United States Department of Agriculture
Natural Resources Conservation Service

H Y D R O . E X E

Hydrology Tools

Version 1.10

March 2001

written by:
Clinton W. Liezert PE
Civil Engineer
E-34669

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Introduction:

Hydrology Tools (HYDRO), as the name implies, is a collection of tools or routines that are used in the evaluation of the hydrology for a watershed. In this instance hydrology is defined as “the scientific study of the properties, distribution, and effects of water on the earth's surface … “ Most of the capabilities of an earlier program titled “RUNOFF” are contained within this program.

Many of the terms and procedures used in this program can be found in Section IV of the NRCS[1] National Engineering Handbook or Chapter 2 of the NRCS National Engineering Field Handbook.

Some of the features or tools contained in the program are as follows:

- an associated database of soil properties that provides for the automated retrieval of the “hydrologic soils groups” for many soil types. (This database can be modified or maintained by using a separate program titled “data_ed.exe”.)
- automatic retrieval of frequency based rainfall data from a database that is also maintainable using the “data_ed.exe” program.
- automated computation of the “runoff curve number” that is commonly associated with the NRCS soil cover complex method for determining runoff. This curve number eventually leads to the volume and rate of runoff that will be generated by a specific rainfall amount.
- a variety of procedures for determining the time of concentration for a watershed.
- computation of an array of peak discharges for a watershed. Also included in this calculation are peak discharges associated with drainage needs. These calculations are consistent with those found in Chapters 2 and 14 of the NRCS National Engineering Field Handbook.
- computation of the coordinates of a hydrograph for a specific storm event and viewing a graphical presentation of these coordinates.
- comparison of two hydrographs in an effort to evaluate the impacts of changes that might be made to the hydrologic characteristics of a watershed. These changes are most often associated with developing areas or urbanization.
- the ability to maintain the information for several watersheds in computer memory at one time as well as the ability to copy data between watersheds in order to facilitate data entry.

[1] NRCS – National Resource Conservation Service (Formally Soil Conservation Service).

Supporting Files:

The hydrology tools program is contained in a file called ***"HYDRO.EXE"***. In order to run, it must be supported by at least seven and as many as twelve additional files on the default drive. If vital files are missing, a message will appear on program initialization identifying the missing files. The recommended setup follows:

BRT71EFR.EXE	This is a runtime module that is copyrighted to Microsoft Quick BASIC ™
OH_ENG.CFG	The file containing all of the specifics about your computing system such as type of printer, type of monitor, where data is saved, etc.
CLIMATE.DAT	Climate data, including rainfall information, is maintained in this "random access" file. The data within this file can be managed using a supporting program titled *"data_ed.exe"*.
SOILS.DAT	This data file includes the hydrologic soil group associated with each of the soils. Soils.dat is a "random access" file that can be managed using a supporting program titled *"data_ed.exe"*.
HYDRO.STD	This file contains the default values or any standard values that may apply to this program. The data in this file is controlled by the "modify defaults" portion of the program (see page 14)
HYDRO.ST2	Many of the values that support the program such as minimum and maximum values, formula coefficients, land use descriptions and associated hydrologic soil groups etc. are contained in this ASCII file. While this data can be edited using conventional text editors, it is recommended that changes be left to the experts.(See Page 19 for details related to the contents of this file.)
HYDRO.HLP	A file that contains help information related to this program. The program will run without this file but there will obviously be no help information available if the file is not present. Should the program be run without this file, a "dummy" file will be created with this file name containing no data. The information in the "real" file can be modified or clarified using a supporting program named *"edithelp.exe"*.
DIMHYD.DAT	A file that defines the dimensionless hydrograph. The information is this file is necessary for the hydrograph development routine.

RAIN*.DAT	There is a table for each of the rainfall distributions that are available. Each file contains the data definition of the associated distribution pattern.
BROWSE.COM	This utility program is used so that some of the reports can be generated in a file format and then viewed on the screen in a controllable manner.

Loading HYDRO:

"HYDRO" can be loaded several ways. Make certain that you are in the subdirectory where the engineering programs reside. The main **"Ohio Engineering Menu"** can be loaded first by entering **"ENGMENU"** at the DOS prompt (C>) and then selecting the "**H**ydrology Tools" program from the choice list. If the Hydrology tools does not exist in the list of programs, use a text editor like notepad or edit and enter the following line in the file named "engmenu.dat".

"hydro.exe", "Hydrology Tools"

The second option is to simply enter **"HYDRO"** at the DOS prompt. The program can also be executed using the procedures for launching a DOS program appropriate with the version of Windows that is being used. Typically this is done by creating a "pif" file or a "short cut". Refer to your Windows manual if you are using Windows.

Special Keys:

In addition to the normal "arrow" keys, "Page Up" and "Page Down", several special purpose keys are available at various times in the program. A brief description of the function of these keys follows. Additional information on these keys can be found by using the **F1** key within the program. (It should be noted that the mouse will also simulate the arrow keys, the left button simulates the return key and the right button duplicates the escape key.)

¿ This is a very important key in that inputs are not registered to the program until the **"return"** (↵) key is pressed. Failing to press the "return" key might result in an error message or it might result in computations being made without the input you thought you had made. Remember to input the requested data and then **press return** **(¿)** before computing, printing or saving the data. It should be noted that the **tab key** will provide the same response as the return key.

Esc The escape key is most often used to "back up" one action or level in the program. In other words, take you back from whence you cometh. For example, if you are in the data entry screen, "*Esc*" will take you back to the main HYDRO menu. If you are in the main HYDRO menu, "*Esc*" will afford you an opportunity to exit from the program.

F1 This function key will display help information if it is available. On some screens, you will be offered an option of selecting help for the particular entry where the cursor is, the entire screen or special keys.

