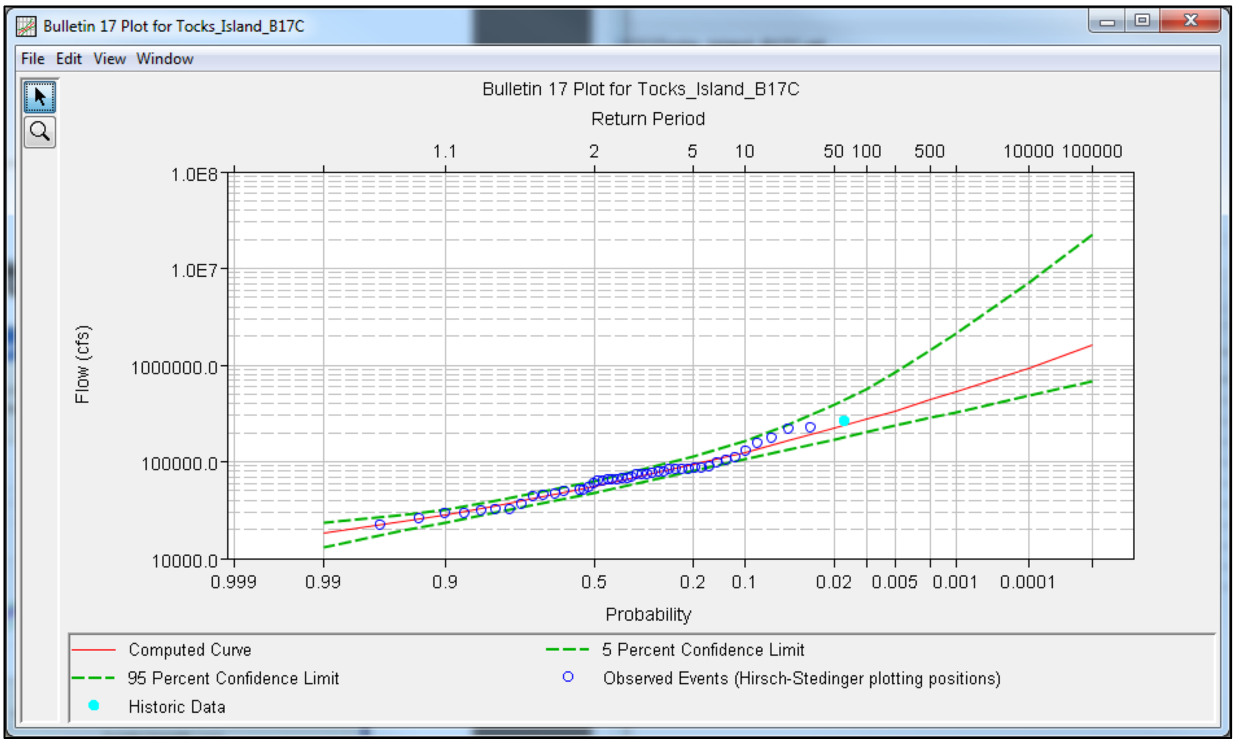
US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-SSP

Statistical Software Package



User's Manual

Version 2.1

July 2016

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14. ABSTRACT
The Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) allows the user to perform statistical analyses of hydrologic data. The current version of HEC-SSP can perform peak flood flow frequency analysis using Bulletin 17B and 17C procedures, a general frequency analysis using any type of hydrologic data, a volume frequency analysis, a duration analysis, a coincident frequency analysis, and a balanced hydrograph analysis. Data storage and management is handled either through the use of text files (ASCII, XML) or the Hydrologic Engineering Center's Data Storage System (HEC-DSS).

15. SUBJECT TERMS
HEC-SSP, flood frequency, statistics, Bulletin 17B, Bulletin 17C, Expected Moments Algorithm, flow, stage, computer program, hydrologic data, volume-duration, statistical analysis, balanced hydrograph, data storage, reporting tools, frequency curves, confidence limits, low outliers, high outliers, potentially influential low flows, regional skews

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Statistical Software Package, HEC-SSP, User's Manual

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Foreword

The U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP) is software that allows users to perform statistical analyses of hydrologic data.

The first official version of HEC-SSP (Version 1.0) was released in August of 2008. Version 1.1 was released in April, 2009 and included improvements to data entry, results visualization and reporting, and added capability to the volume frequency analysis. Version 2.0 was released in October 2010 and included three new analyses: a duration analysis, a coincident frequency analysis, and a curve combination analysis. Version 2.1, released in July 2016, included improvements to the volume frequency analysis, general frequency analysis, and Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) flow frequency analysis in addition to two new analyses: Bulletin 17C (England, et al., 2015) flow frequency using the Expected Moments Algorithm and a Balanced Hydrograph analysis. These new features are discussed in the User's Manual for Version 2.1.

The HEC-SSP software was designed by Mr. Gary Brunner, Mr. Jeff Harris, Dr. Beth Faber, Mr. Matthew Fleming, Mr. Michael Bartles, and Mr. William Lehman. The HEC-SSP user interface and computation code was programmed by Resource Management Associates. This manual was written by Mr. Michael Bartles, Mr. Gary Brunner, Mr. Matthew Fleming, Dr. Beth Faber, and Ms. Julia Slaughter.

CHAPTER 1

Introduction

Welcome to the U.S. Army Corps of Engineers, Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP). This software allows users to perform statistical analyses of hydrologic data. The current version of HEC-SSP can perform flood flow frequency analysis based on Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) and Bulletin 17C (England, et al., 2015), a generalized frequency analysis on not only flow data but other hydrologic data as well, a volume frequency analysis on high and low flows, a duration analysis, a coincident frequency analysis, and a balanced hydrograph analysis.

HEC-SSP has been implemented using software guidelines established at HEC. These guidelines will produce more consistent results when using HEC software in water resources studies. Also, the guidelines facilitate a common graphical user interface and "look and feel" for HEC software in the PC environment. Recent HEC software implemented under these guidelines include: rainfall-runoff analysis (HEC-HMS), river hydraulics (HEC-RAS), reservoir system analysis (HEC-ResSim), flood damage analysis (HEC-FDA), flood impact analysis (HEC-FIA), and ecosystem function analysis (HEC-EFM). HEC software implementation is under the guidance of Christopher N. Dunn, Director, Hydrologic Engineering Center.

This chapter discusses the general philosophy of HEC-SSP and gives a brief overview of the capabilities of the software. An overview of this manual is also provided.

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General Philosophy of HEC-SSP

HEC-SSP is designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface (GUI), separate statistical analysis components, data storage and management capabilities, mapping, graphics, and reporting tools.

Over a period of many years, HEC has supported a variety of statistical packages that perform frequency analysis and other statistical computations. Historically, the programs that received the most use within USACE were HEC-FFA (Flood Frequency Analysis) and STATS (Statistical Analysis of Time Series Data). HEC-FFA incorporates Bulletin 17B procedures that are used for flow frequency analysis. The STATS software package is used for statistical analysis of time series data. STATS can provide either analytical or graphical frequency analysis, specified by the user. STATS has the capability of computing monthly and annual maximum, minimum, and mean values along with computing a volume-duration analysis. Two other packages that have received a lot of use within USACE are REGFRQ (Regional Frequency Computation) and MLRP (Multiple Linear Regression Program). REGFRQ performs regional frequency analysis and MLRP is a multiple linear regression analysis tool.

The goal of HEC-SSP is to combine all of the statistical analyses capabilities of HEC-FFA, STATS, REGFRQ and MLRP while advancing the realm of statistical hydrology through cutting-edge techniques (such as the use of the Expected Moments Algorithm). The current version of HEC-SSP supports performing flood flow frequency analyses based on Bulletin 17B and Bulletin 17C guidelines, general frequency analyses, volume frequency analyses, duration analyses, coincident frequency analyses, and balanced hydrograph analyses. New features and additional capabilities will be added in future releases.

Overview of Program Capabilities

HEC-SSP is designed to perform statistical analyses of hydrologic data. The following is a description of the major capabilities of HEC-SSP.

User Interface

The user interacts with HEC-SSP through a graphical user interface (GUI). The main focus in the design of the interface was to make it easy to use the software, while still maintaining a high level of efficiency for the user. The interface provides for the following functions:

- File management
- Data entry, importing, and editing
- Statistical analyses
- Tabulation and graphical displays of results
- Reporting facilities

Statistical Analysis Components

Flow Frequency Analysis (Bulletin 17) – This component of the software allows the user to analytically perform annual peak flow frequency analyses. The software implements two algorithms for computing annual peak flow frequencies. The first is contained within Bulletin 17B, which was published by the Interagency Advisory Committee on Water Data in 1982. The second is contained within Bulletin 17C, which was released in draft form by the Subcommittee on Hydrology in December 2015. The Bulletin 17C document is currently being reviewed.

General Frequency Analysis – This component of the software allows the user to perform peak flow frequency analyses by various methods. Additionally the user can perform frequency analysis of variables other than peak flows, such as stage and precipitation data.

Volume Frequency Analysis – This component of the software allows the user to perform a volume frequency analyses on daily flow or stage data.

Duration Analysis – This component of the software allows the user to perform a duration analysis on any type of data recorded at regular intervals. The duration analysis can be used to show the percent of time that a hydrologic variable is likely to equal or exceed some specific value of interest.

Coincident Frequency Analysis – This component of the software assists the user in computing the exceedance frequency relationship for a variable that is a function of two other variables.

Balanced Hydrograph Analysis – This component provides a tool for the creation of balanced hydrographs of multiple durations using existing flow and volume frequency analyses and input hydrograph shapes.

Data Storage and Management

Data storage is accomplished through the use of "text" files (American Standard Code for Information Interchange; ASCII; and Extensible Markup Language; XML), as well as the HEC Data Storage System (HEC-DSS). User input data are stored in flat files under separate categories of study, analyses, and a data storage list. Gage data are stored in a project HEC-DSS file as time series data. Output data is predominantly stored in HEC-DSS, while a summary of the results is written to an XML file. Additionally, an analysis report file is generated whenever a computation is made. This report file is written to a standard ASCII text file.

Data management is accomplished through the user interface. The modeler is requested to enter a Name and Description for each study under development. Once the study name is entered, a directory with that name is created, as well as a study file. Additionally, a set of subdirectories is created with the following names: Bulletin17Results, GeneralFrequencyResults, VolumeFrequencyAnalysisResults, DurationAnalysisResults, CoincidentFreqResults, BalancedHydrograph, Layouts, and Maps. As the user creates new analyses, an analysis file is created in the main project directory. The interface provides for renaming and deletion of files on a study-by-study basis.

Graphical and Tabular Output

Graphics include a map window, plots of the data, and plots of analysis results. The map window can be used to display background map layers. Locations of the data being analyzed can be displayed on top of the map layers. Once data are brought into HEC-SSP, they can be plotted for visual inspection. The frequency curve plots show the results of the analyses, which include the analytically computed curve, the expected probability curve, confidence limits, and the raw data points plotted based on the selected plotting position method. Tabular output consists of tables showing the computed frequency curves, confidence limits, and summary statistics. All graphical and tabular output can be displayed on the screen, sent directly to a printer (or plotter), or passed through the Windows Clipboard to other software, such as a word-processor or spreadsheet.

A report file is available for each analysis. This report file includes the input data, preliminary results, all of the statistical tests (Low and High Outliers, Broken Record, Zero Flows Years, Incomplete Record, Regional Skews, and Historic Information), and final results. This report file is similar to the FFA output file.

Overview of This Manual

This user's manual is the primary documentation on how to use HEC-SSP. The manual is organized as follows:

- Chapters 1-2 provide an introduction and overview of HEC-SSP, as well as instructions on how to install the software.
- Chapter 3 provides an overview on how to use the HEC-SSP software in a step-by-step procedure, including a sample problem that the user can follow.

- Chapter 4 explains in detail how to enter and view data.
- Chapter 5 provides a detailed discussion on how to use the Bulletin 17 Analysis editor.
- Chapter 6 provides a detailed discussion on how to use the General Frequency Analysis editor.
- Chapter 7 provides a detailed discussion on how to use the Volume Frequency Analysis editor.
- Chapter 8 provides a detailed discussion on how to use the Duration Analysis editor.
- Chapter 9 provides a detailed discussion on how to use the Coincident Frequency Analysis editor.
- Chapter 10 provides a detailed discussion on how to use the Balanced Hydrograph Analysis editor.
- Appendix A contains a list of references.
- Appendix B has a series of example analyses that demonstrate the various capabilities of HEC-SSP when performing a Bulletin 17B flow frequency analysis, a General Frequency Analysis, a Volume Frequency Analysis, a Duration Analysis, a Coincident Frequency Analysis, and a Balanced Hydrograph Analysis.
- Appendix C has a series of example analyses that demonstrate the use of HEC-SSP using the Expected Moments Algorithm (EMA) to fit a Log Pearson Type III distribution to annual maximum flow data sets.
- Appendix D has an example detailing the creation of a partial duration series from a daily flow dataset to illustrate the use of the Find Peaks tool within HEC-DSSVue as well as comparing the differences between a partial duration series and an annual maximum series.

CHAPTER 2

Installing HEC-SSP

The user can install HEC-SSP using the program installation package available from HEC's web site. The setup program installs the software, documentation, and the example applications. This chapter discusses the hardware and system requirements needed to use HEC-SSP, how to install the software, and how to uninstall the software.

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Hardware and Software Requirements

Before installing the HEC-SSP software, make sure that the computer has at least the minimum required hardware and software. In order to get the maximum performance from the HEC-SSP software, recommended hardware and software is shown in parentheses. This version of HEC-SSP will run on a computer that has the following:

- Intel Based PC or compatible machine with Pentium processor or higher (a Pentium 4 or higher is recommended).
- A hard disk with at least 100 megabytes of free space
- A CD-Rom drive (or CD-R, CD-RW, DVD), if installing from a CD.
- A minimum of 512 megabytes of RAM (1 Gigabyte or more is recommended).
- A mouse.
- Color Video Display (Recommend running in 1280x1024 or higher resolution, and as large a monitor as possible). Recommend at least a 17" monitor.
- Microsoft Windows XP or 7 (or later versions).

Installation Procedure

Installation of the HEC-SSP software is accomplished through the use of the Setup program.

To install the software onto your hard disk do the following:

1. Download the HEC-SSP setup program from our web page: www.hec.usace.army.mil.

2. Save the setup file in a temporary directory and then execute the "HEC-SSP_21_Setup.exe" file to run the setup program.

3. Follow the setup instructions on the screen.

The install creates a program group called HEC. This program group will be listed under the Programs menu, which is under the Start menu. The HEC-SSP program icon will be contained within the HEC program group, within the HEC-SSP subdirectory. The user can request that a shortcut icon for HEC-SSP be created on the desktop. If the 32-bit application is installed in the default directory, the HEC-SSP executable can be found in the C:\Program Files (x86)\HEC\HEC-SSP\2.1 directory with the name "HEC-SSP.EXE". If the 64-bit application is installed in the default directory, the HEC-SSP executable can be found in the C:\Program Files\HEC\HEC-SSP\2.1 directory with the name "HEC-SSP.EXE".

The HEC-SSP User's Manual and example data sets are also installed with the software. The User's Manual can be viewed by selecting **User's Manual** from the **Help** menu. To view the User's Manual, Adobe Acrobat Reader must be installed. This viewer can be obtained for free from the Adobe web page.

A zip file containing the example data sets described in Appendix B and Appendix C have been installed in the "**…\Examples**" folder within the program directory. The example data sets can be installed by selecting the **Install Example Data** option from the **Help** menu. After selecting the appropriate menu option, a window will open to choose a location to install the example data sets. The program will create two subdirectories within your chosen folder called **SSP_Examples** and **Bulletin_17C_Examples**. Project files with an ".ssp" file extension will be contained in both subdirectories. The test data sets can be loaded by using the **Open Study** option from the File menu and then use the file chooser to select either project file.

Uninstall Procedure

The HEC-SSP Setup program automatically registers the software with the Windows operating system. To uninstall the software, do the following:

- From the Start Menu select Control Panel.
- Select Add/Remove Programs from within the Control Panel folder.
- From the list of installed software, select the HEC-SSP program and press the Remove button.
- Follow the uninstall directions on the screen and the software will be removed from the computer.

CHAPTER 3

Working With HEC-SSP – An Overview

HEC-SSP is an integrated package of statistical analysis modules, in which the user interacts with the system through the use of a Graphical User Interface (GUI). The current version is capable of performing flow frequency analyses based on Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) and/or Bulletin 17C (England, et al., 2015) guidelines, general frequency analyses, volume frequency analyses, duration analyses, coincident frequency analyses, curve combination analyses, and balanced hydrograph analyses. This chapter provides an overview of how a Bulletin 17C flow frequency analyses can be performed with the HEC-SSP software. General frequency and volume-duration frequency analyses can be developed in a similar manner as outlined for the Bulletin 17 analysis.

In HEC-SSP terminology, a **Study** is a set of files associated with a particular set of data and statistical analyses being performed. The files for a study are categorized as follows: study information, data list, and analysis data.

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Starting HEC-SSP

When you run the HEC-SSP Setup program, a new program group called **HEC** and a program icon called **HEC-SSP** are created. They should appear in the start menu under the section called **All Programs**. The user also has the option of creating a shortcut on the desktop. If a shortcut is created, the icon for HEC-SSP will look like Figure 3-1.

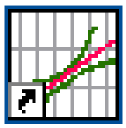


Figure 3-1. The HEC-SSP Icon.

To Start HEC-SSP from Windows:

- Double-click on the HEC-SSP Icon. If you do not have an HEC-SSP shortcut on the desktop, go to the **Start** menu and select **All Programs → HEC → HEC-SSP → HEC-SSP 2.1**.

Overview of the Software Layout

When you first start HEC-SSP, you will see the main window as shown in Figure 3-2, except you will not have any study data on your main window. As shown in Figure 3-2, the main window is laid out with a Menu Bar, a Tool Bar, and four window panes.

The upper right pane (which occupies most of the window area) is the **Desktop Area** (Referred to as the "Desktop" from this point in the manual). This area is used for displaying maps, data editors, and analysis windows.

The upper left pane is called the **Study Explorer**. The Study Explorer acts like an explorer tree for the study. The top level of the tree is the study (“SSP Examples” in this example). Below the study is an analysis branch, a data branch, and a map branch. Under the analysis branch, the first level is the type of analysis. Under each analysis type will be the current user-defined analyses for that type. The data branch lists all of the available data sets that have been brought into the current study. Generally, a data set represents a piece of data at a specific gage location. For example, all of the peak annual flows at a single gage would be stored as a single data set. When an analysis is created, the user selects a data set to be used for that particular analysis. The map branch of the tree contains any maps the user has put together for the study. By default there is automatically a "Base Map" listed under the maps folder.

The lower left pane, and associated tabs, also belongs to the study explorer. This window is used to show additional information about items selected in the study explorer. The tabs are used to switch to different views within the study explorer window. The first tab, labeled Study, shows the explorer view of the study. The second tab, labeled Maps, lists the available maps and map layers associated with each map. The last tab, labeled Files, shows all of the files that make up the current study.

The lower right pane is called the **Message Window**. This window is used to display messages from the software as to what it is doing.

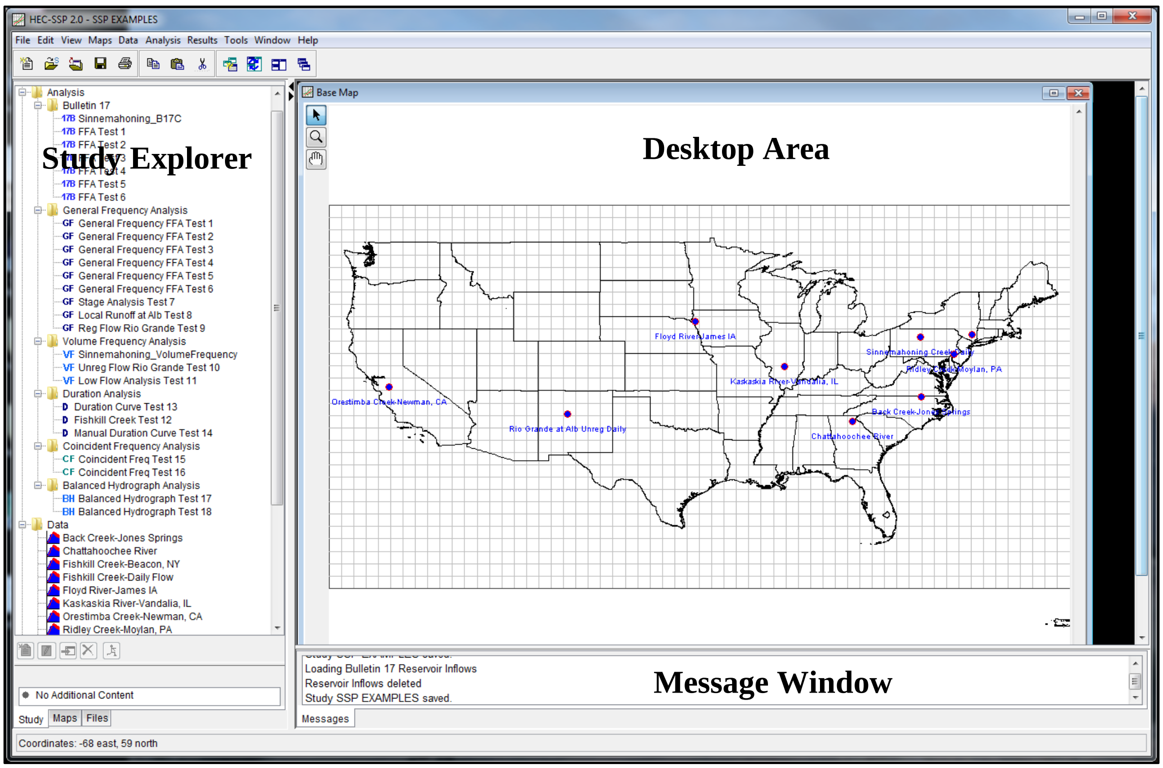
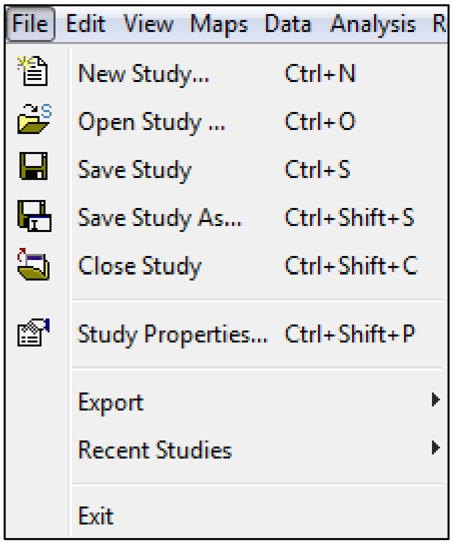


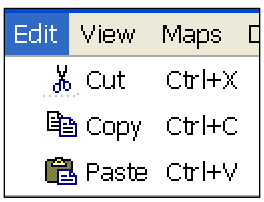
Figure 3-2. The HEC-SSP Main Window.

At the top of the HEC-SSP main window is a Menu bar with the following options:

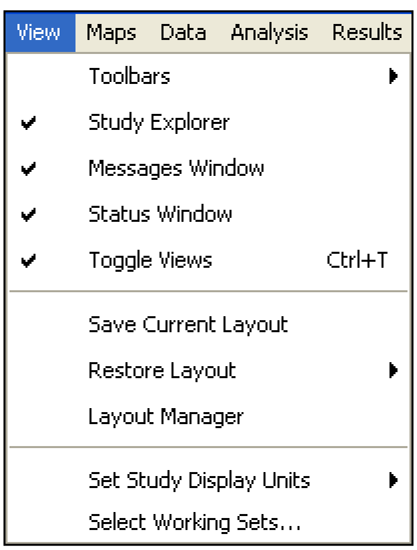
File: This menu is used for file management. Options available under the File menu include New Study, Open Study, Save Study, Save Study As, Close Study, Study Properties, Export, Recent Studies, and Exit. The Study Properties option is used to describe the study. The Export option is used to export HEC-SSP results, stored in the study DSS file, to another DSS file. The Recent Studies option lists the most recently opened studies, which allows the user to quickly open a study that was recently worked on.



Edit: This menu is used for applying the Cut, Copy, and Paste clipboard features to data in editable fields and tables.



View: The View menu allows the user to control display of the toolbars and the study windows. The user can also toggle between viewing all of the panes or just the Main View Pane. The View menu also has options for saving the current layout (currently opened windows and their sizes and locations) and restoring a previously saved layout. The Set Study Display Units option allows the user to switch output between English and metric units.



The Select Working Sets menu option allows the user to group items in each folder and then display only those items in the user interface. For example, Figure 3-3 shows the Bulletin 17 folder in the study explorer. The Edit Working Set editor, Figure 3-4, was used to group all Bulletin 17 analyses that started with "FFA" into one working set. The working set was named "FFA Analyses". This working set was activated by right clicking on top of the Bulletin 17 folder in the study explorer and selecting **Select Working Sets→FFA Analyses**, as shown in Figure 3-5. Only the Bulletin 17 analyses within the working set will then be displayed in the study explorer, as shown in Figure 3-6. To display all Bulletin 17 analysis, right click on top of the Bulletin 17 folder in the study explorer and select **Select Working Sets→No Working Set**.

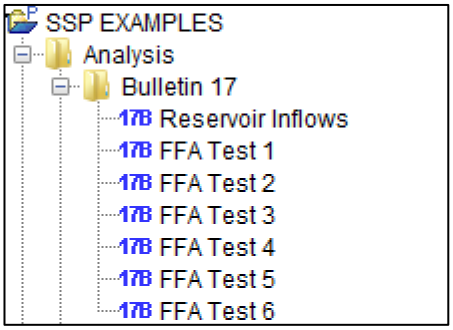


Figure 3-3. Study Explorer before Defining a Working Set.

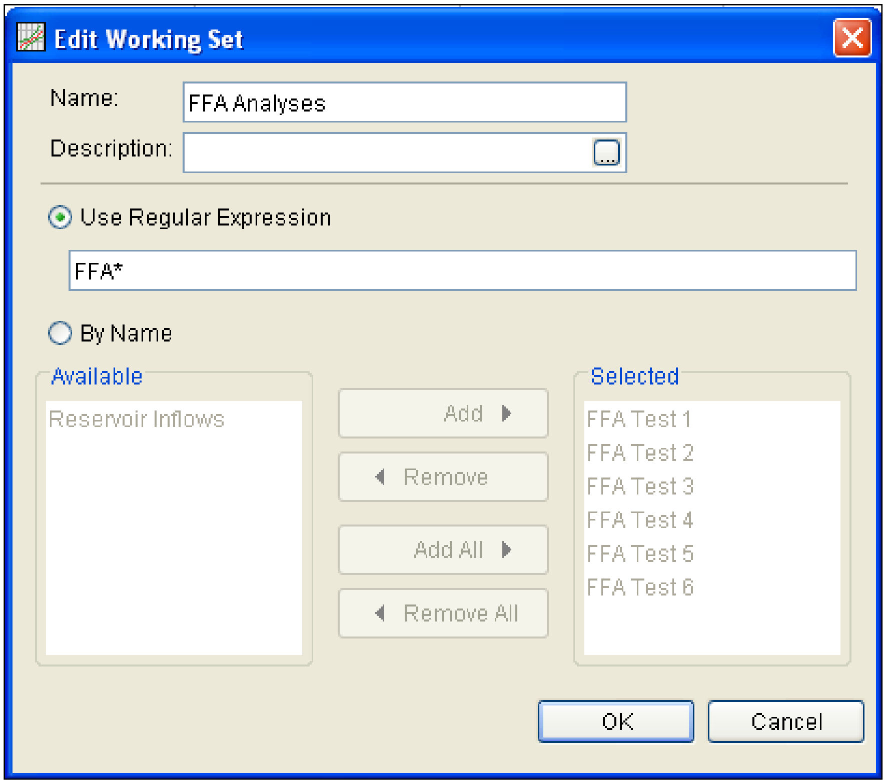


Figure 3-4. Edit Working Set Editor.

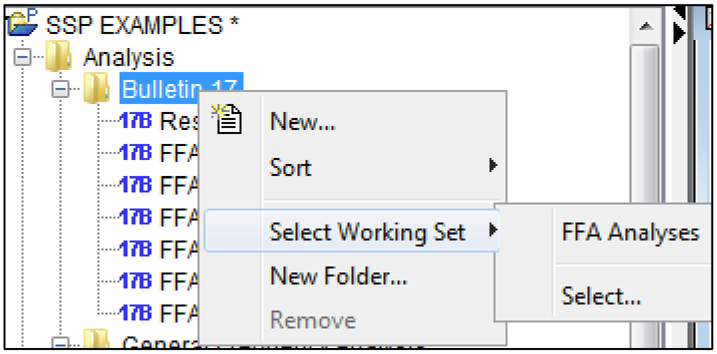


Figure 3-5. Activate a Working Set from the Study Explorer.

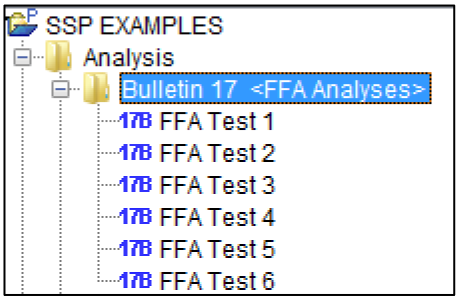
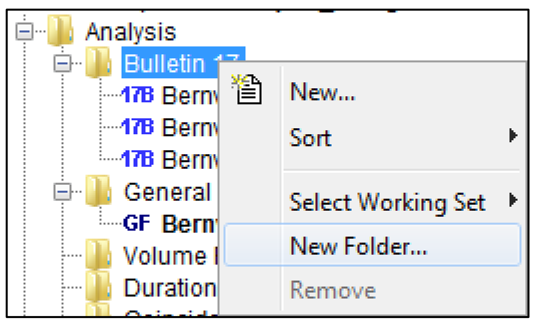
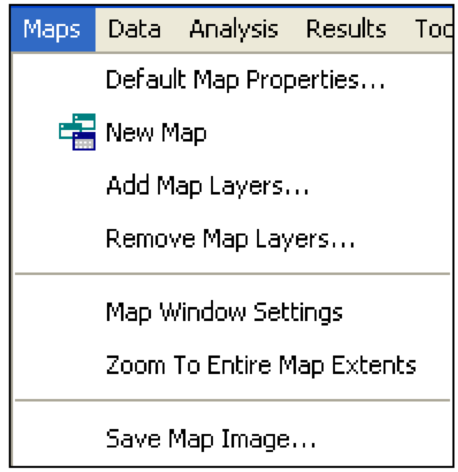


Figure 3-6. Bulletin 17 Folder Only Displays Analyses in Working Set.

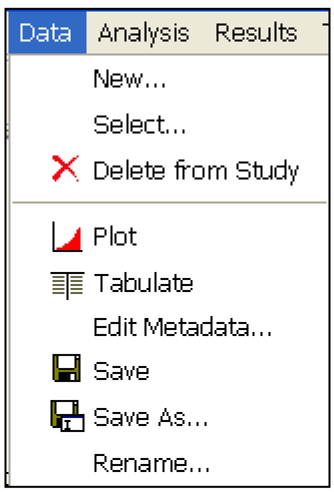


The user may also prefer to group multiple analyses of the same type together using folders. Folders can be created by right clicking on the analysis type of interest and selecting **New Folder…** After the user has named the folder, analyses can be added to the new folder by left clicking on the analysis, holding down the left mouse button, dragging the analysis to the newly created folder, and releasing the left mouse button.

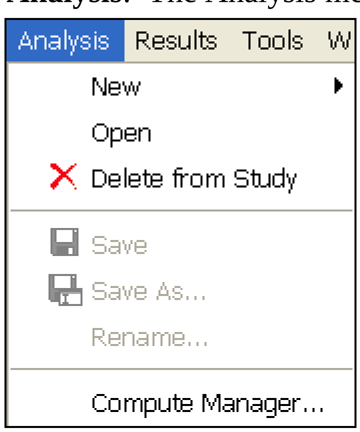
Maps: This menu is used to set the Default Map Properties (Coordinate system, extents, etc…), define a new map, add map layers to the study, and remove a map. Additionally, this menu has the following options available: Map Window Settings (allows the user to turn map layers on and off), Zoom To Entire Map Extents, Save Map Image, Import, and Export. The Zoom To Entire Map Extents option displays the entire set of map layers within the map window. The Save Map Image option can be used to save the current view of the map to a file.



