnesota	Mississippi	Montana	New York	North Carolina
Oklahoma	South Carolina	Texas	Utah	Vermont
Virginia	Washington	Wyoming		

in cooperation with Federal Highway Administration

developed by:
GKY & Associates, Inc., Springfield, VA.
(703-642-5080)

IDEAMATICS, Inc., Washington, D.C.
James J. Adler, Washington, D.C.

To continue, press any key.

Figure 4. Hydrain system shell initial screen.

The second screen contains a statement dealing with the responsibilities of the user and the FHWA. Again, any key can be pressed to continue.

The next screen is the Hydrain Primary Menu, illustrated below in figure 5. The Primary Menu is the principle decision node for the entire Hydrain system. This means that to reach any module in the Hydrain system, the user must begin with this menu. The nine options (or fields) in the Primary Menu are:

- HYDRO - Design Event versus Return Period.
- CDS - Culvert Design System.
- PFP-HYDRA - Storm and Sanitary Sewer Analysis.
- WSPRO - Open Channel Water Surface Analysis.
- HY8 - Penn State Culvert Review.
- DOS - Go back and forth to DOS without leaving Hydrain.
- FILES - File Maintenance.
- INFO PFP - Information on the Hydrain system.
- QUIT - Leave Hydrain programs.

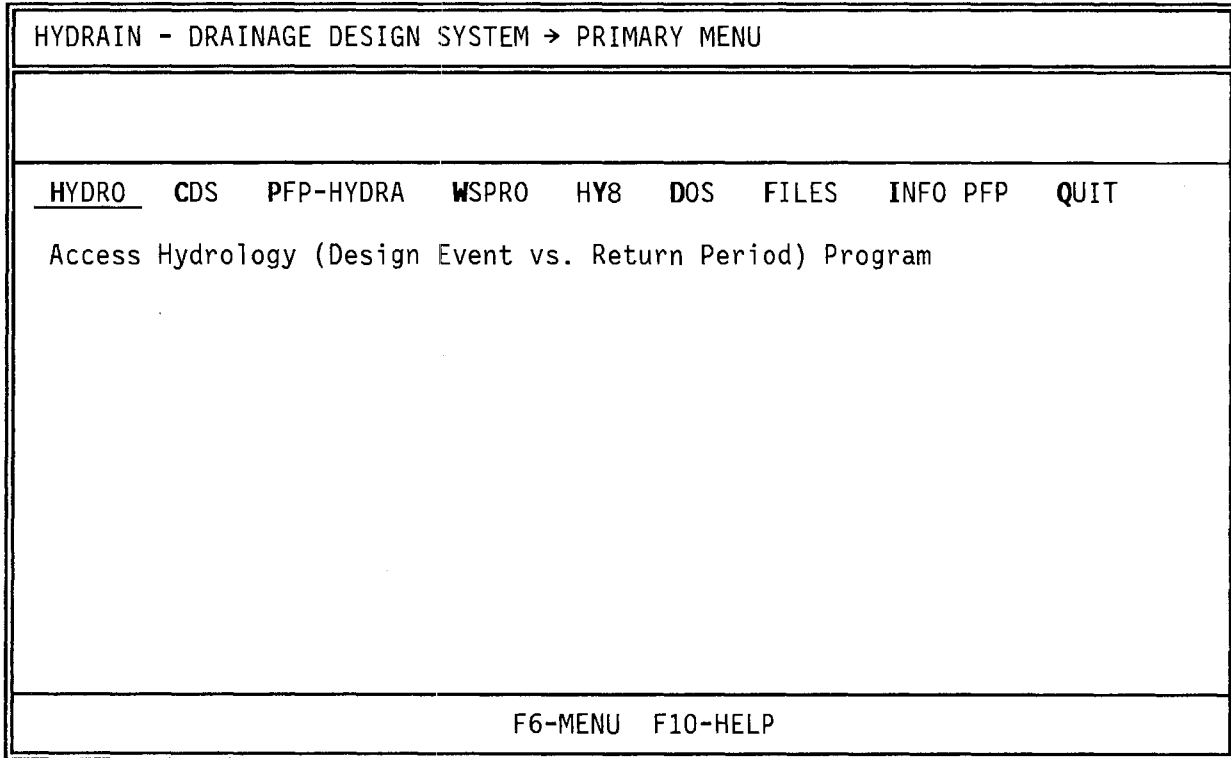


Figure 5. Hydrain primary menu.

2 As discussed earlier, the first five options allow the user to access the engineering modules. The next three (DOS, FILES, INFO PFP) are system modules. The last option, QUIT, will be used to leave Hydrain and return to MS-DOS.

The Primary Menu is set up in what is known as a "ring" menu. This enables the user to move either in the left or right direction using the arrow cursor keys. The use of "ring" indicates that, for example, moving the cursor right of the QUIT option will place the cursor back at the HYDRO option, and vice versa.

The selection of an option within the menu is achieved by the following two methods:

- As was just discussed above, the first method uses the arrow cursor keys to move to a desired option. Hitting the Enter/Carriage Return key (this will be denoted as <CR> henceforth in this chapter) will take the user down that branch. This option will work for every ring menu in every shell program in the entire Hydrain system.
- The alternative method is to strike the highlighted letter in the option the user desires to select. The program will automatically take the user down that branch. For example, if the user strikes I, it is equivalent to manually moving the cursor to INFO PFP and striking <CR>.

The consequences of selecting each engineering option are discussed in greater detail in their respective chapters. A flow chart, presented below in figure 6, shows the branching occurring in each of the engineering modules.