F2 This key has been designated as the **"edit"** key. Pressing this key will afford you the opportunity to edit a previous entry or default value without completely retyping it. In this mode, the system shifts into an automatic "insert" mode and the left and right cursor keys and the backspace key, all become active. Once again, the return **(¿)** key will register your final entry.

F3 In some instances, pressing this key will cause a calculator to pop up on the screen. This is handy when you need to make a quick calculation. Pressing **F1** while the calculator is on the screen will cause a "help" window to appear that explains how to use the calculator.

F4 There are many instances when a message stating **"F4-Choice"** will appear at the bottom of the screen. This means that there is a choice list for making the proper choice for the issue under question. When this occurs, simply press F4, move to the desired selection and press the enter (↵) key.

F5 If noted at the bottom of the screen, pressing the F5 key will cause the report appropriate for the screen that you are on to be printed.

F6 This key causes the work sheet necessary for the cursor location to appear and become active. For example, a worksheet to compute a curve number will appear if the cursor is resting on the curve number position and the option is set to "compute".

F9 This function key causes the computation routines to be implemented. This key can be pressed any time a solution is desired. If there is not sufficient data for a successful computation, an applicable message will be displayed. New or changed values on the input screen will clear previous computations and the F9 key will again be needed when all of the changes have been made.

F10 This key is used to continue from an input screen with a prescribed action once all of the data has been provided.

Alt-P This combination of key strokes will cause the graphical representation of the hydrograph to be printed or plotted on the attached printer.

HYDRO Main Menu -

When the program is first activated, a menu similar to that below will be displayed. The marker identifies the function that is currently active. Pressing "F1" will display a small description of the function. Pressing "Enter" (↵) or the left mouse button will activate the current function. The first letter can also be used to activate any of the specific selections. The right and left arrow keys or the mouse can be used to move the marker.

Tools –	**F**iles	**R**eports	**O**ptions	**Q**uit

Tools:

Selecting "T" for tools will cause the following screen, showing the types of functions or tools that can be processed by the program, to appear.

Tools	**F**iles	**R**eports	**O**ptions	**Q**uit

Peak Discharges
Soil Types
Hydrograph Development
Urban Development
Runoff Curve Number
Time of Concentration

Peak Discharges -

Upon making this selection, an input screen will appear. Most of the activity associated with this program can be accomplished from this screen. By responding to the questions asked on this screen, a complete hydrologic analysis can be made of a watershed or combination of watersheds. Many actions can be made on this screen. A discussion of these actions and a description of the requested information follows:

Peak Discharges & Watershed Identity

Watershed 1 of 1

County .... Medina

Watershed Description ....

Runoff Curve Number ....(Enter)...

Drainage Area ....(Enter)... ac.

Time of Concentration ....(Enter)... hr.

Rainfall Type II

Esc-Menu | F1-Help | F4-Choice | F6-WkSht | F9-Comp | PgUp/PgDn | NUM

Attention is drawn to the information that is or will be displayed at the bottom of the screen. This relates to special action keys that are available in certain instances.

Watershed 1 of 1 - as previously mentioned, the program is capable of maintaining data for several watersheds at one time. Once the screen has been completely filled in, the PgDn key will move to a similar screen for each subsequent watershed. Once you have passed the first watershed, the PgUp key will move backwards through the watersheds that are in memory.

County – the F4 key will present a list of counties that are available to the program. Move the highlight to the county in which your project lies. Selecting the county will make the rainfall associated with that county available for subsequent computations. As previously mentioned, the program can maintain data for several watersheds in memory simultaneously. It is worthy to note that the watersheds can have different counties or rainfall regions.

Watershed Description – this information will be used on any printed results in order to identify the project. It is also used to identify watersheds when they are selected for copying or comparisons. Use a description that is meaningful to the user.

Runoff Curve Number – The runoff curve number is a number that represents the ability of a watershed to generate runoff. It considers several characteristics which mainly include soil type, type of land cover and land cover condition. While the curve number does not reflect a percentage of rainfall that runs off, it is similar to a percentage in that higher numbers produce a greater amount of runoff for a given rainfall.

There are two options for this entry that become available by pressing the F4 key. If a curve number is available from another source or you have one in mind, and the "(Enter)" option is displayed, simply enter the number. If you prefer to compute a curve number, select "compute" from the list that is presented by pressing F4. If "(Comp)" is displayed on this line, pressing F6 will cause a curve number worksheet to appear and the necessary entries can be made. Instructions related to this worksheet are outlined on page 9.

Drainage Area – The drainage area is defined as that surface of land that sheds water to the design point being considered. This program uses drainage area in acres.

This entry has two options as well. The first is to simply enter a number representing the acres in the drainage area. The second option is to use the area that is generated as a part of the curve number computation process. Once again, the desired option is selected from the list presented when F4 is pressed.

Time of Concentration – The time of concentration is defined as the time taken by a drop of water in travelling from the hydraulically most distant point in a watershed to the point under consideration. The time of concentration is responsible for shaping the hydrograph that is created by a runoff event. The shorter the time of concentration, the more the hydrograph is squeezed and the higher the resulting peak discharge.

There are several options available by pressing F4 that will result in an entry for the time of concentration. Once again, an entry can be made or a variety of worksheets are available by pressing F6 when your choice is displayed, that will calculate a time of concentration. These worksheet methods are discussed beginning on page 10.

Rainfall Type – rainfall type defines that manner in which the rainfall is distributed, many times referred to as rainfall distribution. It typically is assigned for a specific region and as such can be set up as a default value. Should a value other than that presented be desired, it can be selected from the list displayed by pressing the F4 key.

Soil Types -

The sole purpose of this routine is to look up the hydrologic soil group that is associated with a specific soil type that exists in the watershed. The soil type or soil name is typically determined by locating the associated watershed on a soil survey map. The hydrologic soil group reflects the ability of a soil to absorb water, which in turn affects the runoff curve number that will be selected to represent a specific plot of land. Soil types are identified by name. When a name is entered, the program automatically retrieved the information from the file titled “soils.dat”. If the program responds with “***” it is an indication that the soil name is misspelled or does not exist in the data base.