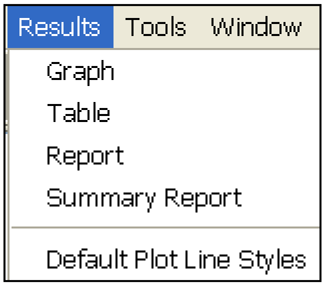
Data: The Data menu allows the user to define a new data set, open the metadata editor, and delete any existing data sets from the data list. Other options include opening a plot and table of the data.

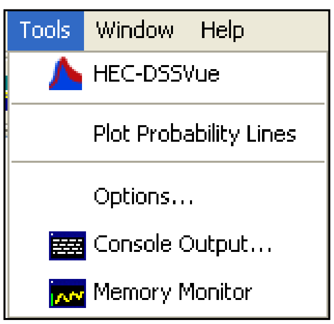


Analysis: The Analysis menu is used to create the various statistical analyses available in the software. Each statistical analysis is saved as a separate file containing the information that is pertinent to that specific analysis type. The current options under this menu item include New, Open, Delete from Study, Save, Save As, Rename, and Compute Manager. The compute manager allows the user to select one, several, or all of the analyses, and then have them all recomputed.

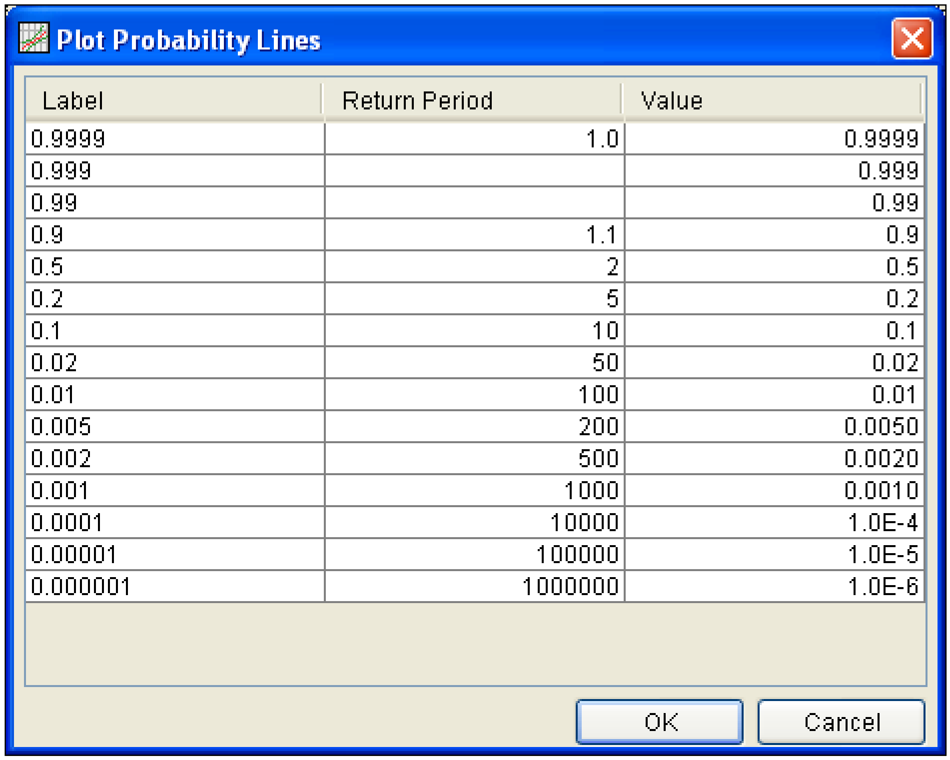


Results: The Results menu allows the user to graph and tabulate any of the existing analyses that have been computed. Additionally, the user can request to view the report file from a analysis. Users must select at least one analysis in the Study Explorer before selecting Graph, Table, Report, or Summary Report. If more than one analysis of the same type are selected (this is accomplished by holding down the control key while clicking on the various analyses), the Graph and Summary Report options will include results from all analyses that are selected. However, when multiple analyses are selected, the Table and Report option bring up separate windows for each of the selected analyses. The Default Plot Line Styles menu option lets the user change the default line styles applied to different data types that are plotted in a graph. For example, the user can change the default line style for high outliers so that they are displayed as black triangular data points when a plot is opened.





Tools: The Tools menu includes HEC-DSSVue, Plot Probability Lines, Options, Console Output, and Memory Monitor. The HEC-DSSVue option brings up the HEC-DSSVue program and automatically loads the current study DSS file. HEC-DSSVue is a DSS utility to tabulate, graph, edit, and enter data into DSS. The Plot Probability Lines option opens an editor, shown in Figure 3-7, that lets the user add, delete, or edit the probability lines and axis labels that are displayed in all frequency curve plots. The Options menu item opens the Options editor that allows the user to set default HEC-SSP options. The **Results** tab in the Options editor, shown in Figure 3-8, allows the user to set the number of decimal digits that are displayed in all results.



Label	Return Period	Value
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0.999		0.999
0.99		0.99
0.9	1.1	0.9
0.5	2	0.5
0.2	5	0.2
0.1	10	0.1
0.02	50	0.02
0.01	100	0.01
0.005	200	0.0050
0.002	500	0.0020
0.001	1000	0.0010
0.0001	10000	1.0E-4
0.00001	100000	1.0E-5
0.000001	1000000	1.0E-6

Figure 3-7. Plot Probability Lines Editor.

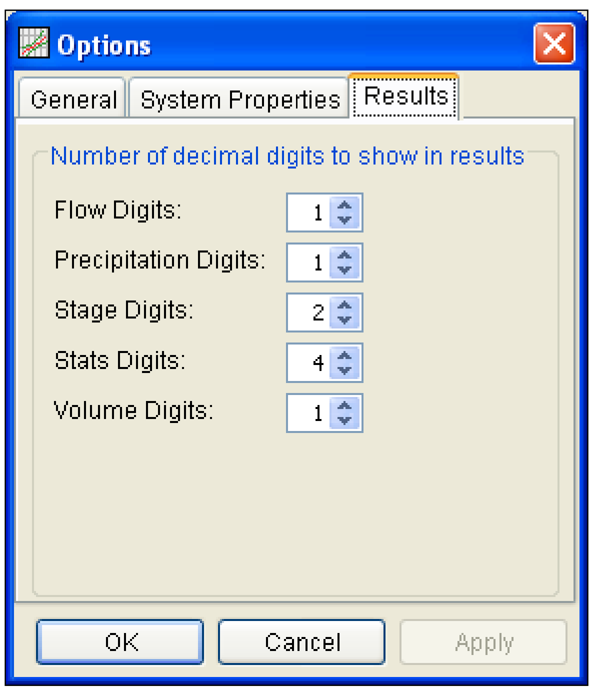
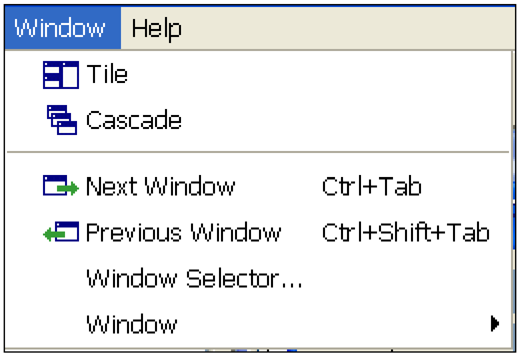
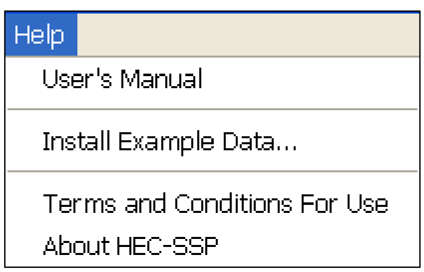


Figure 3-8. Dialog for Controlling the Number of Decimal Digits Shown in Result Tables and Reports.

Window: This menu includes Tile, Cascade, Next Window, Previous Window, Window Selector, and Window. These options are used to control the appearance of the windows in the Desktop area. When more than one window is open (such as a data importer, and various analysis windows), these menu items will help the user organize the windows, or quickly navigate to a specific window. The Tile option can be used to organize all of the currently opened windows in either a vertical or horizontal tile. The Cascade option puts one window on top of the next in a cascading fashion. The Next Window option brings the next window in the list of currently opened windows to the top. The Previous Window brings the last window that was on top back to the top. The Window Selector option brings up a pick list of the currently opened windows and allows you to select the one you want. The Window option has a sub menu list of all the opened windows and allows you to select one.



Help: This menu allows the user to open the HEC-SSP User's Manual, install example data sets, read the terms and conditions of use statement, and display the current version information about HEC-SSP.



Also on the HEC-SSP main window is a Tool Bar. The buttons on the tool bar provide quick access to the most frequently used options under the HEC-SSP File and Edit menus.

Steps in Performing a Bulletin 17C Frequency Analysis

There are five main steps in performing a Bulletin 17C flow frequency analysis using HEC-SSP. Similar steps are required when performing other statistical analyses.

- Starting a new study
- Adding a Background Map (Optional)
- Importing, Entering, and Editing Data
- Performing the Bulletin 17C Frequency Analysis
- Viewing and Printing Results

Starting a New Study

The first step in performing a flow frequency analysis with HEC-SSP is to establish which directory you wish to work in and to enter a title for the new study. To start a new study, go to the **File** menu and select **New Study**. This will open the **Create New Study** window as shown in Figure 3-9.

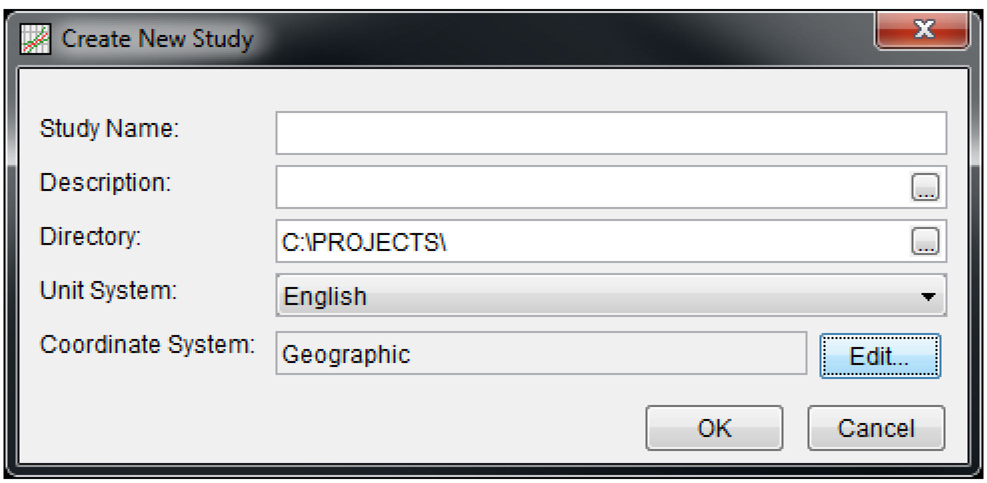


Figure 3-9. New Study Window.

The user is required to enter a name for the study, select a directory to work in (a default location is provided), and select the desired units system. Adding a description of the study is optional. The user should also define a Coordinate System if background spatial data will be plotted. Multiple coordinate systems are provided for use. The choice of a coordinate system will not affect any computed results. Once you have entered all the information, press the **OK** button to have the information accepted. After the **OK** button is pressed, a subdirectory will be created under the user chosen directory. The subdirectory will be labeled with the same name as the user-entered study name. This study directory is where the HEC-SSP project file, as well as other study files and directories will be located. Additionally, a default map window will appear in the Main View Pane. However, the map window will be blank when it first opens.

Adding a Background Map

By default, when you start a new project in HEC-SSP a default map window (called Base Map) will open in the Desktop window. Having a background map is optional in HEC-SSP. Not having a map does not prevent the user from importing and entering data, or performing an analysis and viewing results. The map is mostly a visual aid of the study area. Additionally, when you bring in gage data you can enter the map coordinates of the gage and it will show up on the map. The user must supply a coordinate system other than X-Y (i.e. Geographic) for imported gage data to be displayed properly. Once a gage is located on the map you can right click on it to open a shortcut menu for viewing the data, or graphing and tabulating the results.

To add a map layer to the default map, go to the **Maps** menu and select **Add Map Layers**. When this option is selected a file chooser window will appear, as shown in Figure 3-10, allowing the user to select map layers to bring into the map. The **Create Copy** option on the window will make a copy of the selected map and place it in the Maps subdirectory within the study folder.

Currently, the HEC-SSP software can load the following types of map layers: United States Geologic Survey (USGS) DLG, AutoCAD DXF, shapefile, Raster Image, USGS DEM, Arc Info DEM, ASCII NetTIN, and Mr Sid.

An example map is shown in Figure 3-11. This map contains a shapefile of state boundaries and data locations.

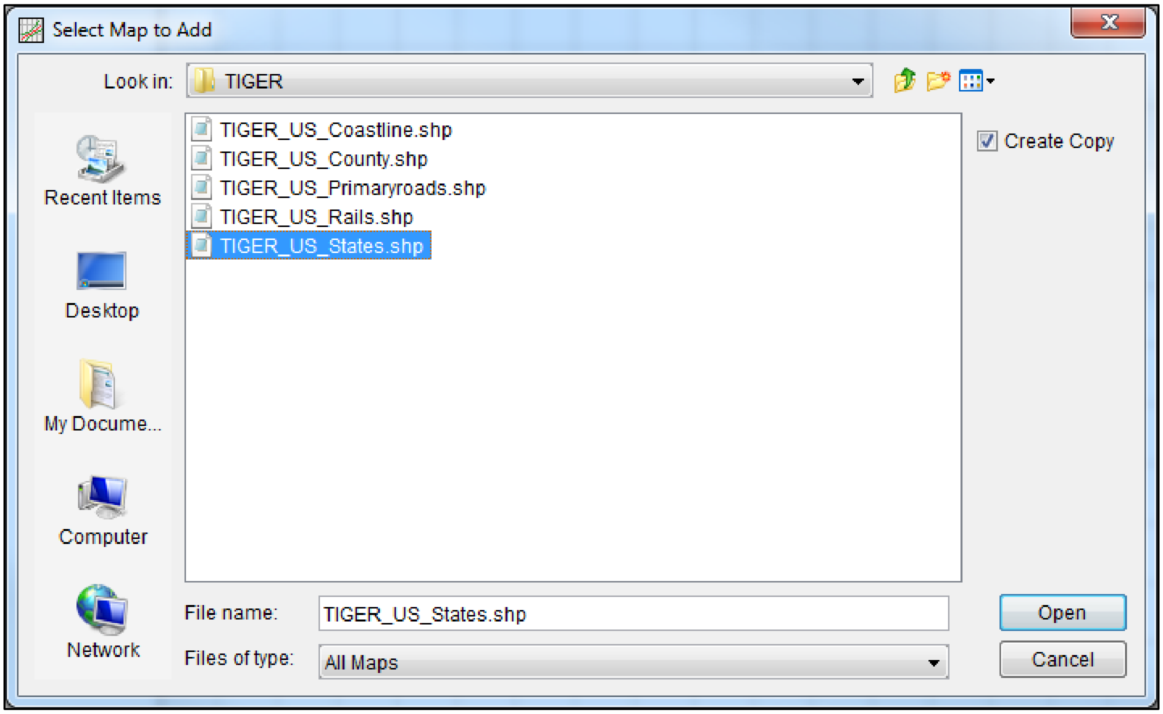


Figure 3-10. Select a Map Layer to add to the Base Map.

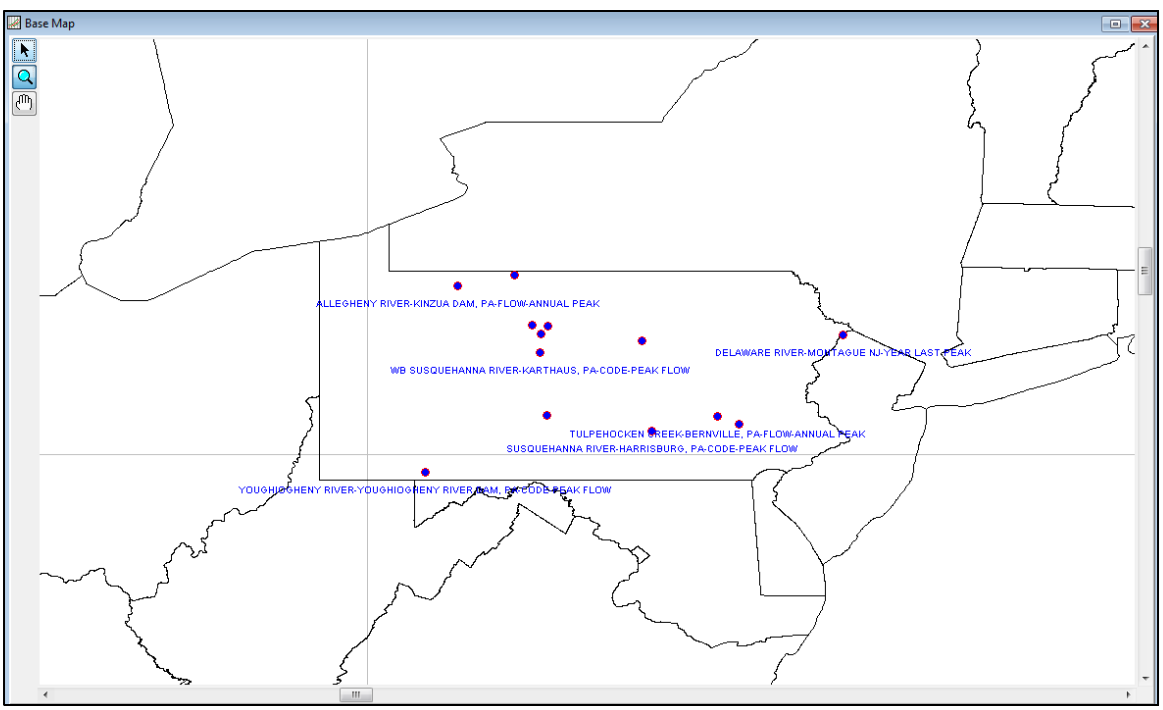


Figure 3-11. Example Background Map.

If more than one map layer is going to be added to a map, then it is up to the user to ensure that all map layers are in the same coordinate system. HEC-SSP does not perform coordinate system projections. Also, HEC-

SSP cannot always determine the coordinate system for all map layers entered. However, under the **Maps** menu is an option called **Default Map Properties**. This menu option can be used to set the default coordinate system for the map layers displayed in HEC-SSP. The user should set the default coordinate system first and then bring in map layers to the study.

Importing, Entering, and Editing Data

Before any analyses can be performed, the user must bring data into the HEC-SSP study. For a peak flow frequency analysis following guidelines in Bulletin 17C, the data must consist of peak annual flow values. To bring data into HEC-SSP go to the **Data** menu and select **New**. This will bring up the **Data Importer** as shown in Figure 3-12.

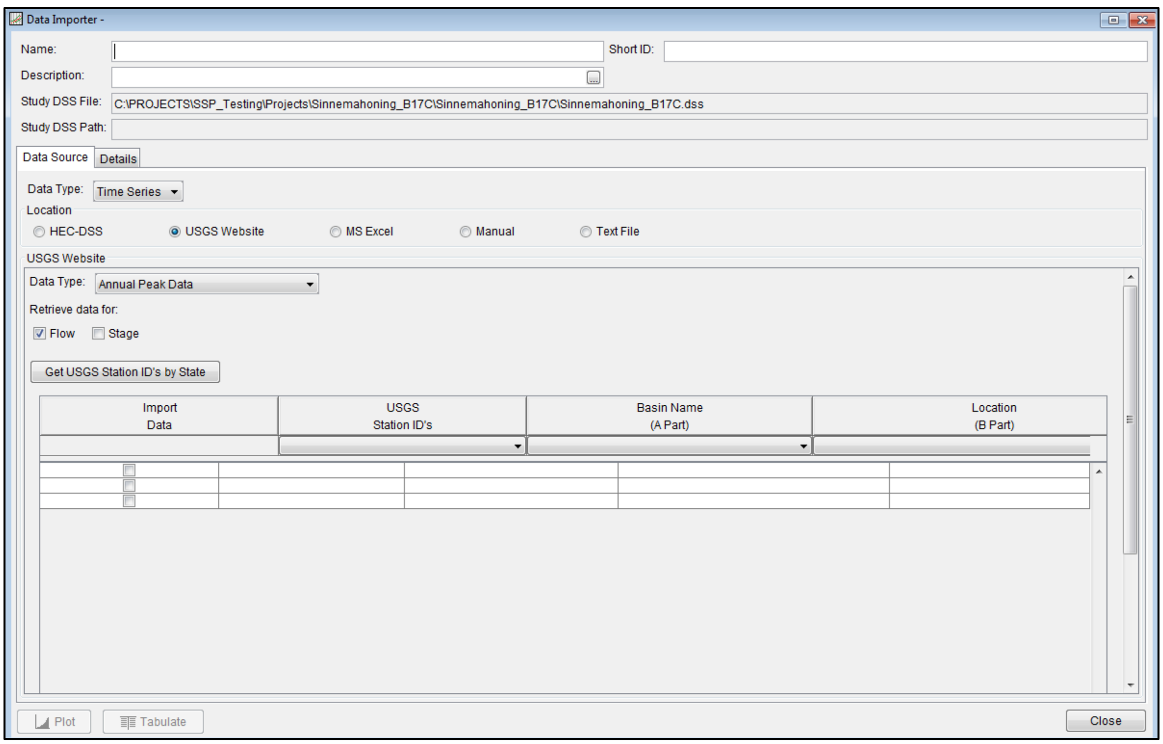


Figure 3-12. HEC-SSP Data Importer.

As shown in Figure 3-12, the Data Importer has fields for the Name, Short Identifier, and the Description of the data at the top of the window. Additionally, it lists the study DSS file name that the data will be stored in once it is brought into the study. The study DSS file is always labeled the same name as your study with the .DSS file extension.

The Data Importer contains two tabs, **Data Source** and **Details**. The **Data Source** tab is shown first. This tab is used for selecting and defining a source for bringing data into the HEC-SSP study. Currently, there are five ways to bring data into an HEC-SSP study: import from another HEC-DSS file, import data from the USGS web site, import from a Microsoft Excel spreadsheet, manually entering the data into a table, and import the data from a text file. All of these methods will import data into the study DSS file.

For this example, importing data from the USGS website will be shown. For a complete description of the data importer see Chapter 4. To import data from the USGS website, first select the **USGS Website** option from the list of five options available in the Location panel. Next, select **Annual Peak Data** as the data type and make sure the **Flow** option is selected. The next step is to press the button labeled **Get USGS Station ID's by State**. When this button is pressed a window will appear (Figure 3-13) allowing the user to select a state from which to get data.

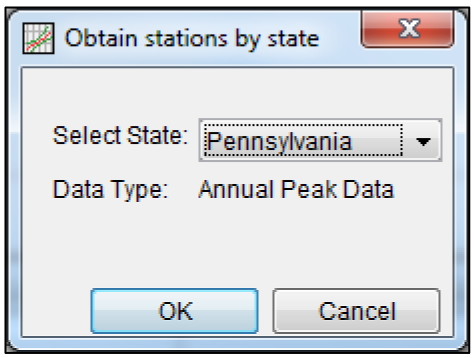


Figure 3-13. Window to Select a State for Downloading Data.

Once a state is selected, press the **OK** button and a list of the available gages from that state will appear in a pick list as shown in Figure 3-14. Check the boxes for all of the gages you would like to import and then press the **Import to Study DSS File** button. Once the import button is pressed, a process will begin during which the data will be downloaded from the USGS website and saved to the study DSS file. HEC-SSP will automatically name the data when importing multiple gages at one time. The USGS import process will download annual peak flow data, and the USGS data quality codes. The quality codes will be added as an addition object to the Data folder.

In addition to the data itself, any metadata that is available will be downloaded and stored with the data. The metadata can be viewed from the **Details** Tab on the Data Importer. Metadata can also be viewed or edited by opening the **Metadata Editor**. To open this editor, place the mouse on top of a data object in the Data folder and click the right mouse button. The shortcut menu contains an **Edit Metadata** option, as shown in Figure 3-15. The metadata editor is shown in Figure 3-16.

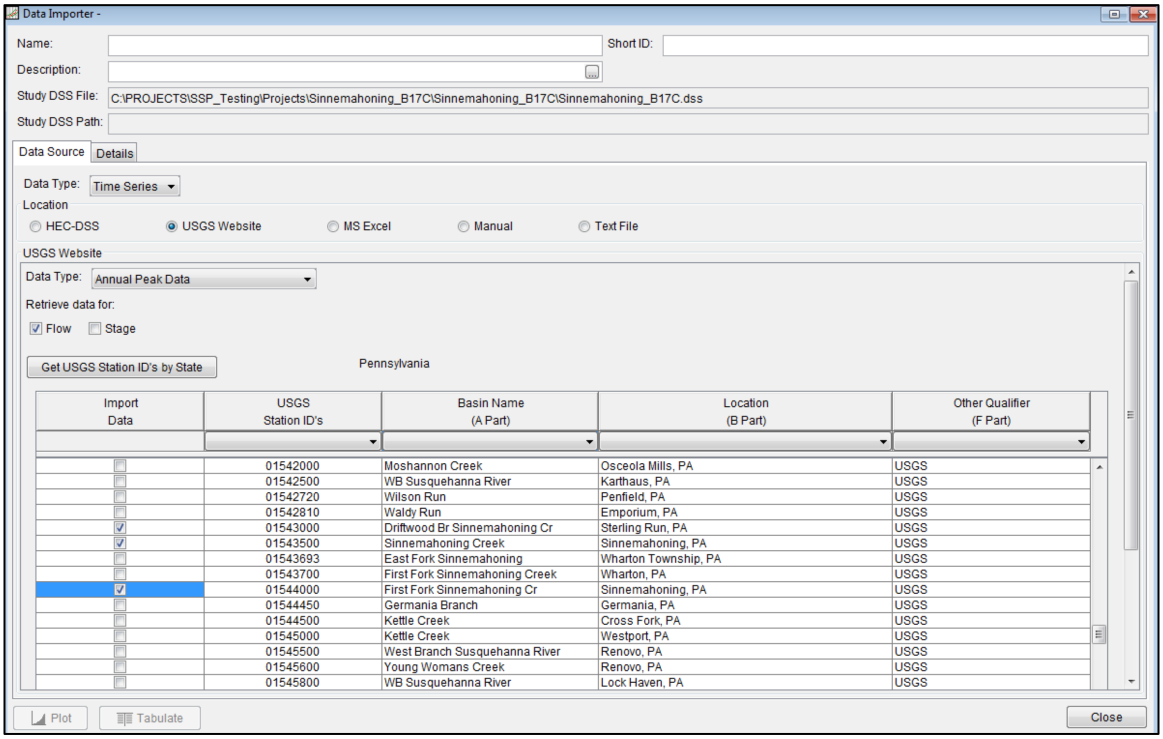


Figure 3-14. Example of Choosing Gages from a USGS State List to Import.

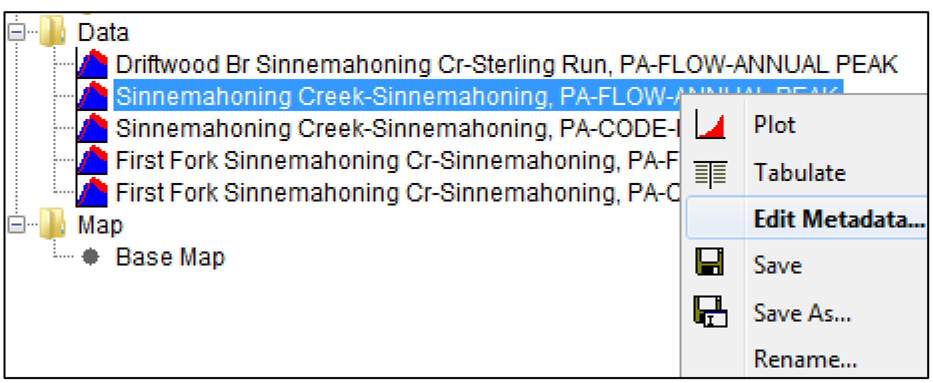


Figure 3-15. Open the Metadata Editor Using the Right Mouse Click Menu.

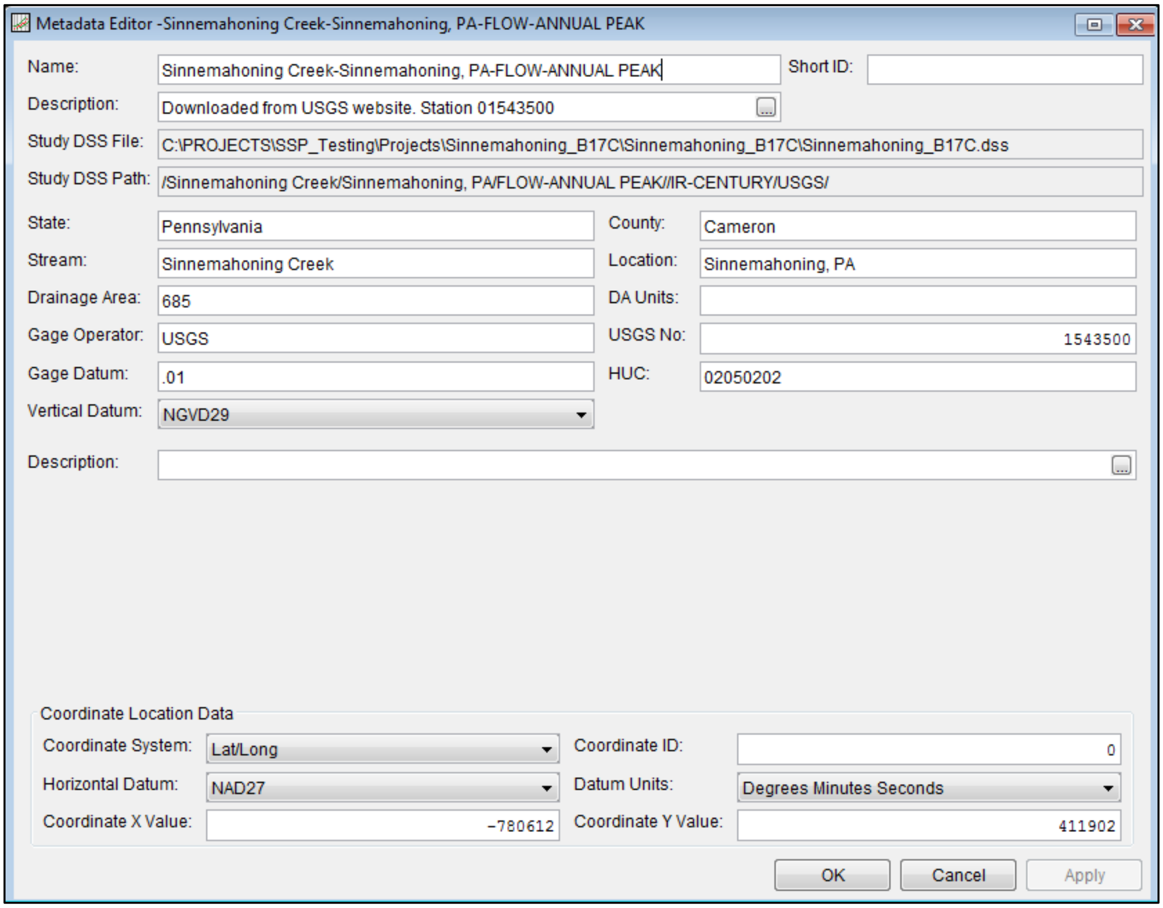


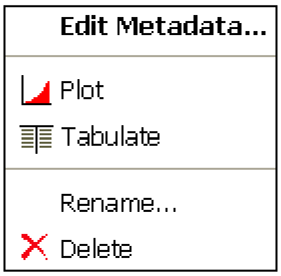
Figure 3-16. Metadata can be Viewed or Edited by Opening the Metadata Editor.

As shown in Figure 3-16, the metadata consists of the State, County, Stream, Location, Drainage Area, DA Units, Gage Operator, USGS Gage No., Gage Datum, HUC (Hydrologic Unit Code), Vertical Datum, and a description field. Additionally, the coordinate location of the data is shown. The coordinate location consists of Coordinate System, Coordinate ID, Horizontal Datum, Datum Units, Coordinate X Value, and Coordinate Y Value. Most of the USGS data is retrieved with the Latitude/Longitude coordinate system as shown in the example. In addition to editing the metadata, the Metadata Editor allows the user to change the name of the data, enter a short identifier, and enter a longer description.

