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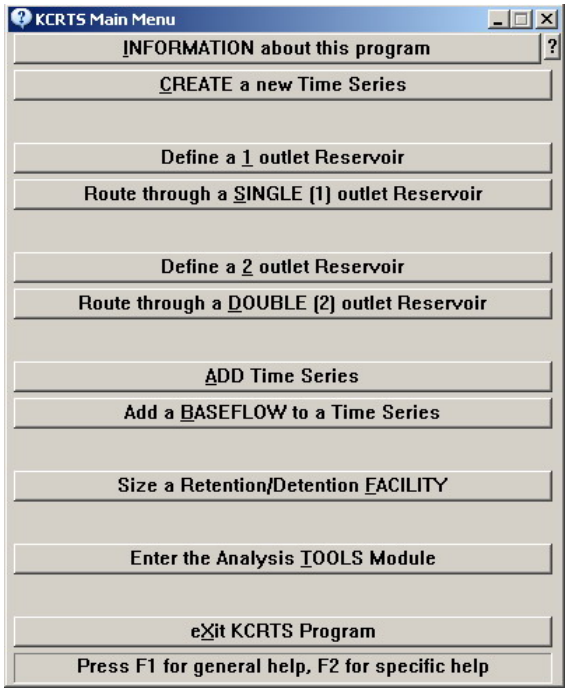
1. MAIN MENU DESCRIPTION

Start the program using one of the three methods described below. The Main Menu box should appear on the screen:



Activation of any of these routines will start from the Main Menu. Menu items can be selected by highlighting the item and pressing enter, or by pressing the letter shown in brackets to the left of the item title. The following is a brief description of the options listed on the menu (Figure 1). All menu choices are described in detail in subsequent sections.

1.1. INFORMATION ABOUT THIS PROGRAM

Selecting *Information About This Program* displays program information.

1.2. CREATE A NEW TIME SERIES

This routine scales and sums the unit-area runoff files for the pervious and impervious land segments specified by the user to create a single composite runoff time series representative of the drainage area. This menu item can be started by pressing the C key by selecting *Create a New Time Series*.

1.3. DEFINE A 1 OUTLET RESERVOIR

This routine creates a stage-storage-outflow table based on user specified values. The reservoir may have more than one release structure; however, all surface discharges are combined in a single stage-outflow relationship to be used within the single outlet routing routine. This menu item can be selected by pressing the 1 key or by selecting the menu item.

1.4. ROUTE THROUGH A SINGLE (1) OUTLET RESERVOIR

This routine creates an outflow time series from a user-specified inflow time series file and single outlet reservoir file (lake, pond, detention pipe, etc.). This routine is based upon the level pool routing technique described in *King County Surface Water Design Manual*. This menu item can be selected by pressing the S key or by selecting the menu item.

1.5. DEFINE A 2 OUTLET RESERVOIR

Same as Define a 1 outlet Reservoir, but modified to accommodate a split outflow from the reservoir, where the flows are directed to two different discharge locations. The user specifies one stage-storage and two stage-outflow relationships for the reservoir. This menu item can be selected by pressing the 2 key or by selecting the menu item.

1.6. ROUTE THROUGH A DOUBLE (2) OUTLET RESERVOIR

Same as Route through a SINGLE outlet Reservoir, but modified to create two outflow time series based on an inflow time series being routed through a reservoir with dual discharge locations. This routine is based upon the level pool routing technique described in *King County Surface Water Design Manual*. This menu item can be selected by pressing the D key or by selecting the menu item.

1.7. ADD 2 TIME SERIES

This routine scales and/or sums multiple time series together creating a single combined time series. The input time series are created by one of the time series program routines. Phasing relationships between the time series can be adjusted by inputting travel times (in even increments of the timestep) to a common point. This menu item can be selected by pressing the A key or by selecting the menu item.

1.8. ADD A BASEFLOW TO A TIME SERIES

This routine adds a constant baseflow to a time series created by one of the time series program routines. The baseflow is added to every timestep of the time series. This menu item can be selected by pressing the B key or by selecting the menu item.

1.9. SIZE A RETENTION/DETENTION FACILITY

This routine provides an approximate design for a retention/detention facility based on user-specified information. The facilities that can be sized include Retention/Detention Ponds, Retention/Detention Tanks, Detention Vaults, and Gravel Infiltration Trenches. Refer to the Section 7 for more information. This menu item can be selected by pressing the F key or by selecting the menu item.

1.10. ENTER THE ANALYSIS TOOLS MODULE

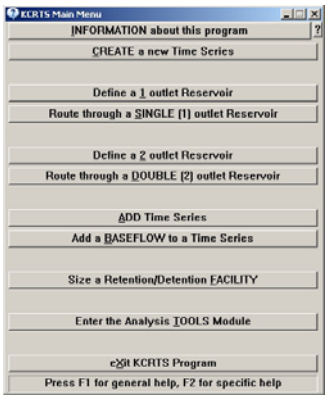
This is a collection of routines that analyzes time series created by one of the time series program routines. The routines include Extract/Plot Hydrographs, Compute/Plot/Compare Flow Durations, Compute/Plot Peaks and Flow Frequencies, and Compute Volumes of a Hydrograph. This menu item can be selected by pressing the T key or by selecting the menu item.

1.11. EXIT KCRTS PROGRAM

This option ends the program and returns the computer to the DOS prompt. This menu item can be selected by pressing the X key or by selecting the menu item.

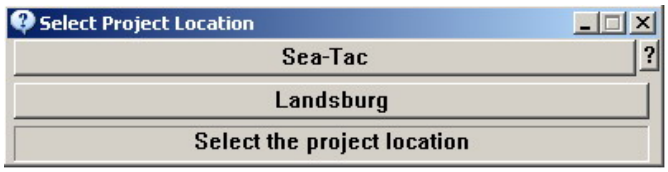
1.12. CLOSE EXEC FILE...CONTINUE INTERACTIVE

This option appears only when operating in the EXEC record mode. When selected, the program will continue interactively but further commands will not be saved to the EXEC file. When running the EXEC file, this EXEC file stops execution at this point, but continues running KCRTS in interactive mode. See The Getting Started section for information on the use of EXEC files.



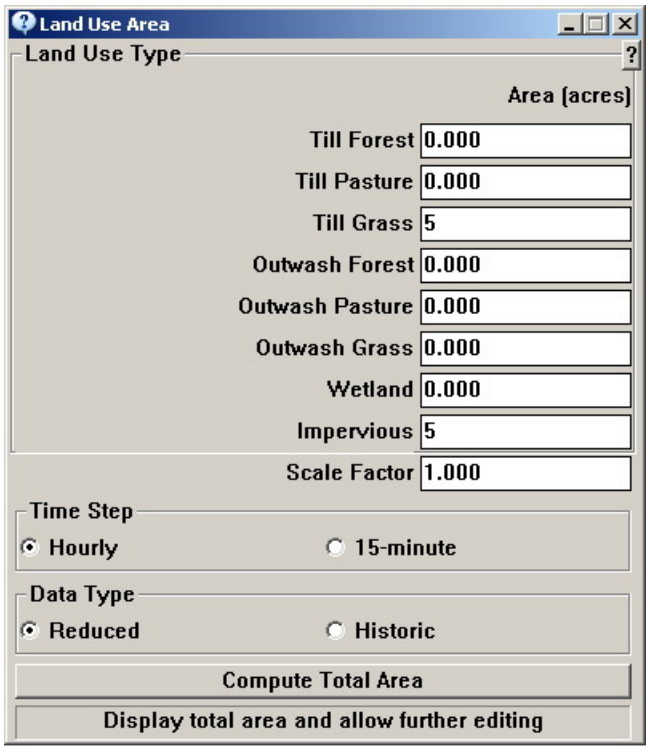
This menu item can be selected with the C key while in the Main Menu.

This routine generates a new time series by scaling and summing the HSPF-generated unit-area runoff files based upon user-specified input. The user may simulate existing, or predict future, runoff conditions from a catchment based on the catchments geographical location, soils, and land-use conditions. This basin information should be collected prior to using the program.



- **Project Location:** The user specifies the region in which the catchment is located by selecting the rain gauge to be used for this analysis. See Design Manual Figure 3.2-D for regional boundaries.

- **Land-Use Areas:** Specify the acreages for each of the soil/land-use combinations for the catchment being analyzed. Refer to Design Manual Table 3.2.2C to determine acceptable land-use assumptions.

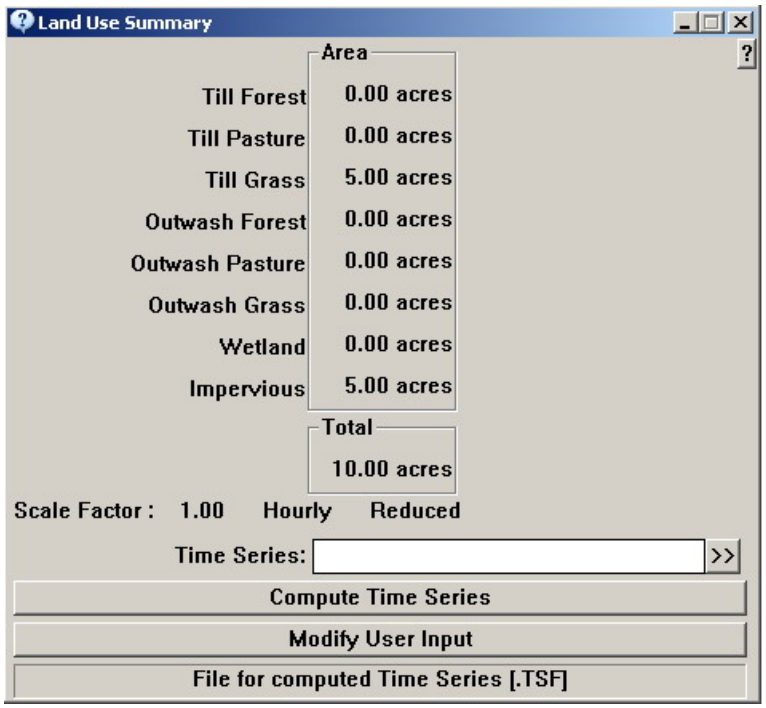


- **Regional Scale Factor:** Specify the regional scale factor. Refer to Design Manual Figure 3.2-D, Regional Scale Factor Map. Scale factors are used to account for the spatial variability of rainfall volumes across the County.
- **Time Step:** Logical choice between hourly and 15-minute to change the timestep, highlight the timestep line. To continue, use the up/down arrow keys.
  - Hourly timesteps: To be used for all new detention facility analysis. Also, appropriate for use with other volume-sensitive level-pool routing situations. Hourly timesteps are not acceptable for determining peak flows to be used for sizing of conveyance and overflow structures.
  - 15-minute timesteps: To be used for analysis of peak sensitive drainage features, such as conveyance and overflow structures. The 15-minute runoff records were developed using 15-minute precipitation records, synthetically created from the historical hourly records based on distributions from shorter 15-minute records at meteorologically similar rain gauges. 15-minute timesteps are not acceptable for determining allowable release rates from new detention facilities. 15-minute timesteps may be used for all developed conditions time series since R/D performance is mostly insensitive to the inflow timesteps.
- **Data Type:** Logical choice between reduced and historical records. To change the data format type, highlight the Data Type line. To continue, use the up/down arrow keys.
  - Reduced: Runoff files containing a set of 8 water years, selected for being statistically similar to the full historical record. The reduced records may be used for all hydrologic analyses except for the downstream volume sensitive point-of-compliance analysis.

- Historical: These are 40+ year records which include the full period of rain data available. These records will be updated periodically as additional meteorological data is obtained. These records are required to be used for downstream volume sensitive point-of-compliance analysis.

Compute Total Area: Select this option when all entries have been made.

KCRTS will now sum the areas inputted by the user and display the areas along with the total acreage. The next screen prompts the user to verify that the correct land use acreages were inputted and allows the user to return to the previous screen if corrections are needed.



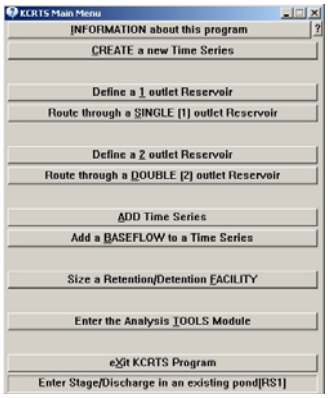
- **Edit Flow Paths (not shown):** Only available with 15-minute timesteps. For representative peak flows from the catchment, specify the lengths and slopes of the longest unconcentrated flowpath for each developed land use area. Leaving the data as zeroes will result in the program using the regular runoff files with default values shown in Table 2.1. Some soil-land use types may not have a prompt for the length and slope, in which case representative peak flows can be obtained from the regionalized parameters without site-specific calibration. When flowpath data has been entered, KCRTS utilizes a special set of runoff files containing the "rainfall excess" for each land-use type. The rainfall excess is the portion of the total rainfall that is available for surface runoff, but which has not been routed across the landscape to the point of concentration for the catchment being analyzed. KCRTS uses standard linear routing procedures in performing the surface routing.
- **Time Series File:** Specify a DOS filename for the time series to be generated. The extension is optional. If no filename extension is specified the program will add a TSF extension.
- **Compute Time Series:** Once the input data has been verified, select Compute Time Series to generate the time series file. The program will return to the KCRTS Main Menu.
- **Modify User Input:** This option returns the user to the previous screen. Select this option to edit data on the previous input screen.

Table 2.1 Developed Land-Use Covers – Default Surface Flow Path Parameters

Land-Use Type	Length (Feet)	Slope (Percent)
Till Grass	400	10%
Outwash Grass	400	5%
Impervious	200	2%

SECTION 3 - DEFINE A 1-OUTLET RESERVOIR/ ROUTE THROUGH A SINGLE (1) OUTLET RESERVOIR

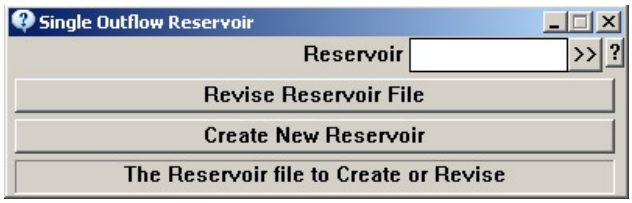
These routines allow the user to describe how a single outlet reservoir (lake, pond, detention pipe, etc.) attenuates flows from a contributing drainage basin. The user may create/modify a routing data file for a reservoir with a single outlet for use in the ROUTE routine. This routine is similar to *ROUTE 2 - Dual Outlet Reservoir Routing* (Page 13). The level pool routing technique used is described in the *King County Surface Water Design Manual* Section 3.2.4.



3.1 DEFINE A 1 OUTLET RESERVOIR [1]

This menu item can be selected with the "1" key while in the main menu.

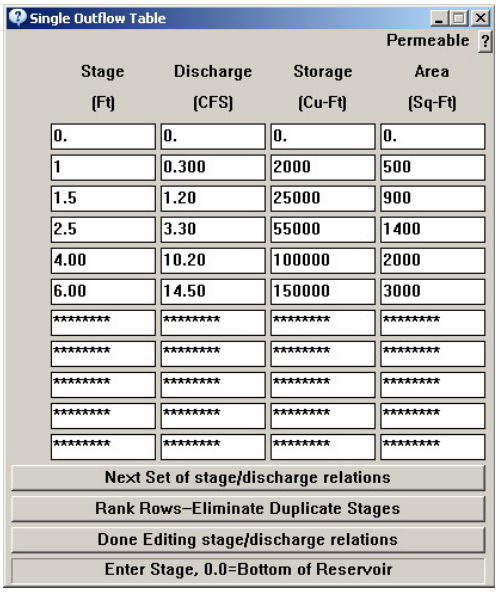
The user is prompted to enter the reservoir file name to be edited.