Hydrograph Development -

There are occasions when making a hydrologic analysis of a watershed that the entire hydrograph is necessary to get a true picture of what is happening in the watershed. The shape of the hydrograph can many times lead an experienced hydrology to the means of solving a specific problem. On other occasions, a hydrograph is a requirement of the procedure being used to complete a design, such as a reservoir routing.

This particular module of the program develops a hydrograph using the procedures outlined in USDA-NRCS Technical Paper 149. This procedure involves a summation of triangular hydrographs leading to a curvilinear hydrograph.

The inputs to this procedure are similar to that previously described. When a hydrograph is developed, only one frequency can be analyzed at a time. It is also worthy to note that differences will be realized in the peak discharges that are reported by this procedure and those for comparable frequencies using the other procedures in the program. This difference is attributable to the difference in theory related to the two procedures.

The following discussion relates to the inputs required for this procedure.

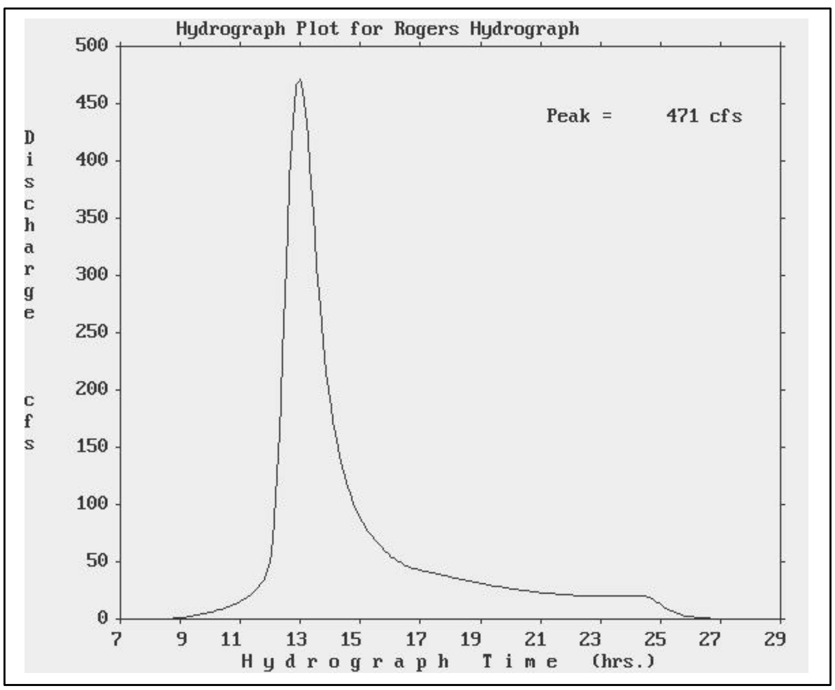
County		Refer to definitions previously defined on page 5
Watershed Description		"
Runoff Curve Number	(Enter)	"
Drainage Area	(Enter)	"
Time of Concentration	(Enter)	"
Rainfall Amount	(Enter..........	"
Rainfall Type		"
Time between Hydrograph Points		0.10 hr.

The "Time between Hydrograph Points" is technically referred to as "Delta D". It is the time increment that determines the base width of the incremental triangles that are eventually summed to form the final hydrograph. In this procedure, the time to peak is calculated first and then the "delta D" is adjusted so that the time to peak and a multiple of delta D coincide. The significance of this entry to the typical user is the manner in which it effects the final answers. Typically, the entry should be relatively small (0.05 to 0.10) for small watersheds (less than 100 acres.) For more specifics, see Technical Paper 149 of the Natural Resources Conservation Service.

Once the data entry screen is complete, pressing the F9 function key will cause the parameters of the hydrograph to be computed and the results displayed on the screen. Once the results have been displayed, to additional options will appear at the bottom of the results. They are:

F5 - which will provide several options for printing out a table of the hydrograph coordinates.

F6 - will cause a graphical view of the hydrograph similar to the one below to be plotted on screen. Pressing the Alt & P keys simultaneously while the plot is on the screen will cause the plot to be printed on the attached printer.



Urban Development -

The original purpose of this module was to analyze the hydrologic impacts of urban development. The procedure can however, also be used simply to compare the peak discharges from two different watershed areas. If the size of the watersheds selected are equal, the procedure will evaluate the changes using the Ohio Division of Soil & Water Conservation Districts Model Ordinance. The premise of this procedure is that changes in a watershed that result in accelerated runoff, cause the downstream drainage network to readjust its size in order to handle the increases. Many time this readjustment results in severe erosion and potential damage to downstream structures. Based on the degree of increase in runoff, the procedure identifies a "critical storm" event. Once the critical storm has been identified, the model ordinance states that all post-development storm events as frequent as the critical storm must be contained and released at a one year pre-development rate. In addition, all post-development storm events less frequent than the critical storm must have their peak rates held to the pre-development rates.

This selection in the program will analyze the watersheds using the above procedure. Initially the user must select the two watersheds that are to be compared. This obviously means that at least two watershed need to have been entered in the system. The watersheds are selected using the F4 key to display the watersheds available, moving to the choice and selecting it. Once both watersheds have been selected, the process is activated by pressing the F10 key. The program will calculate and display the seven peaks associated with the two chosen watersheds. If the watersheds are equal in size, the program will determine the "critical storm" and identify it using a "<->" symbol. It will then proceed by displaying the maximum acceptable discharges from the watershed after development. Pressing the F5 key while the results are displayed on the screen will generate a report of the results.

The parameters used to make this evaluation can be adjusted or modified using the "Modify Parameters" option of this program described on page 14.