If the metadata does not download automatically, the user has the option to enter any of the information by hand. Metadata is not generated automatically for any of the other four data sources. Therefore, entering the metadata is required if the user wants it to be carried along with the study.

After the data is imported into the study, the user can select any one of the gages in the Data folder and **Plot** or **Tabulate** the data. The plot and tabulate options are available from the Data menu and from a shortcut menu that opens by clicking the right mouse button when the pointer is located on top of the gage object in the Data folder. If you select the **Plot** option, you will get a plot of the peak flow data for that gage. If you select the **Tabulate** option, you will get a table containing the data. Data values can be edited within the table; however, the editing mode must be turned on. To turn on editing, select the **Edit→Allow Editing** menu option. Use the **File→Save** or **File→Save As** menu option to save the data when you are satisfied with edits.

If the data has coordinate location information, it will then be plotted on top of the background maps. The software will convert the coordinates of the point data to the default coordinate system of the base map. The user can interact with the plotted points by right clicking on the gage icon in the map and a shortcut menu will appear as shown. The user has the option to edit the metadata, plot, tabulate, rename, or delete the data.



Performing the Bulletin 17C Flow Frequency Analysis

To perform a Bulletin 17C flow frequency analysis, go to the **Analysis** menu and select **New → Bulletin 17 Flow Frequency**. This will bring up an empty Bulletin 17 editor. As shown in Figure 3-17, the user must enter a name for the analysis, a description (optional), and select a flow data set (gage data stored in study DSS file). The DSS File Name and Report File are automatically filled in by the program. For now, the DSS File Name will be the study DSS file and the report file will have the same name as the analysis.

The editor window contains four tabs: General, Options, EMA Data, and Tabular Results. The **General** tab contains settings for Generalized Skew, Expected Probability Curve, Method for Computing Statistics and Confidence Limits, Plotting Positions, Confidence limits, a Time Window Modification, and Low Outlier Test. Default settings are already established for each of the options on the General tab; however, the user can change the default settings.

The **Options** tab contains information on Low Outlier Threshold, Historic Period Data, and User-Specified Frequency Ordinates. These options are not required for most analyses but may be necessary depending upon the data.

The **EMA Data** tab contains information specifically related to flow frequency analyses that make use of the procedures contained within Bulletin 17C, which uses the Expected Moments Algorithm (EMA) to compute flow frequency and confidence limits for the associated flow data set. A detailed description of each of the Bulletin 17C settings and options can be found in Chapter 5, Performing a Bulletin 17 Flow Frequency Analysis. The **EMA Data** tab is shown in Figure 3-18.

Once all of the settings and options have been selected, the user presses the **Compute** button to have the computations performed. When the computations have finished a message window will open stating **Compute Complete**. Press the **OK** button on the message window to close the window. Once the computations have finished the user can begin to look at output.

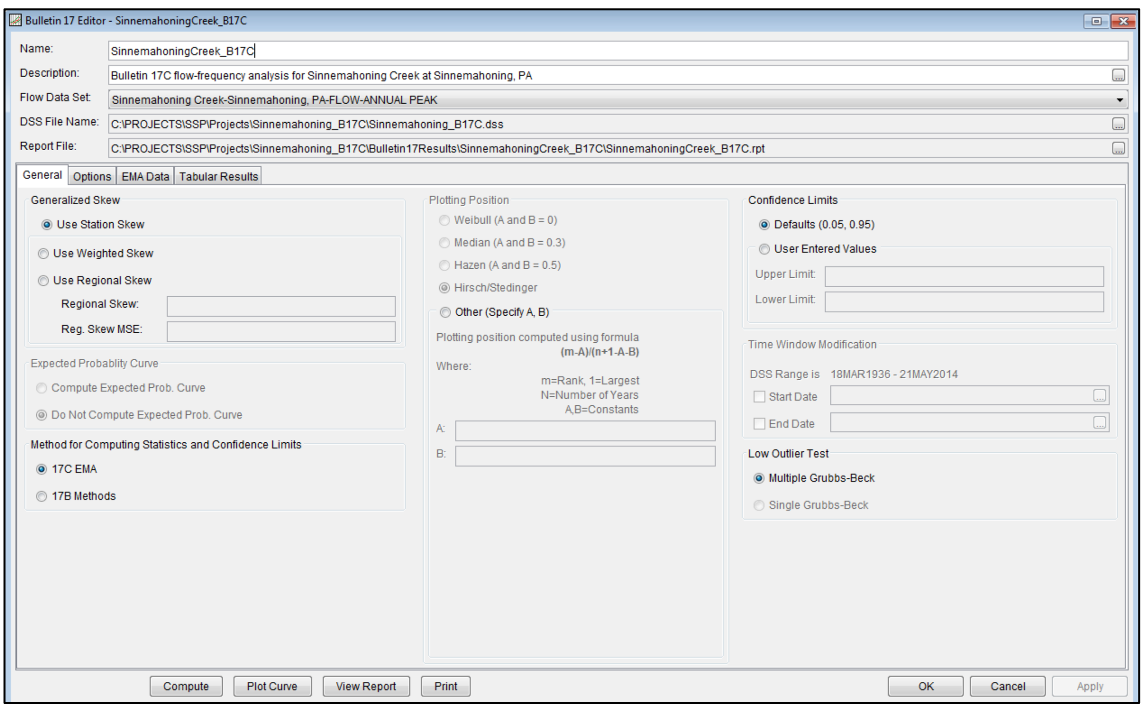


Figure 3-17. Bulletin 17 Flow Frequency Analysis General Tab.

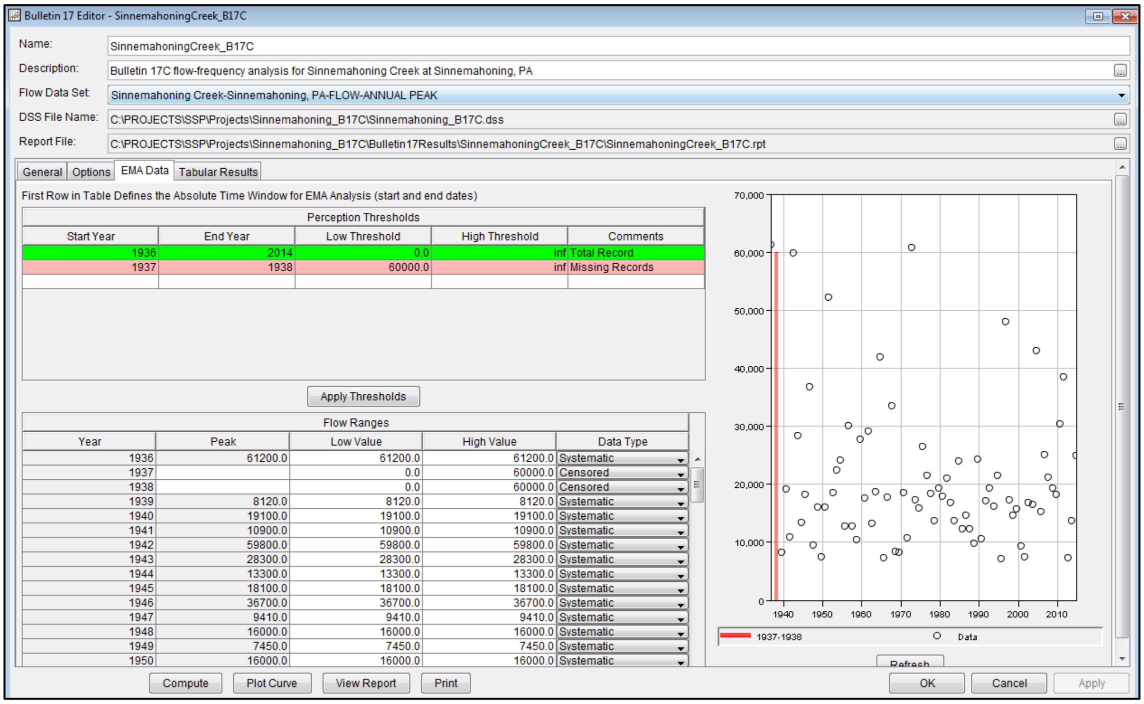
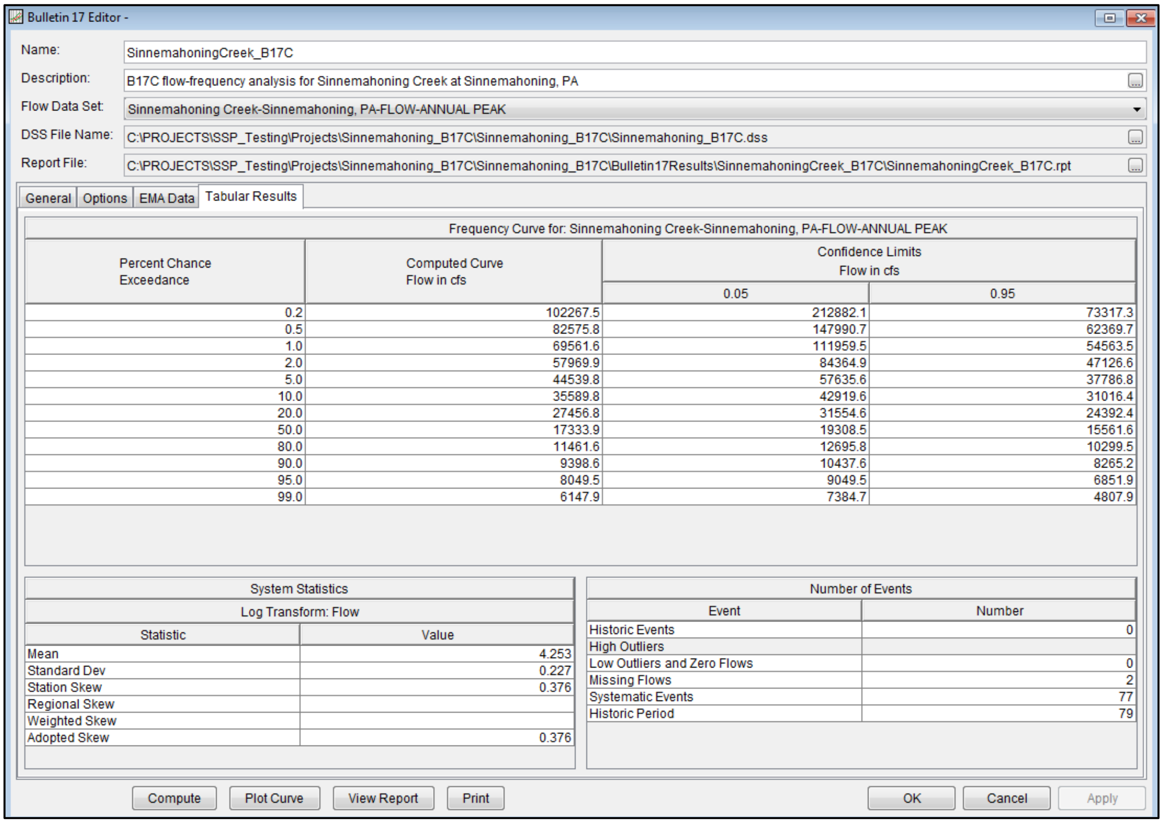


Figure 3-18. Bulletin 17 Flow Frequency Analysis EMA Data Tab.

Viewing and Printing Results

Tabular output can be viewed by selecting the **Tabular Results** tab. When this tab is pressed, a set of tables will appear as shown in Figure 3-19. The primary table on the **Tabular Results** tab consists of percent chance exceedance, computed flow frequency curve, the expected probability adjusted curve (if enabled on the **General** tab), and the 5 and 95 percent confidence limits. The second table (bottom left) contains general statistics about the data, such as the mean, standard deviation, station skew, regional skew, weighted skew, and the adopted skew of the analysis. The third table (bottom right) contains the number of historic events, high outliers, low outliers, zero or missing values, systematic events in the data set, and the number of years in the historic period. The table can be sent to the printer by pressing the **Print** button at the bottom of the analysis window. The user can control the number of decimal digits shown in the result tables and in reports. Select **Options** from the **Tools** menu and then open the **Results** tab, as shown in Figure 3-19.



Frequency Curve for: Sinnemahoning Creek-Sinnemahoning, PA-FLOW-ANNUAL PEAK			
Percent Chance Exceedance	Computed Curve Flow in cfs	Confidence Limits Flow in cfs	
		0.05	0.95
0.2	102267.5	212882.1	73317.3
0.5	82575.8	147990.7	62369.7
1.0	69561.6	111959.5	54563.5
2.0	57969.9	84364.9	47126.6
5.0	44539.8	57635.6	37786.8
10.0	35589.8	42919.6	31016.4
20.0	27456.8	31554.6	24392.4
50.0	17333.9	19308.5	15561.6
80.0	11461.6	12695.8	10299.5
90.0	9398.6	10437.6	8265.2
95.0	8049.5	9049.5	6851.9
99.0	6147.9	7384.7	4807.9

System Statistics	
Log Transform: Flow	
Statistic	Value
Mean	4.253
Standard Dev	0.227
Station Skew	0.376
Regional Skew	
Weighted Skew	
Adopted Skew	0.376

Number of Events	
Event	Number
Historic Events	0
High Outliers	
Low Outliers and Zero Flows	0
Missing Flows	2
Systematic Events	77
Historic Period	79

Figure 3-19. Bulletin 17 Flow Frequency Analysis EMA Tabular Results Tab.

Graphical output can be obtained by pressing the **Plot Curve** button at the bottom of the analysis editor. When this button is pressed, a plot will appear like the one in Figure 3-20. This plot contains the computed frequency curve, the expected probability adjusted curve (if enabled on the **General** tab), the confidence limits, and the data points plotted using the Hirsch/Stedinger plotting position method. Additionally, a plot title is listed at the top. The plot title is by default the user-defined name of the analysis. The user can modify the plot properties by selecting the **Edit→Plot Properties** menu option. A plot properties window will open that lets the user change the line style for each data type, change the axis labels, modify the plot title, and edit other plot properties. The user can also edit line styles by placing the mouse on top of the line or data point in the plot or legend and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. The plot can be printed or sent to the windows clipboard by using the **Print** and **Copy to Clipboard** options found under the **File** menu.

Additional points and lines can be added to a plot by placing the mouse anywhere in the plot area and clicking the right mouse button. Then select the **Add Marker** option to add a line or **Add Marker Point** to add a point. Draw properties can be edited for these user-defined lines and points by placing the mouse on top of the point or line and clicking the right mouse button. Then select the **Edit Properties** option in the shortcut menu.

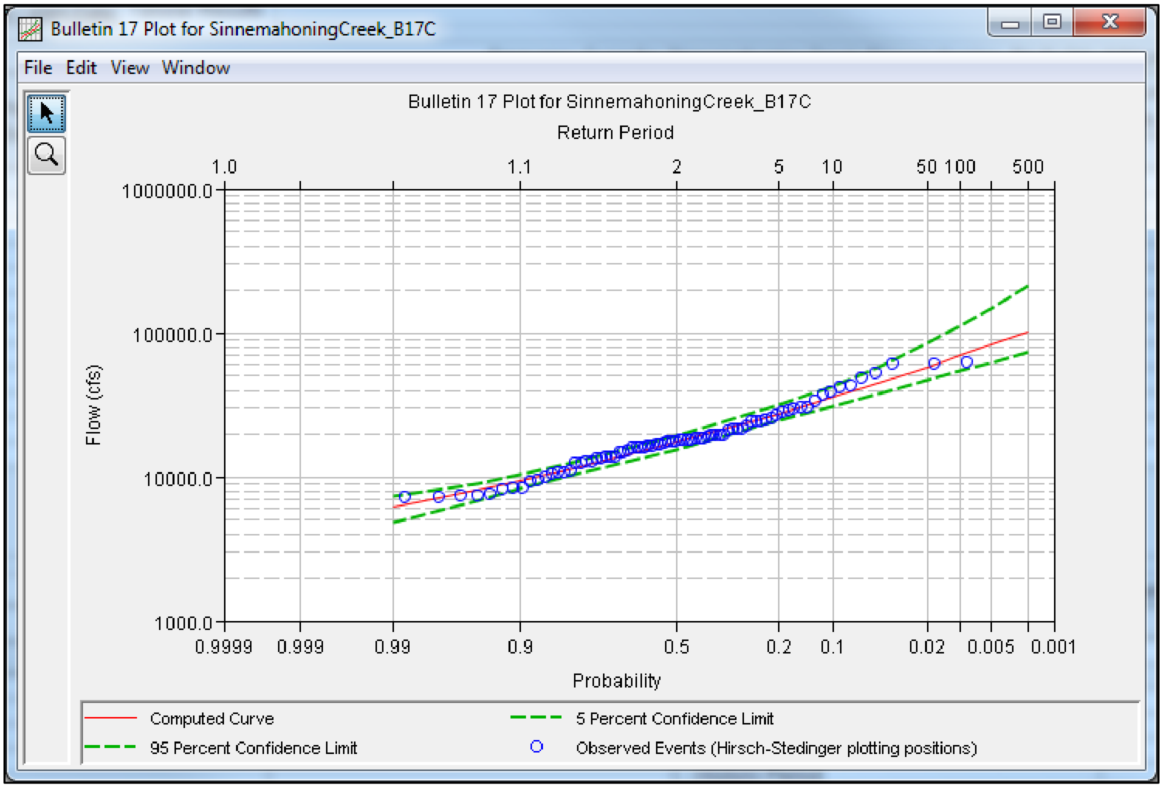
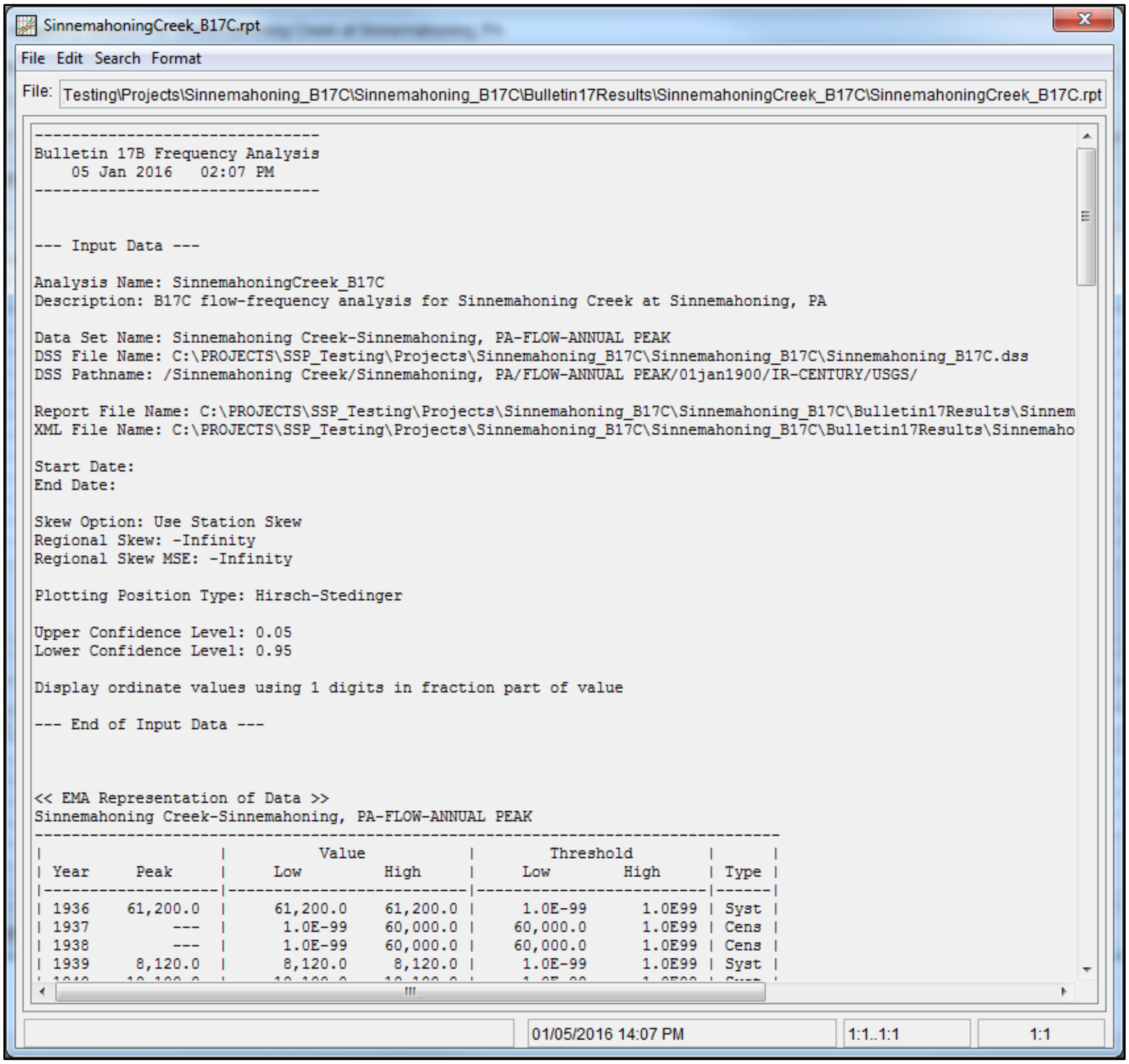


Figure 3-20. Flow Frequency Curve Plot.

The final piece of output available from a flow frequency analysis is a text report file. The report file lists all of the input data and user settings, plotting positions of the data points, intermediate results, each of the various statistical tests performed (i.e. high and low outliers, historical data, etc.), and the final results. This file is often useful for understanding how the software arrived at the final frequency curve. Press the **View Report** button at the bottom of the analysis editor to view the report file. When this button is pressed, a window will appear containing the report as shown in Figure 3-21.



SinnemahoningCreek_B17C.rpt

File Edit Search Format

File: Testing\Projects\Sinnemahoning_B17C\Sinnemahoning_B17C\Bulletin17Results\SinnemahoningCreek_B17C\SinnemahoningCreek_B17C.rpt

```
------------------------------
Bulletin 17B Frequency Analysis
    05 Jan 2016   02:07 PM
------------------------------


--- Input Data ---

Analysis Name: SinnemahoningCreek_B17C
Description: B17C flow-frequency analysis for Sinnemahoning Creek at Sinnemahoning, PA

Data Set Name: Sinnemahoning Creek-Sinnemahoning, PA-FLOW-ANNUAL PEAK
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Sinnemahoning_B17C\Sinnemahoning_B17C\Sinnemahoning_B17C.dss
DSS Pathname: /Sinnemahoning Creek/Sinnemahoning, PA/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Sinnemahoning_B17C\Sinnemahoning_B17C\Bulletin17Results\Sinnem
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Sinnemahoning_B17C\Sinnemahoning_B17C\Bulletin17Results\Sinnemaho

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---



<< EMA Representation of Data >>
Sinnemahoning Creek-Sinnemahoning, PA-FLOW-ANNUAL PEAK
--------------------------------------------------------------------------------
|                   |          Value           |         Threshold        |      |
| Year      Peak    |     Low         High     |     Low         High     | Type |
|-------------------|--------------------------|--------------------------|------|
| 1936    61,200.0  |    61,200.0    61,200.0  |     1.0E-99      1.0E99  | Syst |
| 1937         ---  |     1.0E-99    60,000.0  |    60,000.0      1.0E99  | Cens |
| 1938         ---  |     1.0E-99    60,000.0  |    60,000.0      1.0E99  | Cens |
| 1939     8,120.0  |     8,120.0     8,120.0  |     1.0E-99      1.0E99  | Syst |
```

01/05/2016 14:07 PM | 1:1..1:1 | 1:1

Figure 3-21. Report File from Bulletin 17 Frequency Analysis.

CHAPTER 4

Using the HEC-SSP Data Importer

The HEC-SSP Data Importer is used to import, enter, and view data and the corresponding metadata used in an HEC-SSP study. The current version of HEC-SSP can be used to import annual peak data (flow and stage) and data stored at regular intervals, like hourly flow data.

Contents

Developing a New Data Set

Before any analyses can be performed in HEC-SSP, the user must import or enter data into the study. Importing, entering, and viewing data is accomplished in the **Data Importer**. To open the data importer, go to the **Data** menu and select **New** from the list of options, which will bring up a data importer as shown in Figure 4-1.

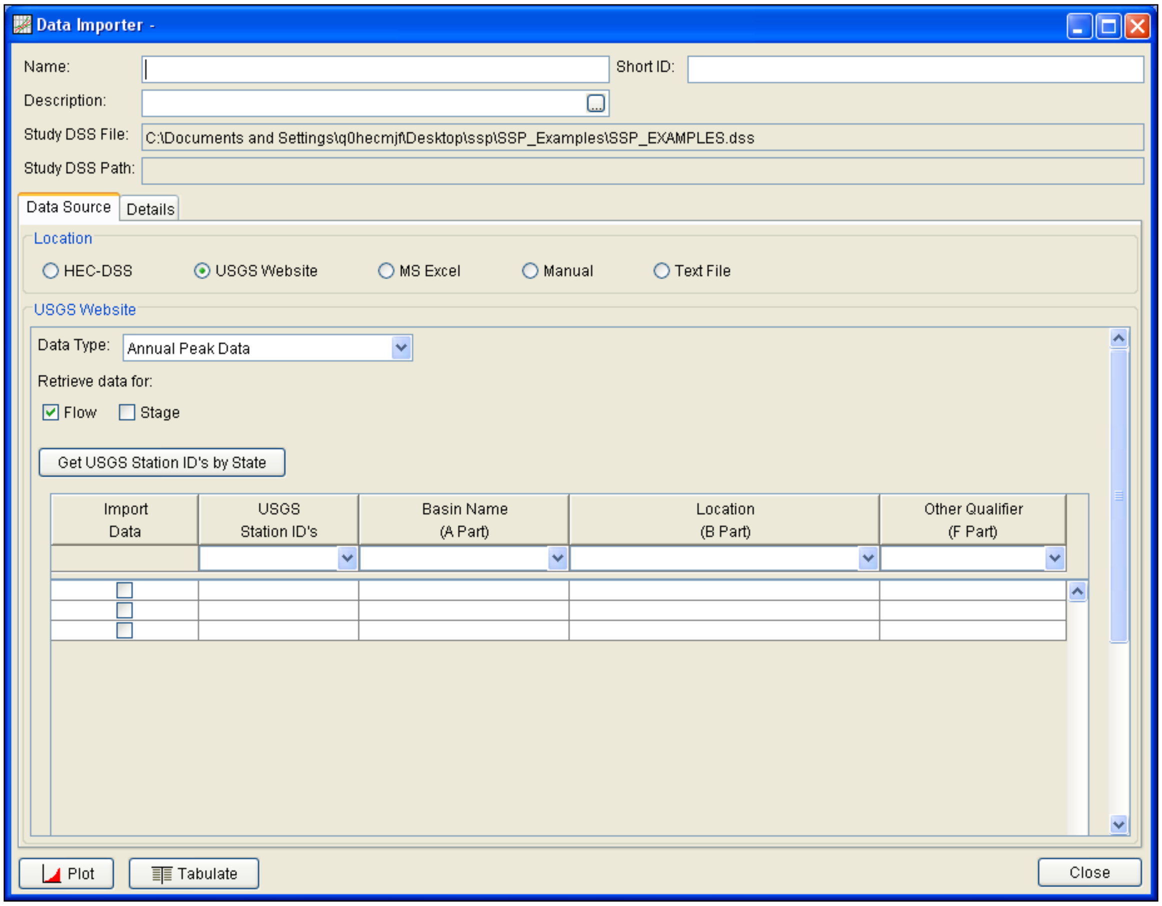


Figure 4-1. HEC-SSP Data Importer.

At the top of the Data Importer, the user can enter a **Name** for the new data set. Optionally, the user can enter a short identifier (limited to 16 characters) and a **Description** of the data set. The study DSS file name is provided. The DSS file is used for storing the data for the study. The user does not have to enter a name when importing or manually entering data. The program will automatically name the data using USGS names or HEC-DSS pathname parts. If a **Name** is entered then it will be combined with the USGS gage name or HEC-DSS pathname parts to create a unique name. The user can rename a data set by selecting the data set in the study explorer and clicking the right mouse button. A shortcut menu should open with a **Rename** menu option. The **Data** menu also contains a **Rename** menu option; however, the data set must be selected in the study explorer before this menu option is active.

The Data Importer contains two main tabs, **Data Source** and **Details**. The **Data Source** tab is used for importing or entering data manually while the **Details** tab is used to describe the data (i.e. metadata). The **Data Source** tab contains five options for getting data into the study DSS file: Importing from an existing HEC-DSS file, importing from the USGS Website, importing from an Excel spreadsheet, entering the data manually, and importing from a text file.

Importing Data from an HEC-DSS File

To import data from an HEC-DSS file into the HEC-SSP study DSS file, first select the **HEC-DSS** radio button on the data importer. Selecting **HEC-DSS** will change the view of the Data Importer to look like Figure 4-2.

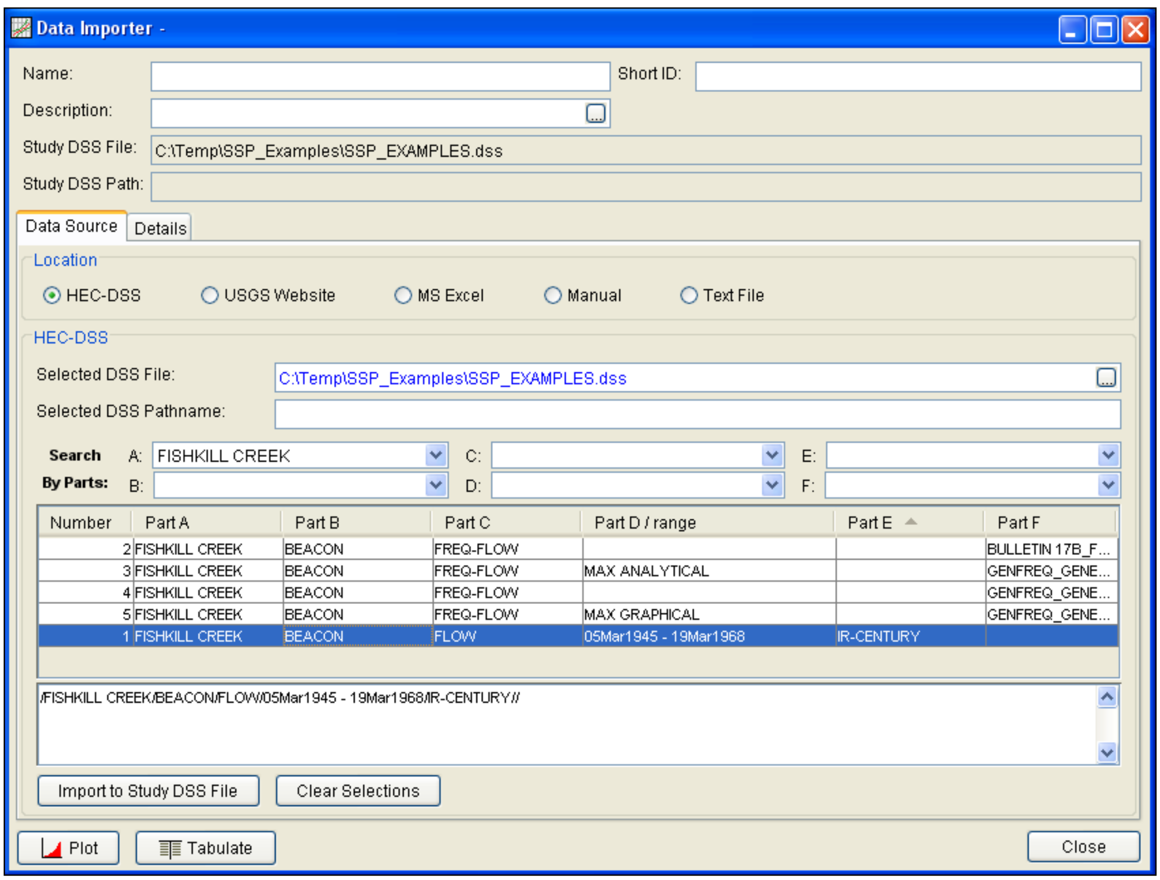


Figure 4-2. Data Importer with HEC-DSS Import Option.

As shown in Figure 4-2, the user first selects a DSS file to import from by typing the path and name or by choosing the file browser at the end of the input field. Once a DSS file is selected, the table of pathnames will be filled with the records that are contained in that DSS file. The user can reduce the number of listed pathnames by selecting pathname parts to filter in the pathname part selection area just above the table. Any pathname part can be used to filter the list down to a more manageable number of pathnames to select from. The user can then select pathnames to import by double clicking on one or more of the listed pathnames in the table. Each selected pathname will show up in the list below the table. Once the user has selected all of the pathnames that they want to import, pressing the **Import to Study DSS File** button enacts the import process. An HEC-SSP data set will be developed for each pathname that was selected.