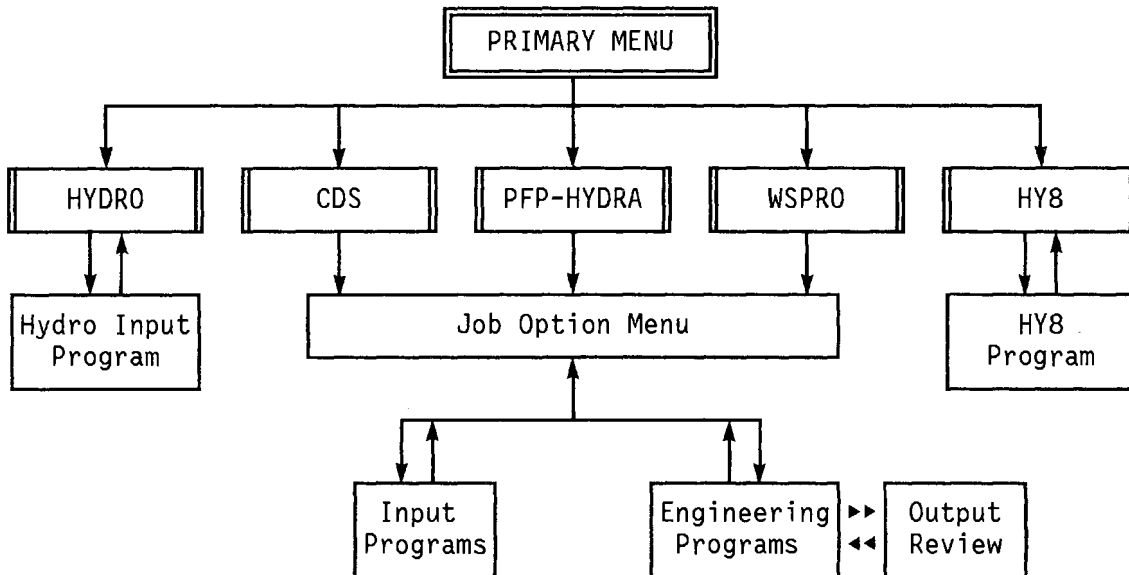


Figure 6. Engineering module flowchart.

Similarly, a flow chart illustrating the branching of the three system modules are shown in figure 7.

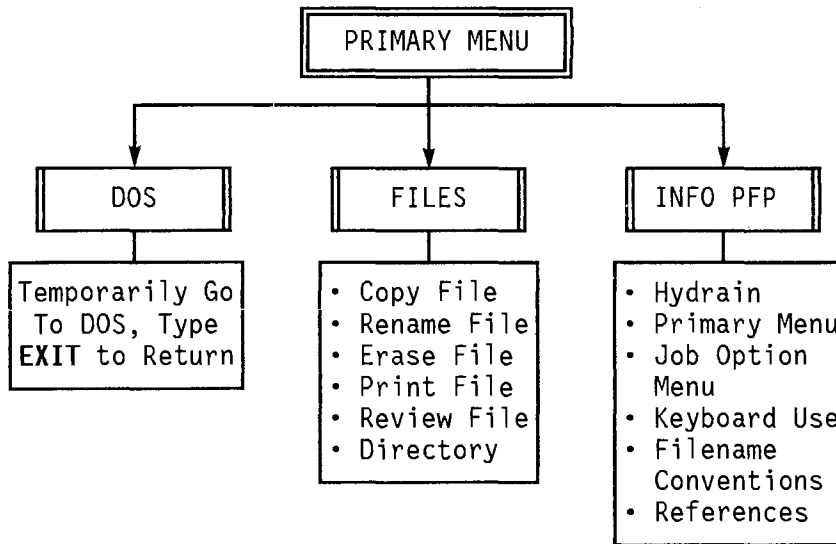


Figure 7. System support modules.

The user will note that upon returning to the primary menu, the cursor will appear on the last option selected. This feature will also occur in the other menus in the Hydrain system shell.

Active Help

As users move from field to field, they will notice an active, one line help message in the bottom portion of the screen. As mentioned earlier, this message provides a descriptive text on the function of the field the cursor is on.

Long Help

The function <F10> activates the long help feature. This allows the user to scan, in some cases, several pages of information regarding a particular field or screen. For the Primary menu, the long help concentrates on the features relevant to using this screen.

Job Option Menu

As seen in figure 8, an important segment of the CDS, PFP-Hydra and WSPRO engineering modules is the Job Option Menu.

A separate Job Option Menu exists for each of the three engineering programs. Instructions on how the user specifically applies the menu are

discussed in more detail later in the report. What will be attempted below is to discuss the general features of the Job Option Menu.

HYDRAIN - DRAINAGE DESIGN SYSTEM → PFP-HYDRA PROGRAM
Access Storm / Sanitary Sewer Design & Analysis (PFP-HYDRA) Program Job Option Menu -- Select job option choice from list
<p style="text-align: center;"><u>Input / Edit Data File</u> Run Program / Review File</p> <p style="text-align: center;">Quit (return to primary menu)</p> <p>Create or edit data for analysis program</p>
F6-MENU F10-HELP

Figure 8. Job option menu screen.

- **Input / Edit Data File** - This is the option selected if the user wishes to enter or edit data for an engineering program. To select this option, move the cursor to the field and press <CR> (or strike the I key).

Choosing this option for CDS or PFP-Hydra will result in a screen where the user is prompted for a filename. The filename screen is shown in figure 9 (showing a CDS configuration). Note that the PFP-Hydra option has a default extension (**HDA**), while CDS does not (there are four possible CDS extensions). The alternatives open to the user are as follows:

- Enter a filename and strike <CR>. The HydRAIN System shell will pass the filename to the appropriate program shell and begin its execution.

HYDRAIN - DRAINAGE DESIGN SYSTEM → CDS PROGRAM
Access Culvert Design System (CDS) Program Type file name (wildcard character ? or * will invoke file menu)
Data File Name - C:\HYDRAIN\CDS*.* _____
F5-CLEAR-F F6-MENU F10-HELP

Figure 9. Filename prompt screen.

- Enter the Hydrain File Management Module to select a file from existing PFP-Hydra or CDS input files on the appropriate subdirectory. This is possible because of the initial default "*" wildcard character (see the MS-DOS Reference for more information on what a wildcard is). The File Management Module is accessed by simply striking <CR>. Users will find themselves in a screen, depicted by figure 10, with a listing of all the files in the appropriate subdirectory. The user can move the cursor through the file listings (using the arrow keys), until a desired filename is reached. Striking <CR> will "grab" this filename. The Hydrain System shell will pass the file to the input program and begin its execution. Should the user enter a filename within the module, it will override the listings and will be the file passed to the program shell. The Hydrain File Management module is used in several areas in the Hydrain System shell. With slight differences, instructions for using it will be the same as discussed above.