Runoff Curve Number -

The runoff curve number is a number that mathematically represents the ability of a watershed to produce runoff. It basically includes the type of cover on the watershed at the time of the design rainfall and the hydrologic soil group that is assigned to the particular soil that is involved. The hydrologic soil group is assigned to each particular soil type by soils specialists.

The land uses are described on this entry form in a spreadsheet format with four columns representing the soil groups. All that is required is to place each acre within the watershed in the proper soil group column and land use row. The program will take each entry and compute a weighted average, which is the runoff curve number for the watershed. Ideally, land use information will be determined by field visits and soil groups will be determined from the most recent soil map of the involved area. During the entry of the land use information, the soil information that was previously entered (soil name and associated hydrologic soils group) is available to those of us with short memories by pressing the F4 function key.

One exception to the above procedure relates to the land use identified as "User defined urban". This land use allows the user to provide input that will result in a modified basic curve number for impervious areas that are typically found in urban developments. If the F9 key is pressed while the cursor is positioned on this entry, an input screen will appear requesting the following information:

Percent Impervious Area - Enter the percentage of the entire area that would be considered impervious or would produce nearly one hundred percent runoff.

Percent Unconnected Impervious Area - unconnected areas are those areas that do no flow directly into the drainage system. In other words they flow over lawn, filter beds, wooded area, etc. before they enter the drainage system.

Pervious Curve Number - enter a curve number for this hydrologic soil group and a pervious condition. Typically a pervious curve number is similar to that of a pasture in good condition.

Once these three entries are made, pressing the F10 key will cause a curve number representing the entered condition will be computed and used in the subsequent weighted computations.

Throughout the above entries, a total drainage area and weighted curve number is updated and displayed at the bottom of the screen. When all of the data has been entered and the total drainage area has been achieved, pressing the "esc" key will return the program to the previous entry screen with a curve number and drainage area (if the drainage area option was selected).

Time of Concentration -

Time of concentration is defined as the time that it takes a drop of water to travel from the hydraulically most distant point in a watershed to the point under consideration. The time of concentration has a direct effect in shaping the hydrograph. Normally, shorter times of concentration generate higher peak discharges.

Since most of us are smart enough not to sit out in the rain and measure the velocity of a drop of water with a laser gun, it is necessary to use a different technique. In reality, the time of concentration would be different with various storm frequencies or times of year. The point that is obvious is that the time of concentration is at best a good guess. This statement is not intended to cause you to give up hope but rather to approach this computation with a sense of conscience and reasonableness.

Three methods to calculate times of concentration are provided by the program. None has preference over any other, it is more a matter of selecting the one that you feel more personally comfortable with. The important thing is that you understand what Tc is all about and that your are as honest and practical with whichever method you select.

EFHB Method - This method is outlined in the NRCS - Engineering Field Handbook, Chapter 2. When this method is selected, an input screen will appear soliciting information to solve the following equation.

$$Tc = \frac{l^{0.8}\left[\left(\frac{1000}{CN}\right)-9\right]^{0.7}}{1140 \cdot Y^{0.5}}$$

Where:

Tc = time of concentration in hours.
l = flow length in feet. This is the distance from the hydraulically most distant point to the design point.
CN = the runoff curve number for the watershed.
Y = the average watershed slope in percent. This is NOT the average slope of the water course but the average of the slope draining into the water course.

Kirpich - this procedure, which used to be solved using a nomograph, can be solved using the following equation.

$$T = \left(\frac{11.9 \cdot L^3}{H}\right)^{0.385}$$

Where:

T = time of concentration in hours.
L = length of the longest watercourse in miles.
H = elevation difference in feet.

TR-55 Method - this method, as its name implies, uses the procedures in Technical Release 55 of the USDA Natural Resources Conservation Service. The method provides for analysis using three different flow conditions. These flow conditions include:

- sheet flow - which would include flow in the extreme upper reaches of the watershed. Care should be used in selecting this flow characteristic as it can really distort the values.
- shallow concentrated flow - this would typically include areas the only have flow during significant rainfall events.
- open channel flow - for this flow type, a defined cross-section to the channel is normally required.

The procedure uses of summation of all of the flow types that are included. A complete definition of these flow types and the data required can be found in the technical release (TR-55).

As previously mentioned, the time of concentration has a direct impact on the answer that is produced and as such it is worthy of your best work. It is also worthy to note that the time of concentration applies to the entire watershed. In the first two methods (EFHB & Kirpich), if the watershed is such that one slope or reach will not accurately represent the entire watershed, the methods can be used in smaller reaches and the incremental values totaled for the composite time of concentration.

Tools **F**iles **R**eports **O**ptions **Q**uit

Get a Job
Save a Job
Remove a Job

Data File Management:

Get a job:

This feature allows data that has been stored or saved on previous occasions, to be retrieved. A list of the data files that are available on the designated drive will be displayed. If your data is on a different drive or in a different subdirectory than the default, pressing **Alt C** will afford an opportunity to select an alternative drive and a new list of available files will appear. Cursor to the job that is desired and press return (↵) or the left mouse button to retrieve the data.

Save a job:

This selection will solicit the information required to save the data for the job that is currently in computer memory. It is wise to visit this area frequently while a large job is being entered so that portions of your work are not lost. You never can tell when the lights might go out or someone might accidentally hit the reset button.

A screen will appear that identifies the data that is to be saved. Refer to the main guide for the Ohio Engineering programs for discussion related to the file naming procedures and assistance related to the information that is requested on this screen. The code used to identify HYDRO data in the file naming scenario is ***"H2O"***.

Remove a job:

Many of us do not like to throw anything away but occasionally reality sets in and we concede to the need. There might be test jobs, old jobs or jobs that you don't want the boss to see, that should be removed from the system. This selection works in a similar manner to retrieving data files. Once the desired file has been selected, you will be asked to confirm your request.

It is desirable to remove data files using this procedure rather than simply erasing them with DOS commands. This procedure also will properly manage other related files and do some minor housecleaning that the DOS procedures do not know about.