Importing Data from the USGS Website

The second way to import data into HEC-SSP is to use the **USGS Website** option. When this option is selected, the data importer will look like Figure 4-3.

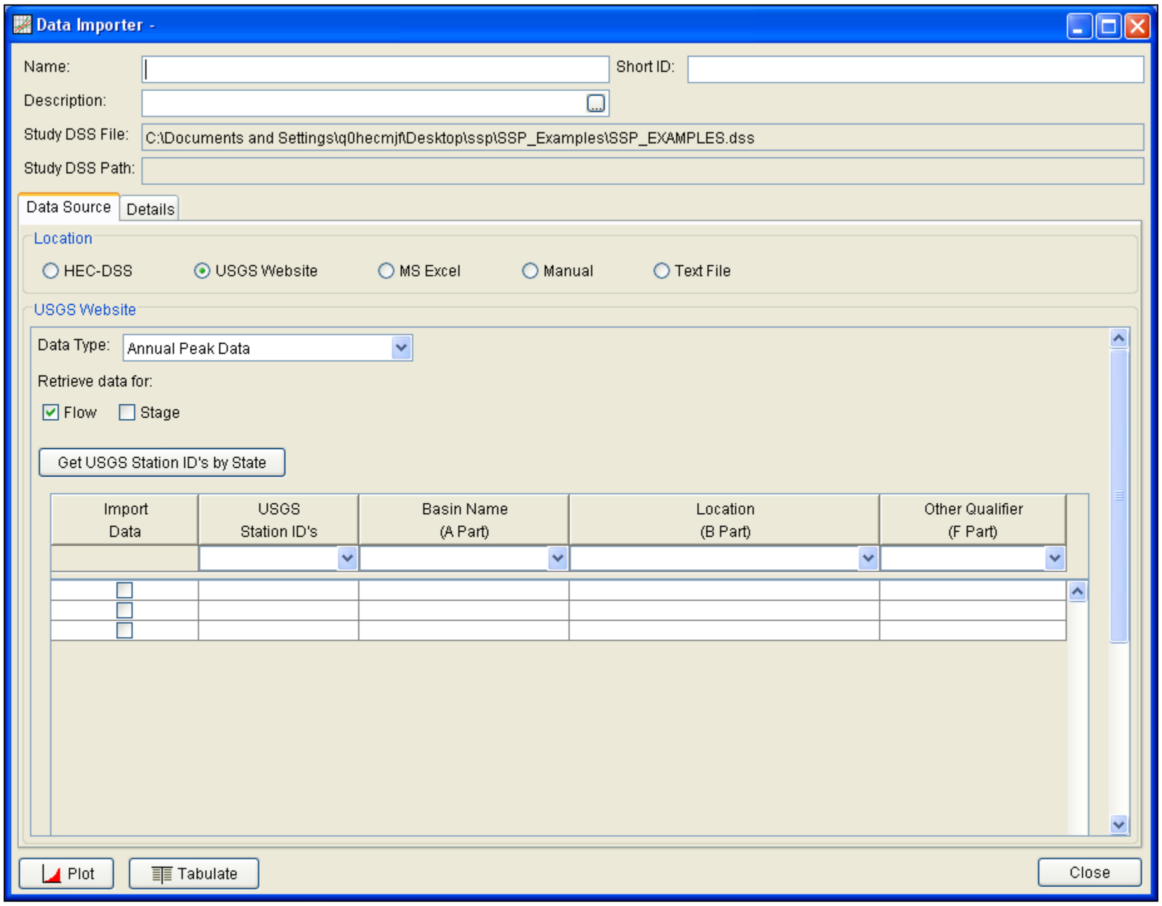


Figure 4-3. HEC-SSP Data Importer with USGS Website Import Option.

The first step in using the USGS import option is to select a data type to import (e.g. Annual Peak Data). Then choose to import **Flow** and/or **Stage** data. Next the user should select the **Get USGS Station ID's by State** button. Selecting this button will bring up a small window that allows the user to select a state in which to acquire data, as shown in Figure 4-4.

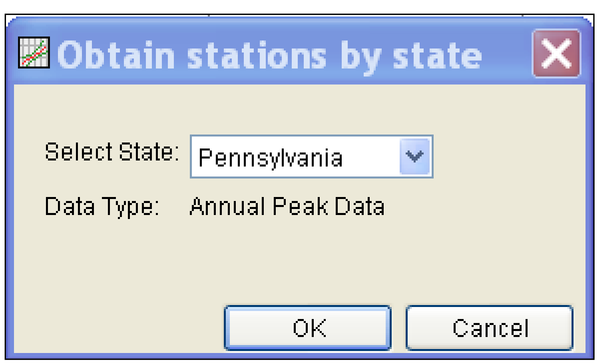


Figure 4-4. Window to Select a State for Importing USGS Data.

Once the user selects a state and presses the **OK** button, a process will begin in which all of the gage locations for that state will be downloaded from the USGS website. A listing of all the gages for that state will then be displayed in the table at the bottom of the data importer. An example of the data importer with a list of USGS gages is shown in Figure 4-5.

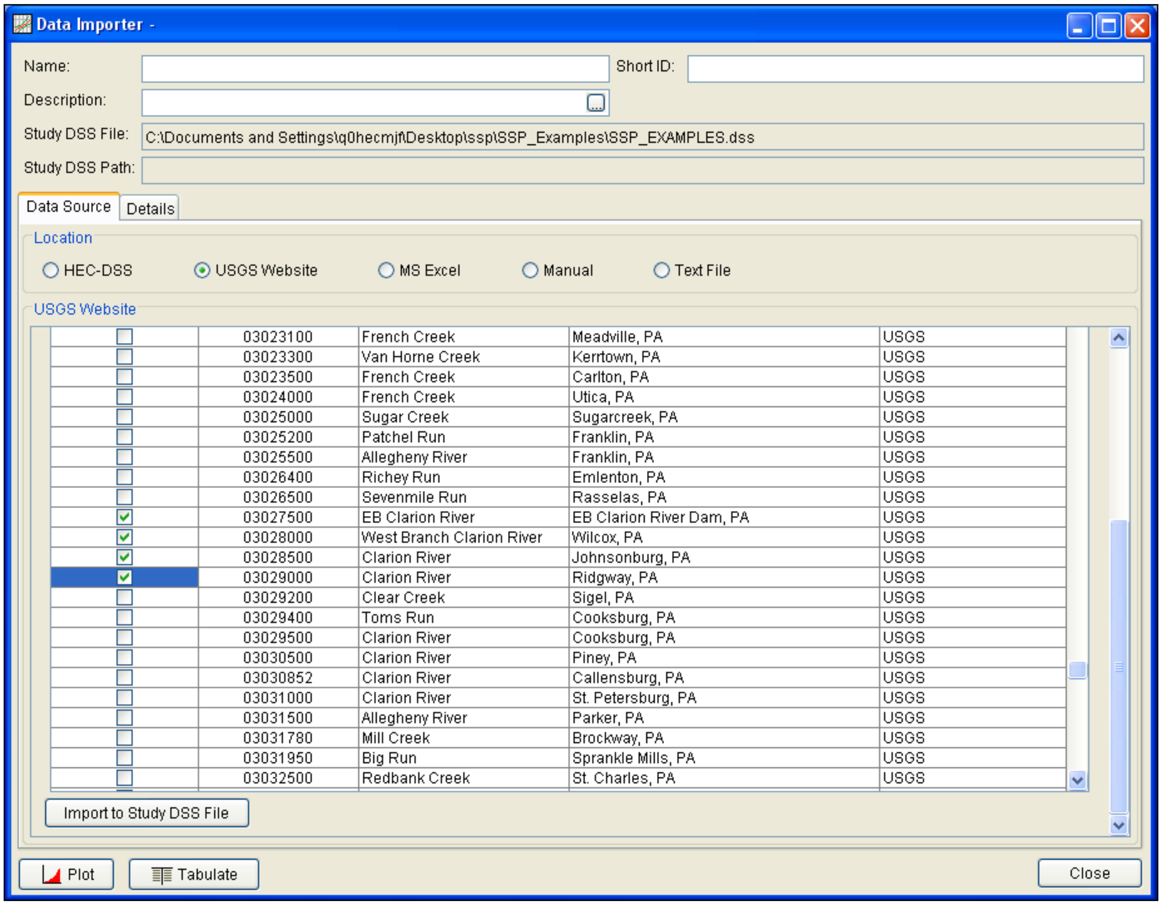


Figure 4-5. Data Importer with USGS Gages Listed in Table.

The next step is to select the desired gages for importing into the HEC-SSP study. The user can filter the list to a smaller number of gages by using the filter drop down boxes at the top of the table. To select a gage for importing, simply check the box in the left hand column for each gage location that is to be imported. After all of the desired locations are selected, press the **Import to DSS File** button to import the data into the study DSS file. Pressing this button will start a process of downloading data from the USGS website. For each selected location, the software will download the Data Quality Codes if they are available. The program issues a message that data quality codes are available and adds the codes as an additional data set to the Data folder. For an explanation of the codes, please visit the USGS website.

Warning: all data downloaded from the USGS website should be reviewed to ensure it is appropriate before any analyses are performed on the data. Some data stored on the USGS website are estimated, not measured. The user should check the data on the USGS website and be aware of the quality of all the data before using it. HEC-SSP will import the annual peak flow and stage quality codes (the program does not import quality codes for daily, instantaneous, and real time data). A description of the quality codes for annual peak flows is contained in Table 4-1 and a description of the quality codes for annual peak stages are contained in Table 4-2.

Table 4-1. Quality Codes for USGS Annual Peak Flow Data.

Code	Description
1	Discharge is a Maximum Daily Average
2	Discharge is an Estimate
3	Discharge affected by Dam Failure
4	Discharge less than indicated value which is Minimum Recordable Discharge at this site
5	Discharge affected to unknown degree by Regulation or Diversion
6	Discharge affected by Regulation or Diversion
7	Discharge is an Historic Peak
8	Discharge actually greater than indicated value
9	Discharge due to Snowmelt, Hurricane, Ice-Jam or Debris Dam breakup
A	Year of occurrence is unknown or not exact
B	Month or Day of occurrence is unknown or not exact
C	All or part of the record affected by Urbanization, Mining, Agricultural changes, Channelization, or other
D	Base Discharge changed during this year
E	Only Annual Maximum Peak available for this year

Table 4-2. Quality Codes for USGS Annual Peak Stage Data.

Code	Description
1	Gage height affected by backwater
2	Gage height not the maximum for the year
3	Gage height at different site and(or) datum
4	Gage height below minimum recordable elevation

5	Gage height is an estimate
6	Gage datum changed during this year

Importing Data from an Excel Spreadsheet

The third option for importing data into HEC-SSP is **MS Excel**. When this option is selected, the data importer will change as shown in Figure 4-6. Currently, HEC-SSP can only import data from Excel 97-2003 Workbooks (*.xls). The first step in importing data from an Excel spreadsheet is to select the browse button, , at the end of the **Excel File** field. Once an Excel file is selected, a data view window will open showing the data contained in the selected spreadsheet. An example Excel® Data Viewer is shown in Figure 4-7.

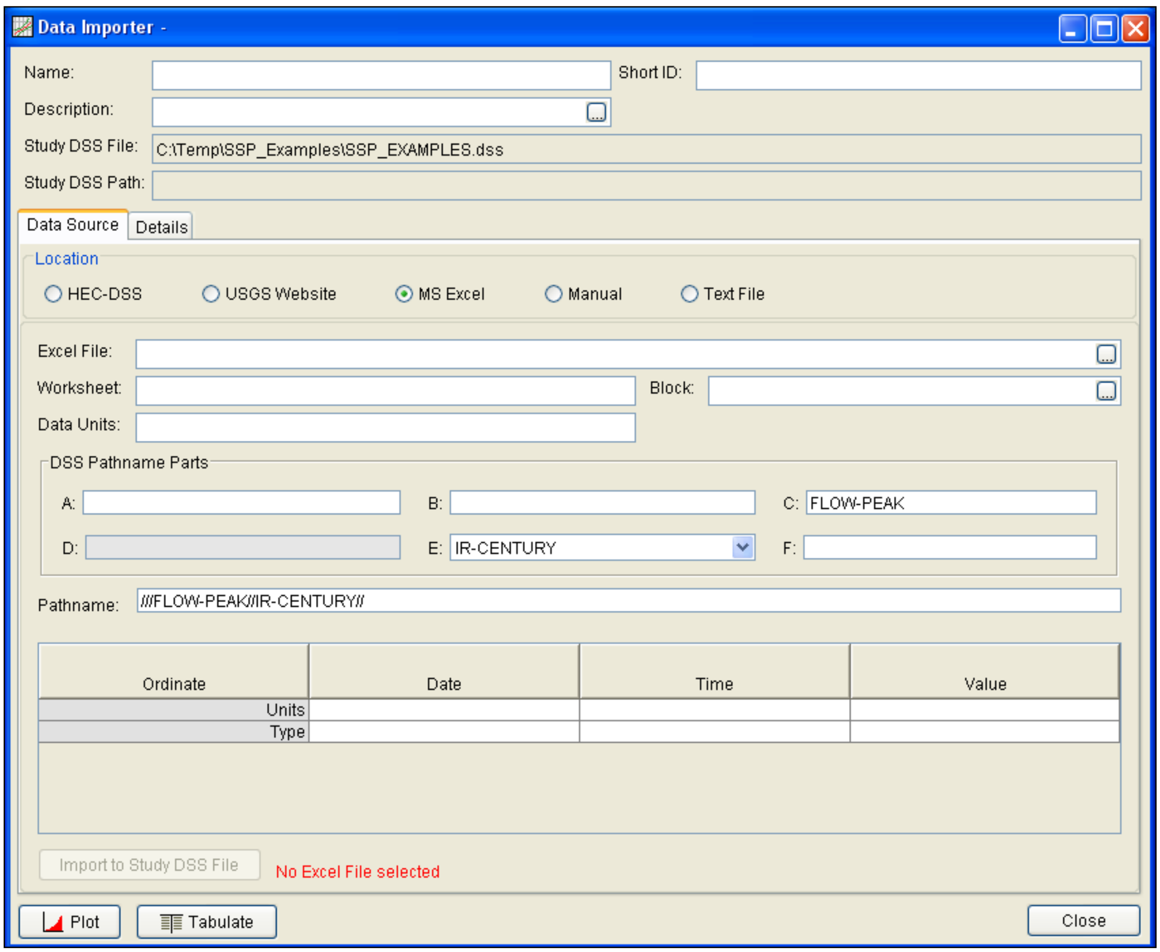
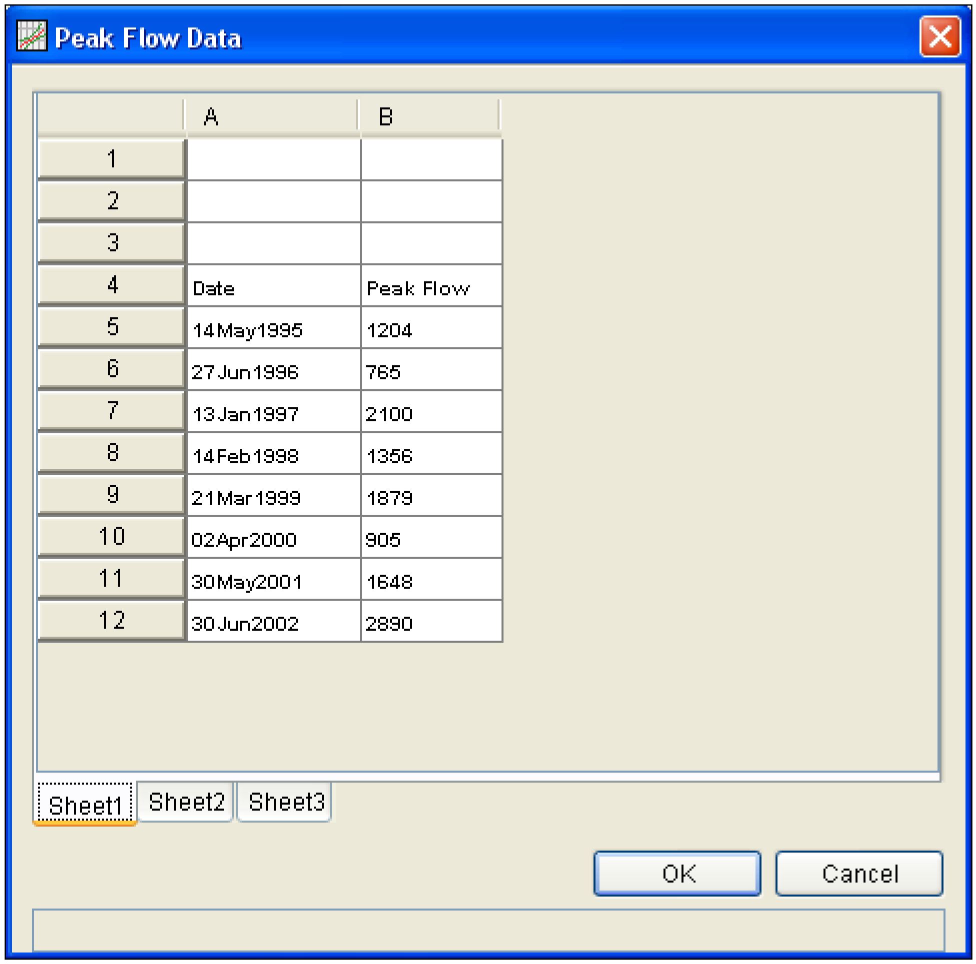


Figure 4-6. Data Importer with MS Excel Import Option Selected.



	A	B
1		
2		
3		
4	Date	Peak Flow
5	14May1995	1204
6	27Jun1996	765
7	13Jan1997	2100
8	14Feb1998	1356
9	21Mar1999	1879
10	02Apr2000	905
11	30May2001	1648
12	30Jun2002	2890

Figure 4-7. Example Excel Data Viewer.

The next step is to highlight the date and data values to be imported into the study (only highlight the data, not the column headings). The data must be in a format of Date in the first column and Data in the second column. The date must be in the Day, Month, Year format (ddmmyyyy) as shown in Figure 4-7. Next, press the **OK** button and the data will be placed in the table at the bottom of the editor. The last step before importing the data is to specify the units of the data, and each of the pathname parts for storing the data in the study DSS file (make sure to edit the C-part pathname if data is not annual peaks). Enter units of **cfs** for data in cubic feet per second or units of **cms** for data in cubic meters per second. The final step is to press the **Import to Study DSS File** button, and the data will be imported.

Entering Data Manually

Another option for getting data into the study is to enter the data manually. When the **Manual** option is selected, the window will change to what is shown in Figure 4-8.

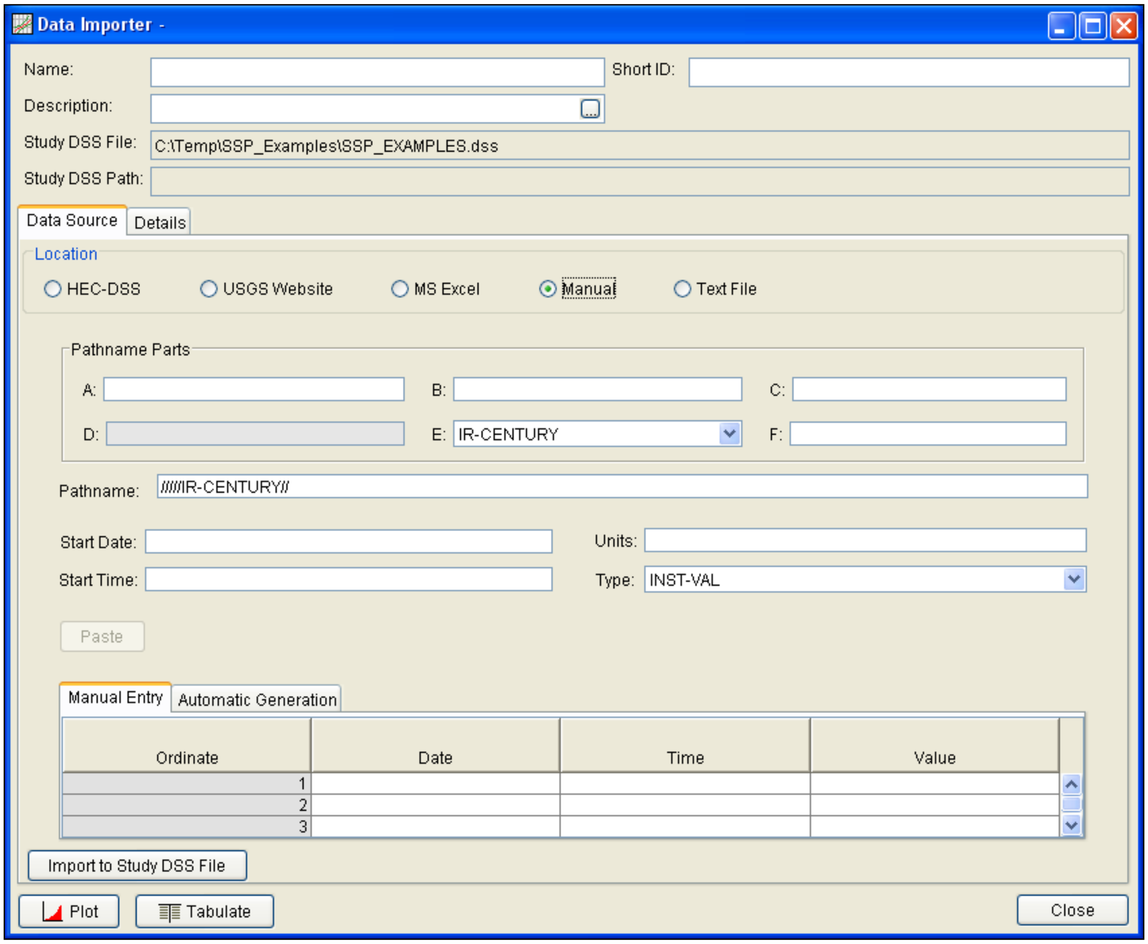


Figure 4-8. Data Importer with Manual Data Entry Option Selected.

To enter data manually, the user enters a name for the data set at the top, along with a short identifier and a description (optional). A starting date and time must be entered. The units of the data must also be defined as well as the data type. The last step before entering the data is to specify the pathname parts for how the data will be stored into the study DSS file. This requires the user to enter a label for the A, B, C, E, and F part of the DSS pathname. Once all of the data labeling is completed, the data can be entered into the table at the bottom of the editor. The user must enter the **Date**, **Time**, and data **Value** for each peak flow value to be entered. After a Date, Time, and Value are entered into a row, a new row will be generated in the table when the user leaves the Value field. The date must be in the Day, Month, Year format (ddmmyyyy). Another option for getting data into the table is to copy it to the clipboard and then paste it into the table. The table supports pasting data one column at a time or you can paste the date, time, and value information all at once. When all of the data are entered into the table, the user presses the **Import to Study DSS File** button and the data will be stored in the study DSS file.

Importing Data from a Text File

The fifth option for importing data into HEC-SSP is a comma delimited **Text File**. When this option is selected, the data importer will change as shown in Figure 4-9.

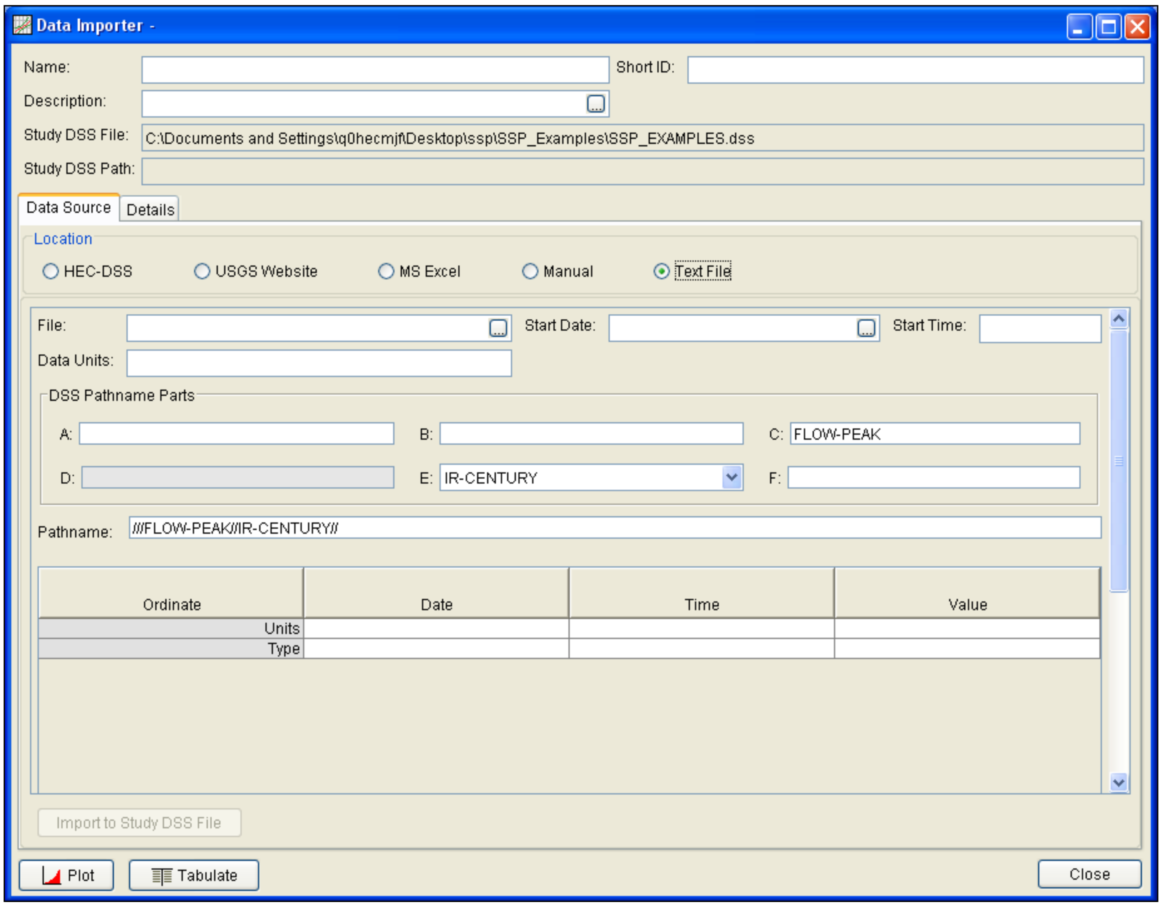
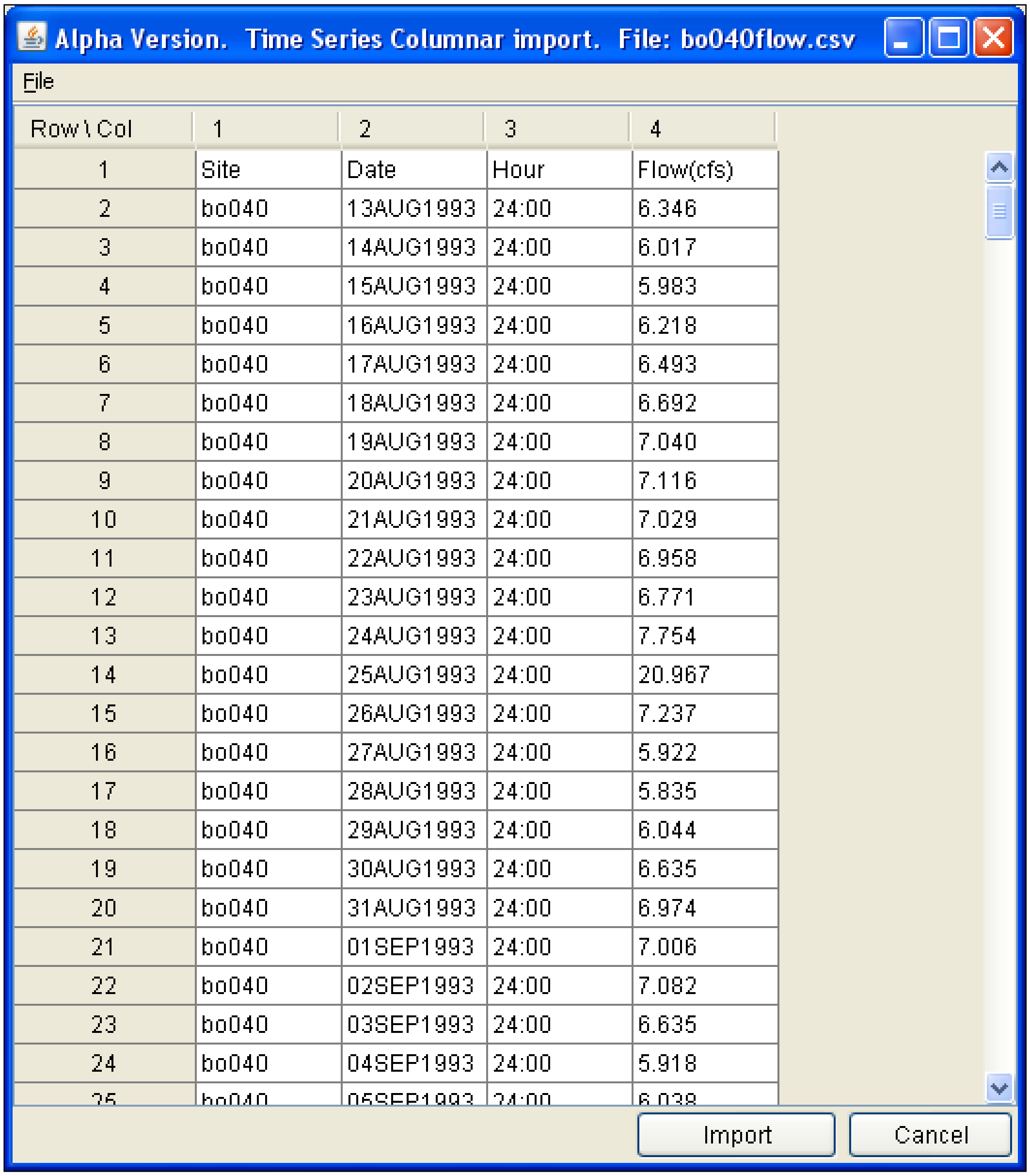


Figure 4-9. Data Importer with Text File Option Selected.

The first step in importing data from a comma delimited Text File is to press the Select File, , button at the end of the **File** field. Once a comma delimited text file is selected, a data view window will open showing the data contained in the selected file. An example text file data viewer is shown in Figure 4-10.



Row \ Col	1	2	3	4
1	Site	Date	Hour	Flow(cfs)
2	bo040	13AUG1993	24:00	6.346
3	bo040	14AUG1993	24:00	6.017
4	bo040	15AUG1993	24:00	5.983
5	bo040	16AUG1993	24:00	6.218
6	bo040	17AUG1993	24:00	6.493
7	bo040	18AUG1993	24:00	6.692
8	bo040	19AUG1993	24:00	7.040
9	bo040	20AUG1993	24:00	7.116
10	bo040	21AUG1993	24:00	7.029
11	bo040	22AUG1993	24:00	6.958
12	bo040	23AUG1993	24:00	6.771
13	bo040	24AUG1993	24:00	7.754
14	bo040	25AUG1993	24:00	20.967
15	bo040	26AUG1993	24:00	7.237
16	bo040	27AUG1993	24:00	5.922
17	bo040	28AUG1993	24:00	5.835
18	bo040	29AUG1993	24:00	6.044
19	bo040	30AUG1993	24:00	6.635
20	bo040	31AUG1993	24:00	6.974
21	bo040	01SEP1993	24:00	7.006
22	bo040	02SEP1993	24:00	7.082
23	bo040	03SEP1993	24:00	6.635
24	bo040	04SEP1993	24:00	5.918

Figure 4-10. Example Text File Data Viewer.

The next step is to highlight the date, time, and data columns. Only highlight the data that will be imported, not the column headings. If there are column headings then they need to be identified. To do this, select the row or rows that do not contain data to be imported. Then click the right mouse button and select the **Skip Row(s)** menu option, as shown in Figure 4-11.