Choosing the **Input / Edit Data File** option for the WSPRO program will have different consequences. As the user will recall from earlier discussions, WSPRO is the only Pooled Fund Project program without a program shell/input program. To enter or edit data for WSPRO, the

user must use a line editor or word processor. The Hydrain System shell facilitates this by placing the user temporarily into DOS after they select the **Input / Edit Data File** option. Once in DOS, the user can execute their word processor. **Two important caveats:** first, the user must use a **WSP** extension for the input file, secondly, the user must type **EXIT** to return to the Hydrain System shell.

HYDRAIN - DRAINAGE DESIGN SYSTEM → CDS PROGRAM									
Access Culvert Design System (CDS) Program Choose analysis data file name from list									
Volume: has no label		Drive : C							
Path : \HYDRAIN\CDS									
Search: *.*		Found : 25 file(s)							
Free : 25000000 bytes									
Choice: <u>RT198</u> <u>SD</u>									
GLADE	SD	1000	10-01-87	08:00	GLADE	SS	1200	10-01-87	08:00
GLADE	CD	2500	10-01-87	08:00	GLADE	CDS	4500	10-01-87	08:00
RT198	SD	1100	10-01-87	08:00	RT198	SS	1200	10-01-87	08:00
RT198	FD	900	10-01-87	08:00	RT198	CDS	3750	10-01-87	08:00
INTST95	SD	2700	10-01-87	08:00	INTST95	SS	2300	10-01-87	08:00
INTST95	CD	3000	10-01-87	08:00	INTST95	FD	900	10-01-87	08:00
INTST95	CDS	8750	10-01-87	08:00	EXMPL	SD	1200	10-01-87	08:00
F5-CLEAR-F F6-MENU F10-HELP									

Figure 10. Hydrain file management screen.

- **Run Program / Review File** - This is the option selected if the user wishes to execute the engineering program and review the output listing. To select this option, move the cursor to the field and strike <CR> (or simply press **R**).

For CDS, PFP-Hydra or WSPRO, choosing this option will once again result in a screen where the user is prompted for a filename. If available, the program will automatically place the filename used in the Input/Edit operation in the file space. Note that the input file extensions for each particular engineering program are already provided. The user needs only to enter the prefix of the filename. As with the previous option, there are two methods for selecting the input filename to be used in the execution.

- Enter a filename and strike <CR>. The Hydrain System shell will pass the filename to the appropriate engineering program and begin its execution. If the file is not present, an error message will appear at the top of the screen.
- Enter the Hydrain File Management Module to select a file from existing WSPRO, PFP-Hydra or CDS input files on the appropriate subdirectory. As discussed earlier, the user can move the cursor through the file listings (with the arrow keys), until a desired filename is reached. Notice that only files with the appropriate input file extensions are considered. Striking <CR> will "grab" this filename. The Hydrain System shell will pass the file to the engineering program and begin its execution. Should the user enter a filename within the module, it will override the listings and will be the file passed to the engineering program.

In either case, the engineering programs will begin to execute with the user supplied input filename. An output filename will be automatically created by the System shell. It will consist of the prefix (or node) of the input filename with a LST extension (LST is an acronym for "listing"). For example, for a WSPRO input file, BRIDGE.WSP, the corresponding output file will be BRIDGE.LST.

The execution time will vary based on problem complexity, type of microcomputer used (and whether it has a math coprocessor), and the engineering model used. Included with those problems are measurements on how long they took to run on various microcomputer configurations.

When the engineering program has finished execution, program control is passed back to the System shell. The System shell immediately calls the Hydrain file review program which loads the output file (or an error file if the program fails) for the users perusal. As described earlier in this chapter, the review program allows the user to move vertically and horizontally (if the width of the output exceeds the width of the screen) through the file. In order to leave the program, the function key <F6> returns the user to the Job Option Menu.

Quit (return to the Primary Menu) - To return to the Primary Menu, the user moves the cursor to the **Quit** field and strikes <CR> (or the user can press Q or the user can press <F6>).

This concludes the segment on the Job Option Menu. Further information can be found in the respective engineering chapters and by using the long help, <F10>. The next section will discuss the System Modules found in the Hydrain System Shell.

System Modules

As remarked on earlier in the chapter, there are three elements in the Hydrain System shell's support modules: DOS, FILES, and INFO PFP.

The DOS Shell

The first element in the support modules is the DOS Shell ability.

It was recognized by users of earlier versions of the Hydrain system that sometimes the need arises for the Hydrain user to temporarily go to DOS, possibly to use a word processor or a spreadsheet. In response to these concerns, DOS shell capability is included in the primary menu.

From a technical sense, the DOS shell works by invoking the DOS command processor from within the Hydrain program. This allows the user to enter DOS while keeping the system shell resident in memory. Typing **EXIT**, causes the command processor to release control, and Hydrain is reactivated.

This is why it is important that the user types **EXIT** and does not reenter Hydrain "normally" or forget that they were in Hydrain and move onto other applications. If the user desires to leave the Hydrain system, they should use the **QUIT** option.

To use the DOS shell, move the cursor to the **DOS** field in the Primary Menu and strike <CR>, or simply press **D**. The following message will be seen:

Type "EXIT" to return to Hydrain

**The IBM Personal Computer MS-DOS
Version 3.1**

(c) Microsoft 1981, 1986

and the user will be placed at the DOS prompt. After finishing using any application software, enter **EXIT** and strike <CR> to return to Hydrain.

The File Maintenance Option

The second system module allows the user to exercise control over the files found in the Hydrain system. This is achieved by using the DOS equivalent commands of **COPY**, **RENAME**, **ERASE** and **PRINT**, providing access to the Hydrain File Review program, and allowing the user to scan the contents of the Hydrain directories.

To select this option, move the cursor to the **FILES** field and press <CR>, or strike **F**. The user will be placed in the File Maintenance menu, reproduced below in figure 11. Once there, any of the six file maintenance options can be selected (the seventh, **QUIT**, will return the user to the Primary menu).