- **Reservoir (filename):** Specify the name of the reservoir file to be edited/created. The default extension is RS1. Note: The reservoir information from a standard R/D facility file can also be read into this routine.

Revise Reservoir File. Select this option to modify an existing reservoir file. At any time, you can cancel all edits by pressing the ESC key.

Create New Reservoir. Select this option to create a new reservoir definition. The user is presented with columns and rows of stage-discharge-storage-permeable area curves. Fill in the data as needed. The first record must be all zeros. The remaining records should be entered in increasing stage order. The user may choose any increment for the stages and the increment may vary. Each record must contain (in order) stage (ft), discharge (cfs), storage (cu ft), and perm-area (sq ft).



- **Stage:** The water surface elevation in relationship to the base elevation datum of the reservoir. First row must be zero and subsequent rows must have increasing stage values.
- **Discharge:** The outflow rate (cfs) from the reservoir at this stage. First row must be zero and subsequent rows must be equal to or greater than the preceding row.
- **Storage:** The reservoir cumulative storage volume (cu ft) at this stage. First row must be zero and subsequent rows must be equal to or greater than the preceding row.
- **Perm-Area:** The reservoir plan view surface area (sq ft) where vertical infiltration can occur at this stage. If infiltration is not being modeled, the column may contain all zeros. First row may be non-zero and subsequent rows must be equal to or greater than the preceding row.

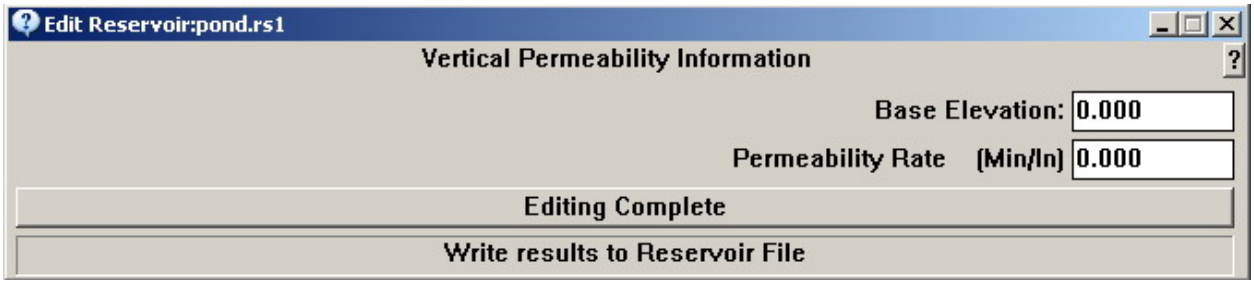
***Next Set of Stage/Discharge Relations*:** Select this option if additional rows are desired. There is a maximum of 20 rows of routing data per reservoir.

***Rank Rows—Eliminate Duplicate Stages*:** Select this option if the stages (first column) are not in ascending order. Rows can be deleted by changing the stage to 0.0 and selecting this option. To insert a row, add data to the bottom of the table and select this option.

- **To add new row*:*** insert new data in first blank row at bottom of existing data. Select this option and the new data will be moved up into the table based on the stage elevation.
- **To delete existing row:** Change the stage value of the row to be deleted to 0.0. When selected, this option looks for duplicate stage entries and will delete the second duplicate entry.

***Done Editing Stage/Discharge Relations*:** Select this option to continue once all routing data has been correctly entered.

The user is then prompted to enter the Base Elevation (elevation at 0 stage) and vertical permeability rate.



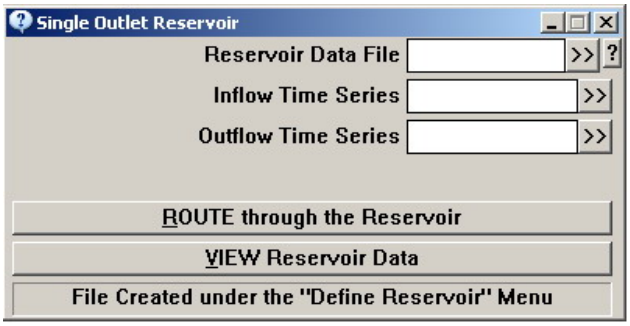
- **Base Elevation:** The elevation of the reservoir at stage = 0.0, usually based on KCAS datum.
- **Vertical Infiltration (Min/In):** The average vertical infiltration of the reservoir soils in minutes per inch. Vertical infiltration is the inverse of the design infiltration rate determined per Section 5.4 of the Surface Water Design Manual.

Editing Complete: Select this menu item to continue. All of the reservoir information will be saved to the reservoir file.

3.2 ROUTE THROUGH A SINGLE (1) OUTLET RESERVOIR [S]

This menu item can be selected with the [S] key while in the Main Menu.

The user is prompted to identify reservoir and time series data files to be used in the routing routine. This routing calculates a new outflow time series based on the inflow time series and reservoir data.

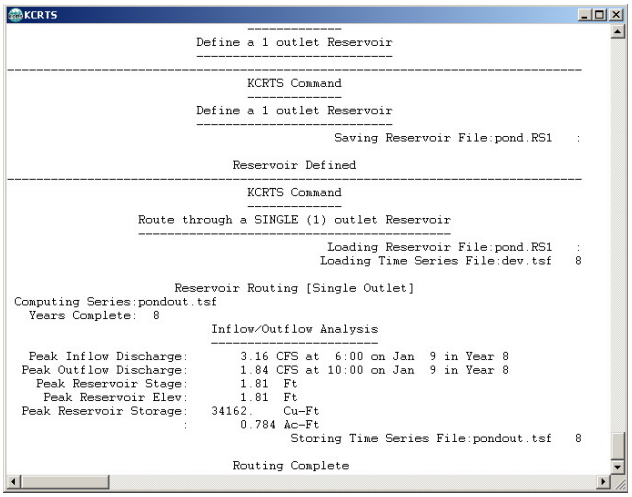


- **Reservoir Data File (filename):** Designate a reservoir file (see *Define a 1 Outlet Reservoir*) or a Retention/Detention facility. For a reservoir file, the extension does not need to be entered. A default extension of RS1 is assumed. For a Retention/Detention facility, the full name must be entered, including the extension RDF.
- **Inflow Time Series:** Enter the name of the time series file to be routed through the reservoir. A TSF extension is assumed.
- **Outflow Time Series:** Enter the name of outflow time series which is generated during routing. The TSF extension will be automatically added.

Review Reservoir Data: Select this option to review the reservoir data before routing.

Route through the Reservoir: Select this option to perform the reservoir routing.

The program calculates a new "outflow" time series based on the inflow time series and routing data. When the process is completed, the results will be displayed in the main KCRTS window:



```
KCRTS
                                  --------------
                         Define a 1 outlet Reservoir
                         ---------------------------
-----------------------------------------------------------------------------
                                 KCRTS Command
                                  --------------
                         Define a 1 outlet Reservoir
                         ---------------------------
                                     Saving Reservoir File:pond.RS1    :

                              Reservoir Defined
-----------------------------------------------------------------------------
                                 KCRTS Command
                                  --------------
                   Route through a SINGLE (1) outlet Reservoir
                   -------------------------------------------
                                     Loading Reservoir File:pond.RS1    :
                                    Loading Time Series File:dev.tsf   8

                        Reservoir Routing [Single Outlet]
 Computing Series:pondout.tsf
   Years Complete:  8
                           Inflow/Outflow Analysis
                           -----------------------
   Peak Inflow Discharge:       3.16 CFS at  6:00 on Jan  9 in Year 8
  Peak Outflow Discharge:       1.84 CFS at 10:00 on Jan  9 in Year 8
    Peak Reservoir Stage:       1.81  Ft
     Peak Reservoir Elev:       1.81  Ft
  Peak Reservoir Storage:   34162.    Cu-Ft
                         :       0.784 Ac-Ft
                                     Storing Time Series File:pondout.tsf   8

                              Routing Complete
```

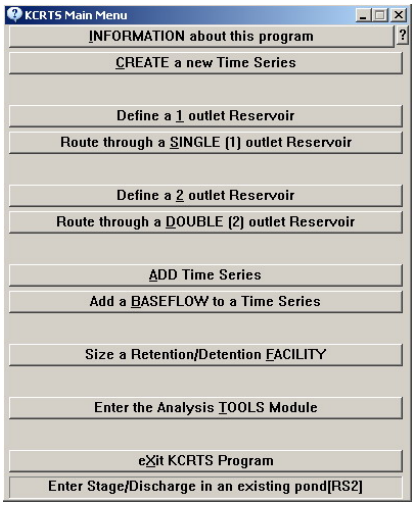
- **Peak Inflow Discharge (cfs):** The maximum inflow rate, including date and time, of the specified time series entering the reservoir.
- **Peak Outflow Discharge (cfs):** The maximum discharge rate from the reservoir, including date and time, for this outflow time series.
- **Peak Reservoir Stage And Elevation (ft):** The maximum water surface stage for this inflow time series and routing data. The Peak Reservoir Elevation is equal to the Peak Stage plus the Base Elevation specified in the routing data file.
- **Peak Reservoir Storage (cu-ft, ac-ft):** The maximum storage volume of the reservoir for this inflow time series in cubic-feet and acre-feet. The timing of the maximum storage volume (and water surface) coincides with the timing of the Peak Outflow Discharge.

CAUTION

Routing Data Has Been Extrapolated...: If this message is displayed, the inflow time series has exceeded the capacity of the reservoir. The program extrapolates the routing data to create a larger reservoir and continues execution. The extrapolation is based on the linear relationship between the last two data lines in the reservoir data table. The user should modify the reservoir data file to cover the full range of flows encountered.

SECTION 4 - DEFINE A 2-OUTLET RESERVOIR/ ROUTE THROUGH A DOUBLE (2) OUTLET RESERVOIR

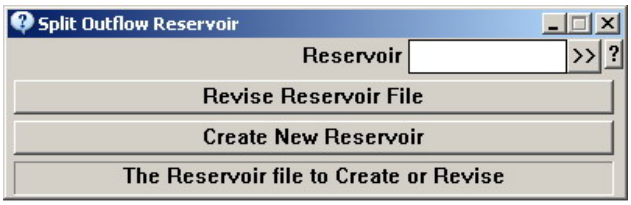
These routines allow the user to describe how a dual outlet reservoir (lake, pond, detention pipe, etc.) may attenuate flows from a contributing drainage basin. This routine is similar to ROUTE 1 - Single Outlet Reservoir Routing (Page 3-1). The level pool routing technique used is described in the *King County Surface Water Design Manual* Section 3.2.4.



4.1 DEFINE A 2-OUTLET RESERVOIR [2]

This menu item can be selected with the 2 key while in the main menu.

This option allows the user to create/modify a routing data file for a reservoir with dual outlets for use in the Route 2 Outlet routine.

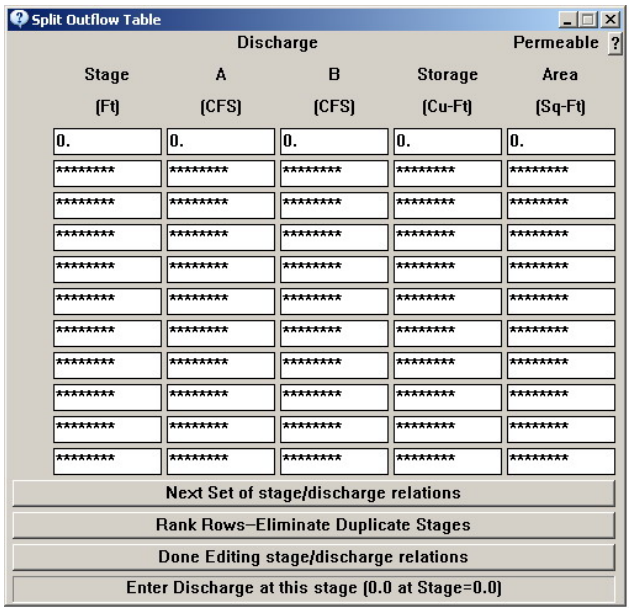


The user is prompted to enter the reservoir file to be edited. The default extension is RS2.

The user is presented with columns and rows of stage-discharge-storage-permeable area curves. Each record must contain (in order) stage (ft), discharge (cfs), storage (cu ft), and perm-area(sq ft). The first record must be all zeros. The remaining records should be entered in increasing stage order.

Revise Reservoir File: Select this option to modify an existing reservoir file.

Create New Reservoir: Select this option to create a new reservoir definition.



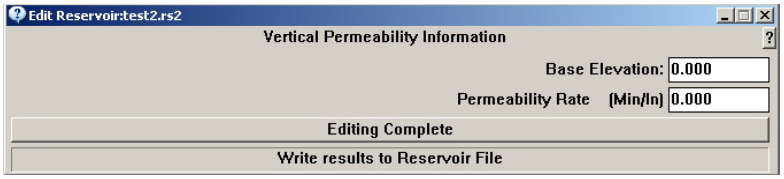
- **Stage:** The water surface height in relationship to the bottom elevation of the reservoir. First row must be zero and subsequent rows must have increasing stage values.
- **Discharge:** The surface outflow rate (cfs) from the reservoir at this stage. First row must be zero and subsequent rows must be equal to or greater than the preceding row.
- **Storage:** The reservoir cumulative storage volume (cu ft) at this stage. First row must be zero and subsequent rows must be equal to or greater than the preceding row.
- **Perm-Area:** The reservoir cumulative surface area (sq ft) where infiltration can occur at this stage. May be entered as all zeros unless infiltration is to be considered. If infiltration is not being modeled the column may contain all zeros. First row may be non-zero, subsequent rows must be equal to or greater than the preceding row.

***Next Set of Stage/Discharge Relations*:** Select this option if additional rows are desired. There is a maximum of 20 rows of routing data per reservoir.

***Rank Rows-Eliminate Duplicate Stages*:** Select this option if the stages (first column) are not in ascending order. Rows can be deleted by changing the stage to 0.0 and selecting this option. To insert a row, add data to the bottom of the table and select this option.

***Done Editing Stage/Discharge Relations*:** To continue once all routing data has been entered correctly, select this option.

The user is then prompted to enter Base Elevation (elevation at 0 stage) and infiltration data.



Base Elevation: The elevation of the reservoir at stage = 0.0, usually based on KCAS datum.

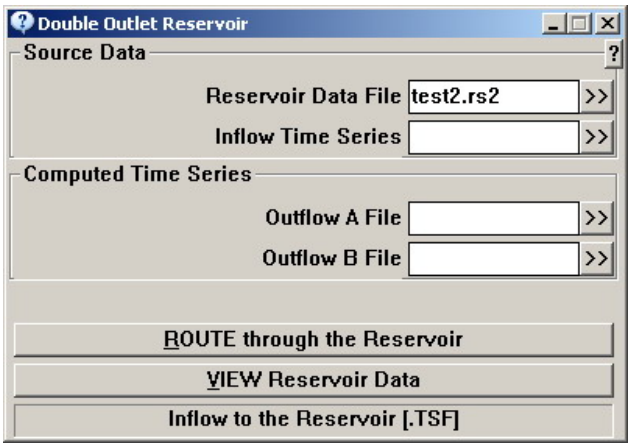
- **Vertical Infiltration (Min/In):** The average vertical infiltration of the reservoir soils in minutes per inch. Vertical infiltration is the inverse of the design infiltration rate determined per Section 5.4 of the Surface Water Design Manual.