Reports:

Tools **F**iles **R**eports **O**ptions **Q**uit

All Watersheds
Selected Watershed
Urban Evaluation
Hydrograph Data

Many of the reports that are available from this program can be generated from the individual design screens by pressing the F5 function key. This selection from the main menu provides the means to print or generate all of the reports available in the program.

All Watersheds:

As implied, this selection will print the reports for all of the watersheds that have been entered into the program. They will be printed in the same order as entered, which is a point that might be important to consider when the data is initially entered.

Selected Watersheds:

This selection allows you to generate the reports for only those watersheds that are desired. This way you can eliminate the watersheds that are optional or trial designs from the package of reports.

Urban Evaluation:

This selection will generate the same report that is generated by pressing the F5 function key from the design screen.

Hydrograph Data:

This selection generates a report including the coordinates of the hydrograph. The screen and printed options are typical tabular reports. The version that is sent to a file can be used for a variety of purposes. The format of this report is ASCII which can be read by most software applications. Since the format is basically generic, the data can be moved around as needed. For example, the file could be read by a standard text editor, reformatted and read into another engineering application such as a pond design program. The file could also be read into an application such as EXCEL or LOTUS and plotted, routed, or added to other hydrograph data.

Options:

Tools **F**iles **R**eports **O**ptions **Q**uit

Clear Memory
C**o**py a Drainage Area
Modify Parameters
Program Details
Switch Printers
Temporary Exit to DOS

The options selection from the main menu serves two basic functions. It is an information center and it contains several features or functions that help make this program easier to use.

Clear memory:

If you get to the point that you have things so messed up that you would like to start over, this is the routine to use. It will give you a fresh start. Everything previously in memory will be gone after this operation. If there is a chance that you may change your mind, it might be wise to save the data before proceeding with this option.

Copy a Drainage Area:

Many times when changes to watershed are analyzed, only a few of the watershed characteristics change. This procedure is included in the program to avoid the necessity of re-entering data that hasn't changed. The procedure allows all of the watershed characteristics to be copied to a new data set or in essence a new watershed. Then all you need to do is go into the new watershed definition and change the appropriate items. Another option is to leave the data the same and hopefully you will get the same answers for both watersheds.

Two entries will appear on the screen. The first is the source watershed and the second is the target watershed. Either choice can be changed using the F4 key. Normally the target will appear as "New Watershed" as a default. The only way to change this title is to return to the "Tools - Watershed Identity", screen. Typing the new name while choosing the target watershed will not get the name changed. This point is made because it is possible to copy a watershed several times only to find that when you print out the information that you have several "New Watershed's".

Modify Parameters:

The "modify parameters" portion of the program is designed to add versatility and to allow the program to be as user friendly as possible. Selection of this option will cause the following screen to appear. The choices presented control the manner in which the program responds as data is entered. The choices made will determine the default values or values that you normally use, to automatically appear when specific screens appear.

Modify Parameters

Curve Number Method .... Compute a value
Drainage Area Method .... Use value from CN computations
Time of Concentration Method .... EFH Method
Rainfall Distribution II
Hydrograph Dev. Time Increment..... 0.10 hr.

Critical Storm Evaluation Parameters:
Frequency used to determine critical .... 1-yr.
Frequency used to control discharge .... 2-yr.

Frequency Controlled	Range of Increase in % of runoff		
1-yr.	0	to	10
2-yr.	10	to	20
5-yr.	20	to	50
10-yr.	50	to	100
25-yr.	100	to	250
50-yr.	250	to	500
100-yr.	500	to	9999

Esc-Menu F1-Help F4-Choice NUM

The first four choices on this screen are modified using the F4 choice key. The choices that are made will be subsequently used as default values on other data entry screens.

Hydrograph Dev. Time Increment - refers to the delta D that was discussed on page 8. The value selected will be eventually used as a default.

Frequency used to determine critical - this is the storm event that is used to evaluate the increase in runoff as outlined in the ODNR model ordinance. In the example, the one year event would be evaluated with the runoff for the two senarios calculated and the percent increase determined. This percentage will eventully determine the "critical storm."

Frequency used to control discharge - this procedures mandates that all storm events more frequent than the critical storm be released at a rate that does not exceed the discharge that corresponds to this entry. In the example, all storms more frequent than the critical storm will be allowed to release at a maximum value equal to the 2 yr pre-development discharge.

The remaining changes available on this screen relate to the percentage of increases in runoff that define the "critical" storm array.

Program Details:

This selection will display some specifics related to the program including the date of the last revision or change. Many times there are subtle changes made to the program that do not merit changing the version number for the program. The date of these changes is normally available using this feature.

Switch Printers:

If two different printers are available on your computer system, this option will allow you to change the identity of the printer that the program uses. Basically, this action changes the value of the codes that control the manner in which the printer behaves. For example, the codes that cause the printer to print in compressed code, etc.

Temporary Exit to DOS:

Many times it would be nice or even necessary to execute a DOS command while in the program. As an example, you can't remember the subdirectory where your data is so you need to check several subdirectories or even diskettes. This option will quickly return to the system prompt and still keep your program and data in memory. When you are ready to return to the program, simply enter "exit". There is one important point to remember! Be certain that you have returned to the subdirectory that contains the engineering program before entering "exit".

Tools **F**iles **R**eports **O**ptions **Q**uit

Return to Engineering Menu
Exit to DOS System

Quit:

The response to "quit" can generate several responses depending upon how your particular system is set up. If the main "engmenu.exe" file is available, you might be offered an option of returning to the Engineering Menu, exiting to the operating system (which could be the DOS prompt, windows, or the batch file that originally called the hydrology tools program) or going directly to one of several other engineering programs. If this "engmenu.exe" file does not exist, you will simply be asked to confirm that you really do want to quit.

In any case, you will be warned if unsaved data has been entered so that you will have at least two chances to accidentally lose your data.