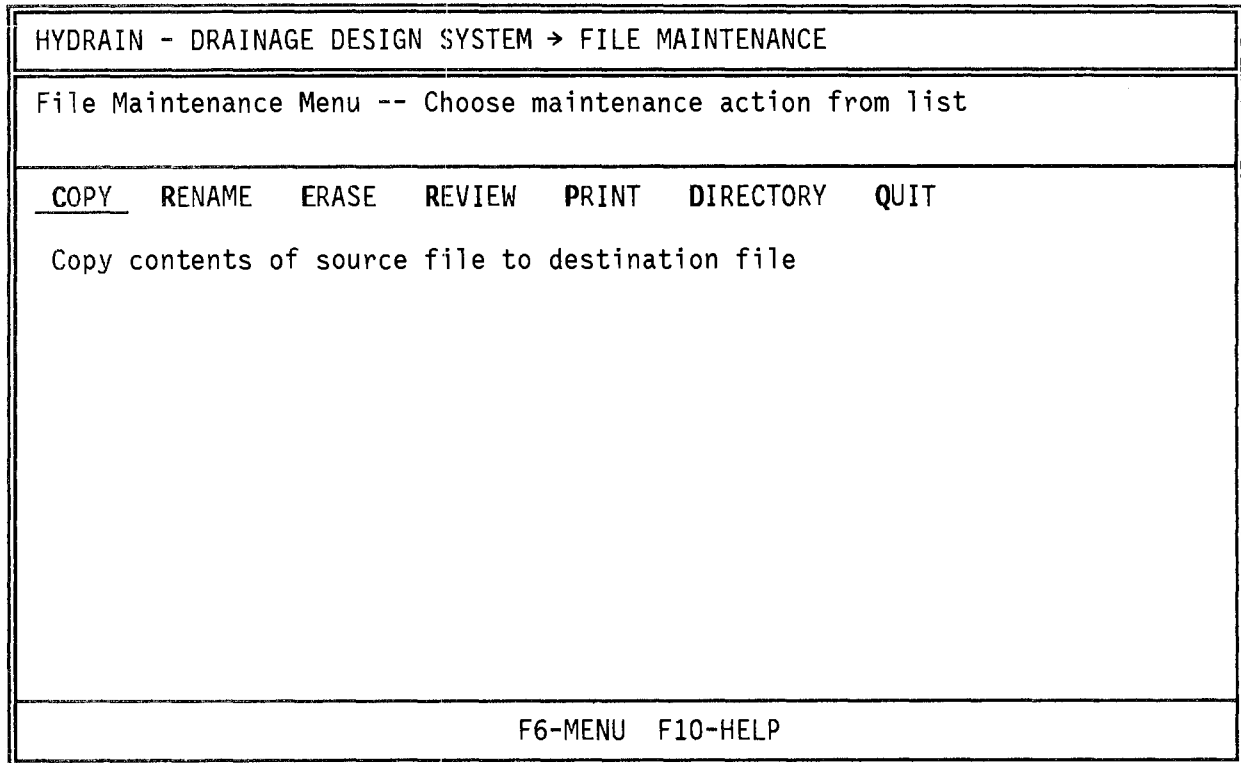


Figure 11. File maintenance screen.

The user will be prompted for a filename. The screen is similar to that seen earlier in figure 9.

Wildcards are provided as a default filename. As with the earlier options in the Job Option menu, there are two alternatives for selecting the filename to be used in the operation. In both cases, the Hydrain File Management module will be used to some extent.

- Enter a filename and strike <CR>. The drive and path for the file can be an element of the filename (for example, to review the file **READ.ME** on drive **A:**, the complete filename would be entered as: **A:\READ.ME**). If the drive and path are not supplied by the user, the program will search for the file on the default directory, initially defined as the directory containing the Hydrain system shell program. Note - this default directory can be changed by using methods discussed below in the second alternative.
- Enter the Hydrain File Management Module to select a file from input files found on any of the Hydrain directories by striking <CR>. A Hydrain Directory Selection menu, depicted in figure 12, will appear. This menu allows the user to select the directory on which the file will be found. To select a directory, move the cursor to the desired directory and hit <CR> (or press the highlighted letter).

HYDRAIN - DRAINAGE DESIGN SYSTEM → FILE MAINTENANCE
Review contents of target file on screen Choose Hydrain directory which contains target file
<p style="text-align: center;"> <u>SYSTEM Directory</u> HYDRO Data Directory CDS Data Directory PFP-HYDRA Data Directory WSPRO/HY7 Data Directory HY8 Data Directory INTERMEDIATE Directory OUTPUT Directory MISCELLANEOUS Directory QUIT </p> <p>Access Hydrain System Program Directory</p>
F6-MENU F10-HELP

Figure 12. Hydrain directory selection menu.

Note - the user did not need to make this selection earlier, in the Job Option menu, because the correct directory was determined by the program when the user chose the engineering module that he or she wished to enter (remember the definition of the Hydrain file structure - every module can have its own unique directory).

The directory just selected by the user becomes the default Hydrain directory. This feature enables the user to change the default drive and path by simply choosing any valid Hydrain directory. It will remain the default directory until it is again changed in this manner.

After choosing the directory, the user will be placed into the Hydrain file management screen (figure 10). As discussed earlier, the user can move the cursor through the file listings (with the arrow keys), until a desired filename is reached. Striking <CR> will "grab" this filename. Should the user enter a filename within the module, it will override the listings and will be the selected file.

If only one filename is required for the option, such as would be the case for **ERASE**, **REVIEW** or **PRINT**, the program will find the file (if it cannot, an

Summary of Operations

Entry to engineering programs is via the Hydrain System shell. Other operations are listed in table 1.

Table 1. Hydrain system operations.

Engineering Program	Input* Generation	Input Edit	Run* Control	Input/Output Review and Print
HYDRO	HYDRO shell or W.P.**	same	HYDRO Shell	HYDRAIN Shell
PFP-HYDRA	HYDRA shell or W.P.	same	HYDRAIN Shell	HYDRAIN Shell
CDS	CDS shell or W.P.	same	HYDRAIN Shell	HYDRAIN Shell
WSPRO	W.P.	W.P.	HYDRAIN Shell	HYDRAIN Shell
HY8	Engineering Program Itself	Engineering Program Itself	Engineering Program Itself	Print Screens During Program Operation

*All programs except HY8 use batch file operations. HY8 secures data from the user as it is processing.

Note - the acronym **W.P. indicates that a word processor or line editor can also be used in the specified operation.

Appendix: READ.ME File

December 2, 1987
Version 712.A

HYDRAIN USER DOCUMENTATION POOLED FUND PROJECT (READ.ME)

This Pooled Fund Project (PFP) documentation provides a brief overview of the installation procedure, the system shell, and each of the engineering programs which comprise the highway drainage design system (HYDRAIN). At this time, the engineering programs include HYDRO (hydrology), PFP-HYDRA (storm and sanitary sewers), CDS (culvert design system), WSPRO (bridge and open channel backwater) and HY8 (Penn State culvert review program). Further documentation for each of the engineering programs is cited at the end of this document.