Editing Complete: Select this menu item to continue. All of the reservoir information will be saved to the reservoir file.

4.2 ROUTE THROUGH A DOUBLE (2) OUTLET RESERVOIR

This menu item can be selected with the D key while in the Main Menu.

The program calculates two new "outflow" time series based on the inflow time series and reservoir data.

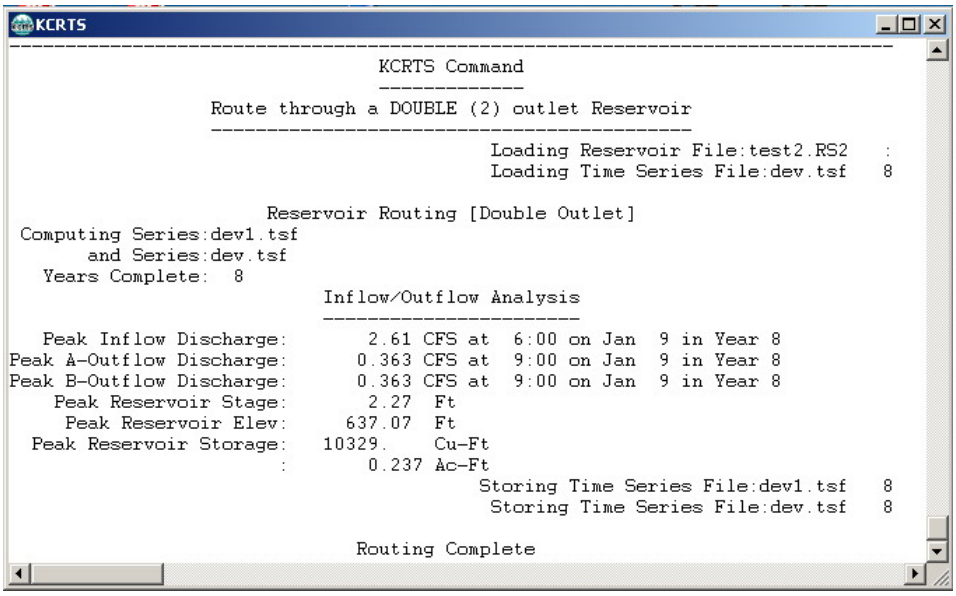


- **Reservoir Data File (filename):** Designate the reservoir file to be used in the routing. For a reservoir file the extension does not need to be entered, a default extension of RS2 is assumed.
- **Inflow Time Series (filename):** Enter the name of the time series to be routed through the reservoir. The TSF extension is assumed.
- **Outflow A File (filename):** Enter the name of the outflow time series which is generated at discharge point A. A TSF extension is automatically added by KCRTS.
- **Outflow B File (filename):** Enter the name of the outflow time series which is generated at discharge point B. A TSF extension is automatically added by KCRTS.

View Reservoir Data. Select this option to review the reservoir data before routing.

Route through the Reservoir. Select this option to perform the reservoir routing.

The program calculates two new outflow time series based on the inflow time series and the reservoir data. When the process is completed the following screen is shown in the main KCRTS window.

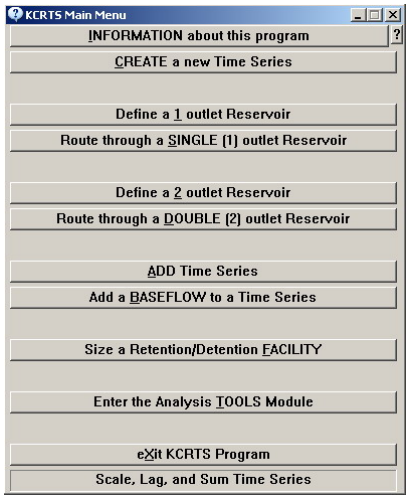


```
KCRTS
-----------------------------------------------------------------------------
                              KCRTS Command
                              -------------
                 Route through a DOUBLE (2) outlet Reservoir
                 -------------------------------------------
                                        Loading Reservoir File:test2.RS2   :
                                        Loading Time Series File:dev.tsf   8

                      Reservoir Routing [Double Outlet]
 Computing Series:dev1.tsf
       and Series:dev.tsf
   Years Complete:  8
                           Inflow/Outflow Analysis
                           -----------------------
   Peak Inflow Discharge:       2.61 CFS at  6:00 on Jan  9 in Year 8
Peak A-Outflow Discharge:      0.363 CFS at  9:00 on Jan  9 in Year 8
Peak B-Outflow Discharge:      0.363 CFS at  9:00 on Jan  9 in Year 8
    Peak Reservoir Stage:       2.27  Ft
     Peak Reservoir Elev:     637.07  Ft
  Peak Reservoir Storage:   10329.    Cu-Ft
                       :       0.237 Ac-Ft
                                        Storing Time Series File:dev1.tsf   8
                                         Storing Time Series File:dev.tsf   8

                            Routing Complete
```

- **Peak-Inflow (cfs):** The maximum inflow rate, including date and time, of the specified time series entering the reservoir.
- **Peak-Outflow (cfs) A:** The maximum discharge rate exiting the reservoir, including date and time for this outflow time series at discharge point A.
- **Peak-Outflow (Cfs) B:** The maximum hourly discharge exiting the reservoir, including date and time for this inflow time series at discharge point B.
- **Peak-Stage-Elev (ft):** The maximum water surface stage for this inflow time series and routing data. The Peak Reservoir Elevation is equal to the Peak Stage plus the Base Elevation specified in the routing data file.
- **Peak Reservoir Storage:** The maximum storage volume of the reservoir for this inflow time series in cubic-feet and acre-feet. The timing of the maximum storage volume (and water surface) coincides with the timing of the Peak Outflow Discharge.

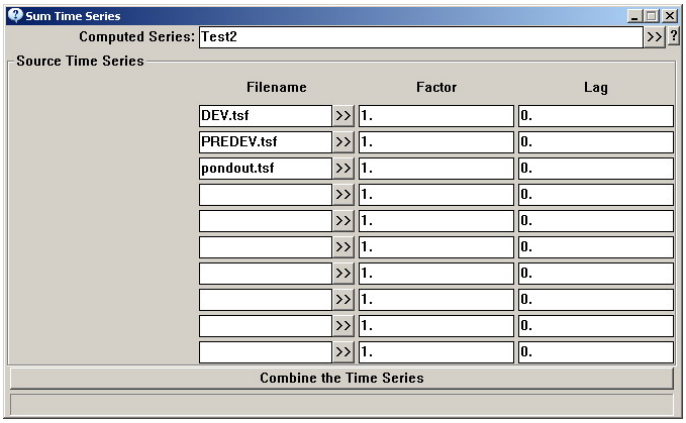
CAUTION

Routing Data Has Been Extrapolated...: If this message is displayed, the inflow time series has exceeded the capacity of the reservoir. The program extrapolates the routing data to create a larger reservoir and continues execution. The extrapolation is based on the linear relationship between the last two data lines in the reservoir data table. The user should modify the reservoir data file to cover the full range of flows encountered.



This menu item can be selected with the A key while in the Main Menu.

This routine allows the user to sum, scale, and lag existing time series files and create a new time series. The summing of time series allows the user to simulate the confluence of multiple drainage areas at a common point. Phasing and scaling of time series or a single time series can also be done.



Computed Series. Specify the filename of the time series to be created. If not specified, the program will add the TSF default extension.

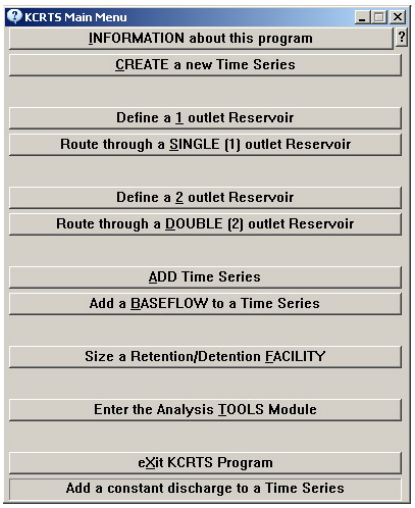
Source Time Series:

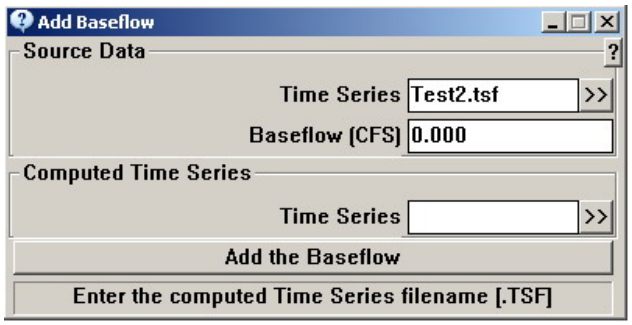
- **Filename.** Specify the filenames of the time series to be summed. The TSF extension is assumed. If only one filename is given, that time series will be scaled and lagged based on the user's input.
- **Multiplying Factor.** Scale factors can be used to create a time series with different total areas but identical land-use composition. For example, a time series file for a 10-acre site with 40% impervious and 60% grass can be created from a time series created for a 100-acre site with the same percent land use by scaling the larger time series by 0.1. To scale a time series edit the Multiplying Factor default value of 1.0.

- **Lag Time.** By specifying a lag time, the user accounts for the travel times of the drainage areas to a common point of interest. Time lags can be entered in even increments of the timestep being used. Travel time of less than 1 timestep should be entered as zero.
- **Combine the Time Series.** Select this menu item to generate the Computed Time Series file. Once executed the program will return to the Main Menu and the results will be displayed in the Main KCRTS window.

This menu item can be selected with the [B] key.

This routine allows the user to add a baseflow to a time series. A constant flow is added to every timestep in the time series file. The input is an existing time series and a baseflow. The output is a new time series.

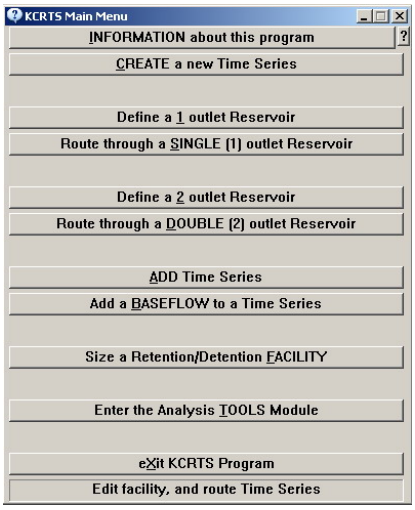




- **Source Data Time Series (filename):** Enter the name of the time series to which the base flow is to be added.
- **Computed Time Series (filename):** Enter the name of the time series which is created when the base flow is added.

Add the Baseflow: Select this menu item to execute command and save the computed time series.

This menu item can be selected with the "F" key while in the main menu.



The following R/D facility design routines are useful tools for the preliminary sizing of various retention and detention facilities including: ponds, tanks, vaults, infiltration ponds, infiltration tanks, and gravel trench/beds.

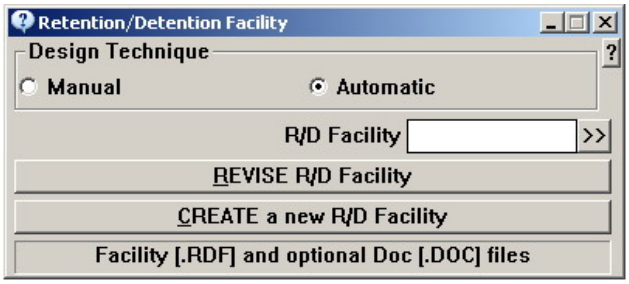
These routines substantially reduce the amount of time required to perform laborious and tedious calculations and eliminate associated mathematical errors. They allow an engineer to analyze a variety of situations and can be used to compare design options. It is important to understand that the results only reflect the data read by the program and are no more accurate than the judgment of the designer/modeler when input information is chosen. The designer/modeler should not blindly rely on these tools but should use them as supplemental aids to proper analysis and design.

7.1 WHAT THE R/D FACILITY DESIGN PROGRAM CAN DO

The routines within this program can aide the designer in developing preliminary sizing and routing characteristics for developing the layout of various detention facilities and control structures. In the automatic sizing mode, the program determines the storage volume required for a single storm event called the primary design hydrograph (PDH) and the specified maximum allowable (target) release rate for that event. The target release rate and facility depth sets the size of the upper orifice. The PDH is then iteratively routed through facilities of varying size until the full storage depth is utilized and the target discharge is met. This yields the minimum storage volume required to meet the target discharge for the storm specified as the PDH (i.e., 10-year outflow event). The routine then routes several other storm event hydrographs through the facility and displays the results. The designer can use these additional hydrographs to iteractively size additional orifices to meet other performance objectives (i.e., control 2-year discharges). Detailed examples of facility sizing procedures and strategies are included in the KCRTS User's Guide.

7.2 FACILITY SIZING

When this menu item is selected from the main menu, the following screen appears.



- **Design Technique.** The user chooses between *Automatic* and *Manual* mode.

  In *Automatic* mode, the program designs the smallest facility that will route the Primary Design Hydrograph through the facility while maintaining the Primary Target Release Rate.

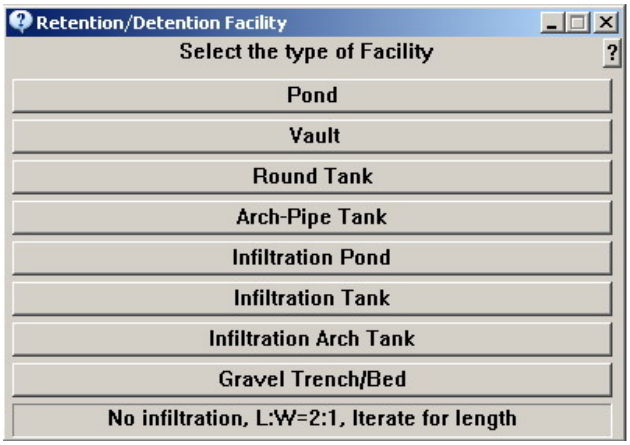
  Manual mode is similar to the automatic mode except the user controls all of the facility parameters, including the bottom area and orifice sizes. This mode is useful for fine-tuning duration matching facilities.

- **R/D Facility (filename).** The user specifies the name of the file to which the facility design information is to be stored. KCRTS assumes or will add an RDF extension if one is not given. Facility files may be used in the Route 1 Outlet routine or time series routing may be done within Size A Facility.

Create a new R/D Facility. Select this item to design a new facility. All information will be zeroed, and the user will begin entering the facility information.

Revise R/D Facility. Select this item to edit an existing facility, enter the existing filename and select. An existing facility may be edited and saved to a different filename without losing the original facility data file.

If *Create a new R/D Facility* is chosen, the following screen appears.



- Select the type of facility to be sized.

The following sections describe the different facility types and the user input required for each.