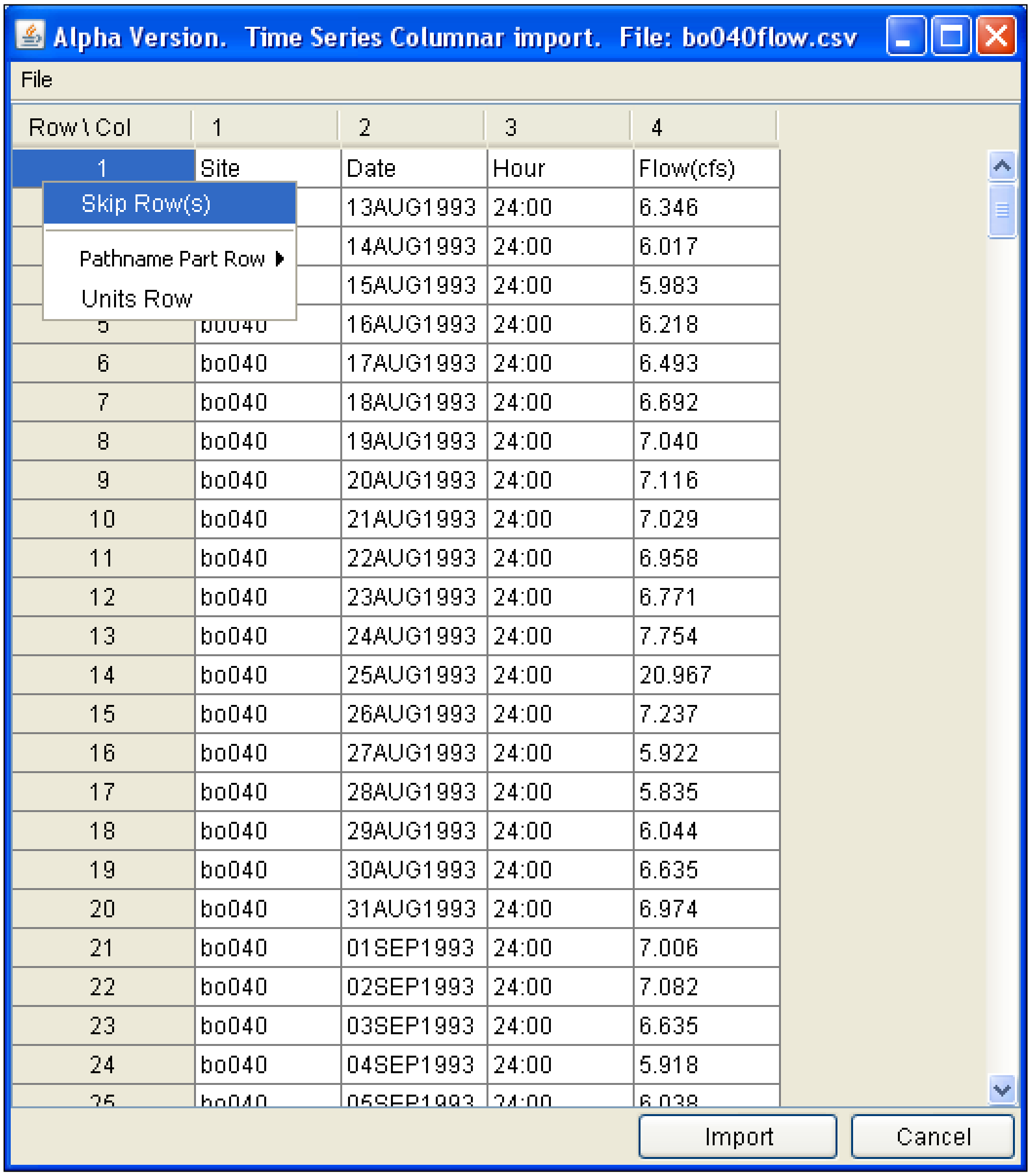


Figure 4-11. Identify Rows that do not Contain Data to be Imported.

To identify the date and time columns, place the mouse pointer on the column number at the top of the table and click the right mouse button. Then move the mouse pointer to the **Date – Time Column** option to see an additional menu of options, as shown in Figure 4-12. Figure 4-12 shows that column 2 will be defined as the date column. The date must be in the Day, Month, Year format (ddmmyyyy). The data viewer will highlight the date and time columns once they have been defined.

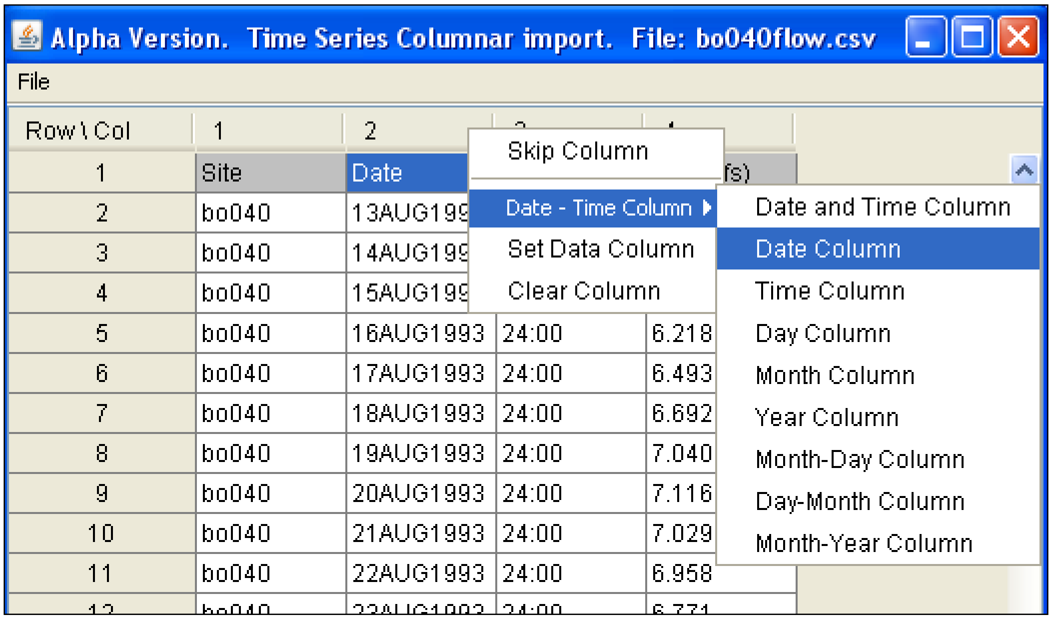


Figure 4-12. Identify Date and Time Columns.

To define the data column, place the mouse pointer on the column number at the top of the table and click the right mouse button. Then choose the **Set Data Column** menu option from the shortcut menu. Another editor will open, as shown in Figure 4-13, that allows the user to define the pathname parts, data units, and data type. After defining these data properties, click the **Import Now** button to import the data and data properties into the Data Importer. You can edit the data values or data properties in the data importer before importing the data to the study. The final step is to press the **Import to Study DSS File** button, and the data will be imported.

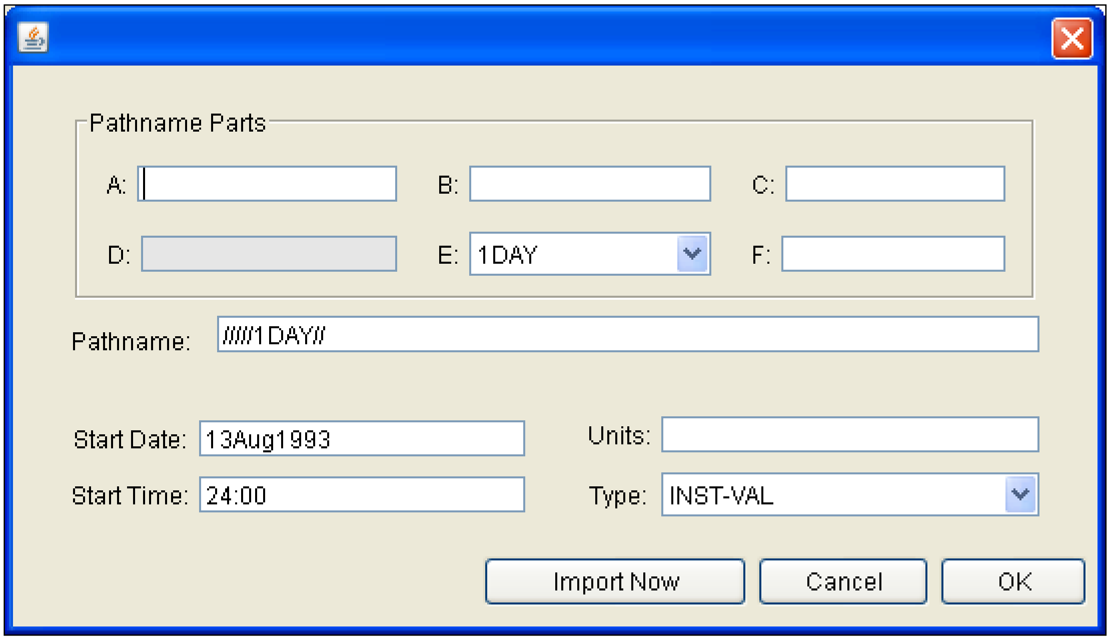


Figure 4-13. Editor for Defining the Data Properties.

Metadata

When downloading data from the USGS website, in addition to the raw data, the software will also attempt to download any metadata available for each gage location. When using one of the other four methods for importing data, the user can manually enter metadata by selecting the **Details** tab, as shown in Figure 4-14. The metadata consists of the State, County, Stream, Location, Drainage Area, DA Units, Gage Operator, USGS Gage No., Gage Datum, HUC (Hydrologic Unit Code), Vertical Datum, and a description field. Additionally, the coordinate location of the data is shown. The coordinate location consists of Coordinate System, Coordinate ID, Horizontal Datum, Datum Units, Coordinate X Value, and Coordinate Y Value. If coordinate system data are entered, data icons and text labels will show up on the background map at the specified locations.

Metadata can be viewed and edited any time after the data has been imported into the study by opening the **Metadata Editor**. To open the Metadata Editor, place the mouse pointer on top of a data set in the Data folder and then click the right mouse button. Choose the **Edit Metadata** option from the shortcut menu, as shown in Figure 4-15. The Metadata Editor will look exactly like the Details tab on the Data Importer. The Metadata Editor can also be opened from the Data menu and from a shortcut menu that opens by right clicking on a data icon in a background map.

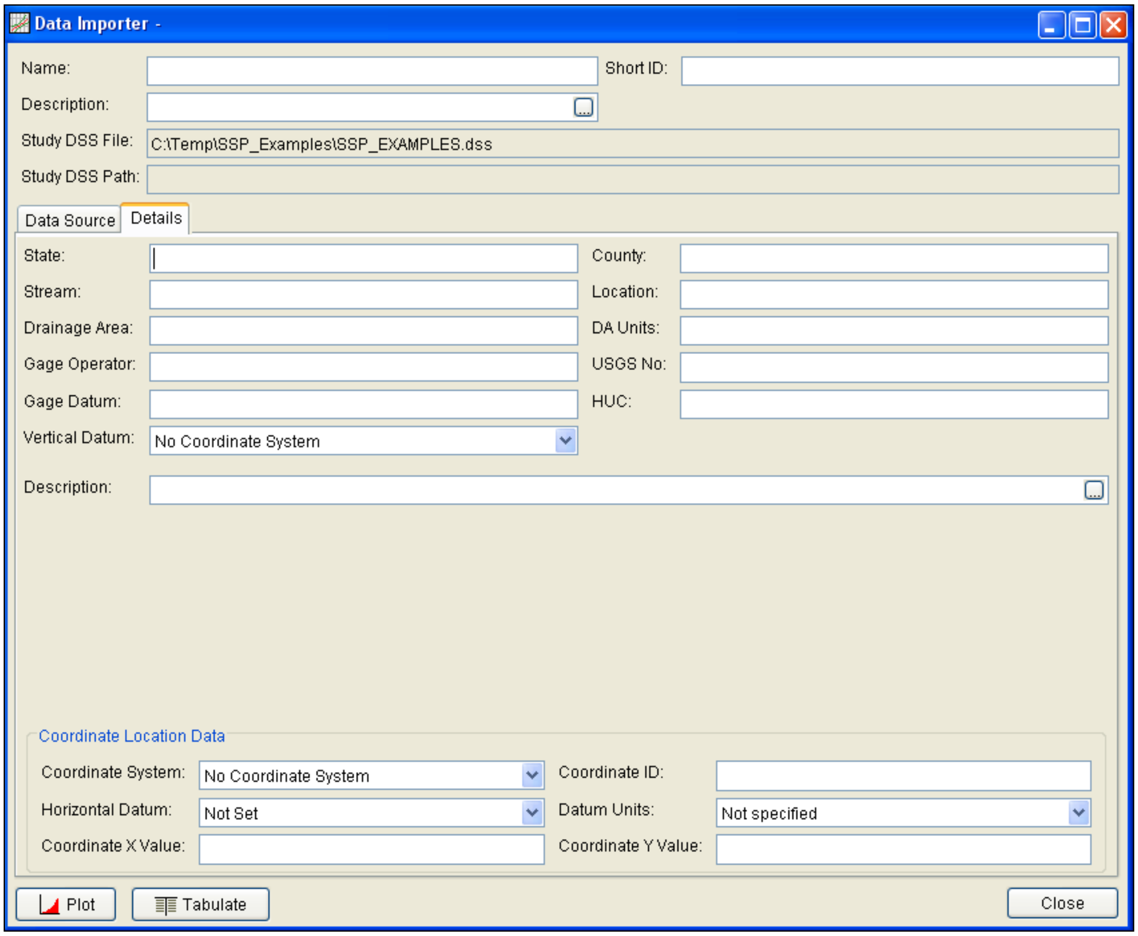


Figure 4-14. Details Tab on the HEC-SSP Data Importer.

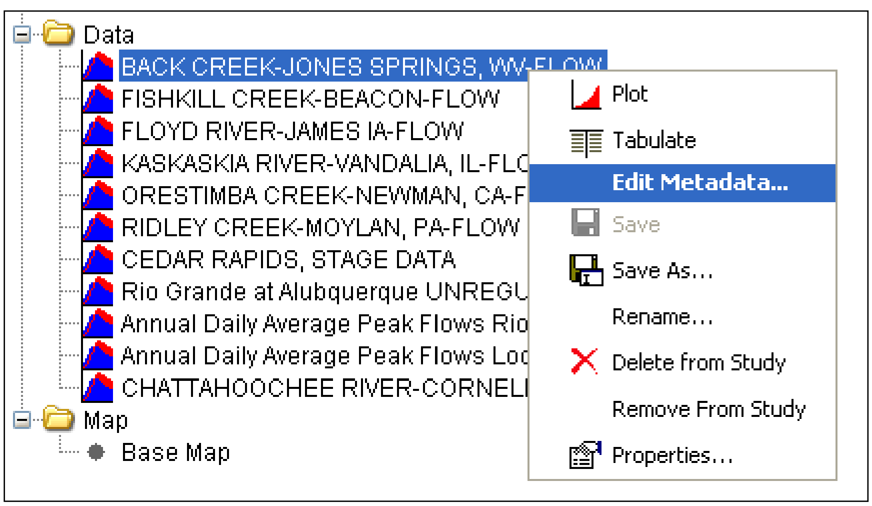


Figure 4-15. Menu Option for Opening the Metadata Editor.

Plotting and Tabulating the Data

After the data is imported into the study, the user can select any one of the data sets in the study explorer. A shortcut menu will open when clicking the right mouse button while a data set is selected. The shortcut menu contains options to change the name, plot, and tabulate the data. These options are also available from the Data menu; however, the data must be selected in the study explorer before these options are available. If you select the **Plot** option, you will get a plot similar to the one shown in Figure 4-16.

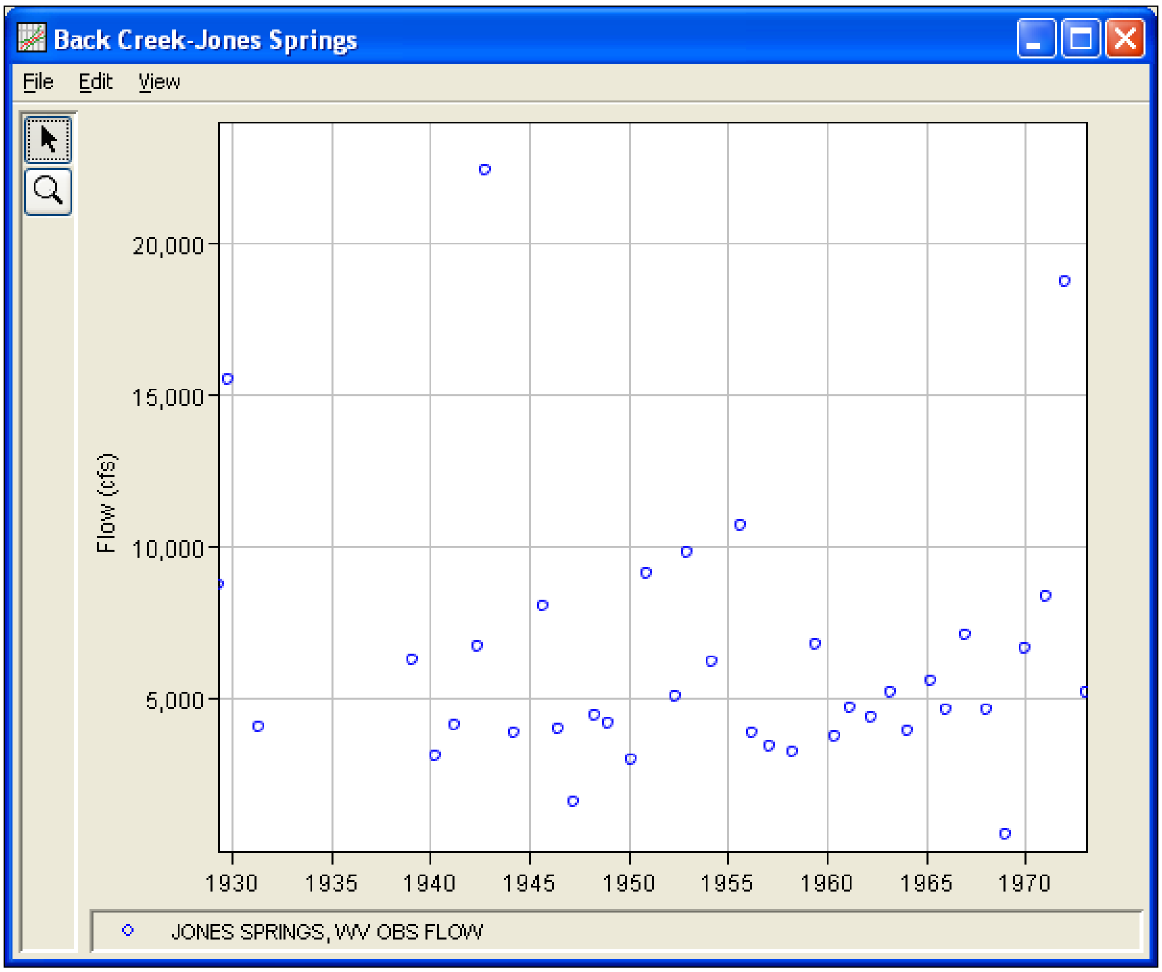


Figure 4-16. Plot of Peak Annual Flow Data.

If you select the **Tabulate** option, a table will open with the data listed as shown in Figure 4-17. Data values in the table can be edited after selecting the **Edit→Allow Editing** menu option. To save any edits, select the **File→Save** menu option.

/BACK CREEK/JONES SPRINGS, WV/FLOW/...

File Edit View

Ordinate	Date	Time	JONES SPRIN... FLOW OBS
Units			CFS
Type			INST-VAL
1	17 Apr 1929	12:00	8,750
2	23 Oct 1929	12:00	15,500
3	08 May 1931	12:00	4,060
4	04 Feb 1939	12:00	6,300
5	20 Apr 1940	12:00	3,130
6	06 Apr 1941	12:00	4,160
7	22 May 1942	12:00	6,700
8	15 Oct 1942	12:00	22,400
9	24 Mar 1944	12:00	3,880
10	18 Sep 1945	12:00	8,050
11	03 Jun 1946	12:00	4,020
12	15 Mar 1947	12:00	1,600
13	14 Apr 1948	12:00	4,460
14	31 Dec 1948	12:00	4,230
15	02 Feb 1950	12:00	3,010
16	05 Dec 1950	12:00	9,150
17	28 Apr 1952	12:00	5,100
18	22 Nov 1952	12:00	9,820
19	02 Mar 1954	12:00	6,200
20	19 Aug 1955	12:00	10,700
21	15 Mar 1956	12:00	3,880
22	10 Feb 1957	12:00	3,420
23	27 Mar 1958	12:00	3,240
24	03 Jun 1959	12:00	6,800
25	09 May 1960	12:00	3,740
26	19 Feb 1961	12:00	4,700
27	22 Mar 1962	12:00	4,380
28	20 Mar 1963	12:00	5,190

Figure 4-17. Table Containing Peak Annual Flow Data.

CHAPTER 5

Performing a Bulletin 17 Flow Frequency Analysis

The current version of HEC-SSP allows the user to perform flow frequency analyses using two different methodologies which are commonly referred to as Bulletin 17B and Bulletin 17C. This chapter discusses in detail how to perform a Flow Frequency Analysis within HEC-SSP using either method.

Contents

Bulletin 17B vs. Bulletin 17C

The Bulletin 17B guidance has guided the development of peak flow frequency analyses within the United States since the early 1980's. This guidance recommended the use of the Log Pearson Type III probability distribution for annual peak flows on unregulated streams fit by the Method of Moments (Interagency Advisory Committee on Water Data, 1982). Using the Bulletin 17B methodology, distribution parameters are estimated from the moments of the sample data (i.e. mean, standard deviation and skew). Bulletin 17B also includes adjustments to those parameters for non-standard data (missing years, flows below gage base, or estimated flows), low outliers, and historical events. Adjustments can be made with a series of specified procedures including the conditional probability adjustment and the historical adjustment (weighted moments) procedure. The Bulletin 17B methodology characterizes the peak flow in each year as either (1) part of the systematic (observed) record, for which a point estimate of flow exists or (2) an historical event from a time before a gage was present but for which an estimate of flow can be made.

The Bulletin 17C guidance brings a change to the computation of peak flow frequency within the United States. This guidance incorporates changes motivated by four of the items listed as future work within Bulletin 17B and more than 30 years of post-Bulletin 17B research on flood processes and statistical methods (England, et al., 2015). As part of the Bulletin 17C methodology, the moments/parameters of the Log Pearson Type III distribution are estimated using the Expected Moments Algorithm (EMA). Like Bulletin 17B, the Bulletin 17C/EMA (17C EMA) methodology also estimates distribution parameters based on sample moments, but does so in a more integrated manner that incorporates non-standard, censored, or historical data at once, rather than as a series of adjustment procedures (Cohn, Lane, & Baier, 1997). The use of Bulletin 17C procedures can also provide improved confidence intervals for the resulting frequency curve that incorporate diverse information appropriately, as historical data and censored values impact the uncertainty in the estimated frequency curve (Cohn, Lane, & Stedinger, 2001). Within the 17C EMA methodology, every annual peak flow in the analysis period, whether observed or not, is represented by a flow range. That range might simply be limited to the gaged value when one exists. However it could also reflect an uncertain flow estimate.

Starting a New Analysis

A flow frequency analysis can be started in two ways within the software, either by right clicking on the Bulletin 17 folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **Bulletin 17 Flow Frequency**. When a new flow frequency analysis is selected, the Bulletin 17 Editor will appear as shown in Figure 5-1.

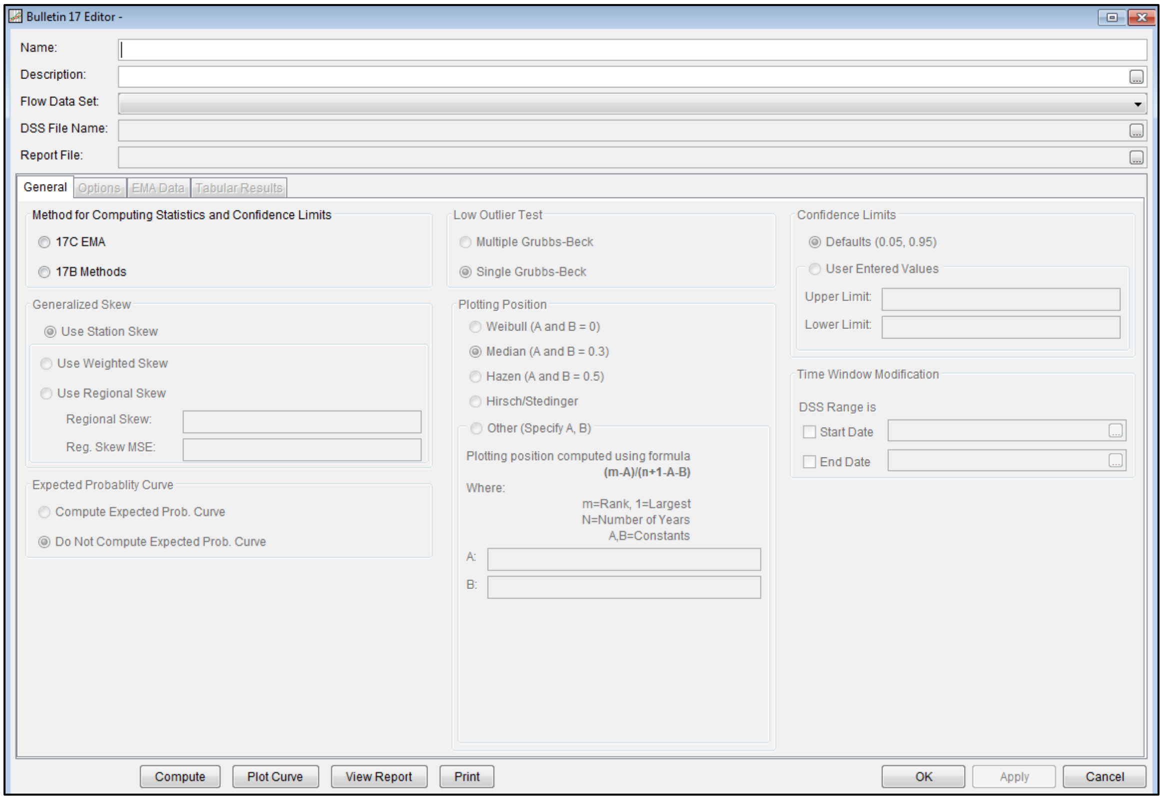


Figure 5-1. Bulletin 17 Flow Frequency Analysis Editor.

The user is required to enter a **Name** for the analysis, while a **Description** is optional. An annual peak flow data set must be selected from the available data sets stored in the current study DSS file (see chapter 4 for importing data into the study). The list of data that can be selected for a Bulletin 17 analysis will only include those data that have an irregular interval, like IR-CENTURY and IR-YEAR (E-part pathname). Once a Name is entered, and a flow data set is selected, the **DSS File Name** and **Report File** will automatically be populated. The DSS filename is by default the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

General Settings, Options, and Computations

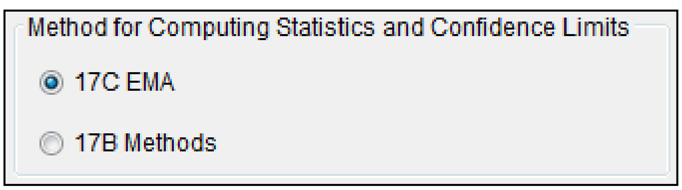
Once the analysis name and flow data set are selected, the user can begin setting up the analysis. Four tabs are contained on the Bulletin 17 editor. The tabs are labeled **General**, **Options**, **EMA Data** (which is non-selectable unless the analysis is set to use **17C EMA** methods), and **Tabular Results**.

General Settings

The first tab contains general settings for performing the flow frequency analysis (Figure 5-1). These settings include:

- Method for Computing Statistics and Confidence Limits
- Generalized Skew
- Expected Probability Curve
- Low Outlier Test
- Plotting Positions
- Confidence Limits
- Time Window Modification

Method for Computing Statistics and Confidence Limits

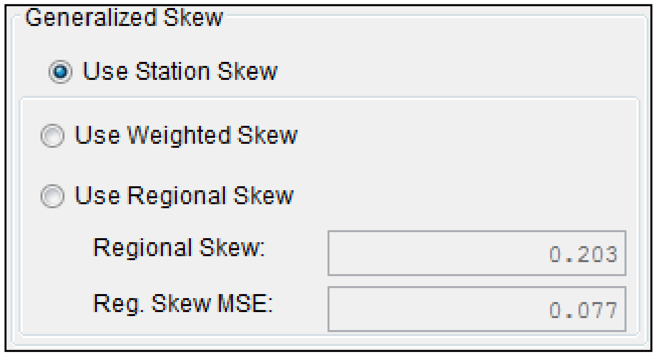


There are two choices available for computing flow frequency statistics and confidence limits within HEC-SSP: 17C EMA and 17B Methods. The user is referred to the Bulletin 17C publication for in depth discussions regarding the differences between Bulletin 17B and Bulletin 17C. In general, 17C EMA will provide the same computed flow frequency curve as Bulletin 17B methods when there are no historical events/periods and no low outliers included within the analysis. Also, the computed confidence intervals will be nearly the same when using a skew that is near zero.

Choosing either 17C EMA or 17B Methods will invoke different options throughout the flow frequency analysis (for instance, choosing the 17C EMA method results in the inability to compute the expected probability curve). When opening a new Bulletin 17 analysis, the user must select a method for computing statistics and confidence limits before proceeding with the analysis. Until a method is selected, all other options will be inactive.

Generalized Skew

There are three options contained within the generalized skew setting: Use Station Skew, Use Weighted Skew, and Use Regional Skew. The default skew setting is **Use Station Skew**. With this setting, the skew of the computed curve will be based solely on computing a skew from the data points contained in the data set. No weighting with regional skew will be performed to compute the final skew.

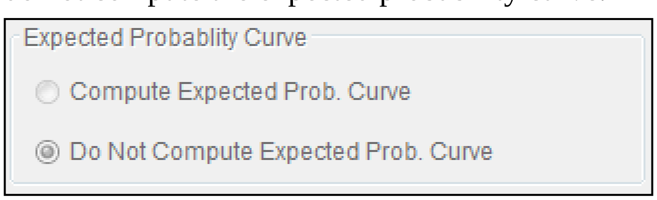


The **Use Weighted Skew** option requires the user to enter a generalized regional skew and a Mean-Square Error (MSE) of the generalized regional skew. This option weights the computed station skew with the generalized regional skew based upon the inverse of the mean square error in each skew estimate. The equation for performing this weighting can be found in Bulletin 17B (equation 6). If a regional skew is taken from Plate I of Bulletin 17B (the skew map of the United States), the value of MSE = 0.302. Additional estimates of regional skew to be used in peak flow and flow-duration statistical analyses are being developed by the USGS and others; for example, see (Parrett, et al., 2010).

The last generalized skew option is **Use Regional Skew**. When this option is selected, the user must enter a generalized regional skew and an MSE for that skew. The program will ignore the computed station skew and use only the regional skew.

Expected Probability Curve

This setting has two options: compute the expected probability curve and do not compute the expected probability curve. The default setting is to not compute the expected probability curve. When using the **17C EMA** method to compute statistics and confidence limits, the expected probability curve is not computed.

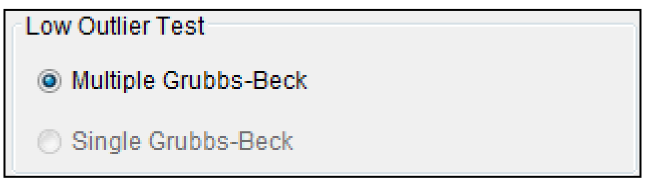


However, when using the Bulletin 17B method and computing the expected probability curve, this curve will be shown in both the result tables and the plots as an additional curve. The expected probability adjustment is a correction for bias in the computed frequency curve. The bias is caused by uncertainty due to the shortness of the data record. The Method of Moments estimation of the Log Pearson III parameters produces a median estimate of each frequency curve quantile, and the adjustment changes to a mean (unbiased) estimate, which is different from the median because of the skewness of the uncertainty distribution. The reader may review the discussion in Bulletin 17B about the expected probability curve adjustment for an explanation of how and why it is computed.

The use of the expected probability curve is a policy decision. It is most often used in establishing design flood criteria. The basic flood frequency curve without the expected probability adjustment is the curve used in computation of confidence limits, risk, and in obtaining weighted averages of independent estimates of flood frequency discharge (Interagency Advisory Committee on Water Data, 1982).

Low Outlier Test

This option allows the user to choose the test that is performed to identify low-value data points that depart significantly from the trend of the remaining data and inappropriately affect the extreme quantiles in the upper tail of the frequency curve. There are two options for testing low outliers within HEC-SSP: Multiple Grubbs-Beck and Single Grubbs-Beck.