INSTALLATION

Before installing the Hydrain System on a microcomputer, the following criteria must be satisfied:

- o The minimum equipment configuration (MEC) is present.
- o The operating system must be MS-DOS 3.1 (or higher)
- o Backup copies of the Hydrain diskettes have been made to prevent accidental loss of data.

To install the Hydrain System on a microcomputer, place the diskette labeled PFP Distribution Disk - I (Hydrain) into the disk drive. At the disk drive prompt type:

INSTALL (and strike <CR>)

The program will create the directories and subdirectories described earlier and begin to transfer Hydrain System Shell programs, files and data. The user's AUTOEXEC.BAT file will have a file, HYDRAIN.DFN, concatenated to the end. The CONFIG.SYS will also be modified. The changes to these files will allow the microcomputer to support the file management structure discussed in the Hydrain Documentation.

Soon, the user will receive a prompt:

Place PFP distribution disk 2 (Hydro Input Program) into disk drive
Strike any key when ready...

This second diskette contains the HYDRO programs and files. The program checks if the microcomputer has a math coprocessor chip, and transfers the appropriate executable files. If the microcomputer does not have a math coprocessor, executables compiled to run without a coprocessor are substituted for the "normal" programs.

Note: If the user does not have a math coprocessor, it is strongly recommended that one should be purchased (price ~ \$100). Otherwise it can take (in some cases) substantially longer to run an engineering program.

Again, the user will receive a prompt:

Place PFP distribution disk 3 (PFP-Hydra Input Program) into disk drive
Strike any key when ready...

In this manner, the user will be prompted for additional diskettes until the entire series of diskettes have been placed onto the hard drive (there are a total of nine diskettes). When the installation procedure is finished, a message will appear on the screen stating so, and the user will be returned to DOS.

To test the installation, warm boot the microcomputer (this is achieved by holding down the Ctrl, Alt, and Del keys at the same time). The computer will boot up, reading the modified AUTOEXEC.BAT and CONFIG.SYS files and setting an environment that Hydrain can use.

HYDRAIN PROGRAMS AND SUPPORT FILES

Nine 360K diskettes are included with HYDRAIN and they can be categorized into two major groups: programs and support files. The programs are the executable files which govern the flow of HYDRAIN and perform the engineering analyses. The support files provide data and help messages to the programs as needed. The following is a complete listing of HYDRAIN computer files with a description of each file, and the location of the file if using the standard file management structure:

Executable Programs:

Program	Description	Location
HYDRAIN.EXE	- system shell	hydrain directory
HDOANL.EXE	- HYDRO engineering program	" "
HDOINP.EXE	- HYDRO program shell	" "
CDSANL.EXE	- CDS engineering program	" "
CDSINP.EXE	- CDS program shell	" "
HYDRA.EXE	- PFP-HYDRA engineering program	" "
HYDRAI.EXE	- PFP-HYDRA program shell	" "
WSPRO.EXE	- WSPRO engineering program	" "

ACDSKDIR.EXE	----		"	"
ACTXFLMD.EXE	----	Hydrain system shell support programs	"	"
ACWKFLMD.EXE	----		"	"
EQUAT.EXE	----	- Hydro equation module program	"	"
HDAINT.EXE	----	- PFP-HYDRA intermediate program	"	"
TITLE.EXE	-----		"	"
MAINMENU.EXE	----	HY8 Culvert Analysis Program executable programs	"	"
SM.EXE	-----		"	"
FLOW.EXE	-----		"	"
HYD.EXE	-----		"	"
ROUTE.EXE	-----		"	"
BRUN10.EXE	-----		"	"
BRUN20.EXE	-----		"	"
PFPHY8.BAT	-----		"	"

Support files:

READ.ME	-	overview documentation for Hydrain (this document)		hydrain directory
HYDSCR.HLP	-	PFP-HYDRA input program long help	"	"
HYDLIN.HLP	-	PFP-HYDRA input program short help	"	"
EQUAT.DAT	----		"	"
EQUAT.I1	----	Equation module support files	"	"
HDN.ERR	-		HYDRAIN SYSTEM error file	"
RAIN.PFP	-	national rainfall database		shared files dir.
HYDRAIN.HLP	-	system shell long help (9 files)	"	" "
HDOINP.HLP	-	HYDRO input program long help (there are 16 of these files)	"	" "
CDSSCR.HLP	-	CDS input program long help	"	" "
CDSLIN.HLP	-	CDS input program short help	"	" "
HDOFIL.DFN	----		"	" "
HDOMEN.DFN	----	HYDRO Definition Files	"	" "
HDOHLP.DFN	----		"	" "
HDOFLD.DFN	----		"	" "

THE SYSTEM SHELL

The system shell is a managerial program that presents option and help menus to lead a user through HYDRAIN. Therefore, new users need not possess advanced microcomputer skills and can begin using HYDRAIN productively almost immediately. (Furthermore, once in the system shell, the user has immediate access to "help" files by striking the F10 key.)

The system shell is initiated from its resident subdirectory by typing HYDRAIN and <CR>. The opening screens will appear on your display. The first screen displays the sponsors of HYDRAIN and the second displays a disclaimer. Press any key twice to access the primary menu.

The primary menu allows the user to choose one of the five engineering programs, utilize the system maintenance options, review help screens, or to exit the system. The job option menu allows the user to select a file to create, edit, review or print a file, or allow the user to run a program.

Primary Menu

The primary menu allows the user to choose between the following options:

- HYDRO - Design Event versus Return Period.
- CDS - Culvert Design System.
- PFP-HYDRA - Storm and Sanitary Sewer Analysis.
- WSPRO - Open Channel Water Surface Analysis.
- HY8 - Penn State Culvert Review.
- DOS - Go back and forth to DOS without leaving Hydrain.
- FILES - File Maintenance.
- INFO PFP - Information on the Hydrain system.
- QUIT - Leave Hydrain programs.

Two means of selecting an option are available to the user. The first is to use the cursor keys to move to the desired menu option and strike <CR>. Notice that a line of "active" help provides the user with a short description of each option. Another method for selecting an option is to simply strike the first letter of the desired menu item (e.g. to choose the CDS option, simply strike "C"). Selection of one of the engineering program options results in the job option menu described in the next section.