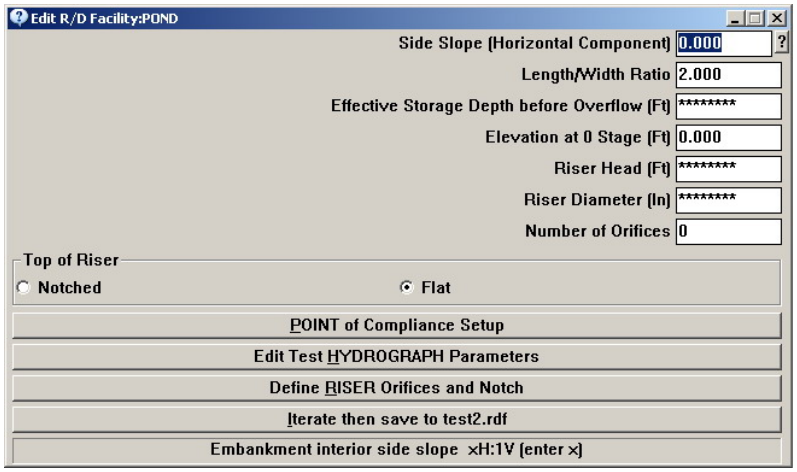
Note: The following selections appear at the bottom of the data input screens for all facility types.

Point of Compliance Setup
Edit Test Hydrograph Parameters
Define Riser Orifices and Notch
Iterate then save to (Filename)

Refer to Section 7.2.7 for a description of these options.

7.2.1 POND

This type of facility has a trapezoidal cross-section with a rectangular bottom. The default bottom area length-to-width ratio is 2:1. The side slopes are constant and identical for all sides. The following screen appears when this facility type is selected.

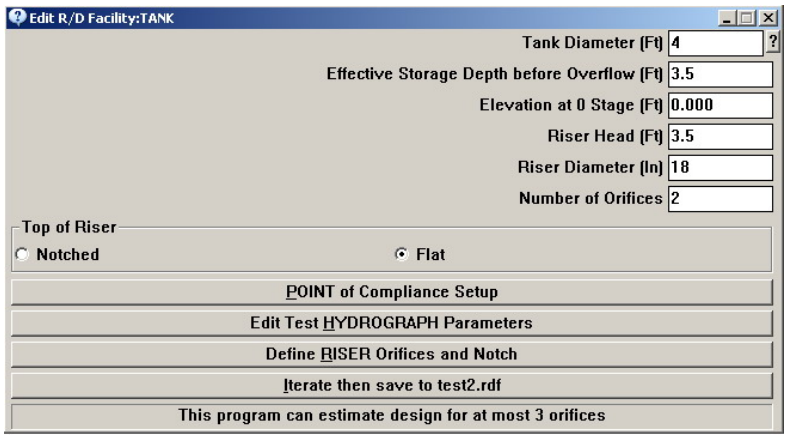


- **Side Slope (Horizontal Component).** The side slope is a ratio of the horizontal component to the vertical component. The vertical component is set at 1. For example, for a facility with a 3-to-1 side slope, the user would enter 3 for the horizontal component.
- **Length/Width Ratio.** Equal to facility length divided by facility width. The L/W ratio is measured at the bottom of the live storage. The ratio can be set between 1 and 10. The default ratio is 2.0.
- **Bottom Width/Length/Area (Sq Ft).** The bottom width/length/area only appears when using the facility design routine in Manual mode. It is adjusted to control the volume of the pond. KCRTS uses the following rules in handling these variables.
  - **Bottom Length and Width specified. Bottom Area not specified.** KCRTS saves the length and width specified. Displays showing L/W ratio or bottom area are calculated based on these values.
  - **Bottom Length, Width, and Area specified.** KCRTS will use the ratio of the length/width and then calculate a new bottom length and width based on bottom area and L/W ratio. (To specify a 20,000 square foot bottom area at 6:1 L/W ratio, set Length =6, Width=1, and Area=20000.)
  - **Bottom Length and Area specified.** KCRTS calculates the bottom width based on area and length specified. If resulting L/W ratio is less than 1.0, KCRTS will swap the Length and Width to maintain a ratio greater than 1.0.
  - **Bottom Width and Area specified.** KCRTS calculates the bottom length based on area and width specified. If resulting L/W ratio is less than 1.0, KCRTS will swap the Length and Width to maintain a ratio greater than 1.0.
  - **Bottom Area specified only.** KCRTS will use default 2:1 L/W ratio and calculates bottom length and width.

- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of the facility reservoir, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero. Elevation adjustments do not affect the size of the facility.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically, the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows. Riser diameter does not affect the size of the facility.
- **Number of Orifices.** The number of orifices can vary from 1 to 3. For most designs, 2 orifices are adequate.
- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3.4 of the *King County Surface Water Design Manual* for equations used. It is recommended that the Flat option be used for all iterative sizing and that if the final elevation of the uppermost orifice is unfeasible, to switch the design mode to manual before replacing the upper orifice with a notched release structure.

7.2.2 TANK

A tank is simulated in KCRTS as a horizontal cylindrical structure. The following screen appears when this facility type is selected.

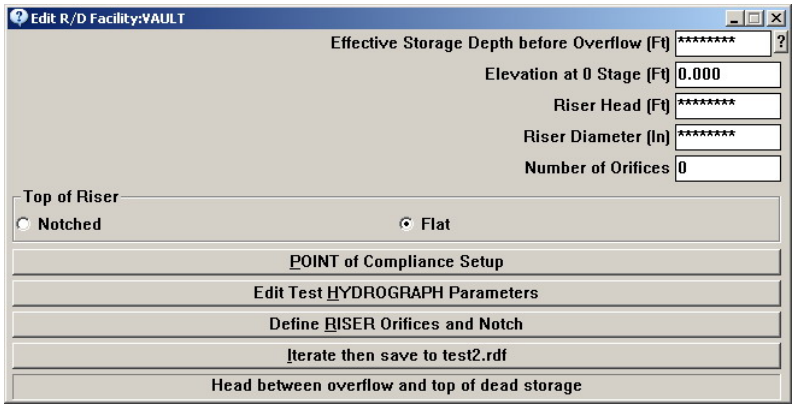


Tank Diameter (Ft). The tank diameter is the inside diameter of the tank.

- **Tank Length (Ft).** The tank length only appears when using the facility sizing routine in Manual mode. It is adjusted to control the volume of the tank.
- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of the facility, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically, the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows.
- **Number of Orifices.** The number of orifices can vary from 1 to 3. For most designs, 2 orifices are adequate.
- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3 of the *King County Surface Water Design Manual* for equations used. It is recommended that the Flat option be used for all iterative sizing and that if the final elevation of the uppermost orifice is unfeasible, to switch the design mode to manual before replacing the upper orifice with a notched release structure.

7.2.3 VAULT

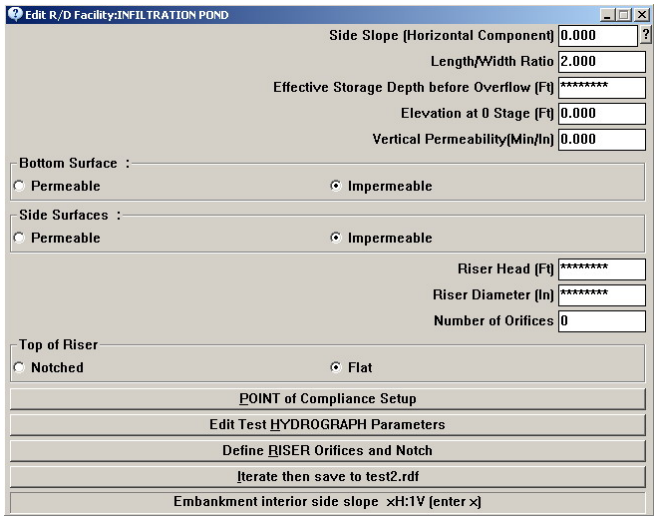
A vault is simulated as a rectangular storage structure. The following screen appears when this type of facility is selected.



- **Bottom Length (Ft), Bottom Width (Ft), Bottom Area (Sq Ft).** These parameters only appear when in Manual mode of Size a Facility, and are used to control the volume of the facility.
- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of the facility, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically, the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows.
- **Number of Orifices.** The number of orifices can vary from 1 to 3. For most designs, 2 orifices are adequate.
- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3 of the *King County Surface Water Design Manual* for equations used. It is recommended that the Flat option be used for all iterative sizing and that if the final elevation of the uppermost orifice is unfeasible, to switch the design mode to manual before replacing the upper orifice with a notched release structure.

7.2.4 INFILTRATION POND

The infiltration pond is similar to the Pond described in the previous section. The infiltration pond can facilitate infiltration of water through the bottom and side walls of the facility. The following screen appears when this facility type is selected.

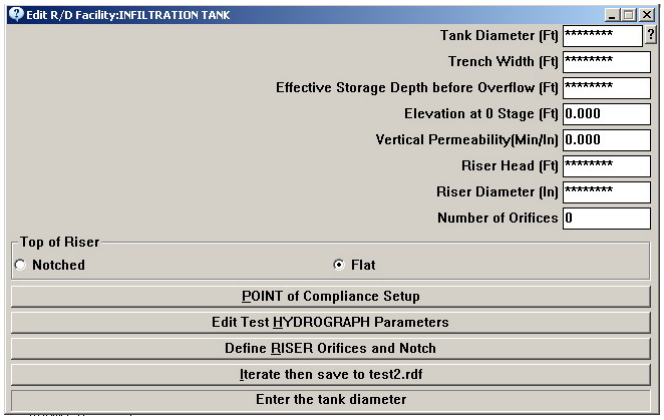


- **Side Slope (Horizontal Component).** The side slope is a ratio of the horizontal component to the vertical component. The vertical component is set at 1. For example, for a facility with a 3-to-1 side slope, the user would enter 3 for the horizontal component.
- **Bottom Length, Width, and Area (Sq Ft).** The bottom length/width/area only appears when using the facility design routine in Manual mode. They are adjusted to control the volume and Length/Width ratio of the pond. Infiltration Pond routine uses the same data input protocol as the Pond Routine, see Section 7.2.1.
- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of the facility, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero.
- **Vertical Infiltration (Min/In):** The average vertical infiltration of the reservoir soils in minutes per inch. Vertical infiltration is the reciprocal of the design infiltration rate determined per Section 5.4 of the Surface Water Design Manual.
- **Bottom Surface/Side Surfaces (Permeability).** The user specifies which portions of the facility are permeable. The space bar can be used to toggle between permeable and impermeable.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth, during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows.
- **Number of Orifices.** The number of orifices from 1 to 3. For most designs, 2 orifices are adequate. For infiltration facilities, the bottom orifice may be set above 0.0 or the number of orifices set to zero.

- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3 of the *King County Surface Water Design Manual* for equations used.

7.2.5 INFILTRATION TANK

The Infiltration Tank is similar to the Tank described in a previous section. The infiltration tank allows for infiltration through the bottom half of the tank. The following screen appears when this facility type is selected.

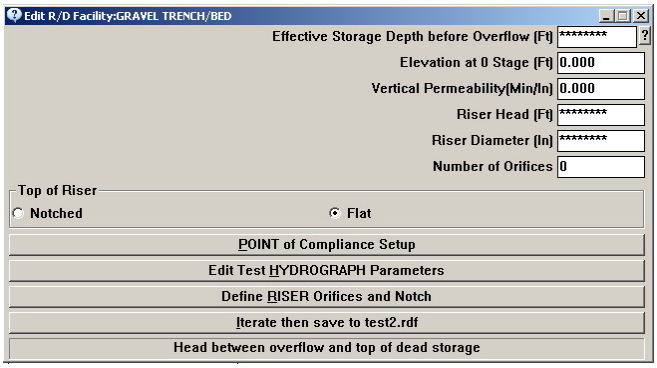


- **Tank Diameter (Ft).** The tank diameter is the inside diameter of the tank.
- **Tank Length (Ft).** The tank length only appears when using the facility sizing routine in Manual mode. It is adjusted to control the volume of the tank.
- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of facility, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero.
- **Vertical Infiltration (Min/In):** The average vertical infiltration of the reservoir soils in minutes per inch. Vertical infiltration is the reciprocal of the design infiltration rate determined per Section 5.4 of the Surface Water Design Manual.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically, the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows.
- **Number of Orifices.** The number of orifices from 1 to 3. For most designs, 2 orifices are adequate. For infiltration facilities, the bottom orifice may be set above 0.0, or the number of orifices set to zero.
- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3 of the *King County Surface Water Design Manual* for equations used. It is recommended that the Flat option be used for all iterative sizing and that if the final elevation of the uppermost orifice is unfeasible, to switch the design mode to manual before replacing the upper orifice with a notched release structure.

7.2.6 GRAVEL TRENCH/BED

A Gravel Trench/Bed is rectangular with vertical side walls. Infiltration occurs through the bottom of this type of facility. The following screen appears when this facility type is selected.

- **Bottom Length (Ft), Bottom Width (Ft)**. These parameters only appear in Manual mode of Size a Facility, and are used to control the volume of the facility.
- **Bottom Area (Sq Ft).** The bottom area only appears when using the facility design routine in Manual mode. It



  is adjusted to control the volume of the trench. KCRTS maintains a 30 percent void ratio in the gravel trench.
- **Effective Storage Depth before Overflow (Ft).** The effective storage depth is the depth of the active storage in the facility. It does not include "dead" storage at the bottom of facility, nor any depth needed for head on overflow structures or "freeboard."
- **Elevation at Stage 0.0 (Ft).** The elevation at stage 0.0 is the elevation at the bottom of the effective storage depth. It may be an actual elevation tied to a common datum or it may be zero.
- **Vertical Infiltration (Min/In):** The average vertical infiltration of the reservoir soils in minutes per inch. Vertical infiltration is the reciprocal of the design infiltration rate determined per Section 5.4 of the Surface Water Design Manual.
- **Riser Head (Ft).** The riser head is the height of the riser control structure measured from the 2-year normal flow depth in the outfall pipe. Typically, the designer will equate the 2-year flow depth to the pipe invert for calculation purposes and then lower the pipe invert by a dimension equivalent to the flow depth during the detailed design stage. Riser heads greater than the effective storage depth implies the invert of the outfall pipe is lower than the bottom of the storage reservoir.
- **Riser Diameter (In).** The riser diameter is the inside diameter of the riser. This sets the overflow capacity of the facility for calculation purposes. The routine does not simulate spillway overflows.
- **Number of Orifices.** The number of orifices from 1 to 3. For most designs, 2 orifices are adequate. For infiltration facilities, the bottom orifice may be set above 0.0 or the number of orifices set to zero.
- **Top of Riser.** The user may specify the top of the orifice as Flat or Notched. Refer to Section 5.3 of the *King County Surface Water Design Manual* for equations used. It is recommended that the Flat option be used for all iterative sizing and that if the final elevation of the uppermost orifice is unfeasible, to switch the design mode to manual before replacing the upper orifice with a notched release structure.