*** Technical Information ***

Drainage Curve Discharges:

The drainage curve discharge values are based on a curve fit scenario that was developed to match the values published in the NRCS Engineering Field Handbook - Chapter 14. The procedure uses the following equation with the coefficients listed in the table. These values are "hard coded" in the program and are not normally changeable.

$$Peak = e^{\left(a \cdot (Ln(Ac))^2 + b \cdot \ln(Ac) + c\right)}$$

e = 2.71828

Drainage Curve	Drainage Area	a	b	c
"A"	> 350 Ac.	-0.02521	0.947937	-0.04408
	<= 350 Ac.	0.001019	0.969817	-1.09068
"B"	<= 400 Ac.	-0.03221	1.278686	-2.39084
	> 950 Ac.	0.009232	0.543676	0.416784
	> 350 and <= 950 Ac.	-0.03297	0.948471	-0.36161
"C"	<= 350 Ac.	-0.08015	1.694746	-3.73142
	> 4100 Ac.	0.018345	0.50082	-0.27782
	> 350 and <= 4100 Ac.	0.101542	-0.7342	4.254433
"D"	> 600 Ac.	0.015636	0.581695	-1.16638
	<= 600 Ac.	-0.11165	1.970504	-4.76066

Format of Data Files:

The following information is provided for those of you who like to dig into the program files and figure out how they work or possibly make some sneaky edits to the data. The list below is a typical saved data file. Each line is followed by a line(s) contained in brackets ([]) that explain the line above. These "bracketed" lines will not be found in an actual data file. Some spaces have been added below to make it easier to read. **Keep in mind** that the quote and comma symbols are **very important** to the program.

```
"Data Version ...... ","H2O-1.0"    [used to evaluate format of data]
"Project Name ...... ","Roger Test"
"State ............. ","Ohio"
"County ............ ","Medina"
"Designer .......... ","cwl"
"Compared watersheds ",2,3          [indicates that watersheds number 2
                                      and 3 were used for comparison]
"Wadsworth","C  "
"Rittman","C  "
"Ellsworth","C  "
"EndOfSoils"
"Number of Areas ... ",3
"Region / County ..... ","Medina"   [region used for rainfall retrieval]
"Watershed Descrip ... ","Rogers Hydrograph"
"Curve Number ........ ",0,80,82    [Curve number method used and curve
                                      number for each method]
"Drainage Area ....... ",0,450,10   [Drainage are method used and results
                                      for each method]
"Time of Concentration ",0,1.4,0,0,0
                                    [Time of concentration method used
                                      and results of all three methods.]
"Rainfall Type ....... ",3
"Hydrograph Rainfall . ",0,4.5,0    [Rainfall determination method (enter
                                      or retrieve)and amount for each
                                      method]
"Delta D ............. ",.1         [time increment used for hydrograph
                                      calculation]
"Percent of PmP ...... ",0          [percent of probable maximum
                                      precipition, if used.]
"Percent Impervious Area ....",0,0,0,0
"Percent Unconnected ........",0,0,0,0  [values used to calculate user
                                          input curve number, for each
                                          hydrologic soil group.]
"Pervious Curve Number ......",0,0,0,0
"TR55 Meth Parameters "             [parameters used in TR-55, Tc
                                      calculation, if used]
0,0,0," ",0,0,0
0,0,0," ",0,0,0
"Land Use Data"                     [land uses & acreage for this
                                      watershed.]
3,"  Poor condition; grass cover < 50%       ",1,0,0,0
4,"  Fair condition; grass cover 50% to 75%  ",0,2,0,0
5,"  Good condition; grass cover > 75%       ",0,0,3,0
7,"  Paved lots; roofs, drives, streets      ",0,0,0,4
-999
"Region / County ..... ","Medina"   [Repeat as above for each subsequent
                                      watershed area.]
"Watershed Descrip ... ","Pre-Development"
"Curve Number ........ ",0,75,0
```

```
"Drainage Area ....... ",0,45,0
"Time of Concentration ",0,2,0,0,0
"Rainfall Type ....... ",3
"Hydrograph Rainfall . ",0,0,0
"Delta D ............. ",0
"Percent of PmP ...... ",0
"Percent Impervious Area ....",0,0,0,0
"Percent Unconnected ........",0,0,0,0
"Pervious Curve Number ......",0,0,0,0
"TR55 Meth Parameters "
0,0,0," ",0,0,0
0,0,0," ",0,0,0
"Land Use Data"
-999
"Region / County ..... ","Medina"   [Repeat as above for each subsequent
                                       watershed area.]
"Watershed Descrip ... ","Post Development"
"Curve Number ........ ",0,80,0
"Drainage Area ....... ",0,45,0
"Time of Concentration ",0,1.6,0,0,0
"Rainfall Type ....... ",3
"Hydrograph Rainfall . ",0,0,0
"Delta D ............. ",0
"Percent of PmP ...... ",0
"Percent Impervious Area ....",0,0,0,0
"Percent Unconnected ........",0,0,0,0
"Pervious Curve Number ......",0,0,0,0
"TR55 Meth Parameters "
0,0,0," ",0,0,0
0,0,0," ",0,0,0
"Land Use Data"
-999
```

Supporting Files:

HYDRO.STD

The following is an example of the data that is contained in the file named *"hydro.std"*. This data is maintained using the "Modify Defaults" option and any changes that are made will be saved in this file.

```
"*Preferred Curve Number Method*      ",1
"*Preferred Drainage Area Method*     ",1
"*Preferred Tc Method*                ",1
"*Preferred Rainfall Distribution*    ",3
"*Default Hydrograph Time Increment*  ",.1
"*Freq for determining critical storm*",1
"*Freq to control as critical*        ",2
"*Ranges of increased runoff by frequency*"
  10  20  50 100 250 500
```