Information on the various aspects of the system shell is found in the INFO option. The information includes menu descriptions, function key descriptions, file naming conventions, a PFP bibliography, and other useful information.

The FILES option allows the user to manipulate files for both input and output purposes. These manipulations include copying, renaming, deleting, and printing. In addition, the user can check a directory to verify the status of existing files.

Job Option Menu

After selecting any of the available engineering program options, the job option menu appears. The job option menu allows the user to choose from the following options:

- Input / Edit Data File.
- Run Program / Display File.
- Quit (Return to Primary Menu).

Two means of selecting an option are again available. The first is to use the cursor keys to move to desired menu item and strike <CR>. Notice that a line of "active" help provides the user with a short description of each

option. Another method for selecting an option is to simply strike the first letter of the desired menu item (e.g. to choose the "Run Program / Display File" option, simply strike "R").

Selection of any of the first two options will result in a prompt for the file name on which the intended action is to be taken. These input file names may be up to 60 characters long including drive specification and path, but excluding the extension (or suffix). The three letter extension is automatically assigned by HYDRAIN. Output files created as a result of the action will automatically have the same file name as the input file, but with a ".LST" extension.

Function Keys

HYDRAIN includes a series of specially defined function keys which are used throughout the system shell and each of the program shells. They are used as follows:

- F1 - Back up one field.
- F2 - Move forward one field.
- F3 - Back up one screen.
- F4 - Move forward one screen (similar to carriage return).
- F5 - Delete all data in the field on which the cursor is positioned.
- F6 - Return to the principal menu in the current session, saving the data if appropriate.
- F7 - Abort the current session and do not save the data.
- F8 - Undefined.
- F9 - Undefined.
- F10 - HELP - strike for additional long help. The help message corresponds to the field the cursor is on when F10 is pressed.

Cursor Keys

- Left arrow - moves the cursor to the left one field or space.
- Right arrow - moves the cursor to the right one field or space.
- Up Arrow - moves the cursor up one field.
- Down Arrow - moves the cursor down one field.

Other Keys

- <CR> - Enter/Carriage Return - Continue to the next screen.
- Esc - Operates as F3 function key.
- PgDn - Moves screen display forward one page.
- PgUp - Moves screen display backwards one page.
- Home - Moves to beginning of display.
- End - Moves to end of display.

Backspace Deletes spaces in a field one at a time.

ENGINEERING PROGRAMS

HYDRO (Hydrology)

HYDRO is the hydrology component of the HYDRAIN system. This program was developed as part of the Pooled Fund effort to combine existing approaches for rainfall and runoff analyses into one computerized program. Within the HYDRAIN system, HYDRO can be used either alone or in coordinated drainage design studies, providing hydrological information so that other programs can analyze culverts, constructed and natural channels, storm sewers, bridge constrictions and other situations where flooding and flood mitigation are important. The HYDRO analysis program provides rainfall/flow inputs for other system elements (bridge, pipes, culverts) to act upon. The output includes a hydrograph, rainfall frequency/duration/intensity curves, and a triangular hyetograph.

The Hydro input program primary menu allows the user to choose between the following options:

- RETRIEVE data from an existing input dataset (worksheet). If an input dataset is being created, the user does not need to use this option, but can simply go to the EDIT option.
- EDIT and Enter design rainfall or design flow input data. This is the option that will be used to access the hydrological analysis selections and to execute the input datasets.
- STORE data into a worksheet file. If the user forgets to save the data before leaving the input program, it is automatically saved in a file called LASTIME.HDO that can be retrieved the next time the user enters the program.
- QUIT the Hydro input program and return to the HYDRAIN System Shell. Save all data in a file called LASTIME.HDO.

To select an option, use the cursor keys to move to desired menu item (or field) and strike <CR>. Notice that a line of "active" help provides the user with a short description of each option. Another method for selecting an option is to simply strike the highlighted letter of the menu item you wish to select, for example, to choose the Retrieve option, strike the R key

Each of these choices results in another menu with choices specific to the option chosen. At any time, the user may press the F10 key to access the full screen help.

Design Rainfall

There are two design rainfall options. The first option is used to determine rainfall intensities. The second option builds an IDF curve. Both

options use an unique rainfall intensity database (RAIN.PFP) that contains rainfall values for the contiguous United States to perform calculations. The first option also allows the user to input their own duration and/or rainfall intensity values. Brief summaries of the options follow:

o Rainfall Intensity Determination

The rain option calculates the rainfall intensity (inches/hour) for a desired return period and a duration (assumed to be time of concentration in hours) at a site. Additionally, this option can use Yen and Chow's Method to create a triangular hyetograph (intensity-vs-time) for the site. If desired, users can input their own duration (time of concentration) and/or intensity.

o Intensity-Duration-Frequency Curve

The second design rainfall option creates an intensity duration frequency (IDF) curve for the desired site and return period. The duration ranges from 5 minutes up to 24 hours. The frequency (return period) ranges from 2 to 100 years. A plotting routine puts these IDF ordinates on a graph where the y-axis is intensity (inches/hour) and the x-axis is duration (hours). Two graphs are created: one plots all points for durations up to 24 hours; the second details the first 2 hours of the first curve.

Because this option uses the rainfall intensity database, the site must be in the continental United States. The IDF option does not allow the user to input a rainfall intensity.

When the rainfall database is used, and a return period of less than 2 years is entered, the program will set the return period equal to 2. A warning message is not generated when this occurs, but the change in return period is reflected in the title of the IDF curve. If a return period greater than 100 is entered, HYDRO sets the value to 100.

Design Flow

There are four design flow options. These are: rational method, user developed equations, log Pearson type III analysis, and user supplied design flow. These options can produce input to other HYDRAIN programs.

o Rational Method

This option uses the rational method equation ($Q = CiA$) to calculate the peak flow (in ft^3/s) at a site. The rainfall intensity is calculated for a specific return period and duration (time of concentration) using a unique rainfall database (RAIN.PFP), or it can be entered by the user. The area variable is developed using seven land use conditions as subareas. Default runoff coefficients are provided (or can be replaced at the Users option). A unit hydrograph can be developed using Constant's modification of Snyder's method.

o User Developed Equations

This option allows the user to develop their own site specific and general peak flow equations (or use USGS 3 and 7 Parameter Regression Equations). The user inputs the equation in its algebraic form. For example:

$$Q_{25} = \text{SLOPE} * \text{AREA} ** 0.147 + \text{INTENSITY} * \text{DURATION} \dots)$$

The user would only need to enter the equations once. A unit hydrograph can be developed using the resulting calculated peak flows.