7.2.7 ADDITIONAL FACILITY INFORMATION

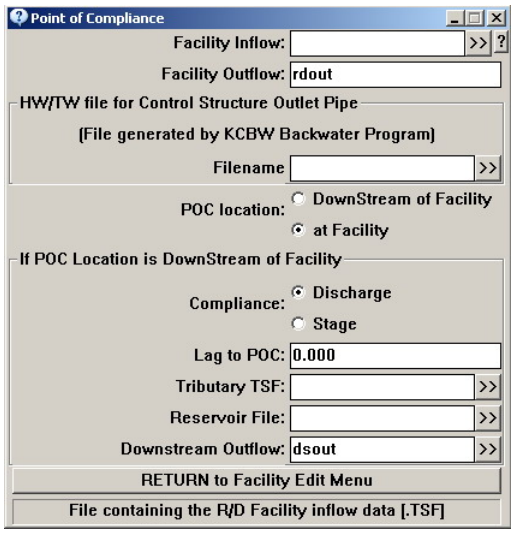
The menu items which appear at the bottom of the facility data input screens and are described in the following sections:

Point of Compliance Setup - Section 7.2.7.1
Edit Test Hydrograph Parameters - Section 7.2.7.2
Define Riser Orifices and Notch - Section 7.2.7.3
Iterate then save to (Filename) - Section 7.2.7.4

7.2.7.1 Point of Compliance Setup

The Point of Compliance setup includes the specification of all timeseries files to be used in sizing the facility as well as allowing the designer/modeler to adjust where compliance with the applicable performance standard will be achieved. Under some circumstances, the "point-of-compliance" is not measured at the outflow from the facility, but rather at some point downstream of the facility. In Automatic sizing mode, the Iteration routine can be used to directly size a facility such that a specified downstream condition is achieved. This enhanced iteration feature is only available in KCRTS Version 4.2x and later. This item can be selected by pressing the P key. When selected, the following screen appears:

- **Facility Inflow.** The user is prompted to enter the filename of the inflow time series to be routed through the facility. A TSF extension is assumed. This timeseries includes all runoff which under developed condition will flow through the facility.



- **Facility Outflow.** To change the outflow time series filename, highlight the *Facility Outflow* line. Overwrite the existing filename with the new filename (filename extensions are handled by KCRTS).

The default setup is to save the outflow time series to filename RDOUT.TSF. The downstream point-of-compliance is turned off, and no analysis will be performed. The file overwrite notification is turned off, so all previous runs using the same outflow time series name will be automatically overwritten with the most current facility performance.

- **HW/TW file for Control Structure (optional).** This option allows the designer to consider tailwater effects of the downstream drainage system on the discharge capacity of the control structure. By leaving this item blank, the designer/modeler is assuming that the outlet from the control structure is a free outfall with no tailwater effects. If designed with a free outfall assumption, a final design adjustment to the control structure outlet is recommended. The recommended adjustment is to lower the invert of the control structure outlet pipe by a distance equal to the 2-year headwater on the outlet pipe, making the actual operating head of the orifices closer to the assumption of free outfall.
- **POC =.** This defines where the point of Compliance [POC] calculations are to be performed. The default point of compliance is at the facility outflow. POC= *Facility Outflow*. If designing to a downstream point of compliance (common downstream POC situations described below), the POC should be toggled to *Downstream Outflow*.

If the project contains developed areas which will bypass the R/D facility:

The POC is defined as the point where bypassed flows and facility outflows recombine (usually at the project site boundary), which is downstream of the R/D facility. To verify performance, the bypass time series must be added to the facility outflow time series prior to assessing compliance with the regulatory standard. The following steps will set up the auto analysis to assess performance at the POC.

- **POC=** Using the spacebar, toggle to *Downstream*.
- **Compliance:** Set to *Discharge* for bypass area analysis to match the predeveloped discharge conditions at the point of compliance.
- **Lag to POC:** Enter the travel time for the facility outflows to travel to the POC. Travel times, or lags, can be specified in even increments of the timestep.
- **Tributary TSF:** Enter the filename of the time series file, which includes onsite areas tributary to the POC but not tributary to the R/D facility. If more than one non-detained tributary area is present, these can be summed by using the [A] Add 2 Time Series routine, of the Main Menu, before setting up the Auto Analysis.
- **Reservoir File:** Leave blank for bypass area scenario.
- **Downstream Outflow:** Specify a filename for the time series, representing developed flows at the POC. The default filename is DSOUT. For this scenario DSOUT will be the sum of RDOUT.TSF and the Tributary bypass TSF.

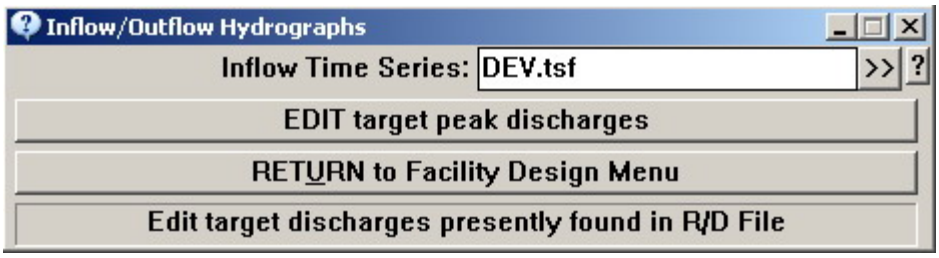
If the project discharges to a downstream volume sensitive flooding problem:

The POC is defined at the outfall of the reservoir file defining the flooding area. To verify performance, the discharges and storage volumes at different water levels in the POC must be determined and inputted into a Route 1 Outlet data file (RS1) prior to assessing compliance with the regulatory standard. The following steps will set up the auto analysis to assess performance at the POC.

- **POC=** Using the spacebar, toggle to *Downstream.*
- **Compliance:** Set to *Stage* to match existing stage elevations in the downstream reservoir. Set to *Discharge* to match existing surface discharge conditions from the downstream reservoir.
- **Lag to POC:** Enter the travel time for the facility outflows to travel to the POC. Travel times, or lags, can be specified in even increments of the timestep.
- **Tributary TSF:** Enter the filename of the time series, which is the entire runoff tributary to the POC but not tributary to the R/D facility. If the facility outflow is the sole source of runoff to the downstream system, leave the line blank. If more than one off-site or on-site bypass tributary areas are present, these can be summed and lagged by using the [A] Add 2 Time Series routine, of the Main Menu, before setting up the Auto Analysis.
- **Reservoir File:** Specify the filename of the reservoir file defining the stage-storage-discharge at the POC. This file must be in the single outlet (RS1) format. See section 3.1 for details on creating a single outlet reservoir file.
- **Downstream Outflow:** Specify a filename for the time series, representing the developed outflows from the POC reservoir. The default filename is DSOUT. The reservoir inflow is the sum of RDOUT.TSF and the Tributary TSF. The reservoir inflow is not saved. For this scenario, DSOUT will be the routed outflow from the downstream reservoir.

7.2.7.2 Edit Test Inflow Hydrograph Parameters

The Test Inflow Hydrograph List is a list of storm events which can be used in place of the entire time series for sizing of retention/detention facilities in Automatic mode. In Automatic mode, the iteration routine will update the list of events to include the annual peak DISCHARGE events at the point of compliance. The designer can use these event hydrographs to completely size a Level 1 detention facility and to initially size a Level 2 detention facility. Also, this is where the user can adjust the length of the test inflow hydrographs by changing the size of the Event Window. Select this option and the following screen appears:



- **Inflow Time Series.** The program displays the inflow timeseries file specified by the user in the Point of Compliance Setup screen. The filename of the inflow timeseries can be changed in either location. A TSF extension is assumed.
- **Event Window.** Controls the length of the test inflow hydrographs in units of months. For most designs, this can be left set to 1. The program will automatically increase the event window if the iteration routine determines that the facility is subject to prefilling before the start of the test hydrograph. By increasing the length of the hydrograph event window, the storm event(s) causing the prefilling will be included in the test hydrograph(s).

7.2.7.2.1 EDIT TARGET PEAK DISCHARGES

Select this option to extract the event dates from the inflow time series and to specify the Primary Design Hydrograph (PDH) and target release rates. The program will create a list of annual peak events in ranked descending order corresponding to the 8 peak annual runoff events found in the inflow time series. **WARNING:** Selection of this option resets the entire test hydrograph list including target release rates and primary design hydrograph number. The test inflow hydrographs are organized based on their relative ranking as follows.

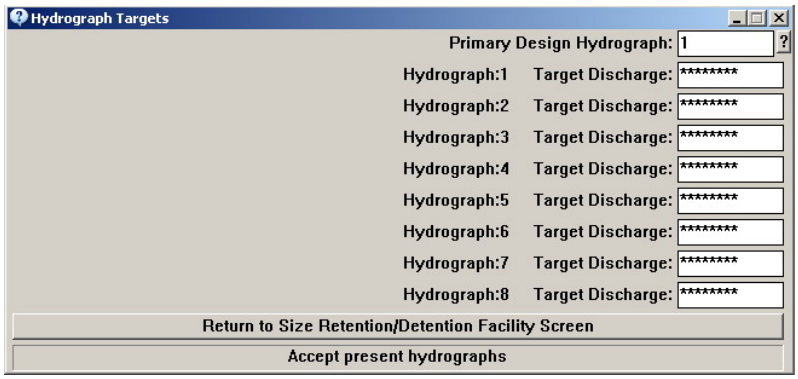
Since the facility must be sized to control the events that create the highest outflows (annual peak outflow events), modifications to the hydrograph list may be necessary. Once the initial facility is sized, it is necessary to route the full time series and to update the event dates based on the actual outflow time series rather than inflow time series. KCRTS performs this event date verification automatically during the automatic sizing iteration routine. If KCRTS determines that the event dates corresponding to the annual peak outflows do not match the event dates in the test inflow hydrograph list, KCRTS will update the event dates in the list and re-iterate the facility size with the updated Test Hydrograph List. This process is repeated until the event date and rank of each hydrograph has been verified, such that the peak outflows from the hydrographs have the plotting positions shown below.

Test Hydrograph Number	Relative Rank of Hydrographs (Annual Peak Outflows)	Outflow Time Series Plotting Position (Return Period) Sea-Tac/Landsburg
1	1	100-yr
2	2	25
3	3	10
4	4	5
5	5	3
6	6	2
7	7	1.3
8	8	1.1

When using *Historical* data set: Eight annual peaks are extracted based on their gringorten plotting positions to be closest to common return periods of interest. Below are the plotting positions selected based on a 50-year historical record. For other lengths of record the rank and return period will vary.

Test Hydrograph Number	Inflow Hydrograph Rank and Assumed Outflow Time Series Plotting Position (Return Period) Sea-Tac/Landsburg
1	1 | 89.5-yr
2	2 | 32.1
3	3 | 19.6
4	6 | 9.0
5	7 | 7.6
6	10 | 5.2
7	26 | 2.0
8	39 | 1.3

The dates of test hydrographs 1 through 8 appear on this screen.



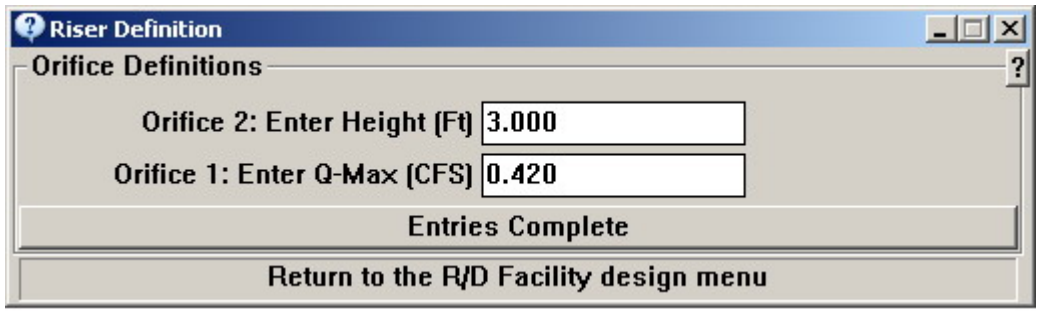
- **Primary Design Hydrograph.** This appears near the top of the screen. The user must identify the primary design hydrograph. The primary design hydrograph is the largest event which the facility is being sized to contain. For example, if the facility is being sized to match the 2-year and the 10-year developed flows with their respective predeveloped levels, the 10-year outflow event is chosen as the Primary Design Hydrograph. For the reduced record, the 10-year event is the third ranked annual peak, which corresponds to Test Hydrograph 3. Therefore, the PDH number would be set to 3.
- **Target Discharge.** The target discharge may be set for any of the design hydrographs identified but it **must be set for the Primary Design Hydrograph**. If the facility is being sized to match the 2- and 10-year developed peak flows with the respective predeveloped peak flows, the Target Discharge for the third event in the list is set at the 10-year predeveloped peak flow and the Target Discharge for the sixth hydrograph in the list is set at the 2-year predeveloped peak flow.

7.2.7.2.2 RETURN TO FACILITY DESIGN MENU

Select this option to return to the facility data input screen.

7.2.7.3 Define Riser Orifices and Notch

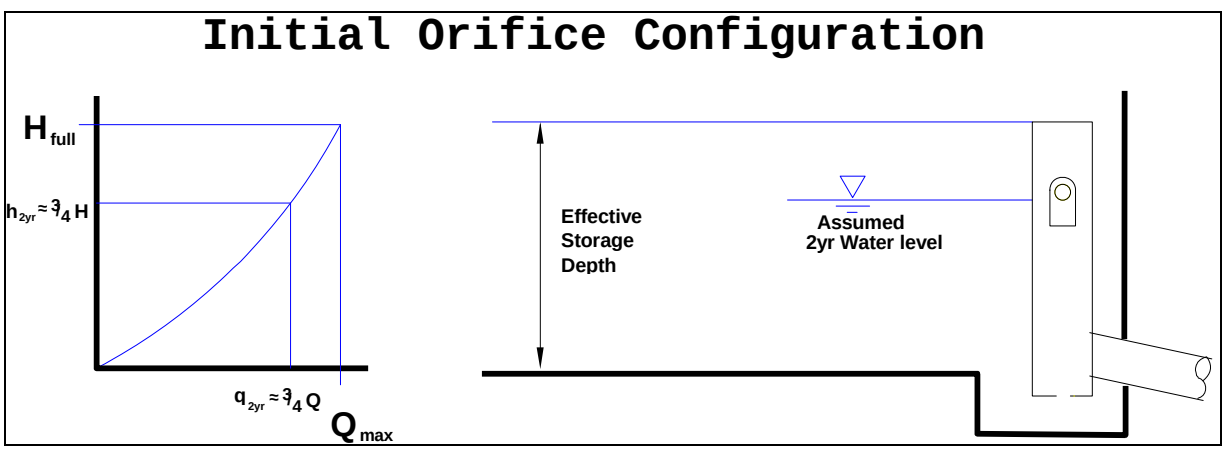
Select this option to specify the outlet orifice configuration and one of the following screens appears.



This screen appears when sizing a facility in *Automatic* mode. The user may specify the orifice data for up to three orifices. The number of orifices is specified in the main Edit Facility screen. A two-orifice design is recommended for most applications. When in *Automatic* mode the user is required to specify the orifice release rate for all but the uppermost orifice. The release rate, Q-max, is the discharge for the orifice under "pond-full" conditions. When in *Manual* mode, the user specifies the actual orifice diameter. In most cases, the user is advised to use the *Automatic* mode for the first iteration of sizing a facility. Subsequent iterations for refining the facility size can be performed in *Manual* mode.