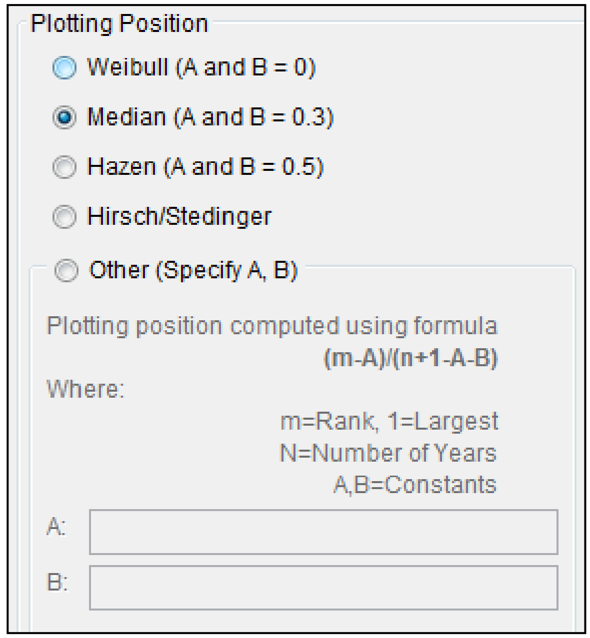


These low-value data points can significantly distort the entire computed flow-frequency curve due to the use of logarithms within both the 17B and 17C EMA methods. These distortions are more severe with the 17C EMA method. As part of the development of the Bulletin 17C methodology, the standard Single Grubbs-Beck low outlier test was expanded to more successfully identify multiple low outliers (also referred to as potentially influential low floods, or PILFs). Therefore, the only option available when using the 17C EMA method within HEC-SSP is the Multiple Grubbs-Beck test. When low outliers are calculated using the Multiple Grubbs-Beck test, both perception thresholds and flow ranges are modified within the 17C EMA framework to prevent excessive influence on the computed flow frequency curve. Example 2 within Appendix C presents an instance where multiple low outliers are identified using the

Multiple Grubbs-Beck test and the resulting modifications that are made within the 17C EMA framework.

When using the 17B methodology, the default test is the Single Grubbs-Beck test.

Plotting Positions



Plotting positions are used for plotting the input flow data set on a probability scale along with the computed frequency curve and confidence limits. There are five options for computing plotting positions within HEC-SSP: Weibull, Median, Hazen, Hirsch/Stedinger, and user entered coefficients. The only method available for computing plotting positions when using the 17C EMA method is Hirsch/Stedinger (Hirsch and Stedinger, 1987). The default method when using the Bulletin 17B method is the Median plotting position formula. When using 17C EMA methods and the Hirsch/Stedinger plotting position formula, flow data screened as low outliers (a.k.a. Potentially Influential Low Floods) are assigned a plotting position using the Median plotting position formula within HEC-SSP.

The generalized plotting position equation is:

$$P = \frac{(m - A)}{(n + 1 - A - B)}$$

where: m = rank of flood values with the largest equal to 1.

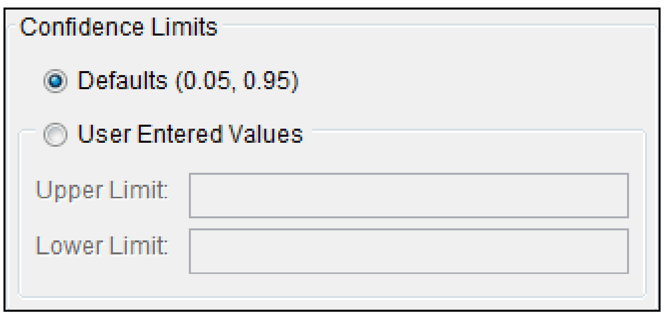
n = number of flood peaks in the data set.

A & B = constants dependent on which equation is used (Weibull A and B=0; Median A and B = 0.3; and Hazen A and B=0.5).

Plotting positions represent estimates of the exceedance probability of each data point (peak flow). Different plotting position formulas can give very different values for the probabilities of the highest and lowest points in the data set. In both the Bulletin 17B and 17C EMA methodologies, the plotting of data on the graph by a plotting position method is only done as a guide to assist in evaluating the computed curve. The plotting position method selected does not have any impact on the computed curve.

Confidence Limits

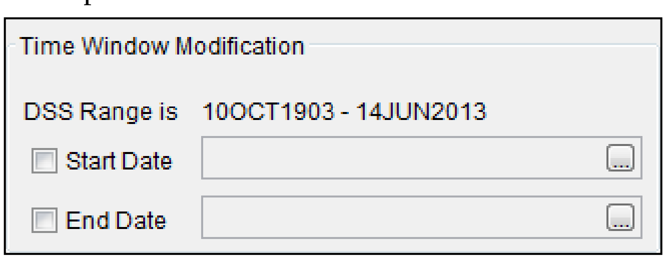
The computed flow frequency curve is only an estimate of the probability distribution of the larger parent population. Confidence limits can be used to provide a measure of the uncertainty of the estimated exceedance probability of a selected discharge or a measure of the uncertainty of the discharge at a selected exceedance probability. Confidence limits computed when using the 17C EMA methodology are outlined in Bulletin 17C, Appendix 6. Confidence limits computed when using the 17B methodology are outlined in Bulletin 17B, Appendix 9. Generally speaking, the confidence intervals computed with 17B procedures are less accurate than those computed using the 17C EMA methodology. The 17B methodology neglects the uncertainty in the estimated skew coefficient and does not recognize or use historical information.



By default, HEC-SSP calculates the 90 percent confidence interval for all flow frequency analyses (i.e. the 5% and 95% confidence limits). By comparison, the default confidence interval used within the USGS PeakFQ program is 95% (i.e. 2.5% and 97.5% confidence limits) (Veilleux, Cohn, Flynn, Mason, & Hummel, 2013). The confidence limits must be entered in decimal form (i.e. 95% = 0.95, and 5% = 0.05). The user has the option to override the default values and enter whatever values they would like for the confidence limits.

Time Window Modification

This option allows the user to narrow the time window used for the analysis. The default is to use all of the annual peak flow data contained in the selected data set. The user can enter either a start date for the analysis, and end date, or both a start and end date. If a start and/or end date are used, they must be dates that are encompassed within



the data stored in the selected data set. The date range for the selected data set is shown in the editor just above the **Start Date** field.

Any dates entered within the Time Window Modification will be ignored when using the 17C EMA Method for Computing Statistics and Confidence Limits. When using 17C EMA, changes to the start and end period should be made within the **EMA Data** tab.

Options

In addition to the general settings, there are also several options available to the user for modifying the computations of the frequency curves. These options include:

- Low Outlier Threshold
- Historic Period Data
- User-Specified Frequency Ordinates

When the Options tab is selected, the Bulletin 17 Editor will appear as shown in Figure 5-2.

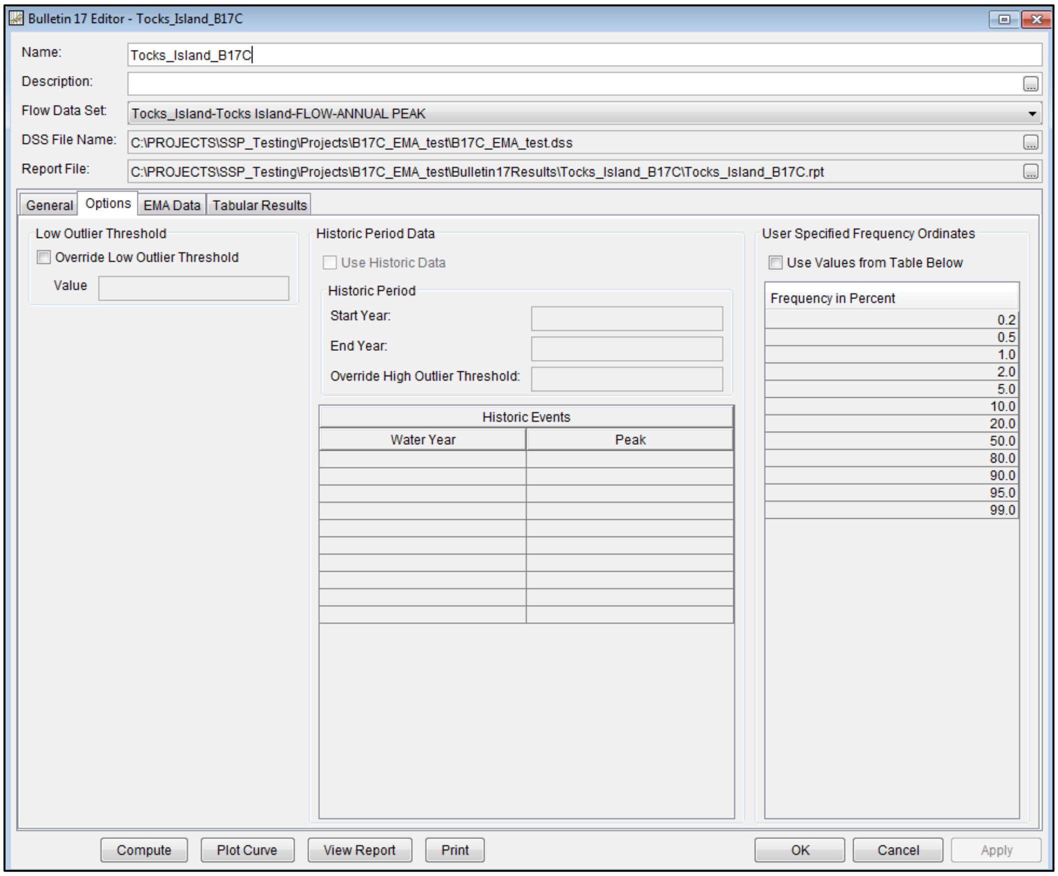
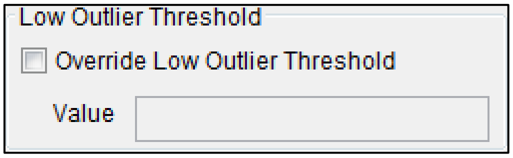


Figure 5-2. Bulletin 17 Editor with Options Tab Selected.

Low Outlier Threshold

High and low outlier tests are based on the procedures outlined in Bulletin 17B and Bulletin 17C. The calculated outlier thresholds are used as default values for the high and low outlier thresholds in HEC-SSP. The user has the option to enter a different value for the low outlier threshold if the Single or Multiple Grubbs-Beck low outlier tests do not adequately identify low outliers. If a value is entered for the low outlier threshold, then this value will override the computed value. When applying the outlier tests, HEC-SSP will identify both high and low outliers. However, only low outliers will be removed from the data set when performing the analysis. If a high outlier is identified in the data set, the analyst should try to incorporate historical period information to extend the time period for which the high outlier(s) is (are) considered to be the maximum value(s). When using Bulletin 17B procedures, the low outlier threshold



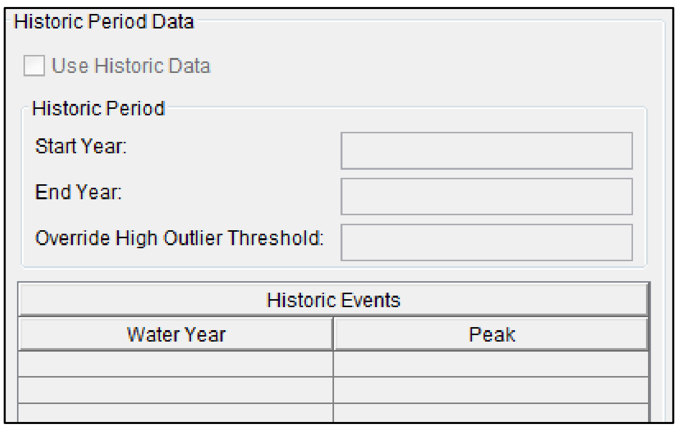
cannot be set to a value that would censor more than 50 percent of the peak flows.

To override the computed low outlier threshold, simply check the box and enter the value.

Historic Period Data

This option is only available when using Bulletin 17B procedures. To make use of historic data within the 17C EMA procedures, this information should be entered on the **EMA Data** tab.

All historic data that provides reliable estimates of flood peaks outside the systematic record should be used in order to improve the estimated flood frequency curve. Flood information of large events outside of the systematic record can often be used to extend the record to a historic period much longer than that of the systematic record. HEC-SSP uses historic data specified in this table as recommended in Bulletin 17B.



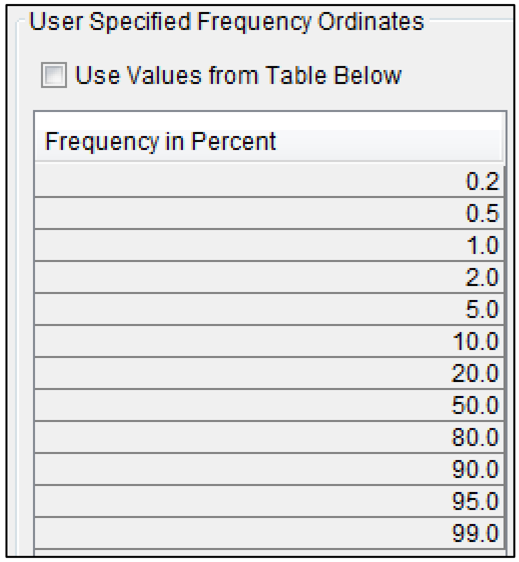
However, to use historic data in a 17B analysis within HEC-SSP, check the box labeled **Use Historic Data**. The user can enter a starting year for the historic period, ending year for a historic period, and a high threshold value. If the user enters a high threshold value, then any value in the systematic record greater than that value will also be treated as a historical flood peak. The user can also enter historic flood peaks that are not contained in the systematic record. This is done in the table at the bottom labeled **Historic Flood Peaks**. All years must be entered as water year values (October 1 through September 30). If a start year is not entered, then the assumed start year is the earliest year of the systematic record and any historical values that have been entered. If an end year is not entered, then the assumed end year is the latest year in the systematic record and any entered historic values.

Note: The program treats all data in the data set as systematic data when using Bulletin 17B procedures. If historic events are included in the data set, then the user must define the analysis time window (General tab – Time Window Modification) so that it only bounds the systematic record. Then the user must define the historic events in the Historic Events table.

The user is directed to Example 6 in Appendix B for an instance of using the historic data adjustment within a Bulletin 17B analysis.

User Specified Frequency Ordinates

This option allows the user to change or add to the frequency ordinates for which the resulting frequency curve and confidence limits are computed. The default values listed in percent chance exceedance are 0.2, 0.5, 1, 2, 5, 10, 20, 50, 80, 90, 95, and 99. Check the box next to **Use Values from Table below** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the frequency values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Use Values from Table below** option is not checked. Finally, all values in the table must be between 0 and 100. Note that these values have no impact on the computed frequency curve, but rather only the values of the curve that are reported.



EMA Data

The Bulletin 17C methodology represents a shift in the determination of peak flow frequency and how data is used within peak flow frequency analyses. When using the 17C EMA methodology, additional data is required in order to compute peak flow frequency, confidence intervals, and plotting positions. This new information includes perception thresholds and flow ranges. Every year in the analysis period must have perception thresholds and a flow range specified. The additional data that is required for use within a 17C EMA analysis is accessed/input within the EMA Data tab, as shown in Figure 5-3.

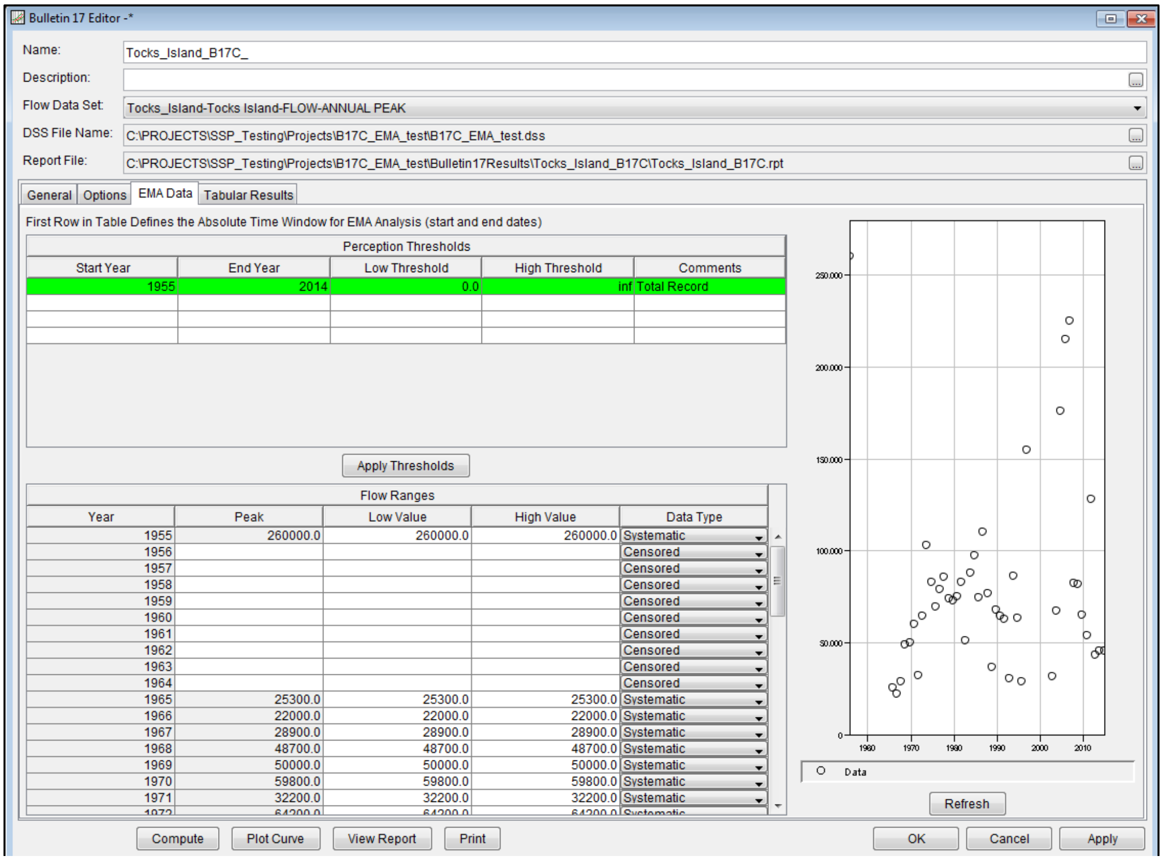


Figure 5-3. Bulletin 17C Analysis EMA Data Tab.

Perception Thresholds

The EMA procedure introduces the new concept of Perception Thresholds. Perception thresholds define the range of streamflow for which a flood event could have been observed. The inherent assumption and consequence is that any year for which an event was not observed and recorded must have had a peak flow rate outside of (usually below) the perception range.

Consider the example of an historical flood in 1882 estimated as 50,000 cfs, and then a gage was installed in 1926. This flood estimate suggests a perception threshold of 50,000 cfs to infinity, because there is evidence that a value as low as 50,000 cfs was noted/perceived (with high water marks, indirect evidence, and/or hydraulic modeling) during the ungaged period. One can further assume that any flow larger than 50,000 cfs would also have been perceived, and so any flow not perceived must have been less than 50,000 cfs. Therefore, for the unobserved period of 1883 to 1925, we assign the complementary flow range of 0 to 50,000 cfs to represent the likely range of peak flows during the unobserved period. The perception threshold and flow range for this hypothetical dataset is shown in Figure 5-4.

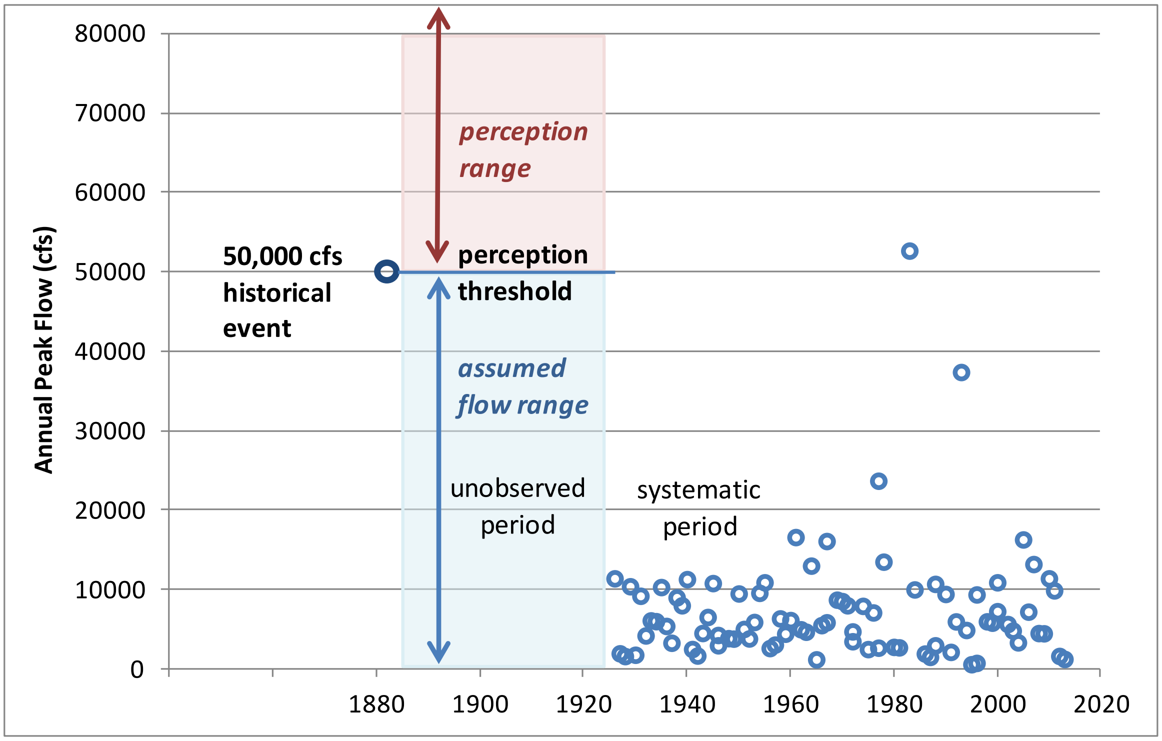
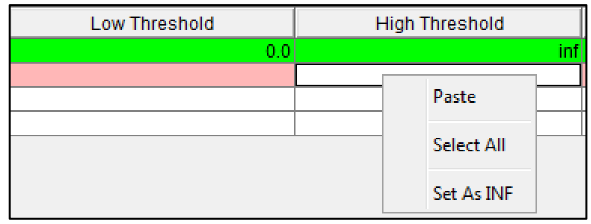


Figure 5-4. Example Showing a Perception Threshold and Flow Range.

The first row within the Perception Thresholds table will automatically be created to span the entire period of record of the selected Flow Data Set. The start and end year of this first perception threshold can be modified to alter the analysis time frame. This first perception threshold must have a low value of 0 and a high value of infinity. Additional rows within the perception threshold table supersede the rows above, for the specified time frame. Within HEC-SSP, perception threshold time frames should not overlap one another.

For any missing years in the analysis period, perception thresholds <u>other than</u> zero to infinity must be entered after the first row. The reason for this requirement is that a perception threshold of zero and infinity presumes any flow that occurred could have been observed, implying that unobserved years would not be possible. Therefore, unobserved years must have a perception threshold with either a lower bound greater than zero or an upper bound less than infinity. Most commonly, since very large flows do tend to be observed in some way (as historical events are estimated based on some evidence in the watershed), a lower bound greater than zero is chosen.



To assign a value of infinity within the High Threshold column, double left-click to begin editing the desired cell, right-click, and select **Set as INF** (infinity). Use the Comments column to provide a descriptive note to a perception threshold. The use of this column is not required. The comment associated with the first perception threshold will be automatically set to “Total Record”.

Multiple rows within the Perception Thresholds table can be sorted using chronological order by right-clicking within the table and selecting Sort by Start Year. Similarly, rows can also be inserted or deleted by right-clicking within the table.

When low outliers are detected using the Multiple Grubbs-Beck test, the perception threshold low value for systematic events will be changed to use the smallest non-screened annual peak flow. Further discussion regarding the impacts of low outliers on perception thresholds is contained within the Appendix C EMA examples.

Flow Ranges

The Bulletin 17B methodology limited the use of annual peak flow data to point-value flow estimates or zero flows. The 17C EMA methodology represents each annual peak flow within the analysis period as a range, whether it was observed or not. The flow range for a given year is assumed to be the value itself for an observed value or the complement of the perception threshold for that same year.

Flow data can be classified within one of three categories: Systematic, Censored, and Historical. This choice is specified in the Data Type column of the Flow Ranges table and can be changed by the user. By default, all flow data contained within the associated Flow Data Set will be set to Systematic while missing years will be set to Censored. Historical data generally refers to flood peaks that occurred outside of the systematic data collection period. Within the USGS NWIS database, a qualification code of “7” will indicate the presence of an historical peak. If this flow data is contained within the associated Flow Data Set, it will be labeled as Systematic by default. The user should change the data type to Historical.

By default, the low and high value for an observed (gaged/systematic) flood event is set equal to the gage estimate. The perception thresholds for these data points are 0 to infinity. However, if there is uncertainty about the flow estimate, the range can expand to represent the possible value(s).

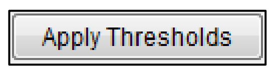
Similar to unobserved years in the historical period, if a crest stage gage is unable to estimate flow below a gage base of perhaps 50 cfs, then the perception thresholds would be 50 cfs to infinity, and the associated flow range for an event marked as “limited by gage base” is 0 to 50 cfs, which is set as the complement of the perception thresholds. The flow range for all three data types can be manually altered by the user. Figure 5-5 demonstrates several possible flow ranges and data types.

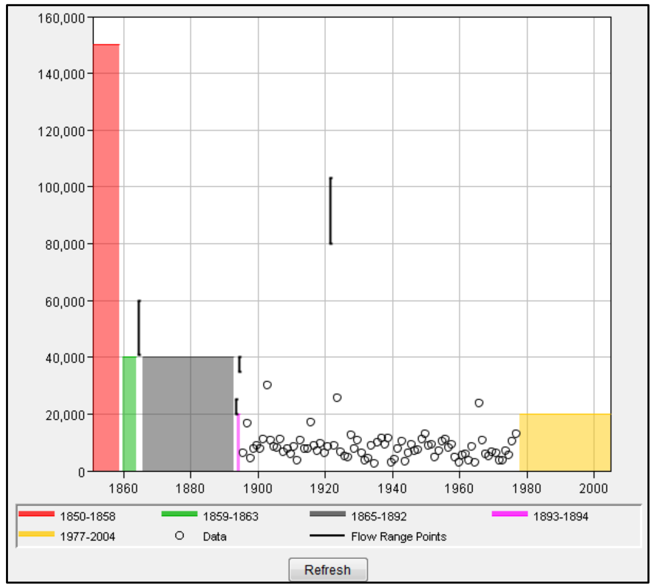
Flow Ranges				
Year	Peak	Low Value	High Value	Data Type
1955	260000.0	234000.0	286000.0	Historical
1956		0.0	50000.0	Censored
1957		0.0	50000.0	Censored
1958		0.0	50000.0	Censored
1959		0.0	50000.0	Censored
1960		0.0	50000.0	Censored
1961		0.0	50000.0	Censored
1962		0.0	50000.0	Censored
1963		0.0	50000.0	Censored
1964		0.0	50000.0	Censored
1965	25300.0	25300.0	25300.0	Systematic
1966	22000.0	22000.0	22000.0	Systematic

Figure 5-5. Example Flow Range Table with Systematic, Censored, and Historical Data.

When a flow event is reported as only a high and low value, a peak value should be estimated by taking the average of the low and high values. The peak value is used to compute a plotting position as well as within the Multiple Grubbs-Beck low outlier threshold computation.

The Apply Thresholds button can be used to automatically fill out the flow range table with the complementary flow ranges. For example, if a perception threshold is specified for a period of missing flow data with a low value of 50,000 cfs and a high value of infinity, the complementary flow range for each missing year would be set to 0 to 50,000 cfs after hitting Apply Thresholds. **The user should ensure that the peak, low, and high values within the flow range table are appropriate for use before computing the analysis.**





The plot within the EMA Data tab contains the flow values and the complementary Flow Ranges (as determined by the input Perception Thresholds) for the analysis period. The Perception Thresholds themselves are not contained within this figure.

The Refresh button will update the plot if changes are made to either the flow values or Perception Thresholds/Flow Ranges.

The user can double left-click the chart to create a separate window containing the plot. Colors, symbols, and various chart properties can then be edited.

When low outliers are detected using the Multiple Grubbs-Beck test, the high value within the flow range for systematic events will be changed to use the lowest non-screened annual peak flow. Further discussion regarding the impacts of low outliers on flow ranges is contained within the Appendix C EMA examples.

National Water Information System Qualification Codes

HEC-SSP will import the National Water Information System Qualification (NWIS) annual peak flow and stage qualification/quality codes when available (the program does not import quality codes for daily, instantaneous, and real time data). A description of the quality codes for annual peak flows is contained within Table 4-1 and a description of the quality codes for annual peak stages is contained within Table 4-2. These qualification codes can be examined by the user to inform the choice of perception thresholds, flow ranges, and data types.

Figure 5-3 contains an example peak discharge time series and the treatment of the NWIS qualification codes using EMA (Paretti, Kennedy, & Cohn, 2014). Within this example, the shaded area represents the historical period (H) and the nonshaded area represents the systematic record (S). The seven types of peak streamflow data are:

1. Historical discharge (NWIS code 7, Q_{hist}) and historical perception threshold specified with an upper perception threshold (T_1 and $T_{2\ thresh\ upper}$).
2. Mean daily maximum (NWIS code 1) is described with an upper discharge interval bound ($Q_{1\ int\ upper}$) equal to a perception threshold and a known discharge as the lower interval bound ($Q_{1\ int\ lower}$).
3. A recorded gage height, missing the corresponding discharge, could be used to estimate a discharge interval ($Q_{2\ int}$) where both interval bounds are uncertain.
4. Discharge greater than known maximum discharge (NWIS code 8) and used as the lower interval bound ($Q_{3\ int\ lower}$) and an upper interval bound equal to a perception threshold ($Q_{3\ int\ upper}$).
5. Missing peak flow data for a portion of the period of record but a correlated nearby gage could be used to set an upper perception threshold ($T_{3\ thresh\ upper}$).
6. A discharge less than a known recordable gage base flow (NWIS code 4) is describable with a lower interval bound ($Q_{4\ int\ lower}$ = zero) and an upper interval bound ($Q_{4\ int\ upper}$) equal to the minimum gage base discharge.
7. Systematic peak flow discharge (Q_{sys}).

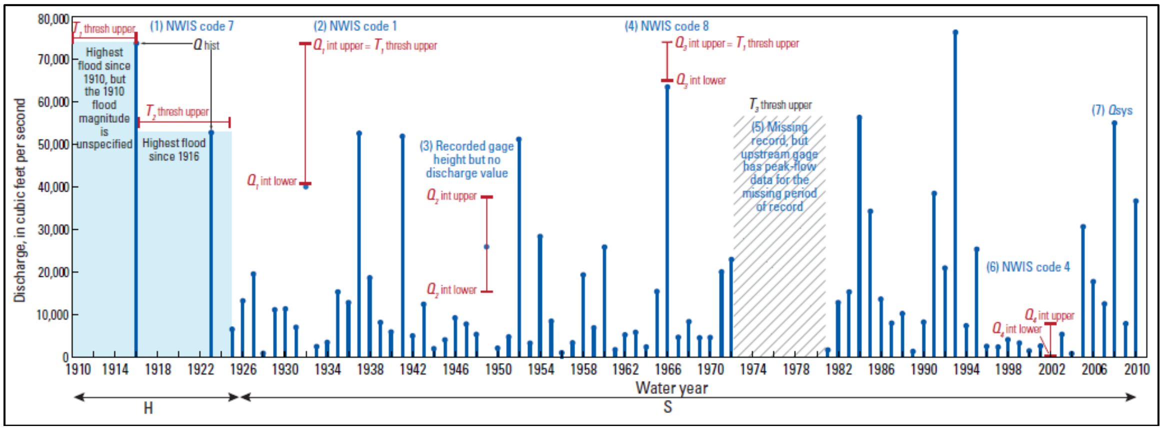


Figure 5-6. Example Peak Discharge Time Series and the Treatment of the NWIS Qualification Codes used within the Expected Moments Algorithm (Paretti, Kennedy, & Cohn, 2014).

Compute

Once the new analysis has been defined, and the user has all of the settings and options the way they want them, performing the computations is simply a matter of pressing the **Compute** button at the bottom of the Bulletin 17 Editor. If the computations are successful, the user will receive a message that says **Compute Complete**.