● Log Pearson Type III

This option uses log Pearson type III analysis with USGS gauge station data to calculate the peak flow (in ft^3/s) at a site. A unit hydrograph can be developed using Constant's hydrograph method. The gauge station data must be provided by the user. Several sources of this information are provided in the HYDRAIN System Shell resources help screen.

****NOTE**** The log Pearson type III analysis is designed for 30 or more records; however, the program has been run successfully with as few as 7.

● Design Hydrograph

This option develops a unit hydrograph for a given flow across a specific site. The option uses Constant's method (a version of Snyder's method) to create the unit hydrograph.

The hydrology program (HYDRO) uses an .HDO extension for inputting / editing data and executing the program. If no extension is added by the user, the System Shell will automatically append the correct extension.

HYDRO also provides rainfall/flow data for other system elements including hydrographs, rainfall intensity/duration/frequency curves, and hyetographs. The filename extensions for the above output are as follows:

" .QT " = This extension contains the ordinates of a hydrograph (ie: flow (Q) vs. time (T)). If desired, this file can be incorporated into the other engineering programs (i.e.: into CDS using the XXXX.CD. work deck, and into PFP-HYDRA using the "UHY" Command).

" .HYE " = This extension contains the ordinates of a hyetograph (ie: rainfall intensity (I) vs. time (T)). If desired, this file can be incorporated into PFP-HYDRA using the "HYE" command.

" .IDF " = This extension contains the ordinates of an Intensity-Duration-Frequency (IDF) curve (for a duration from 5 minutes to 24 hours). If desired, this file can be incorporated into PFP-HYDRA using the "RAI" command.

CDS (Culvert Design System)

The Culvert Design System (CDS) can design a culvert or review an existing or proposed culvert. It investigates hydrograph relationships, culvert shapes, materials, and inlet types. Data may be obtained to allow manual plotting of culvert performance curves. CDS can generate a hydrograph, determine culvert size, and identify the flow type, outlet conditions for velocity, Froude number, and brink depth. The system provides four distinct types of analysis that can be classified into two broad options: design and review.

The "design option" selects a culvert size and number of barrels compatible with the engineering data, environmental constraints, and site geometry. With this option, the user can request that CDS consider any or all of the following culvert types: round concrete, round metal, arch concrete, arch metal, oval concrete (horizontal placement only), and concrete box. There is an upper limit of six barrels for commercial culverts or five for concrete box culverts.

The user must select one of two methods of design: irrigation design or drainage design. The irrigation design method ignores any upstream pond storage and selects a culvert capable of passing the peak discharge. Irrigation ditches in western States operate for long periods at full or near full capacity, thereby precluding any available pond storage. The drainage design method uses any temporary upstream pond storage by routing a hydrograph through the site.

Provision has been made in the design option for the user to obtain data for manually plotting a culvert performance curve. This is accomplished by the user identifying the design discharge and five other performance discharges deemed suitable to define a performance curve. With these discharges, the system will first size a culvert using the design option and then review this design culvert size using the five performance discharges. This satisfies FHWA requirements for a culvert performance curve and assists in making a flood hazard assessment provided the basic flood (100-year event) is one of the five performance discharges. It is not necessary to input the five performance discharges in order to secure a culvert design, however.

The "review option" provides hydraulic performance data for a specific culvert identified by the user. In this option, the user identifies the culvert type (in accordance with those listed above), size, inlet type, slope, and number of barrels.

The review option uses the same equations as the design option. Again, users must indicate whether the specific culvert is to be reviewed using the irrigation design method or the drainage design method.

The review can also be used to obtain a culvert performance curve for a predetermined culvert size and geometry. With this option, the program reviews the specified culvert size, type, and geometry using the discharges provided (six maximum).

CDS provides the user with a choice of two hydrograph alternatives in either the design or review options. The first alternative allows the user to input up to six hydrographs for a given discharge; these may be generated in HYDRO. Each of the six discharges that can be input to the system also require input of their own unique hydrograph. The second alternative is where the user does not elect to input a hydrograph. With the second alternative, the system generates a hydrograph internally based on the State of Wyoming's flood studies. These studies are for semiarid regions having watersheds ranging from 0 to about 15 square miles. In Wyoming's snowmelt regions, urbanized watersheds and any watersheds greater than 15 square miles, it is necessary to input a hydrograph for the design to be valid. (An alternative in Wyoming's snowmelt region would be to specify the irrigation design option as snowmelt hydrographs tend to have relatively long duration hydrographs.)

Data should be gathered prior to data entry and analysis activities. Typical data needs depend upon the work deck combination and include:

- o Channel cross section.
- o Friction factor.
- o Desired culvert type.
- o Culvert length and slope.
- o Channel slope.
- o Road profile.
- o Height of overtopping.
- o Storage versus stage.
- o Design flow.
- o Hydrograph (from HYDRO).

If the user is inputting / editing CDS work decks (intermediate files used to generate CDS input), the file name convention specifies that one of the five following extensions be used:

- " .SD " = "STAGE DISCHARGE". This deck contains the headwater stage discharge or downstream channel cross-section tables.
- " .SS " = "STAGE STORAGE". This deck contains table of stage versus storage or a table describing the upstream cross section.
- " .CD " = "CULVERT DESIGN". This deck contains data to select culvert types and characteristics, and peak flows. The user can also determine whether to review an existing culvert or to design a culvert.
- " .FD " = "FLOW DISTRIBUTION". This deck is included to obtain the flow-distribution for a channel.

For most common applications, CDS work decks are combined into one of the following nine combinations. The work decks must be combined in the indicated

order for each type of analysis. Once the work decks are combined, the resultant input file will have a prefix supplied by the user and a suffix ".CDS".