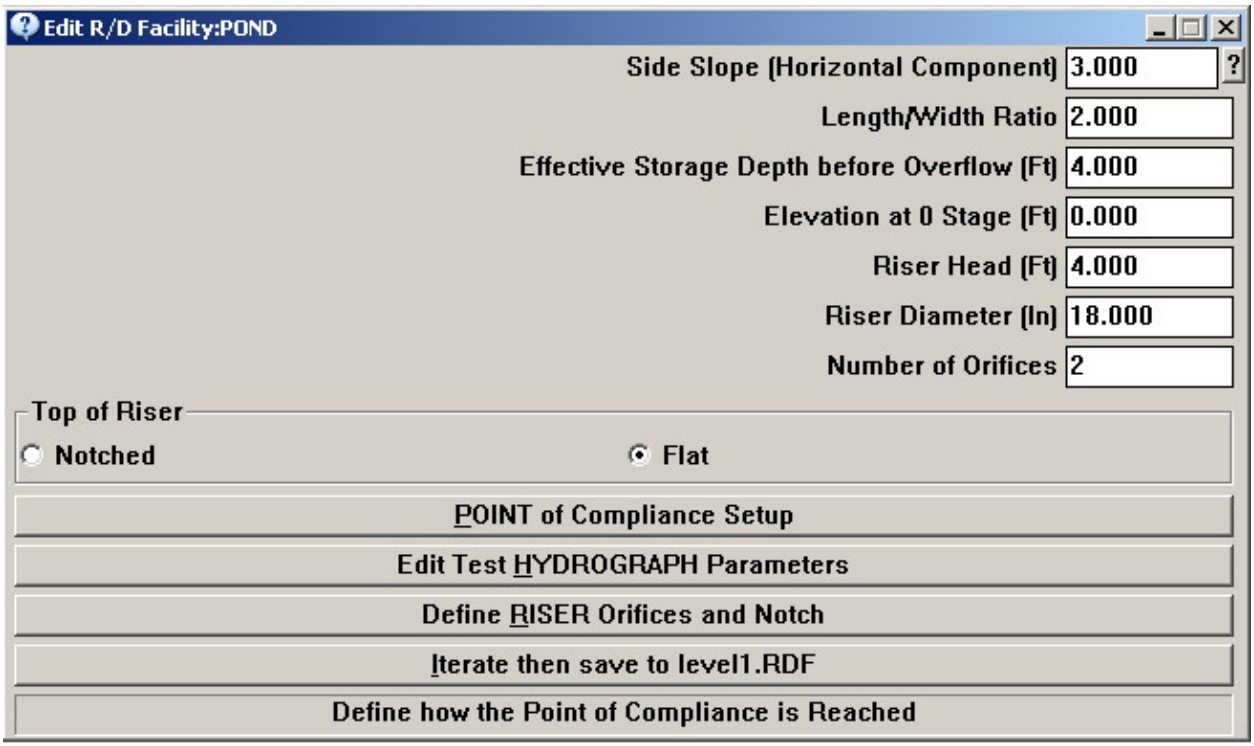
The following rules of thumb apply for the first iteration when sizing a facility with two orifices in *Automatic* mode:

- Set the release rate for the lower orifice so that the lower target release rate is 75 percent of full stage discharge at the lower orifice (i.e., multiply the lower target release rate by 4/3 to calculate the lower orifice Q-max)
- Set the height of the second orifice at 75 percent of the effective storage depth.

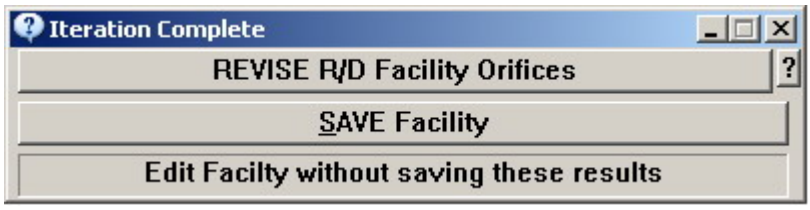


7.2.7.4 Iterate Then Save To (filename).

Select this option when all of the facility parameters have been entered.

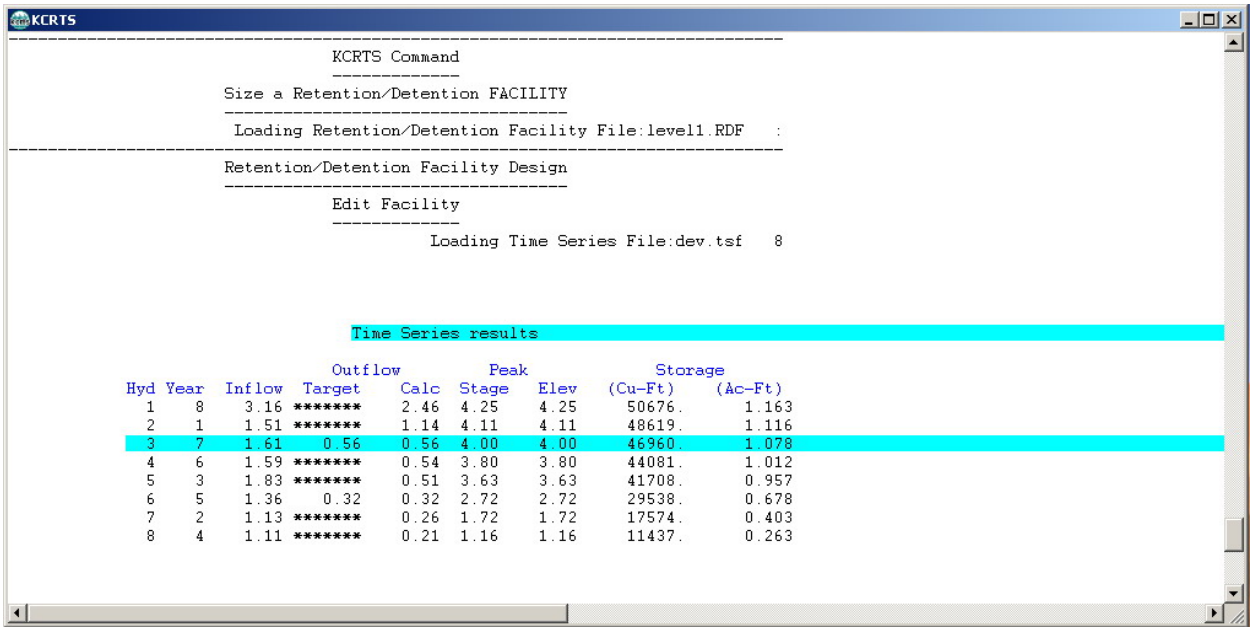


The program will now iterate the Primary Design Hydrograph (PDH), or full period of record, to determine the minimum size facility that meets the specified target discharge/stage for the PDH. The routine will next route, through the sized facility, the eight test hydrographs and display a summary table. The user may view the results in the main KCRTS window. The first check should be to verify that the "iteration complete" message is displayed. This will be displayed in a separate box in the main KCRTS window.

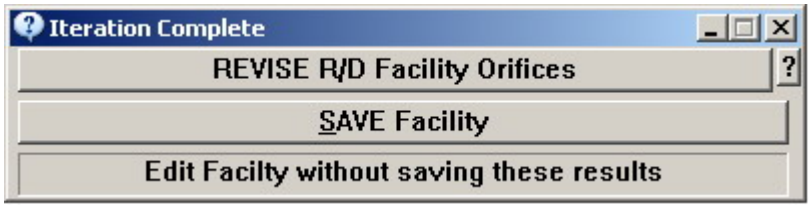


Note that the calculated outflows are decreasing in magnitude as you move down the hydrograph summary list.

If in ranked order, the assumed ranking versus flow frequency plotting positions are the same as indicated in Section 7.2.7.2.1. The following is an example of the screen that appears in the main KCRTS window .



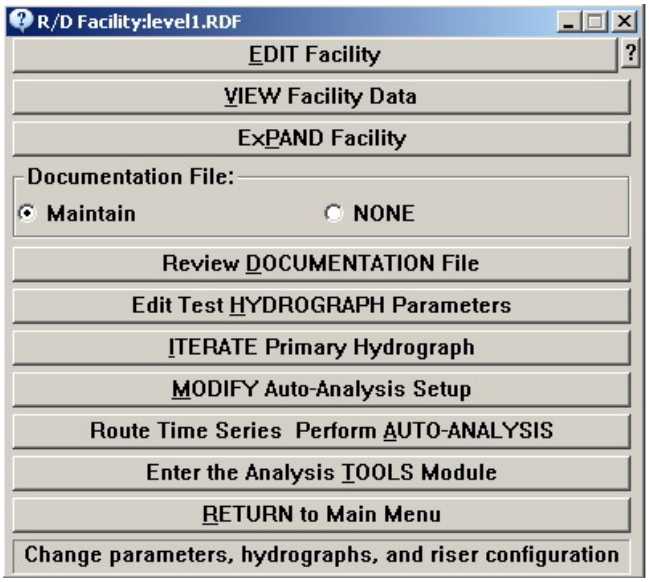
Hyd	Year	Inflow	Outflow Target	Outflow Calc	Peak Stage	Peak Elev	Storage (Cu-Ft)	Storage (Ac-Ft)
1	8	3.16	*******	2.46	4.25	4.25	50676.	1.163
2	1	1.51	*******	1.14	4.11	4.11	48619.	1.116
3	7	1.61	0.56	0.56	4.00	4.00	46960.	1.078
4	6	1.59	*******	0.54	3.80	3.80	44081.	1.012
5	3	1.83	*******	0.51	3.63	3.63	41708.	0.957
6	5	1.36	0.32	0.32	2.72	2.72	29538.	0.678
7	2	1.13	*******	0.26	1.72	1.72	17574.	0.403
8	4	1.11	*******	0.21	1.16	1.16	11437.	0.263



Revise R/D Facility. Select this option if the results viewed when viewing the results in the main KCRTS window indicate the need to modify the facility data. Important: If the outflow peaks are not ranked from highest to lowest, save the facility, route the entire time series, and update the event dates only of the Test Hydrograph List. If calculated outflows are aligned properly, make adjustments to the orifice configuration until desired performance is achieved.

Save Facility Parameters. Select this option to save the facility parameters. For Level 2 or 3 performance standard, this option is typically selected after the first iteration. For Level 1 performance standard this option is typically selected once final orifice adjustments have been made. After saving the facility, the entire time series should be routed through the facility to check outflow performance.

7.2.8 RETENTION/DETENTION FACILITY MENU



7.2.8.1 EDIT Facility

Select this option to return to the Edit Facility data input screen.

7.2.8.2 VIEW Facility Data

Select this option to view the existing facility data.

7.2.8.3 ExPAND Facility

Select this option to increase the storage volume at a particular stage. The program will increase the volume at this particular stage by the given percentage and then adjust the facility's bottom dimensions accordingly by using the same side slope and stage discharge relationship. The stage height entered must be greater than zero and less than or equal to the effective storage depth of the facility. The user is presented with the option of overwriting the facility data or changing the file name.

7.2.8.4 Documentation File

This option allows the user to document the facility specifications and performance in a text file. The documentation file is saved with the same filename as the facility, but with a DOC filename extension. When maintained the documentation file records summaries of actions performed by the user. This includes time series routing and analytical tools when performed within Size a Facility. If the facility is resaved and the previous facility file overwritten, the documentation file is also overwritten. If the modified facility is saved to a new filename, the previous documentation file (and facility file) will be retained. Documentation files are stored in ASCII text files and may be viewed and printed from a text editor. The documentation file is controlled from the Retention/Detention Facility Menu. The user may choose between *NONE* and *Maintain* by selecting the appropriate radio button.

7.2.8.5 Review DOCUMENTATION File

This option allows the user to view the documentation file for the last saved facility.

7.2.8.6 Edit Test Inflow HYDROGRAPH List

This option allows the user to access the same routines as when the Select Test Inflow Hydrograph option is chosen from the Edit Facility data input menu. Refer to Section 7.2.7.1 for more information.

7.2.8.7 ITERATE Primary Hydrograph

This option allows the user access to the same routine described under the Edit Facility data input menu. The Primary Design Hydrograph will be iterated, the facility re-sized, and the eight test hydrographs routed through the revised facility. The designer may view the results of the iteration and routing by hitting the F-10 key.

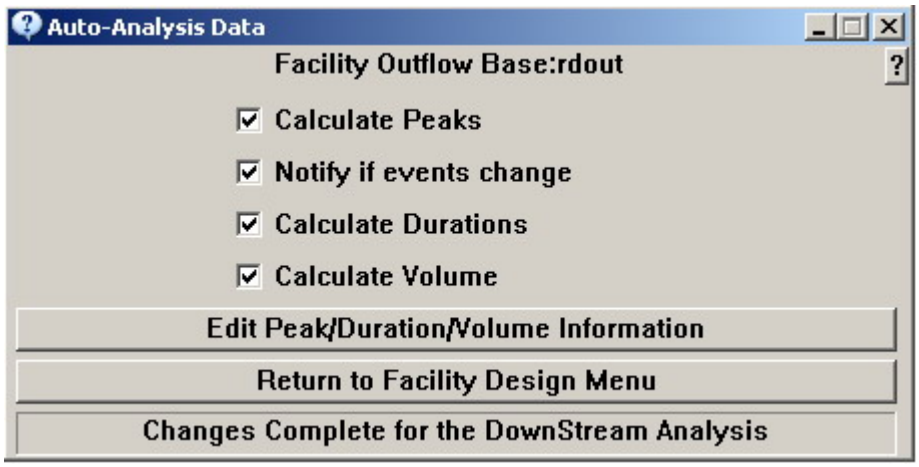
7.2.8.8 MODIFY Auto-Analysis Setup

This routine allows the user to setup the facility analysis once and then each time the time series is routed all the same Analysis Tools routines are run and displays are echoed to the screen. This routine is useful to the designer for two reasons:

1. Facility sizing is an iterative process, requiring repetitive steps to assess performance and make adjustments.
2. Facility performance cannot be verified solely with the test inflow hydrographs. Performance is verified by analyzing the full outflow time series against the regulatory standard. Routing the time series may identify the need to update the test inflow hydrograph list to include the storm events (annual peaks) which compose the flow frequency curve of the OUTFLOW time series.

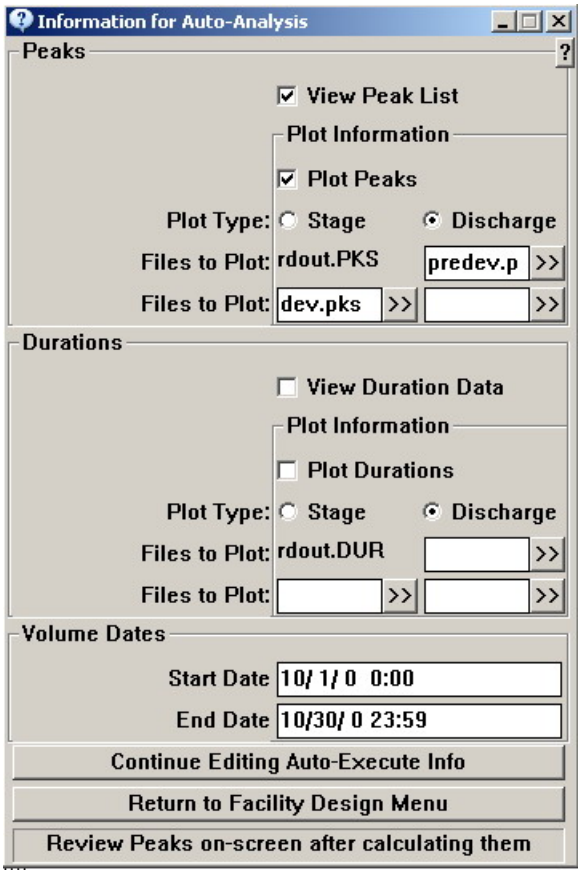
Note: The storm event dates which compose the inflow flow frequency curve will be different than the storm event dates comprising the outflow flow frequency curve. The inflow annual peak flow events typically will include more high intensity short duration events. The outflow annual peak events will typically be events with large runoff volumes, irrespective of inflow peaks.