At this point, the user can begin to review the results of the flow frequency analysis.

Multiple Bulletin 17 analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finished computing the analyses.

Viewing and Printing Results

The user can view output from the flow frequency analysis directly from the Bulletin 17 Editor. The output consists of tabular results, a frequency curve plot, and a report documenting the data and computations performed.

Tabular Output

Once the computations for the flow frequency analysis are completed, the user can view tabular output by opening the **Tabular Results** tab. When this tab is pressed, the results will be displayed as shown in Figure 5-7.

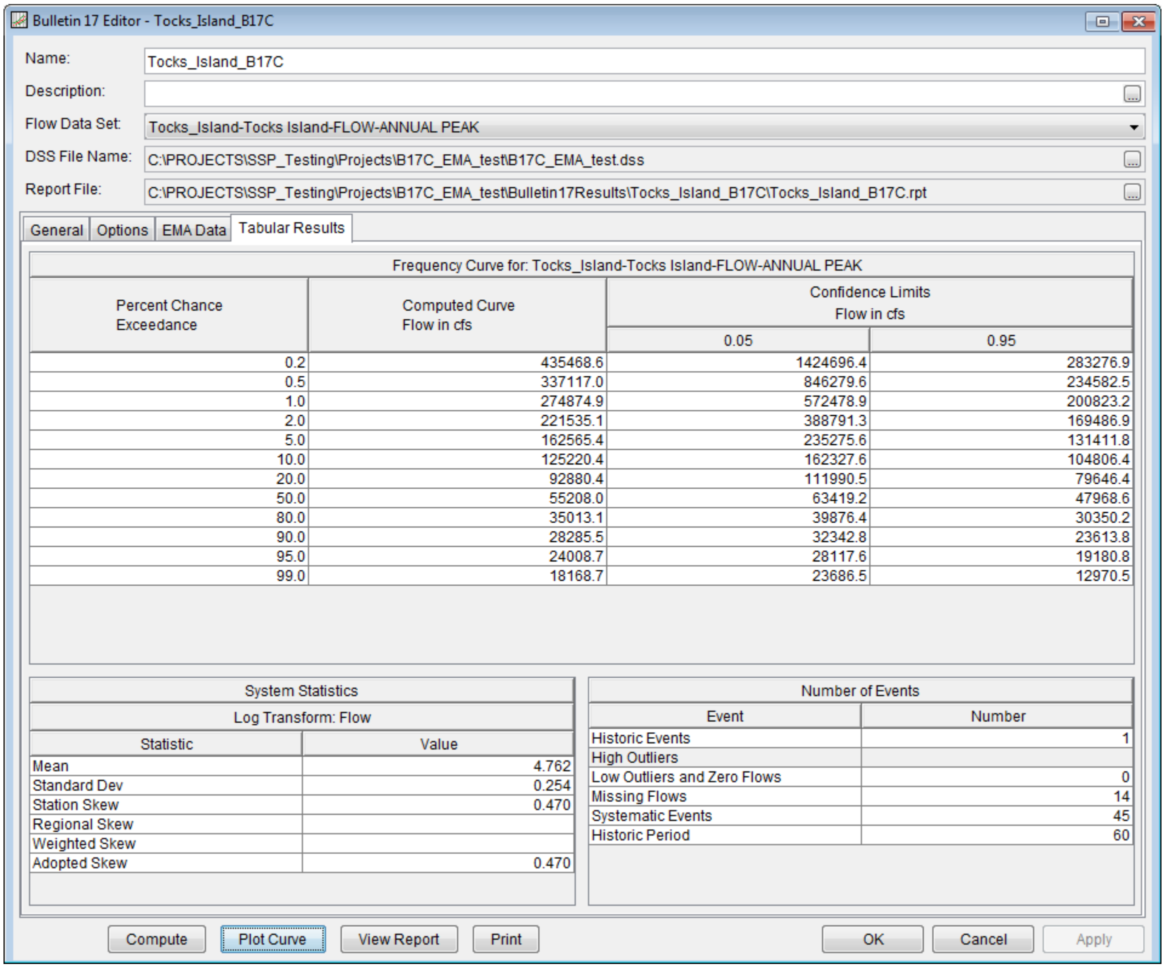


Figure 5-7. Bulletin 17 Editor with Tabular Results Tab Active.

Output on the results tab consists of three tables: Frequency Curves, Statistics, and Number of Events. The **Frequency Curve** output table contains the percent chance exceedance ordinates, the computed Log Pearson III frequency curve quantiles, the expected probability adjusted frequency curve quantiles (if selected on the General tab), and the computed confidence limits (0.05 and 0.95, by default). Data in the frequency curve table can be re-sorted. Click the **Percent Chance Exceedance** column header (two mouse clicks are required the first time). The percent chance exceedance ordinates, along with frequency curve and confidence limits values, will sort so that the lowest values are on top or the highest values are on top. The **Statistics** table contains the mean of the data in log space, standard deviation in log space, station log-space skew, user entered regional skew, weighted skew (weighted between station skew and regional skew), and the adopted skew for the analysis. The **Number of Events** table tabulates the number of historic events, high outliers (not calculated when using 17C EMA), low outliers and zero flows, missing values, systematic events, and the number of years in the historic period.

The tabular results can be printed by using the **Print** button at the bottom of the Bulletin 17 Editor. When the print button is pressed, a window will appear giving the user options for how they would like the table to be printed.

Graphical Output

Graphical output of the frequency curves can be obtained by pressing the **Plot Curve** button. When the Plot Curve button is pressed, a frequency curve plot will appear in a separate window as shown in Figure 5-8. The user can modify the plot properties by selecting the **Edit→Plot Properties** menu option. A plot properties window will open that lets the user change the line style for each data type, change the axis labels, modify the plot title, and edit other plot properties. The user can also edit line styles by placing the mouse on top of the line or data point in the plot or legend and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis.

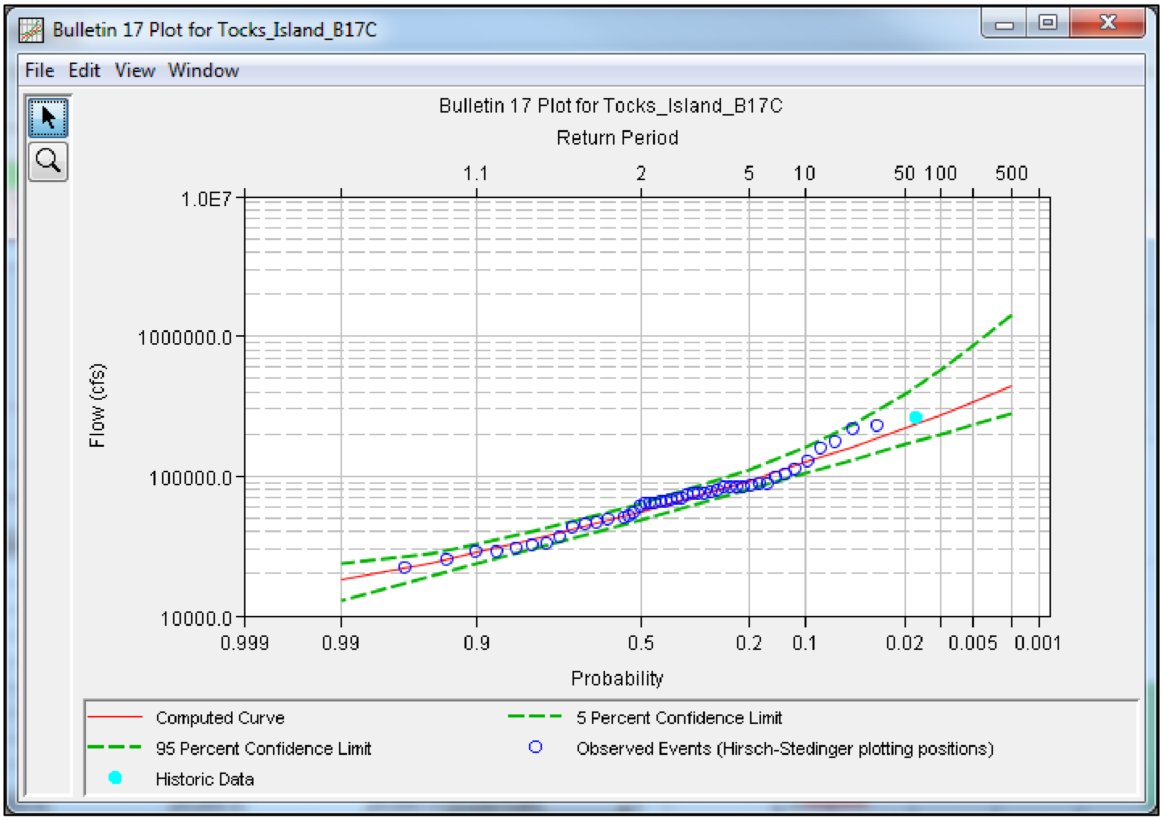


Figure 5-8. Example Frequency Curve Plot.

The frequency curve plot can be sent to the printer by selecting the **Print** option from the **File** menu at the top of the window. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The graphic can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file. Currently, four file formats are available for saving the graphic to disk, windows metafile, postscript, JPEG, and portable network graphic.

The data contained within the plot can also be tabulated by selecting **Tabulate** from the **File** menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the graphics options as a template (**Save Template)** and applying previously saved templates to the current graphic (**Apply Template**).

The **Edit** menu on the graphic window contains several options for customizing the graphic. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties.

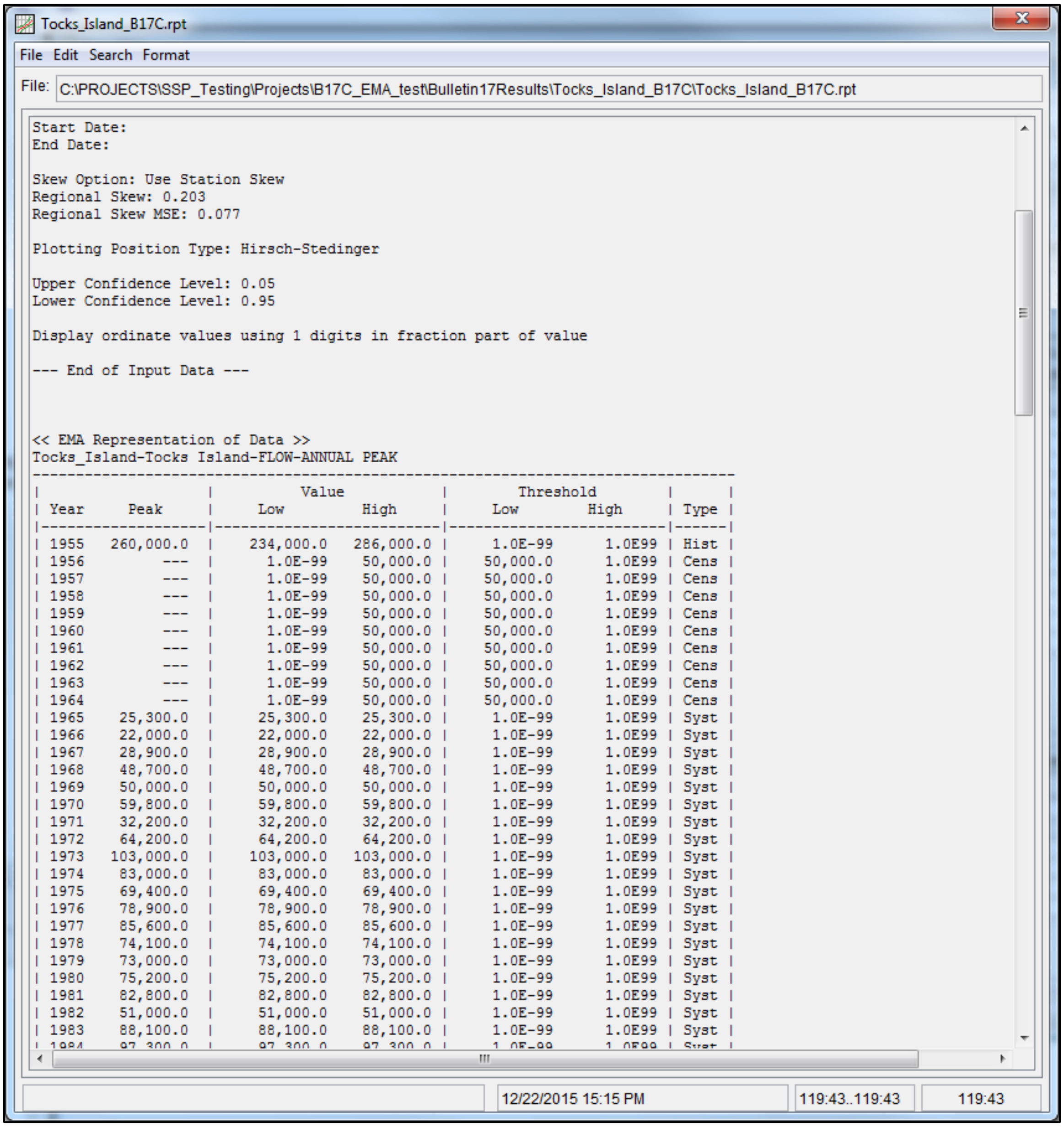
Also, a shortcut menu will appear with further customizing options when the user right-clicks on a line on the graph or the legend.

The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing graphics in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User's Manual for details on customizing plots.

Viewing the Report File

When the Bulletin 17 computations are performed, a report file documenting the statistical computations is created. The report file lists all of the input data and user settings, plotting positions of the data points, intermediate results, each of the various statistical tests performed (i.e. high and low outliers, historical data, etc…), and the final results. This also includes the EMA estimate of mean square error, effective record length, the Multiple Grubbs-Beck Test low outlier threshold, and the variance for each probability quantile. This file is often useful for understanding how the software arrived at the final frequency curve.

Press the **View Report** button at the bottom of the Bulletin 17 Analysis editor to view the report file. When this button is pressed a window will appear containing the report as shown in Figure 5-9.


Tocks_Island_B17C.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\B17C_EMA_test\Bulletin17Results\Tocks_Island_B17C\Tocks_Island_B17C.rpt

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: 0.203
Regional Skew MSE: 0.077

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

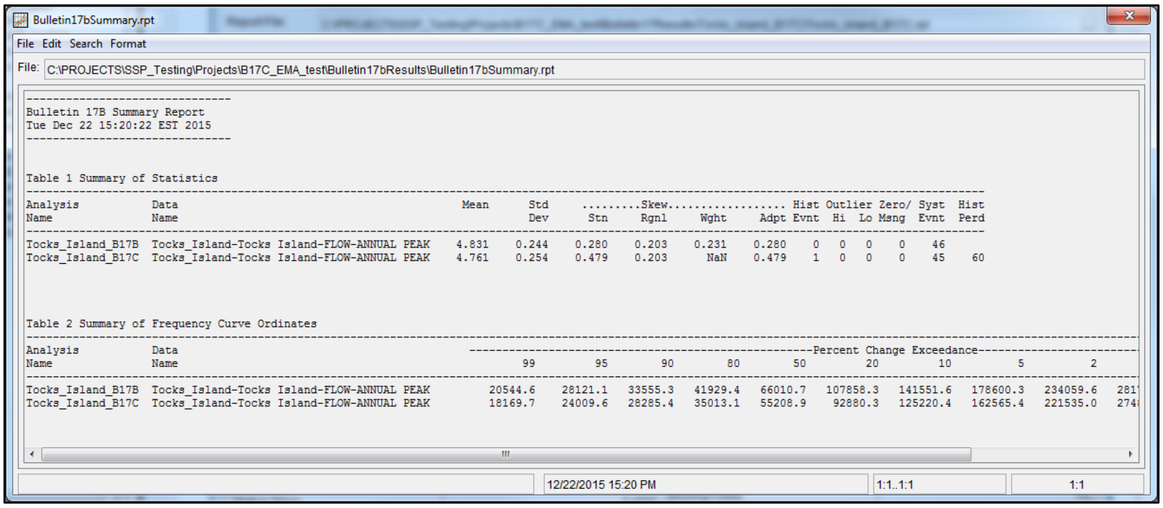
<< EMA Representation of Data >>
Tocks_Island-Tocks Island-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1955	260,000.0	234,000.0	286,000.0	1.0E-99	1.0E99	Hist
1956	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1957	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1958	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1959	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1960	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1961	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1962	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1963	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1964	---	1.0E-99	50,000.0	50,000.0	1.0E99	Cens
1965	25,300.0	25,300.0	25,300.0	1.0E-99	1.0E99	Syst
1966	22,000.0	22,000.0	22,000.0	1.0E-99	1.0E99	Syst
1967	28,900.0	28,900.0	28,900.0	1.0E-99	1.0E99	Syst
1968	48,700.0	48,700.0	48,700.0	1.0E-99	1.0E99	Syst
1969	50,000.0	50,000.0	50,000.0	1.0E-99	1.0E99	Syst
1970	59,800.0	59,800.0	59,800.0	1.0E-99	1.0E99	Syst
1971	32,200.0	32,200.0	32,200.0	1.0E-99	1.0E99	Syst
1972	64,200.0	64,200.0	64,200.0	1.0E-99	1.0E99	Syst
1973	103,000.0	103,000.0	103,000.0	1.0E-99	1.0E99	Syst
1974	83,000.0	83,000.0	83,000.0	1.0E-99	1.0E99	Syst
1975	69,400.0	69,400.0	69,400.0	1.0E-99	1.0E99	Syst
1976	78,900.0	78,900.0	78,900.0	1.0E-99	1.0E99	Syst
1977	85,600.0	85,600.0	85,600.0	1.0E-99	1.0E99	Syst
1978	74,100.0	74,100.0	74,100.0	1.0E-99	1.0E99	Syst
1979	73,000.0	73,000.0	73,000.0	1.0E-99	1.0E99	Syst
1980	75,200.0	75,200.0	75,200.0	1.0E-99	1.0E99	Syst
1981	82,800.0	82,800.0	82,800.0	1.0E-99	1.0E99	Syst
1982	51,000.0	51,000.0	51,000.0	1.0E-99	1.0E99	Syst
1983	88,100.0	88,100.0	88,100.0	1.0E-99	1.0E99	Syst

12/22/2015 15:15 PM 119:43..119:43 119:43

Figure 5-9. Example of the Bulletin 17 Report File.

Plots, tables and reports can also be created by selecting menu options from the **Results** menu. At least one Bulletin 17 analysis must be selected in the study explorer before selecting one of the menu options on the Results menu. Results from multiple analyses are combined in one graph if they are selected in the study explorer when the **Graph** menu option is selected. The **Results→Summary Report** menu option will create a summary table of statistics and frequency curve ordinates for the selected analyses as shown in Figure 5-10.



Bulletin17bSummary.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\B17C_EMA_test\Bulletin17bResults\Bulletin17bSummary.rpt

Bulletin 17B Summary Report
Tue Dec 22 15:20:22 EST 2015

Table 1 Summary of Statistics

Analysis Name	Data Name	Mean	Std Dev	Skew Stn	Skew Rgnl	Skew Wght	Skew Adpt	Hist Evnt	Outlier Hi	Outlier Lo	Zero/ Msng	Syst Evnt	Hist Perd
Tocks_Island_B17B	Tocks_Island-Tocks Island-FLOW-ANNUAL PEAK	4.831	0.244	0.280	0.203	0.231	0.280	0	0	0	0	46	
Tocks_Island_B17C	Tocks_Island-Tocks Island-FLOW-ANNUAL PEAK	4.761	0.254	0.479	0.203	NaN	0.479	1	0	0	0	45	60

Table 2 Summary of Frequency Curve Ordinates

Analysis Name	Data Name	Percent Change Exceedance 99	95	90	80	50	20	10	5	2	
Tocks_Island_B17B	Tocks_Island-Tocks Island-FLOW-ANNUAL PEAK	20544.6	28121.1	33555.3	41929.4	66010.7	107858.3	141551.6	178600.3	234059.6	281
Tocks_Island_B17C	Tocks_Island-Tocks Island-FLOW-ANNUAL PEAK	18169.7	24009.6	28285.4	35013.1	55208.9	92880.3	125220.4	162565.4	221535.0	274

12/22/2015 15:20 PM 1:1..1:1 1:1

Figure 5-10. Summary Table for Selected Bulletin 17 Analyses.

CHAPTER 6

Performing a General Frequency Analysis

The current version of HEC-SSP allows the user to perform generalized frequency analyses of flow and stage data, as well as other data types. The user can choose between different analytical distributions or perform a graphical fit to the data. This chapter discusses in detail how to use the General Frequency Analysis editor in HEC-SSP.

Contents

Starting a New Analysis

A general frequency analysis can be started in two ways, either by right clicking on the General Frequency Analysis folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **General Frequency Analysis**. When a new general frequency analysis is selected, the General Frequency Analysis editor will appear as shown in Figure 6-1.

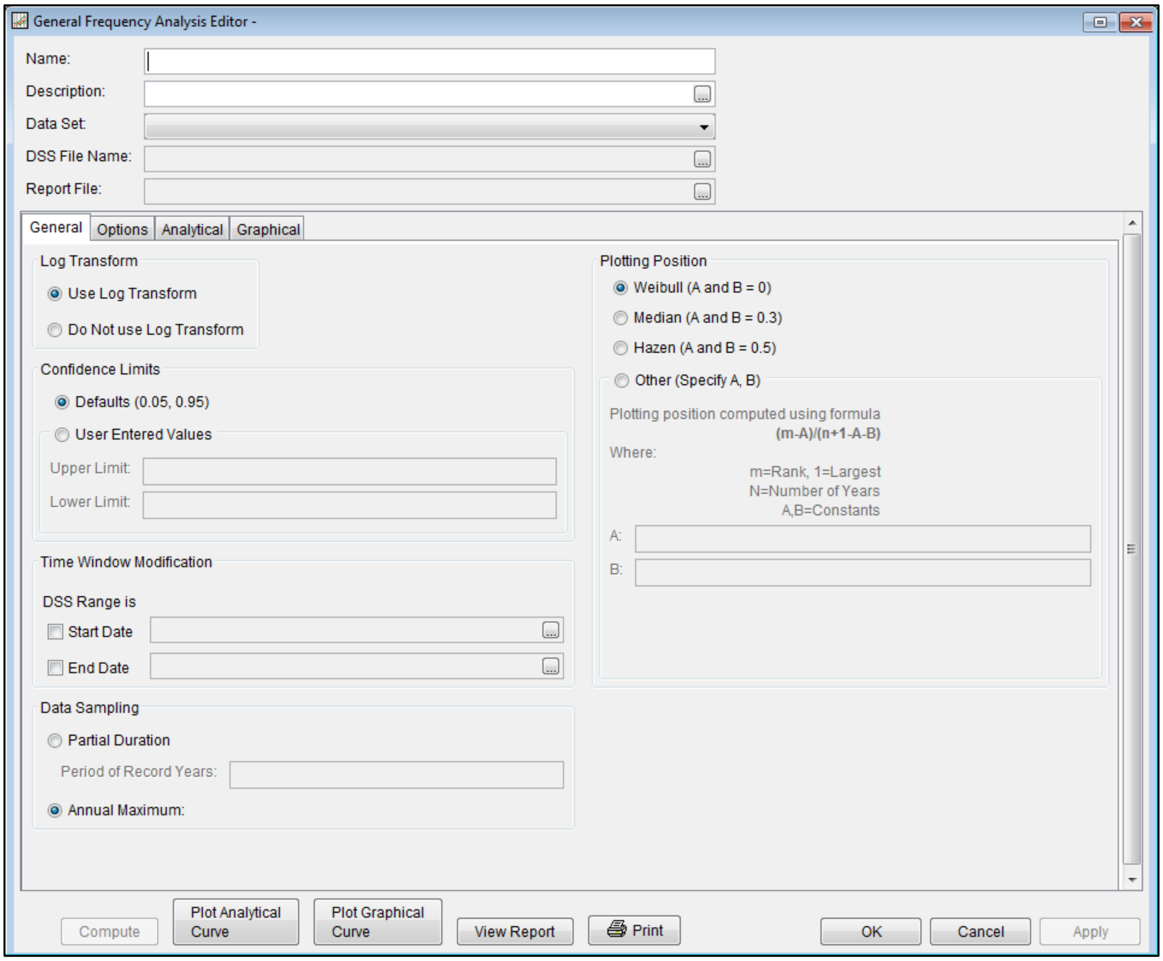


Figure 6-1. General Frequency Analysis Editor.

The user is required to enter a **Name** for the analysis, while a **Description** is optional. A data set (flow, stage, or other) must be selected from the available data sets stored in the current study DSS file (see Chapter 4 for importing data into the study). The list of data that can be selected for a general frequency analysis will only include those data that have an irregular interval, like IR-CENTURY and IR-YEAR (E-part pathname). Once a Name is entered and a data set is selected, the **DSS File Name** and **Report File** will automatically be filled out. The DSS filename is by default the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

General Settings and Options

Once the analysis name and data set are selected, the user can begin to perform the computations. Contained on the General Frequency Analysis editor are four tabs. The tabs are labeled **General**, **Options**, **Analytical**, and **Graphical**. This section of the manual explains the use of the General and Options tabs.

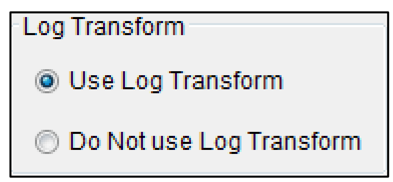
General Settings

The first tab contains general settings for performing the frequency analysis (Figure 6-1). These settings include:

- Log Transforms
- Confidence Limits
- Time Window Modification
- Data Sampling
- Plotting Positions

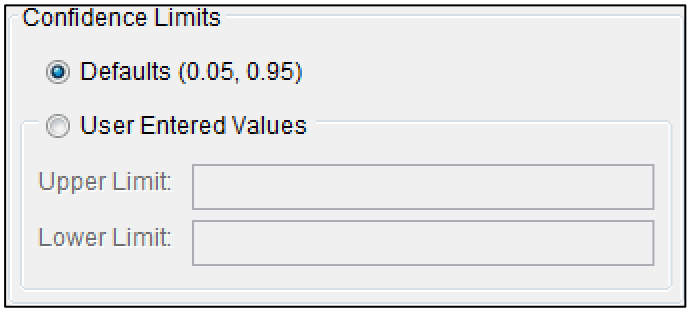
Log Transform

There are two options contained within the Log Transform setting: Use Log Transform and Do not use Log Transform. If the user selects **Use Log Transform** then the logs of the data will be taken first. The frequency analysis will be performed on the logs of the data. If the user selects **Do not use Log Transform**, then the frequency analysis will be performed on the raw data values without taking the logs of the data. The default setting is **Use Log Transform**.



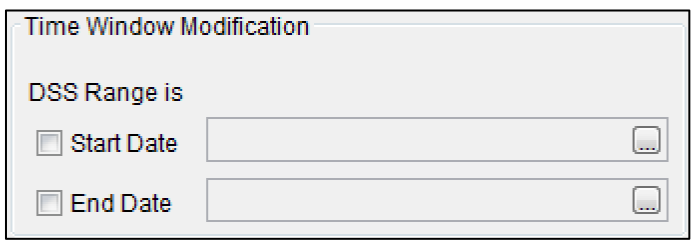
Confidence Limits

Confidence limits provide a measure of the uncertainty in the computed value for a given exceedance probability. The computation of confidence limits is outlined in Bulletin 17B, Appendix 9, and is applied in the same manner here in the general frequency analysis. By default, HEC-SSP calculates the 90 percent confidence interval (i.e. the 5% and 95% confidence limits). The confidence limits must be entered in decimal form (i.e. 95% = 0.95, and 5% = 0.05). The user has the option to override the default values.



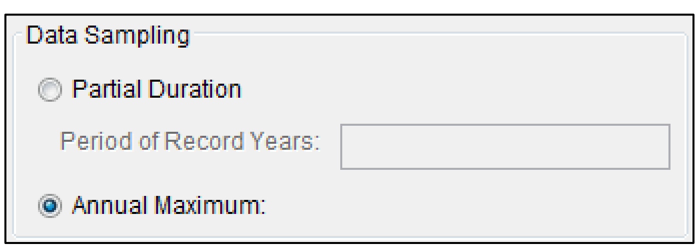
Time Window Modification

This option allows the user to narrow the time window used for the analysis. The default is to use all of the data contained in the selected data set. The user can enter either a start date and end date or both a start and end date. If a start and/or end date are used, they must be dates that are encompassed within the data stored in the selected data set. The date range for the selected data set is shown in the editor just above the **Start Date** field.



Data Sampling

Two methods are available for sampling data within HEC-SSP: Partial Duration and Annual Maximum. An annual maximum series is ordinarily used when the primary interest lies in the larger events or when the second, third, fourth… nth largest



event in any year is of little concern in the analysis. Conversely, a partial duration series represents the frequency of all independent events of interest, regardless of whether two or more occurred in the same year. Partial Duration analyses may be more appropriate for situations where considerable flood damage is wrought by the second or third largest flood events in a given year. However, a flow-frequency curve based upon an annual maximum and a partial duration series will converge to form a single flow-frequency curve as exceedance probability decreases. Commonly, this convergence occurs between the 0.1 and 0.01 exceedance probabilities.

Peak flow data is most often represented by an annual maximum series. For instance, choosing to download annual peak data from the USGS website (as is detailed in Section 4) will result in the import of an annual maximum series. The user is required to produce an appropriate partial duration series for use in a partial duration analysis. This can be achieved in several ways. For instance, the user can manually select independent events from a flow data set with hourly ordinates. However, it is more expedient to use a peak (or minimum) search algorithm, such as the Find Peaks tool that can be used within HEC-DSSVue. This tool will allow the user to filter a continuous data set to find either maximum or minimum values using user-defined minimum threshold, flow differential, and a minimum elapsed time interval between events. Figure 6-2 demonstrates the differences between an hourly flow data set, an annual maximum series, and a partial duration series for a four year span at a particular stream gage location. Please see Appendix D for an example use of the Find Peaks tool to create a partial duration series.

The Period of Record Years is used to extract ranked data points from the associated data set when using the partial duration data sampling. For instance, if the Period of Record Years is set to 50, then the top 50 ranked events will be extracted from the associated data set.

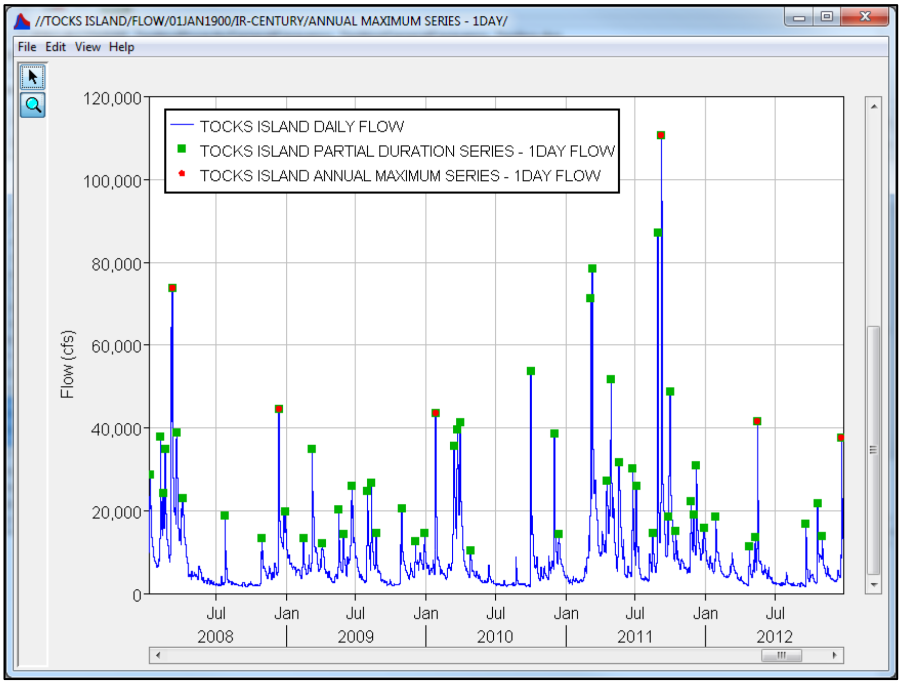
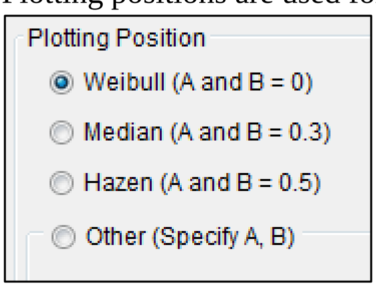


Figure 6-2. Hourly Flow, Annual Maximum, and Partial Duration Series for a Stream Gage.