HYDRO.ST2

The following is an example of the data that is contained in the file named *"hydro.st2"*. This data basically drives the hydrology tools program. The purpose of maintaining the data in such a file is that it can be modified when and if a need arises. This can be accomplished using a text editor. It is **very important** that the format and integrity of the file be maintained (commas, quotes, sometimes even spaces). It is strongly recommended that an original copy of the file be maintained prior to attempting any changes. If the program behaves strangely following modifications to this file, you can always fall back on the original version.

```
"*Program Version or Date*"     ,    "OH-Ver 1.0"
"*Date of last minor fix*"      ,    "5/10/98"
"*Maximum Drainage Area*"       ,     1000
"*Minimum Curve Number*"        ,       45
"*Maximum Curve Number*"        ,       99
"*Minimum Watershed Slope*"     ,         .1
"*Maximum Watershed Slope*"     ,       30
"*Minimum Watershed Length*"    ,       10
"*Maximum Watershed Length*"    ,    10000
"*Minimum Rainfall Amount*"     ,         .1
"*Maximum Rainfall Amount*"     ,       20
"*Surface flow codes and n values*"
"A" , 0.011
"B" , 0.05
"C" , 0.06
"D" , 0.17
"E" , 0.15
"F" , 0.24
"G" , 0.41
"H" , 0.13
"I" , 0.40
"J" , 0.80
"U" , 16.1345
"P" , 20.3282
```

Manning's "n" values used in the following formulae:

Sheet Flow: $T_t = \dfrac{0.007(n \cdot L)^{0.8}}{(P_2)^{0.5} \cdot s^{0.4}}$

Shallow Concentrated Flow: $V = n \cdot (s)^{0.5}$

Peak Discharges are calculated as the result of a mathematical curve fit the uses the following equation with the coefficients associated to the nearest Ia/P value:

$$\log(q_u) = C_0 + C_1 \cdot \log(T_c) + C_2 \cdot [\log \cdot (T_c)]^2$$

Where q_u = unit peak discharge (csm/in.
T_c = time of concentration in hrs.

```
"*Rainfall type  Ia/P      c0            c1          c2*"
    "I"    ,    0.1  ,   2.3055  ,     -0.51429 ,  -0.1175
    "I"    ,    0.2  ,   2.23537 ,     -0.50387 ,  -0.08929
    "I"    ,    0.25 ,   2.18219 ,     -0.48488 ,  -0.06589
    "I"    ,    0.3  ,   2.10624 ,     -0.45695 ,  -0.02835
    "I"    ,    0.35 ,   2.00303 ,     -0.40769 ,   0.01983
    "I"    ,    0.4  ,   1.87733 ,     -0.32274 ,   0.05754
    "I"    ,    0.45 ,   1.76312 ,     -0.15644 ,   0.00453
```

```
     "I"   ,    0.5  ,   1.67889 ,     -0.0693  ,   0
     "IA"  ,    0.1  ,   2.0325  ,     -0.31583 ,  -0.13748
     "IA"  ,    0.2  ,   1.91978 ,     -0.28215 ,  -0.0702
     "IA"  ,    0.25 ,   1.83842 ,     -0.25543 ,  -0.02597
     "IA"  ,    0.3  ,   1.72657 ,     -0.19826 ,   0.02633
     "IA"  ,    0.5  ,   1.63417 ,     -0.091   ,   0
     "II"  ,    0.1  ,   2.55323 ,     -0.61512 ,  -0.16403
     "II"  ,    0.3  ,   2.46532 ,     -0.62257 ,  -0.11657
     "II"  ,    0.35 ,   2.41896 ,     -0.61594 ,  -0.0882
     "II"  ,    0.4  ,   2.36409 ,     -0.59857 ,  -0.05621
     "II"  ,    0.45 ,   2.29238 ,     -0.57005 ,  -0.02281
     "II"  ,    0.5  ,   2.20282 ,     -0.51599 ,   0.01259
     "III" ,    0.1  ,   2.47317 ,     -0.51848 ,  -0.17083
     "III" ,    0.3  ,   2.39628 ,     -0.51202 ,  -0.13245
     "III" ,    0.35 ,   2.35477 ,     -0.49735 ,  -0.11985
     "III" ,    0.4  ,   2.30726 ,     -0.46541 ,  -0.11094
     "III" ,    0.45 ,   2.24876 ,     -0.41314 ,  -0.11508
     "III" ,    0.5  ,   2.17772 ,     -0.36803 ,  -0.09525
"EndRFType"


" Lines of Land Use Information ", 105  [It is important that this number
                                           matches the number of land use
                                           categories contained in the
                                           table.]
  1,"** Developed Urban Areas (VEG ESTAB.) ** ",  0,   0,   0,   0
  2,"Open space (Lawns,parks etc.)            ",  0,   0,   0,   0
  3,"  Poor condition; grass cover < 50%      ", 68,  79,  86,  89
  4,"  Fair condition; grass cover 50% to 75% ", 49,  69,  79,  84
  5,"  Good condition; grass cover > 75%      ", 39,  61,  74,  80
  6,"Impervious Areas                         ",  0,   0,   0,   0
  7,"  Paved lots; roofs, drives, streets     ", 98,  98,  98,  98
  8,"  Paved; roads, curbs and storm sewers   ", 98,  98,  98,  98
  9,"  Paved; open ditches (w/right-of-way)   ", 83,  89,  92,  93
 10,"  Gravel (w/ right-of-way)               ", 76,  85,  89,  91
 11,"  Dirt   (w/ right-of-way)               ", 72,  82,  87,  89
 12,"Urban Districts           Avg % imperv   ",  0,   0,   0,   0
 13,"  Commercial & business       85         ", 89,  92,  94,  95
 14,"  Industrial                  72         ", 81,  88,  91,  93
 15,"Residential districts     Avg % imperv   ",  0,   0,   0,   0
 16,"  1/8 acre lots (town houses) 65         ", 77,  85,  90,  92
 17,"  1/4 acre lots               38         ", 61,  75,  83,  87
 18,"  1/3 acre lots               30         ", 57,  72,  81,  86
 19,"  1/2 acre lots               25         ", 54,  70,  80,  85
 20,"    1 acre lots               20         ", 51,  68,  79,  84
 21,"    2 acre lots               12         ", 46,  65,  77,  82
 22,"Western Desert Urban Areas               ",  0,   0,   0,   0
 23,"  Natural desert (pervious areas only)   ", 63,  77,  85,  88
 24,"  Artifical desert landscaping           ", 96,  96,  96,  96
 25,"User defined urban (F9 to define)        ", -1,  -1,  -1,  -1
 26,"** Developing Urban Area (NO VEG) **     ",  0,   0,   0,   0
 27,"Newly graded area (pervious only)        ", 77,  86,  91,  94
 28,"** Cultivated Agricultural Lands **      ",  0,   0,   0,   0
 29,"Fallow                                   ",  0,   0,   0,   0
 30,"            Bare soil                ----", 77,  86,  91,  94
 31,"            Crop residue (CR)        poor", 76,  85,  90,  93
 32,"            Crop residue (CR)        good", 74,  83,  88,  90
 33,"Row crops                                ",  0,   0,   0,   0
```

```
34,"               Straight row (SR)      poor", 72,  81,  88,  91
35,"               Straight row (SR)      good", 67,  78,  85,  89
36,"               SR + Crop residue      poor", 71,  80,  87,  90
37,"               SR + Crop residue      good", 64,  75,  82,  85
38,"               Contoured (C)          poor", 70,  79,  84,  88
39,"               Contoured (C)          good", 65,  75,  82,  86
40,"               C + Crop residue       poor", 69,  78,  83,  87
41,"               C + Crop residue       good", 64,  74,  81,  85
42,"               Cont & terraced(C&T)   poor", 66,  74,  80,  82
43,"               Cont & terraced(C&T)   good", 62,  71,  78,  81
44,"               C&T + Crop residue     poor", 65,  73,  79,  81
45,"               C&T + Crop residue     good", 61,  70,  77,  80
46,"Small grain                               ",  0,   0,   0,   0
47,"               Straight row (SR)      poor", 65,  76,  84,  88
48,"               Straight row (SR)      good", 63,  75,  83,  87
49,"               SR + Crop residue      poor", 64,  75,  83,  86
50,"               SR + Crop residue      good", 60,  72,  80,  84
51,"               Contoured (C)          poor", 63,  74,  82,  85
52,"               Contoured (C)          good", 61,  73,  81,  84
53,"               C + Crop residue       poor", 62,  73,  81,  84
54,"               C + Crop residue       good", 60,  72,  80,  83
55,"               Cont & terraced(C&T)   poor", 61,  72,  79,  82
56,"               Cont & terraces(C&T)   good", 59,  70,  78,  81
57,"               C&T + Crop residue     poor", 60,  71,  78,  81
58,"               C&T + Crop residue     good", 58,  69,  77,  80
59,"Close-seeded legumes or rotation meadow  ",  0,   0,   0,   0
60,"               Straight row           poor", 66,  77,  85,  89
61,"               Straight row           good", 58,  72,  81,  85
62,"               Contoured              poor", 64,  75,  83,  85
63,"               Contoured              good", 55,  69,  78,  83
64,"               Cont & terraced        poor", 63,  73,  80,  83
65,"               Cont & terraced        good", 51,  67,  76,  80
66,"** Other Agricultural Lands **            ",  0,   0,   0,   0
67,"Pasture, grassland or range               ",  0,   0,   0,   0
68,"                                      poor", 68,  79,  86,  89
69,"                                      fair", 49,  69,  79,  84
70,"                                      good", 39,  61,  74,  80
71,"Meadow -cont. grass (non grazed)       ----", 30,  58,  71,  78
72,"Brush - brush, weed, grass mix            ",  0,   0,   0,   0
73,"                                      poor", 48,  67,  77,  83
74,"                                      fair", 35,  56,  70,  77
75,"                                      good", 30,  48,  65,  73
76,"Woods - grass combination                 ",  0,   0,   0,   0
77,"                                      poor", 57,  73,  82,  86
78,"                                      fair", 43,  65,  76,  82
79,"                                      good", 32,  58,  72,  79
80,"Woods                                     ",  0,   0,   0,   0
81,"                                          ", 45,  66,  77,  83
82,"                                      fair", 36,  60,  73,  79
83,"                                      good", 30,  55,  70,  77
84,"Farmsteads                             ----", 59,  74,  82,  86
85,"** Arid and Semiarid Rangelands **        ",  0,   0,   0,   0
86,"Herbaceous                                ",  0,   0,   0,   0
87,"                                      poor", -1,  80,  87,  93
88,"                                      fair", -1,  71,  81,  89
89,"                                      good", -1,  62,  74,  85
90,"Oak - aspen                               ",  0,   0,   0,   0
```

```
 91,"                                      poor", -1,  66,  74,  79
 92,"                                      fair", -1,  48,  57,  63
 93,"                                      good", -1,  30,  41,  48
 94,"Pinyon - juniper                          ",  0,   0,   0,   0
 95,"                                      poor", -1,  75,  85,  89
 96,"                                      fair", -1,  58,  73,  80
 97,"                                      good", -1,  41,  61,  71
 98,"Sagebrush (w/ grass understory)           ",  0,   0,   0,   0
 99,"                                      poor", -1,  67,  80,  85
100,"                                      fair", -1,  51,  63,  70
101,"                                      good", -1,  35,  47,  55
102,"Desert shrub                              ",  0,   0,   0,   0
103,"                                      poor", 63,  77,  85,  88
104,"                                      fair", 55,  72,  81,  86
105,"                                      good", 49,  68,  79,  84
```