When the *MODIFY Auto-Analysis Setup* option is selected, the following screen appears.



- **Peak Calcs?:** Select *Calculate Peaks* and the program will create a PKS file for the POC outflow time series. The POC time series is the R/D *Facility Outflow* or the *Downstream Outflow* depending how the POC was defined. When selected, the *Edit Peak/Duration/Volume Information* screen allows you to set up the viewing and plotting of the peaks data.
- **If Events Change:** With the enhanced iteration routine of KCRTS Version 4.2 and later, this routine should not find any event date changes if the designer used the PDH iteration routine in Automatic mode. The notification routine was retained so the user could keep the Test Inflow Hydrograph List updated while adjusting the facility in Manual mode. Select *Notifyif events change* to check the event dates and assumed return frequencies of the eight test hydrographs against the POC outflow time series. If, for a given return frequency the event dates of the test inflow hydrograph do not correspond to the event dates of the POC outflow time series, the program notifies the user that the test hydrograph list needs to be updated and prompts the user whether to update events or continue without updating. If sizing in Automatic mode, the Primary Design Hydrograph should be re-iterated and the orifice configuration adjusted as needed before rechecking with the time series routing and Auto-Analysis.
- **Duration Calcs?:** Select *Calculate Durations* and the program will create a DUR file for the POC outflow time series. The POC time series is the R/D *Facility Outflow* or the *Downstream Outflow* depending how the POC was defined. When selected, the *Edit Peak/Duration/Volume Information* screen allows you to set up the viewing and plotting of the duration data.
- **Volume Calcs?:** Toggle to *Calculate Volume* and the program will create a PRN file for the POC outflow time series. The POC time series is the R/D *Facility Outflow* or the *Downstream Outflow* depending how the POC was defined. When selected, the *Edit Peak/Duration/Volume Information* screen allows you to set up the start and end dates for the volume calculation. Viewing of the volume summary is automatic.

Edit Peak/Duration/Volume Information: This option allows the user to control the viewing of the data files to be created, as well as the plotting of the POC data files. The plotting of data can include up to three additional data files (e.g., predeveloped target files). This option also controls the start and end date of the volume calculation option. The following screen appears when this option is selected (if **Calculated Peaks**, **Calculate Durations**, and **Calculate Volumes** are all used).



View Peaks?: Check or uncheck the box to toggle between View and Do Not View.

- **Plot Peaks**?: Check or uncheck the box to toggle between Plot and Do Not Plot.
- **Plot Type**: Select between Discharge and Stage.
- **Additional Peak File**: Enter the filenames of up to three additional peak files (PKS) to be viewed or plotted.
- **View Durations**?: Check or uncheck the box to toggle between View and Do Not View.
- **Plot Durations**?: Check or uncheck the box to toggle between Plot and Do Not Plot.
- **Plot Type**: Check or uncheck the box to toggle between Discharge and Stage.
- **Additional Duration File**: Enter the filenames of up to three additional duration files (DUR) to be viewed or plotted.

Volume Dates

- **Start Date**: Identify the beginning date to be used in the volume calculation.
- **End Date**: Identify the ending date to be used in the volume calculation.

Continue Editing Auto-Execute Info: Select this option to return to the previous screen.

Return to Facility Design Menu: Select this option when all data have been entered correctly.

7.2.8.9 Route Time Series and Perform AUTO-ANALYSIS

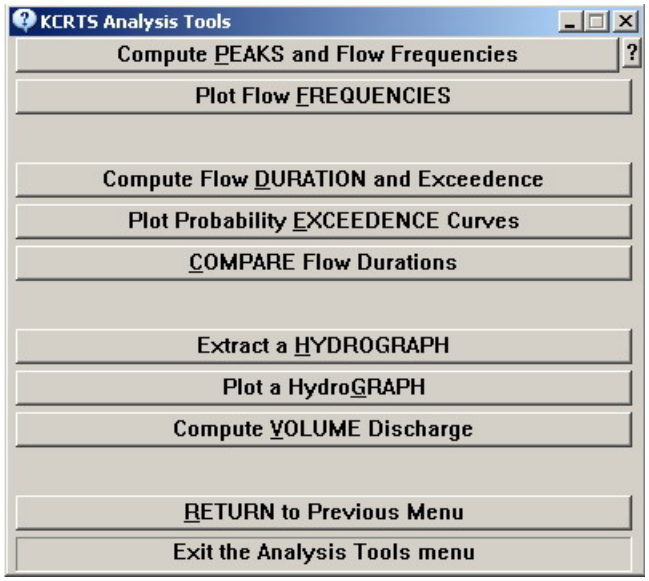
This option initiates the routing of the full inflow time series through the facility currently in memory. In addition to routing, all of the Auto-Analysis routines that have been setup will execute (from top to bottom as shown in the setup menu). Summary tables are echoed to the screen and the Facility Documentation file, if maintained.

7.2.8.10 Enter the Analysis TOOLS Module

Select this option to enter the analysis tools module. See Section 8 for detailed descriptions of Tools routines. This set of routines is repeated in Size a Facility to allow the designer direct access to the Analysis Tools without having to re-start the Facility Design routine.

The *Analysis Tools Module* can be accessed by typing [T] while in the Main Menu.

This module begins by displaying a screen of the following menu items.

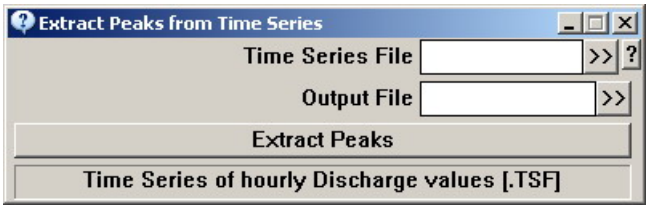


8.1 COMPUTE PEAKS AND FLOW FREQUENCIES

This menu item can be selected with the [P] key.

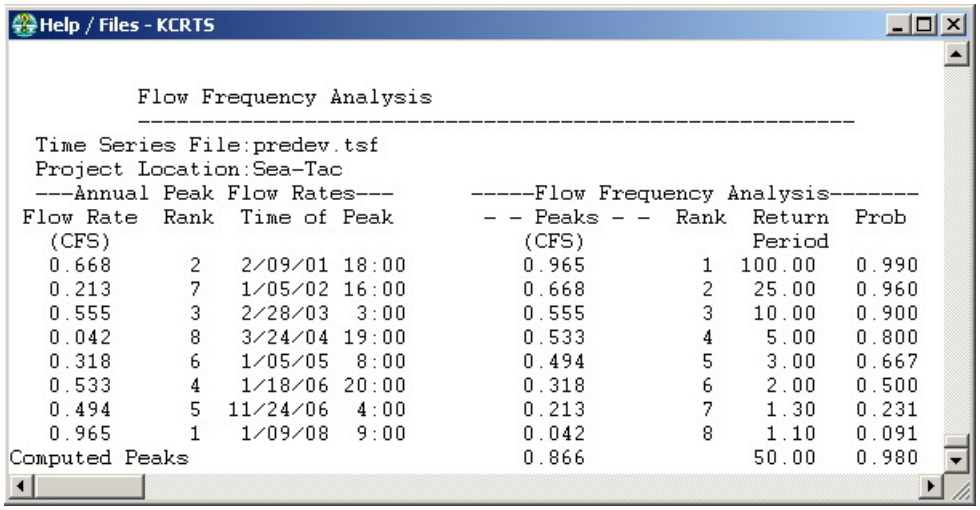
Annual Peak Flow Data are generated by identifying the yearly maximum discharge in each of the water years of data. These peak values are ranked and then assigned return periods/probabilities based on their relative ranking.

- **Time Series File** (filename). The user must enter the filename of the time series to be used in the frequency analysis. A TSF extension is assumed.
- **Output File** (filename). The user may enter a filename for the results of the frequency analysis. A PKS extension is appended to the filename. If no output filename is specified, the results will only be displayed on the screen.



Extract Peaks: Select this option to calculate the Peaks and the results are shown in the in the Help/Files - KCRTS screen, presenting the ranked peaks and associated frequencies for the time series being analyzed.

The left half of the output file contains the date and magnitude of the annual peak for each water year and the relative rank of each annual peak. The right half displays the peak flows according to their rank and assigns to each a return period/probability.



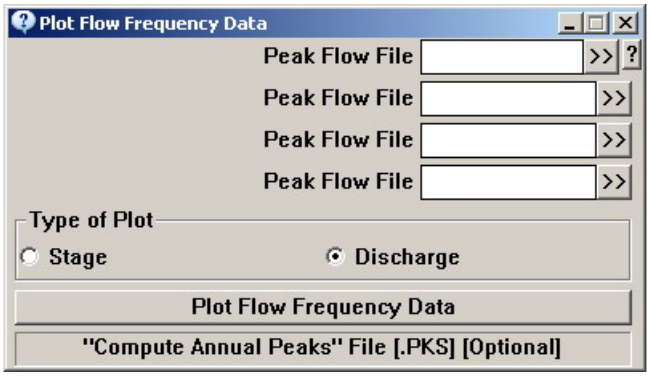
Help / Files - KCRTS

```
          Flow Frequency Analysis
          -------------------------------------------------------
  Time Series File:predev.tsf
  Project Location:Sea-Tac
  ---Annual Peak Flow Rates---       -----Flow Frequency Analysis-------
 Flow Rate  Rank  Time of Peak        - - Peaks - -  Rank  Return  Prob
   (CFS)                                (CFS)             Period
   0.668      2   2/09/01 18:00        0.965          1  100.00   0.990
   0.213      7   1/05/02 16:00        0.668          2   25.00   0.960
   0.555      3   2/28/03  3:00        0.555          3   10.00   0.900
   0.042      8   3/24/04 19:00        0.533          4    5.00   0.800
   0.318      6   1/05/05  8:00        0.494          5    3.00   0.667
   0.533      4   1/18/06 20:00        0.318          6    2.00   0.500
   0.494      5  11/24/06  4:00        0.213          7    1.30   0.231
   0.965      1   1/09/08  9:00        0.042          8    1.10   0.091
Computed Peaks                         0.866             50.00   0.980
```

8.2 PLOT FLOW FREQUENCIES

This menu item can be selected with the [F] key.

The user can plot up to four flow frequency data files to the screen.



- **Peak Flow File** (filename). The user must enter filename(s) of the time series to be plotted. These files are created using the Compute Peaks routine. The assumed filename extension is PKS.
- **Type of Plot.** Plots can be produced using *Discharge* data or *Stage* data. The user may use the space bar to toggle between *Discharge* and *Stage*. When plotting stage data, all PKS files specified must be from routed time series, otherwise stage data would not exist.

Plot Flood Frequency Data: Select this option and the flood frequency curves for the identified time series files are plotted on the screen.

PRINTING GRAPHIC IMAGES:

WKCRTS (Win95 version of KCRTS): To print graphs in WKCRTS using Windows printer drivers, click the WKCRTS icon in the upper left hand corner of the graph window. Select "Print" from the pull down menu to configure printer and print graphic image.

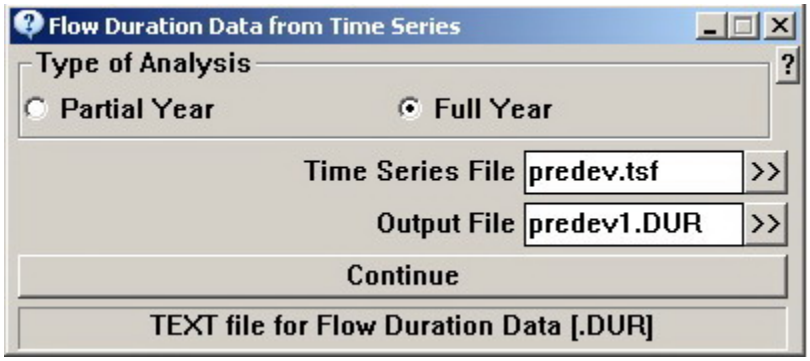
KCRTS in Win95 mode: Pressing *Print-Scrn* key while in Windows environment directs the graphics image to the clipboard, even if KCRTS is running in full screen. The graphics image may be copied from clipboard to other applications, as desired. DOS print screen utilities may be useful in sending graphic images directly to printer.

KCRTS in DOS mode: The printing of graphs can be accomplished using the DOS graphics driver, GRAPHICS.COM. The driver must be installed prior to starting KCRTS. Type HELP GRAPHICS for list of DOS-supported devices. Once installed, a graph can be printed by pressing Shift and Print-Scrn simultaneously. EXAMPLE COMMAND LINE C:\> graphics laserjetii.

8.3 COMPUTE FLOW DURATION AND EXCEEDANCE

This menu item can be selected with the [D] key.

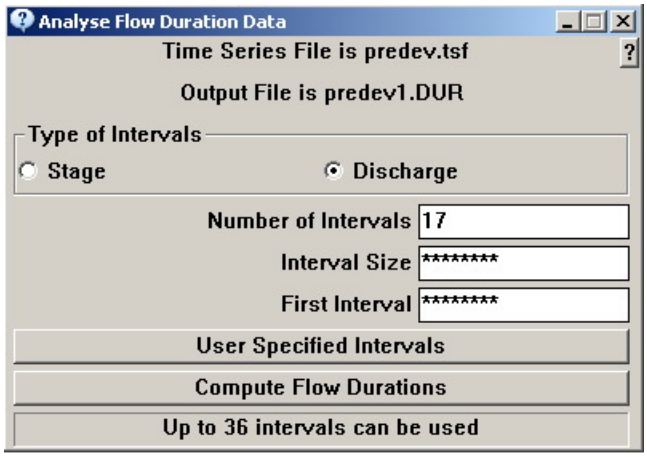
Duration and exceedance analysis simply involves counting the number of timesteps a given flow rate is exceeded and dividing that count by the total number of timesteps. This value is known as the exceedance probability or flow duration. Calculating the exceedance probability at several flowrate "cutoffs" results in a flow duration curve. The program will determine default cutoff values, or the user may define their own. The results are saved in a text file that can be printed or imported into a spreadsheet or similar program for additional analysis.



Flow durations may be calculated over a specific range of flows, such as analyzing the predeveloped time series between 50 percent of the 2-year and the 50-year peak flows. This partial duration curve is useful as a "target" curve for meeting the Level 2 (Stream Protection) detention standard.

- **Type of Analysis.** Select *Full Year* or *Partial Year* duration statistics. Most durational analyses use full year statistics. However, for some fish passage or wetland mitigation alternatives a particular portion of the water year may be of concern. When *Partial Year* is selected the program will prompt for additional date and timestep information. Partial year flow durations should only be calculated using the full historical period of record.
- **Time Series File** (filename). The user must enter the filename of the time series to be used in the frequency analysis. A TSF extension is assumed.
- **Output File** (filename). The user must enter the filename for the results of the duration analysis. The default extension DUR will be added to the filename.

Continue. Select this option to continue with computation of flow duration exceedance data.