The nine options are as follows:

- | | |
|--|---|
| 1. Data review
XXXX.SD | This deck will run alone to generate a stage discharge (rating) curve from downstream cross sectional data. |
| 2. Data review
XXXX.SS | This deck will run alone to determine upstream storage volumes. |
| 3. Dynamic Flow Design or Review
XXXX.SD
XXXX.SS
XXXX.CD | This combination designs or reviews a culvert with upstream storage and routes a hydrograph through the culvert. |
| 4. Steady State Flow Design or Review
XXXX.SD
XXXX.CD | This combination designs or reviews a culvert with steady state (peak) flow. |
| 5. Flow Distribution
XXXX.SD
XXXX.FD | This combination reviews the downstream channel hydraulics (independent of any culvert analyses). |
| 6. Stage Discharge & Storage
XXXX.SD
XXXX.SS | This combination calculates the stage discharge and stage storage curves (independent of culvert analyses). |
| 7. Data Review
XXXX.SD
XXXX.SS
XXXX.FD | This option combines the two previous options; both stage discharge & storage curves with flow distribution. |
| 8. Dynamic Flow Design or Review with Flow Distribution.
XXXX.SD
XXXX.SS
XXXX.CD
XXXX.FD | This combination designs or reviews a culvert with upstream storage and routes a hydrograph through the culvert. A flow distribution is done on the downstream channel. |
| 9. Steady State Design or Review with Flow Distribution.
XXXX.SD
XXXX.CD
XXXX.FD | This combination designs or reviews a culvert with steady state (peak) flow. A flow distribution is done on the downstream channel. |

PFP-HYDRA (Storm and Sanitary Sewers)

PFP-HYDRA can be used to analyze a predescribed or existing sewer system or to create a preliminary design for a new one. In the design mode it can also be used to estimate construction costs including the following categories: bedding, area, excavation, pipe zone, backfill, and surface restoration.

PFP-HYDRA can analyze sanitary, storm, or combined sewers. If the user is designing/analyzing a storm sewer, PFP-HYDRA has the capability of generating flow using hydrographic simulation, or if the contributing land segment is a small, urban watershed, the rational method. The method of flow generation is strictly up to the user.

PFP-HYDRA operates in two basic modes: design and/or analysis. In the design mode, PFP-HYDRA accepts design data (such as friction factor, pipe length, land use characteristics, etc.), generates a design flow, and suggests a system capable of handling the given flow. The output includes such information as recommended pipe diameter, slope, depth of pipe, invert elevations, minimum cover, quantity and velocity of flow, and the estimated total cost of placing the pipe.

The analysis mode input is very similar to that of the design mode. The major difference is that the known characteristics of an existing system are entered instead of generic design criteria. PFP-HYDRA then calculates whether or not the system can accommodate the specified flow. If not, PFP-HYDRA suggests the necessary pipe size to correct the problem. Whether performing a design or an analysis, PFP-HYDRA is capable of handling a system of virtually any practical size.

PFP-HYDRA uses an ".HDA" extension for inputting / editing data and executing the program. The extension is automatically appended by the program shell and should not be added by the user. PFP-HYDRA output file names have the input file name prefix and the ".LST" extension.

WSPRO (Water Surface Profiles)

The Water Surface Profile Computation Model Microcomputer Program has been designed to provide a water-surface profile for six major types of open channel flow situations:

- Unconstricted flow.
- Single-opening bridge.
- Single-opening bridge with spur dikes.
- Single-opening embankment overflow.

- Multiple alternatives for a single job.
- Multiple openings.

WSPRO was originally developed by the United States Geologic Survey (USGS) for the Federal Highway Administration. The original model was a batch mode mainframe program, written in FORTRAN. The members of the Pooled Fund Project decided to use WSPRO as the bridge waterways analysis element of the Integrated Computerized Drainage Design System. WSPRO was downloaded to the microcomputer by the USGS and FHWA. The microcomputer version of WSPRO, is dated August 1987. As yet, WSPRO does not have a user friendly, interactive shell to aid in data input and manipulation, although this is planned as a future HYDRAIN enhancement. The result is that, currently, the user must create or edit an input file on a line editor or word processor.

The input file forms a logical description of the physical characteristics of a waterway. Once the user is comfortable with this method of data setup, the program will provide a simple method for determining water surface profiles. The scheme is similar to the Corps of Engineers HEC-2 program. Both WSPRO and HEC-2 are acceptable to the Federal Emergency Management Agency. WSPRO has the advantage that it utilizes more recent approximations for the backwater effects associated with bridge constrictions.

The Bridge Waterway (and Open Channel) Analysis program (WSPRO) uses an ".WSP" extension for inputting / editing data and executing the program.

HY8 Program

HY8 is an interactive culvert analysis program that utilizes the FHWA analysis methods and information published by pipe manufacturers. The version of HY8 within HYDRAIN does not analyze dynamic response or ponding and does not make automatic trial designs (ie. it will not size a culvert). The program includes modules to allow the user to interactively enter, save, and edit data, to analyze inlet and outlet control for full and partially full culverts, to analyze the tailwater in trapezoidal and coordinate defined downstream channels, to analyze flow over the roadway embankment, and to balance flows through multiple parallel culverts.

The initial logic involves calculating the inlet control and outlet control headwater elevations for the given flow. These elevations are compared and the larger of the two is used as the controlling headwater elevation. Tailwater effects are taken into consideration when calculating these elevations. If the controlling headwater elevation overtops the roadway embankment, an overtopping analysis is done in which flow is balanced between the culvert discharge and the surcharge over the roadway. A balancing technique is also used in the case of multiple barrels. If the culvert is less than full for all or part of its length open channel computations are performed.

A series of data menus, data screens, summary screens, and output screens guides the user through the program. Each menu contains several options to match the desired culvert configuration, while the data screens prompt the user for specific dimensions and coordinates. Summary screens allow the user to edit entered data or change menu selections. Output screens display the output as calculations proceed; hard copy is only obtained using the "print screen" key.

There are three main groups of data to be entered into the program; initial culvert data, downstream channel data, and roadway data. Within the program, the user is sequentially led from one group to the next. From these sets of data, the program develops culvert performance data with or without overtopping. A performance curve can be plotted on a computer with graphics capabilities by typing a 'v' for view. In addition to developing performance curves, the program generates rating curves for uniform flow, velocity, and maximum shear for the downstream channel. Culvert outlet velocities, inlet control head, and outlet control head are also calculated.

REFERENCES

Additional information may be found online through the help facility (F10) or in the Hydrain Documentation Report Volumes.

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