- **Type of Intervals.** The user may use the space bar to toggle between *Discharge* and *Stage* depending on the type of analysis being performed.
- **Number of Intervals.** The user may enter the number of intervals to be used in the duration analysis. The number of intervals must be between 1 and 36. To improve resolution of duration plots, increase the number of cutoffs. A minimum of 16 cutoffs should be used for most analyses.

OPTIONAL: The first interval and interval size control the range of flows to be analyzed. These are usually left blank as KCRTS will set these values automatically to analyze the full range of flows encountered in the time series being analyzed.

- **Interval Size.** The interval size is specified by the user to control the cutoff values. As a general rule, the interval size is calculated by the following relationship.

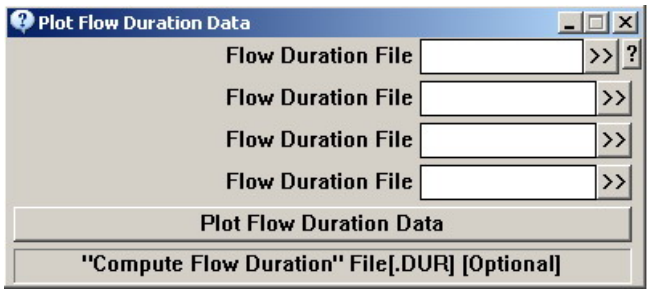
  Interval Size = Upper end of *Discharge* (or *Stage*) range of concern minus the lower end (first interval) of the *Discharge* (or *Stage*) range of concern. That quantity is then divided by one less than the number of cutoffs.
- **First Interval.** The first interval cutoff is specified by the user. This first interval identifies the low end of the *Discharge* (or *Stage*) range being used for the duration analysis.

Compute Flow Durations Select this option to perform the duration analysis. The results are printed to the screen as well as to the filename identified.

8.4 PLOT PROBABILITY EXCEEDANCE CURVES

This menu item can be selected with the [E] key.

The user may plot up to four flow duration data files to the screen.



- **Flow Duration File** (filename). The user may enter up to four filenames to use in the duration plot. These data files are created in the Compute Durations routine. The assumed filename extension is DUR.

Plot Flow duration Data Select this option to plot the flood probability exceedance curves on the screen.

PRINTING GRAPHIC IMAGES:

WKCRTS (Win95 version of KCRTS): To print graphs in WKCRTS using Windows printer drivers, click the WKCRTS icon in the upper left hand corner of the graph window. Select "Print" from the pull down menu to configure printer and print graphic image.

KCRTS in Win95 mode: Pressing *Print-Scrn* key while in Windows environment directs the graphics image to the clipboard, even if KCRTS is running in full screen. The graphics image may be copied from clipboard to other applications, as desired. DOS print screen utilities may be useful in sending graphic images directly to printer.

KCRTS in DOS mode: The printing of graphs can be accomplished using the DOS graphics driver, GRAPHICS.COM. The driver must be installed prior to starting KCRTS. Type HELP GRAPHICS for list of DOS-supported devices. Once installed, a graph can be printed by pressing Shift and Print-Scrn simultaneously.

8.5 COMPARE FLOW DURATIONS

This menu item can be selected with the [C] key.

Compliance with the Level 2 or 3 flow control standard requires the comparison of the duration characteristics of two timeseries files (typically, predeveloped and facility outflow), to determine if the facility performance is within allowable tolerances. In general, the following three criteria apply to duration matching flow control standards.

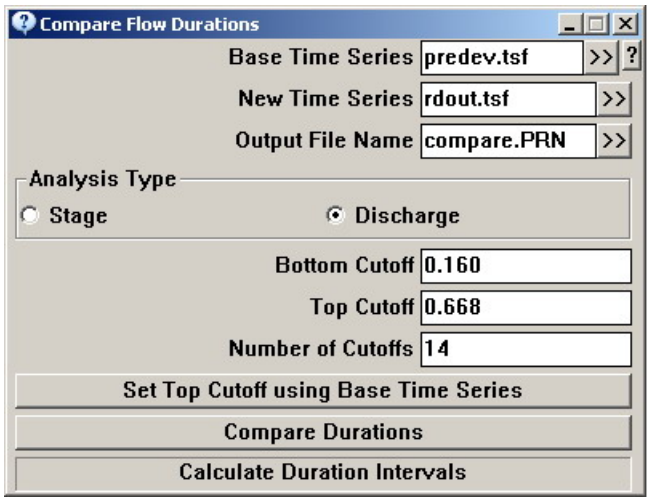
- The facility outflow must be strictly below the predeveloped flow durations at the bottom end of the range of control (typically, 50% of existing 2-year).

- The facility outflow may have brief excursions above the predeveloped (target) flow duration curve, provided the excursions are not more than 10%, measured vertically.
- The facility outflow duration curve may not exceed the predeveloped flow frequency curve for more than ½ of the range of control.

To size a Level 2 or 3 flow control facility, the designer compares these curves graphically and adjusts facility parameters accordingly. However, to check the facility for compliance, this routine provides a more accurate numerical comparison of the two curves being compared.

Base Time Series (filename). The user must enter the filename of the time series to be compared against. This is the existing condition Time Series, from which your "target" duration curve was generated. A TSF extension is assumed.

- **New Time Series** (filename). The user must enter the filename of the time series file which represent the developed condition runoff to be compared to the Base Time Series. This is either the facility outflow or



downstream point of compliance time series file. A TSF extension is assumed.

- **Output File Name** (filename). The user may enter a filename for the results of the duration comparison. A PRN extension is appended to the filename. If no output filename is specified, the results will only be displayed on the screen.
- **Analysis Type.** Two way toggle between *Discharge* and *Stage.*

  Discharge. Select discharge to compare the flow duration statistics of two timeseries files (e.g., predeveloped and R/D outflow).

  Stage. Select stage to compare stage durations of two outflow timeseries from a reservoir. Typically, it will be a comparison of the reservoir outflows generated from two different inflow timeseries (e.g., existing and proposed), routed through the same reservoir file.
- **Bottom Cutoff.** Set the bottom cutoff at the lowest flow/stage value of the range of conditions being controlled. When Analysis Type = Discharge, the bottom cutoff is usually set at 50% of the existing 2-year flow rate, which is the lowest flow value controlled by the Level 2 or 3 standard.
- **Top Cutoff.** Set the top cutoff equal to the largest flow/stage value of the range of conditions being controlled. The utility below *Set Top Cutoff* can be used to automatically set the top cutoff at the largest flow/stage condition found in the base timeseries.
- **Number of Cutoffs.** This controls the number of rows displayed in the output screen and output data file. The program will automatically break up the range of flows/stages into even increments using this

number. This number does not control the maximum positive and negative excursions displayed at the end of the table.

Set Top Cutoff using Base Time Series. Select this to have the program analyze the base timeseries and set the top cutoff equal to the largest event of the period of record. The period of record is first 7 years for the reduced runoff files, and the full record for the historical runoff files.

Compare Durations. Select this when input is complete to execute the routine.

The following is an example output screen.

```
KCRTS
   Base File: predev.tsf
    New File: rdout.tsf
                          Duration Comparison Anaylsis
                          ----------------------------

   Base File: predev.tsf
    New File: rdout.tsf
Cutoff Units: Discharge in CFS
             -----Fraction of Time----- ---------Check of Tolerance-------
  Cutoff     Base       New       %Change Probability   Base      New %Change
   0.160 |  0.89E-02  0.71E-02  -20.1 |  0.89E-02   0.160   0.156    -2.4
   0.199 |  0.62E-02  0.43E-02  -31.7 |  0.62E-02   0.199   0.166   -16.8
   0.238 |  0.49E-02  0.35E-02  -27.4 |  0.49E-02   0.238   0.186   -21.8
   0.277 |  0.37E-02  0.30E-02  -17.8 |  0.37E-02   0.277   0.228   -17.8
   0.316 |  0.28E-02  0.29E-02    1.2 |  0.28E-02   0.316   0.322     1.9
   0.355 |  0.22E-02  0.24E-02   12.8 |  0.22E-02   0.355   0.376     5.7
   0.394 |  0.15E-02  0.19E-02   26.1 |  0.15E-02   0.394   0.412     4.5
   0.434 |  0.10E-02  0.11E-02    7.8 |  0.10E-02   0.434   0.441     1.8
   0.473 |  0.64E-03  0.75E-03   17.9 |  0.64E-03   0.473   0.490     3.6
   0.512 |  0.38E-03  0.34E-03   -8.7 |  0.38E-03   0.512   0.510    -0.2
   0.551 |  0.21E-03  0.23E-03    7.7 |  0.21E-03   0.551   0.556     0.9
   0.590 |  0.15E-03  0.33E-04  -77.8 |  0.15E-03   0.590   0.569    -3.5
   0.629 |  0.98E-04  0.33E-04  -66.7 |  0.98E-04   0.629   0.580    -7.8

Maximum positive excursion = 0.027 cfs (  7.4%)
occurring at 0.371 cfs on the Base Data:predev.tsf
and at 0.399 cfs on the  New Data:rdout.tsf

Maximum negative excursion = 0.057 cfs (-23.0%)
occurring at 0.249 cfs on the Base Data:predev.tsf
and at 0.192 cfs on the  New Data:rdout.tsf

                    Duration Comparison Computed and Saved
                                                Output File:COMPARE.PRN
```

This table contains the summary of the duration comparison of the two time series specified by the user. The left half of the table compares flow durations horizontally in the direction of percent of time exceeded (exceedance probability). The right half of the table compares the flow duration curves vertically, in the direction that the allowable tolerance is measured. Typically, if the below three conditions are met, the facility is meeting the flow duration matching portion of the flow control standards.

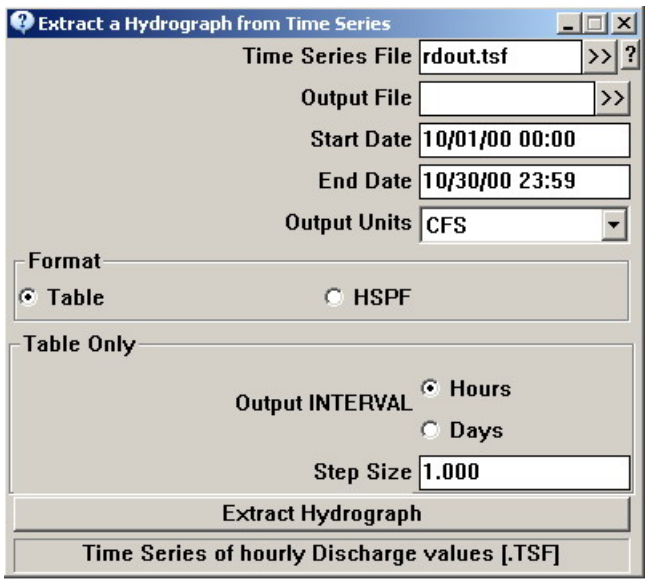
- The duration matching standard (Level 2 or 3 Flow Control Standard) typically requires that the outflow timeseries be strictly at or below existing conditions at the lower range of control. Therefore, the % change value for the first flow cutoff must be zero or negative.
- Above the lowest cutoff the % change may not exceed positive 10 percent. Therefore, the remaining values in the % change column must be less than positive 10. Likewise, the *Maximum positive excursion* must be less than positive 10 percent.
- The duration matching standards typically require that the existing condition duration curve not be exceeded for more than 50% of the flows within the range of control. This means, that the *% change* column may not contain more positive entries than negative ones.

8.6 EXTRACT A HYDROGRAPH

This menu item can be selected by the [H] key.

This menu item allows the user to extract a hydrograph from a time series to be saved as a text file. There is no limit to the length of hydrograph to be extracted. Once extracted, the hydrograph can be read into a spreadsheet or similar program for plotting or additional analysis. The output includes the date and time from the timeseries, the average discharge rate, or total discharge volume over the time interval. Output can be extracted in units of cfs or cubic feet and with a variable timestep. To extract stage data, the units must be cfs, and the step size and interval must be set equal to one time step of the time series being analyzed, hourly or 15-minutes (0.25 hours = 15 minutes).

Time Series File (filename). The user must enter the name of the time series from which the



hydrograph is to be extracted. A TSF extension is assumed.

- **Output File** (filename). The user must specify the name of the file to which the extracted hydrograph is to be written. The default extension of PRN is added to the filename.
- **Start Date.** The user must specify the starting date for the extracted hydrograph.
- **End Date**. The user must specify the ending date for the extracted hydrograph.
- **Output Units.** The user may use the space bar to toggle between *CFS*, *CuFt*, and *Feet.*
- **Format.** The user may use the space bar to toggle between *Table* and *HSPF* to control the format of the output file.
- **Output Interval.** The user may use the space bar to toggle between *Hours* and *Days* for the output interval.
- **Step Size**. The user must specify the step size to be used in the extracted hydrograph. The step size relates to the number of time increments within the original time series file to be combined in producing the extracted hydrograph.

Extract Hydrograph select this option to perform hydrograph extraction.

8.7 PLOT A HYDROGRAPH

This menu item can be selected by the [G] key.

In this menu item, a hydrograph is limited to a maximum of 31 days of discharge values. Hydrographs from up to four different time series can be displayed on the screen at one time. To print a graph, the DOS graphics driver must be enabled prior to running KCRTS. The graph can then be printed by simultaneously pressing the Shift and PrintScreen keys.

- **Time Series File** (filename). The user may specify up to four time series files to plot. A TSF extension is assumed.
- **Type of Hydrograph.** The user may use the space to toggle between *Discharge* and *Stage*.
- **Start Date**. The user must specify the starting date of the hydrograph(s) to be plotted.
- **End Date.** The user must specify the ending date of the hydrograph(s) to be plotted.

Plot Hydrograph(s) Select this option to plot the hydrograph(s).

PRINTING GRAPHIC IMAGES:

WKCRTS (Win95 version of KCRTS): To print graphs in WKCRTS using Windows printer drivers, click the WKCRTS icon in the upper left hand corner of the graph window. Select "Print" from the pull down menu to configure printer and print graphic image.

KCRTS in Win95 mode: Pressing *Print-Scrn* key while in Windows environment directs the graphics image to the clipboard, even if KCRTS is running in full screen. The graphics image may be copied from clipboard to other applications, as desired. DOS print screen utilities may be useful in sending graphic images directly to printer.

KCRTS in DOS mode: The printing of graphs can be accomplished using the DOS graphics driver, GRAPHICS.COM. The driver must be installed prior to starting KCRTS. Type HELP GRAPHICS for list of DOS-supported devices. Once installed, a graph can be printed by pressing Shift and Print-Scrn simultaneously.

8.8 COMPUTE VOLUME DISCHARGE

This menu item can be selected by the [V] key.

This menu item calculates the total volume discharge in Cubic Feet between two dates in a time series.

An optional file name can be provided if you wish to save the data to disk. If not, the results of the analysis are only displayed on the screen.

8.9 EXPAND TOOLS MENU

This option can be selected with the [T] key while in the *Analysis Tools Menu.*

Upon selecting this option, the user is presented with an expanded *Analysis Tools Menu.* These additional tools routines were developed to assess water level fluctuations in reservoirs, such as open-water wetlands. There are no analysis procedures in the Design Manual which require the use of these routines. This expanding menu option may not be present on your version of the program.

8.10 RETURN TO MAIN MENU

Select this item to exit the TOOLS module. This menu item can be selected by the [R] key.