Choosing either Partial Duration or Annual Maximum will enable and disable various other features throughout the General Frequency Analysis. Annual Maximum is the default.

Plotting Positions

Plotting positions are used for plotting the raw data points on the graph.



There are four options for plotting position methodologies within HEC-SSP: Weibull, Median, Hazen, and user entered coefficients. The default method is the Weibull plotting position formula. The generalized plotting position equation is:

$$P = \frac{(m - A)}{(n + 1 - A - B)}$$

where: m = rank of flood values with the largest equal to 1.

n = number of flood peaks in the data set.

A & B = constants dependent on which equation is used (Weibull A and B=0; Median A and B = 0.3; and Hazen A and B=0.5).

Plotting positions are estimates of the exceedance probability of each data point. Different methods can give very different values for the probabilities of the highest and lowest points in the data set. In the General Frequency methodology, the plotting of data on the graph by a plotting position method is only done as a guide to assist in evaluating the computed curve. The plotting position method selected does not have any impact on the computed curve.

Options

In addition to the general settings, there are also several options available to the user for modifying the computations of the frequency curves. These options include:

- Low Outlier Threshold
- Historic Period Data
- User-Specified Frequency Ordinates
- Output Labeling

When the Options tab is selected, the General Frequency Analysis editor will appear as shown in Figure 6-3.

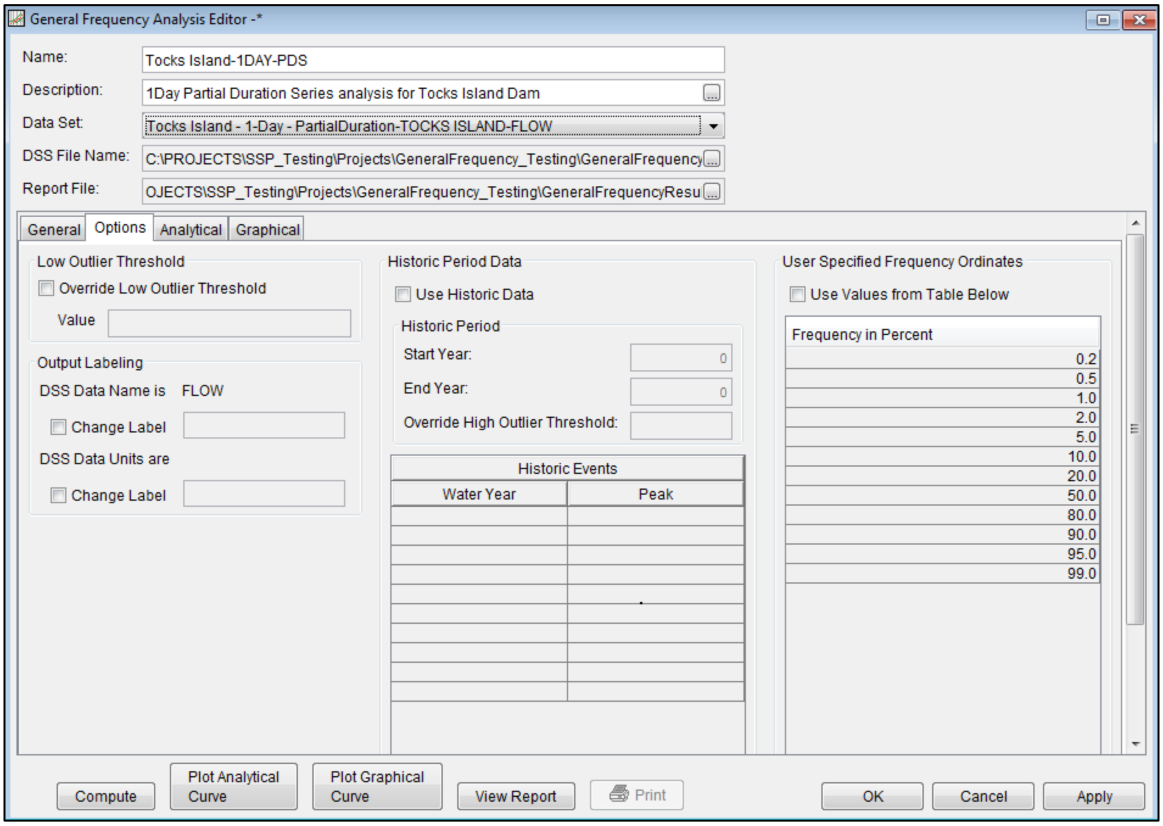
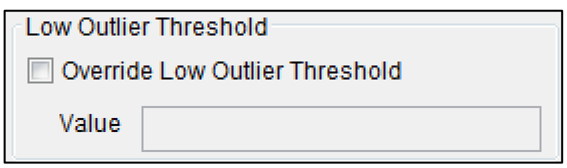


Figure 6-3. General Frequency Editor with Options Tab Selected.

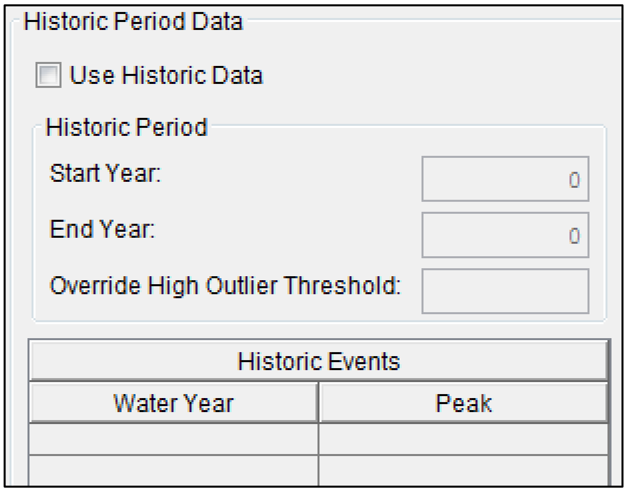
Low Outlier Threshold



High and low outlier tests are based on the procedures outlined in Bulletin 17B, and are applied in the same manner in the General Frequency Analysis. The calculated outlier magnitudes, by the Bulletin 17B procedure, are used as default values for the high and low outlier thresholds in HEC-SSP. The user has the option to enter a different value for the low outlier threshold. If a value is entered for the low outlier threshold, then this value will override the computed value from the Bulletin 17B methodology. When applying the outlier tests, HEC-SSP will identify both high and low outliers. However, only low outliers will be removed from the data set when performing the analysis. If a high outlier is identified in the data set, the analyst should try to incorporate historical period information to extend the time period for which the high outlier(s) is considered to be the maximum value(s). Further discussion of outlier thresholds can be found in Bulletin 17B. To use the low outlier threshold, simply check the box and enter the value.

Historic Period Data

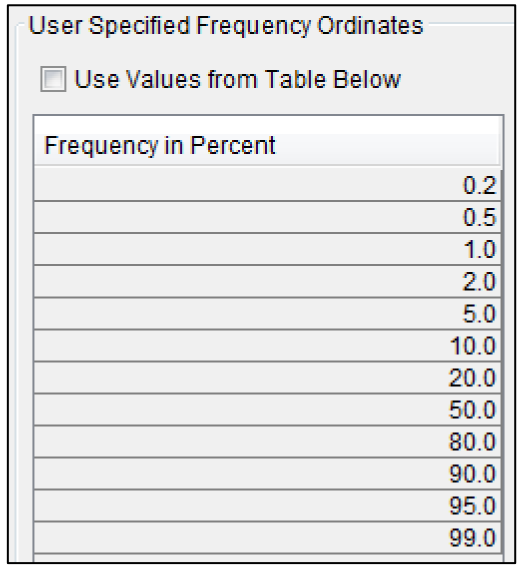
All historic data that provides reliable estimates outside the systematic record should be used in order to improve the frequency computations. Information outside of the systematic record can often be used to extend the record of the largest events to a historic period much longer than that of the systematic record. HEC-SSP uses historic data as recommended in Bulletin 17B. This calculation is applied in the same manner in the General Frequency Analysis. To use historic data, check the box labeled **Use Historic Data**. The user can enter a starting year for the historic period, ending year for a historic period, and a High Threshold value. If the user enters a high threshold value, then any data in the systematic record greater than that value will also be treated as a historical annual maximum. The user can also enter historic data that are not contained in the systematic record. This is done in the table at the bottom labeled **Historic Events**. All years must be entered as water year values (October 1 through September 30). If a start year is not entered, then the assumed start year is the earliest year of the systematic record and any historical values that have been entered. If an end year is not entered, then the assumed end year is the latest year in the systematic record and any entered historic values. Further discussion of the use of historical data can be found in Bulletin 17B.



Note: The program treats all data in the data set as systematic data. If historic events are included in the data set, then the user can define the analysis time window (General tab – Time Window Modification) so that it only bounds the systematic record. Then define the historic events in the Historic Events table. Instead of using the Time Window Modification option, another option is to enter a High Threshold value so that the historic data point(s) would be treated as historic data (rather than part of the systematic record). Please see **Example 6** in **Appendix B** for an example of using the historic data adjustment.

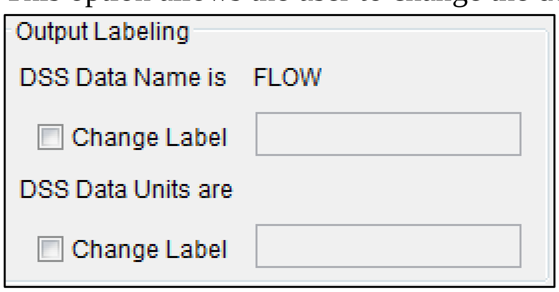
User Specified Frequency Ordinates

This option allows the user to change the frequency ordinates used in computing the resulting frequency curves and confidence limits. The default values listed in percent chance exceedance are 0.2, 0.5, 1, 2, 5, 10, 20, 50, 80, 90, 95, and 99. Check the box next to **Use Values from Table below** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the frequency values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Use Values from Table below** option are not checked. Finally, all values in the table must be between 0 and 100.



Output Labeling

This option allows the user to change the default labels for data contained in the output tables and plots. The user can change both the name of the data as well as how the units of the data are labeled.



Analytical Frequency Analysis

Once the new analysis has been defined and the user has all of the general settings and options the way they want them, the user can choose between performing an Analytical Frequency analysis or a Graphical Frequency analysis. This section of the manual describes how to use the Analytical Frequency analysis option.

When the user selects the **Analytical** tab on the General Frequency Analysis editor, the window will appear as shown in Figure 6-4. As shown, three additional tabs will appear on the screen: Settings, Tabular Results, and Plot.

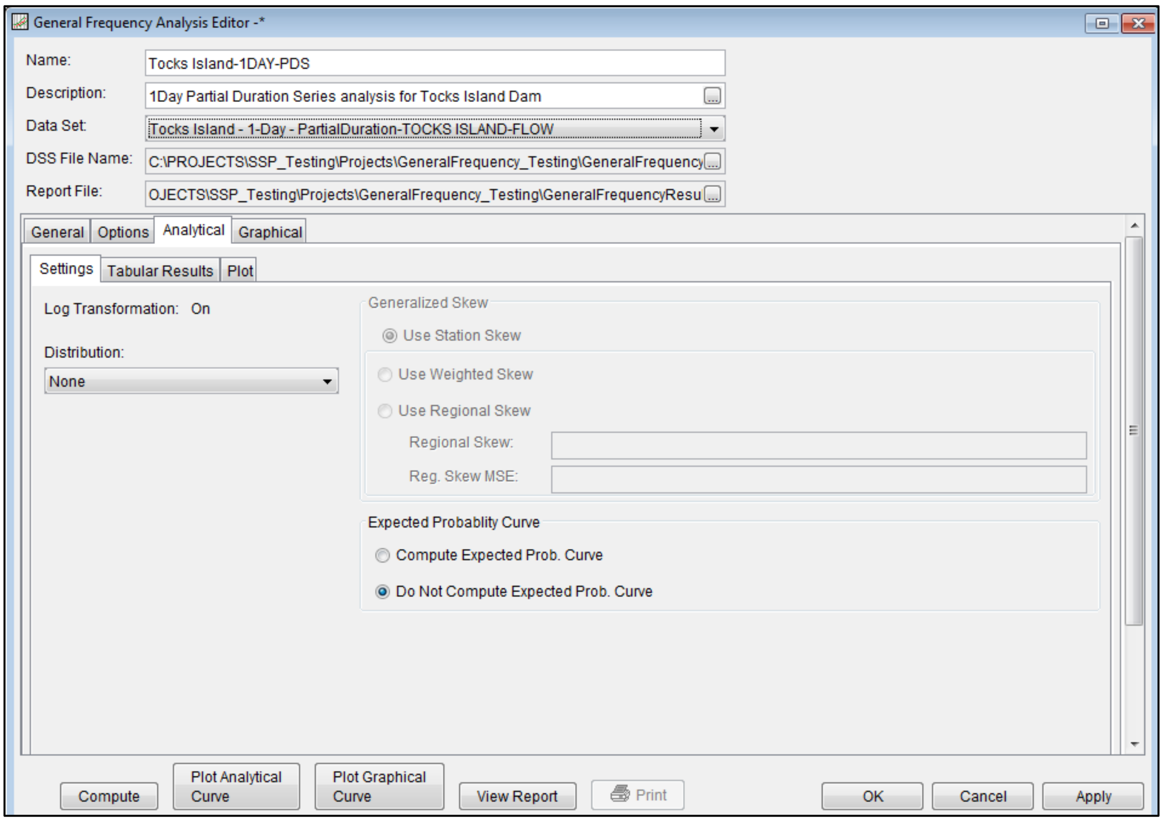


Figure 6-4. Analytical Analysis Tab of the General Frequency Analysis Editor.

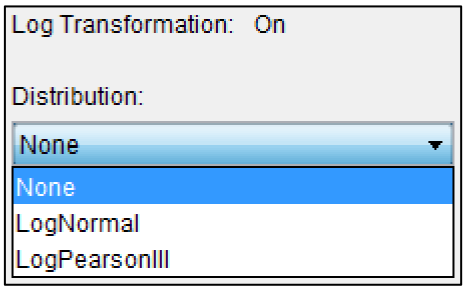
Settings

The **Settings** tab contains additional settings for the analytical frequency analysis. These settings include:

- Distribution
- Generalized Skew
- Expected Probability Curve

Distribution

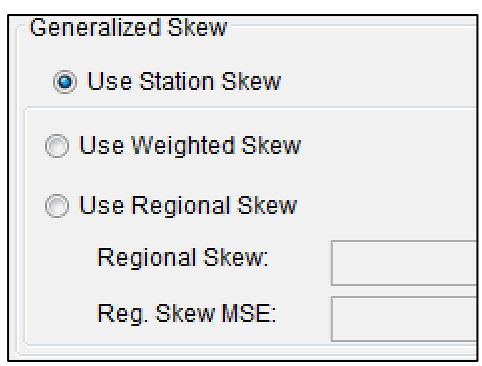
This option allows the user to select from available analytical distributions to perform the frequency analysis. The current version of HEC-SSP contains three distribution choices: None, Normal, LogNormal, Pearson III, and LogPearson III. If the user has selected to transform the data to log space (General tab), then the only available choices for distribution will be None, LogNormal, and LogPearson III. If the user did not select the option to transform the data to log space (General tab), then the only available choices for distribution will be None, Normal and Pearson III. Finally, if the user has selected to use a partial duration series on the General Tab, then no distributions will be available for use.



Generalized Skew

There are three options contained within the generalized skew setting: Use Station Skew, Use Weighted Skew, and Use Regional Skew. The default skew setting is **Use Station Skew**. With this setting, the skew of the computed curve will be based solely on computing a skew from the data points.

To use either of the two other options requires the use of the Log Person III distribution. The **Use Weighted Skew** option requires the user to enter a generalized regional skew and a Mean-Square Error (MSE) of the generalized regional skew. This option weights the computed station skew with the generalized regional skew. The equation for performing this weighting can be found in Bulletin 17B (Equation 6). If a regional skew is

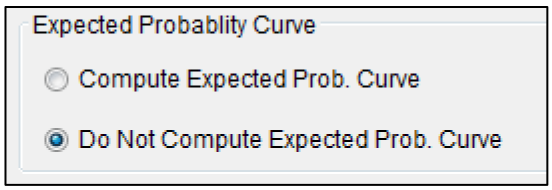


taken from Plate I of Bulletin 17B (the skew map of the United States), the value of MSE = 0.302.

The last generalized skew option is **Use Regional Skew**. When this option is selected, the user must enter a generalized regional skew and an MSE for that skew. The program will ignore the computed station skew and use only the generalized regional skew.

Expected Probability Curve

This setting has two options: Compute the expected probability curve and do not compute the expected probability curve. The default setting is to not compute the expected probability curve. When computed, this curve



will be shown in both the tables and the plots as an additional curve to the computed curve. The expected probability adjustment is a correction for bias in the computed frequency curve. The bias is caused by the skew in the uncertainty due to the shortness of the data record. The Method of Moments estimation of the Log Pearson III parameters produces a median estimate of each frequency curve quantile, and the adjustment changes to a mean (unbiased) estimate, which is different from the median because of a skewed uncertainty distribution. Please review the discussion in Bulletin 17B about the expected probability curve adjustment for an explanation of how and why it is computed. The use of the expected probability curve is a policy decision. It is most often used in establishing design flood criteria. The basic flood frequency curve without the expected probability adjustment is the curve used in computation of confidence limits, risk, and in obtaining weighted averages of independent estimates of flood frequency discharge (Interagency Advisory Committee on Water Data, 1982).

Compute

Once the new analysis has been defined, and the user has all of the General, Options, and Settings information selected the way they want,

performing the computations is simply a matter of pressing the **Compute** button at the bottom of the General Frequency Analysis editor. If the computations are successful, the user will receive a message that says "Compute Complete". At this point, the user can begin to review the results of the Analytical Frequency computations.

Multiple General Frequency analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finished computing the analyses.

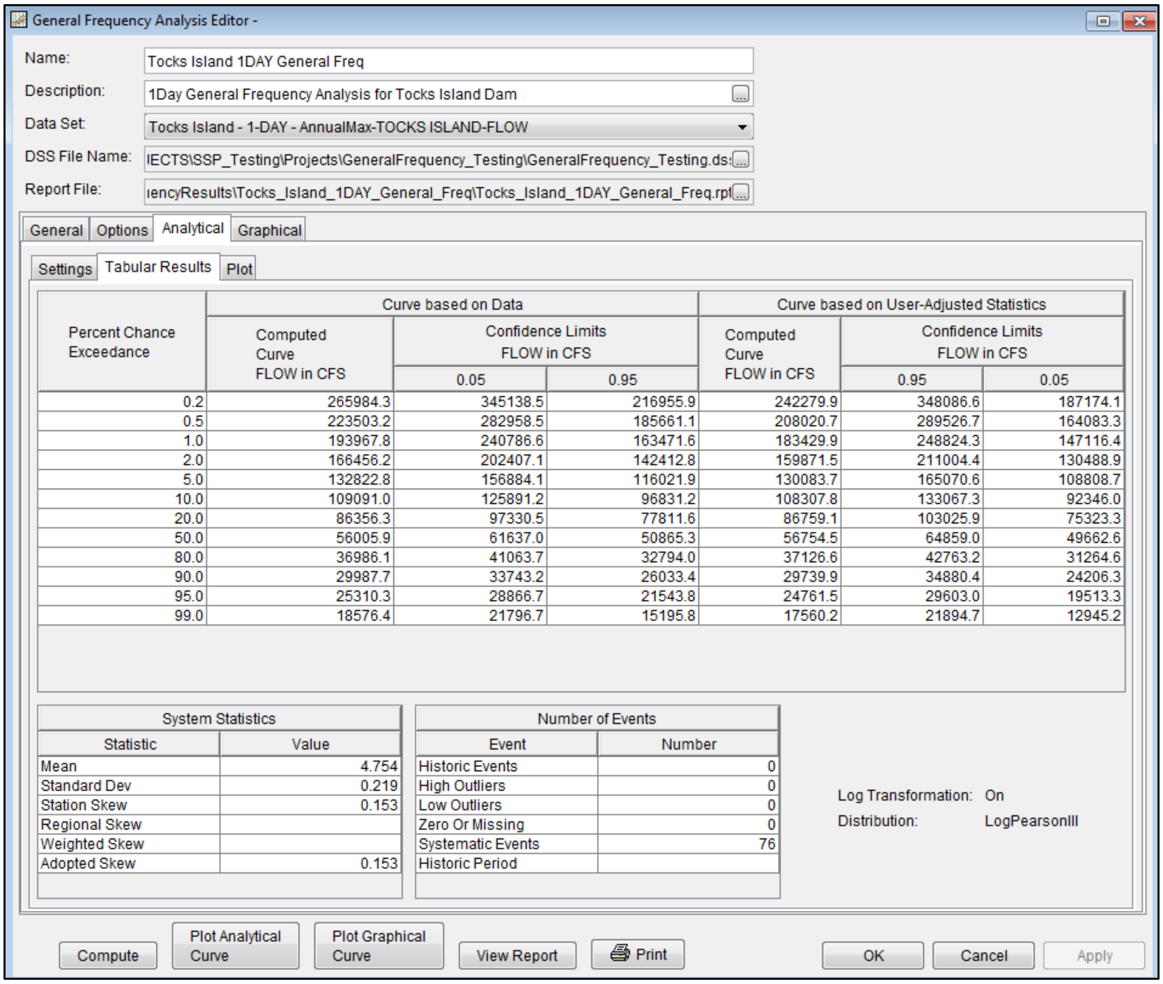
Tabular Results

The **Tabular Results** tab will bring up a table of results for the Analytical Frequency analysis. An example of the results tab is shown in Figure 6-5.

As shown in Figure 6-5, the window contains three tables. The top table contains results of the computed frequency curve. The very left column of the top table is the Percent Chance Exceedance for all the computed values. The next three columns in the top table contain the computed frequency curve and the 95% and 5% confidence limits that correspond to that computed curve. The last three columns of the top table contain a computed frequency curve and confidence limits for an analysis based on user-adjusted statistics for the mean, standard deviation, adopted skew, and equivalent years of record. User entered adjusted statistics are an option that the user can set on the **Plot** tab, which is discussed in detail in the next section of this manual. If the user has not entered adjusted statistics, then these columns will be empty. Data in the frequency curve table can be re-sorted. Click the **Percent Chance Exceedance** column header (two mouse clicks are required the first time). The percent chance exceedance ordinates, along with frequency curve and confidence limits values, will sort so that the lowest values are on top or the highest values are on top.

Two additional tables are shown at the bottom of the window: Statistics and Number of Events. The **Statistics** table consists of the mean, standard deviation, station skew, user entered regional skew, weighted skew (weighted between station skew and regional skew), and the adopted skew for the analysis. The **Number of Events** table contains the number of historic events, high outliers, low outliers, zero or missing values, systematic events, and the number of years in the historic period (this value only comes into play if the user entered historic data).

Additionally, the lower right portion of the table will show if Log Transform is On or Off, and which analytical distribution was selected for the analysis.



Percent Chance Exceedance	Curve based on Data: Computed Curve FLOW in CFS	Confidence Limits FLOW in CFS 0.05	Confidence Limits FLOW in CFS 0.95	Curve based on User-Adjusted Statistics: Computed Curve FLOW in CFS	Confidence Limits FLOW in CFS 0.95	Confidence Limits FLOW in CFS 0.05
0.2	265984.3	345138.5	216955.9	242279.9	348086.6	187174.1
0.5	223503.2	282958.5	185661.1	208020.7	289526.7	164083.3
1.0	193967.8	240786.6	163471.6	183429.9	248824.3	147116.4
2.0	166456.2	202407.1	142412.8	159871.5	211004.4	130488.9
5.0	132822.8	156884.1	116021.9	130083.7	165070.6	108808.7
10.0	109091.0	125891.2	96831.2	108307.8	133067.3	92346.0
20.0	86356.3	97330.5	77811.6	86759.1	103025.9	75323.3
50.0	56005.9	61637.0	50865.3	56754.5	64859.0	49662.6
80.0	36986.1	41063.7	32794.0	37126.6	42763.2	31264.6
90.0	29987.7	33743.2	26033.4	29739.9	34880.4	24206.3
95.0	25310.3	28866.7	21543.8	24761.5	29603.0	19513.3
99.0	18576.4	21796.7	15195.8	17560.2	21894.7	12945.2

System Statistics	
Statistic	Value
Mean	4.754
Standard Dev	0.219
Station Skew	0.153
Regional Skew	
Weighted Skew	
Adopted Skew	0.153

Number of Events	
Event	Number
Historic Events	0
High Outliers	0
Low Outliers	0
Zero Or Missing	0
Systematic Events	76
Historic Period	

Figure 6-5. Tabular Results Tab for Analytical Analysis.

Plot

In addition to tabular results, a **Plot** tab is available for viewing a graphical plot of both the computed frequency curve, as well as a computed curve based on any user-adjusted statistics. When the Plot tab is selected the window will change to what is shown in Figure 6-6.

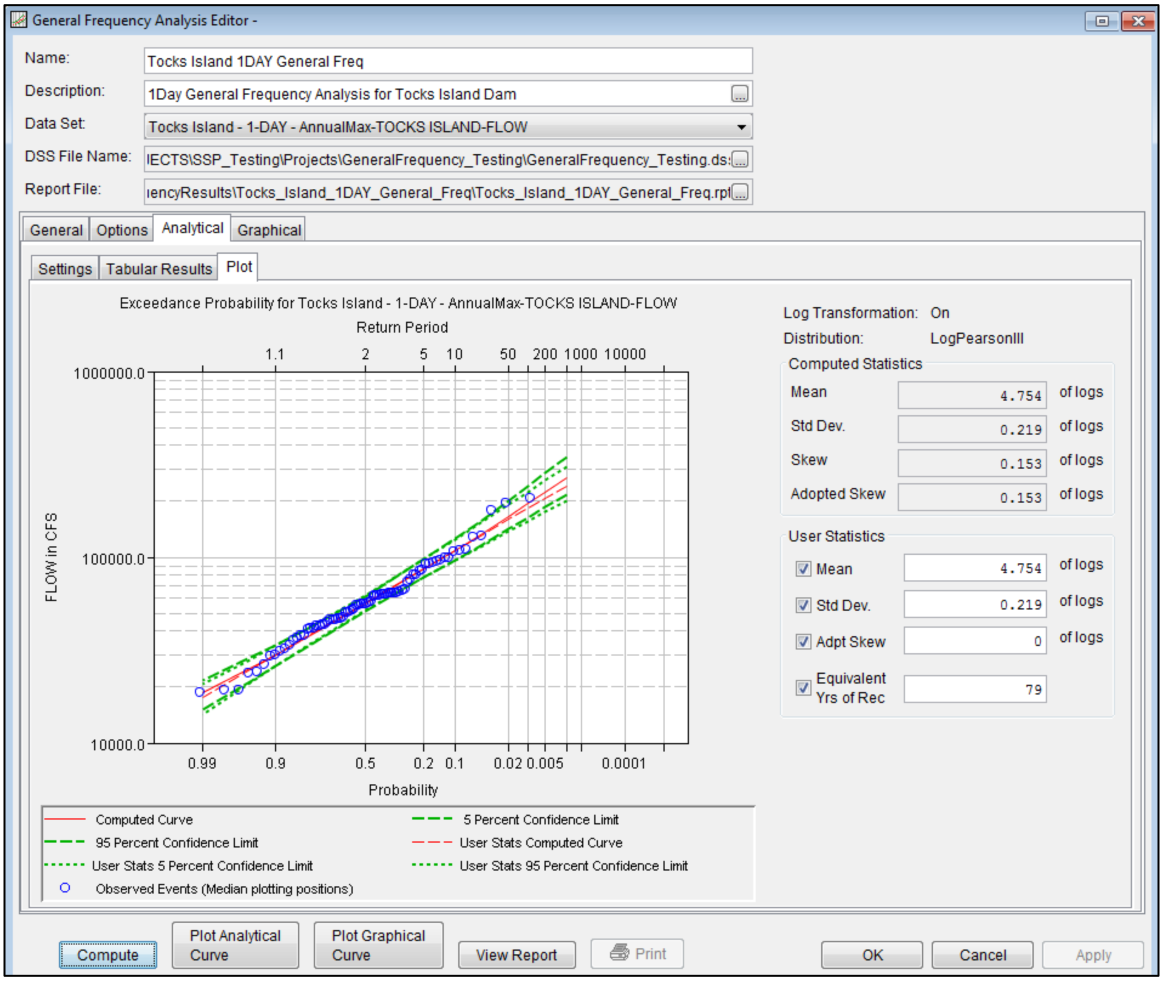


Figure 6-6. Plot Tab of the General Frequency Analytical Analysis.

As shown in Figure 6-6, the plot contains the computed frequency curve, 95% and 5% confidence limits, and raw data points plotted by the user selected plotting position method. The computed statistics for the frequency curve are shown in a table on the right side of the window. Below the computed statistics is a table labeled "User Statistics". There is a check box and a data entry field for the Mean, Standard Deviation, Adopted Skew, and Equivalent Years of Record. The user can enter values into any or all of these fields. Turning on the check box then enables that field to be used in computing a curve with the user entered statistic overriding the computed value from the raw data. The user statistics option allows the user to see how the curve would change if any or all of the statistics were different. When data is entered into the user statistics fields, and the check boxes are turned on, the user must press the compute button again in order for the computations to be performed with the user entered statistics. After the compute button is pressed, both the plot and the table on the Tabular Results tab will be updated to reflect any user entered statistics.

Graphical Frequency Analysis

In addition to an analytical frequency analysis which uses a statistical distribution fit to the data, the user has the option to graphically fit a curve to the data. A graphical fit can be very useful when the available analytical distributions do not provide a good fit to the data. One example of when a graphical frequency analysis is most appropriate is when plotting a frequency curve for flow data that is downstream of a flood control reservoir. Analytical frequency distributions are often not appropriate for describing flow data that is significantly regulated by upstream reservoirs. In general, a portion of the flow frequency data for a highly regulated stream will be very flat in the zone in which upstream regulation can control the flows for a range of frequencies. This type of data lends itself to a graphical fit analysis rather than the use of an analytical equation. Another example of using a graphical fitting technique over an analytical curve is when trying to compute a frequency curve for annual peak stage data at a point on a river. Often the stages will flatten out with decreased frequencies when flows go out into the overbank and floodplain area. Again, this type of data is fitted much better using a graphical fit curve instead of an analytical distribution. Another example of using a graphical fitting technique in lieu of an analytical curve is when a partial duration series is being used instead of an annual maximum series.

When the **Graphical** tab is selected, the editor will display a plot and table as shown in Figure 6-7. Three points are required to define a graphical frequency curve. In the plot, the data will be plotted using the user selected plotting position method. The table to the right of the plot allows the user to enter data values for the frequency ordinates defined on the Options tab.

Additionally, the **Multi-Point Edit** tool can be used to define the frequency ordinates by drawing a curve. To use this tool, begin by selecting the tool on the left side of the editor. Then, define the curve by left clicking within the plot window at the desired locations. To finish defining the curve, right click. It should be noted that the Multi-Point Edit tool will not extrapolate flow frequency information; it will only interpolate to the user-defined frequency ordinates specified on the Options tab. Bold, dashed lines will be displayed on the plot that correspond to the frequency ordinates defined on the Options tab. These vertical lines help to visually identify the locations where flow frequency information will be extracted from the drawn curve. Frequency ordinates must be defined in a decreasing order (when compared to percent chance exceedance).

The **Data Type** and **Equivalent Years of Record** options are required to compute the confidence limits using the order statistics method that is discussed in ETL 1110-2-537. If the data is not flow or stage, select the **Flow** data type when the graphical frequency curve is approximately analytic for extreme probabilities (frequency curve is not relatively flat for extreme probabilities). Select the **Stage** data type when the graphical frequency curve is relatively flat for extreme probabilities (U.S. Army Corps of Engineers, 1997). When the user enters values into the frequency curve table, those values will be plotted as a line on the plot after the **Compute** button is pressed. The idea is to enter values in the table that will create a best fit line of the data, based on the user's judgment.

When using a partial duration series, the **Axis Type** options will become enabled. By default the **Normal (Top N Events)** will be set as the default. The Normal (Top N Events) option will use the Period of Record Years that was defined on the General Tab to extract and plot the top N events. For instance, if the user defined a Period of Record Years of 79 on the Graphical Tab, the top 79 events within the associated partial duration series will be plotted using the Plotting Position defined on the General tab. When using the **Log (All Events)** axis option, all events will be plotted using the average number of events per year to define the x-axis. The two different plotting options are shown in Figure 6-8.

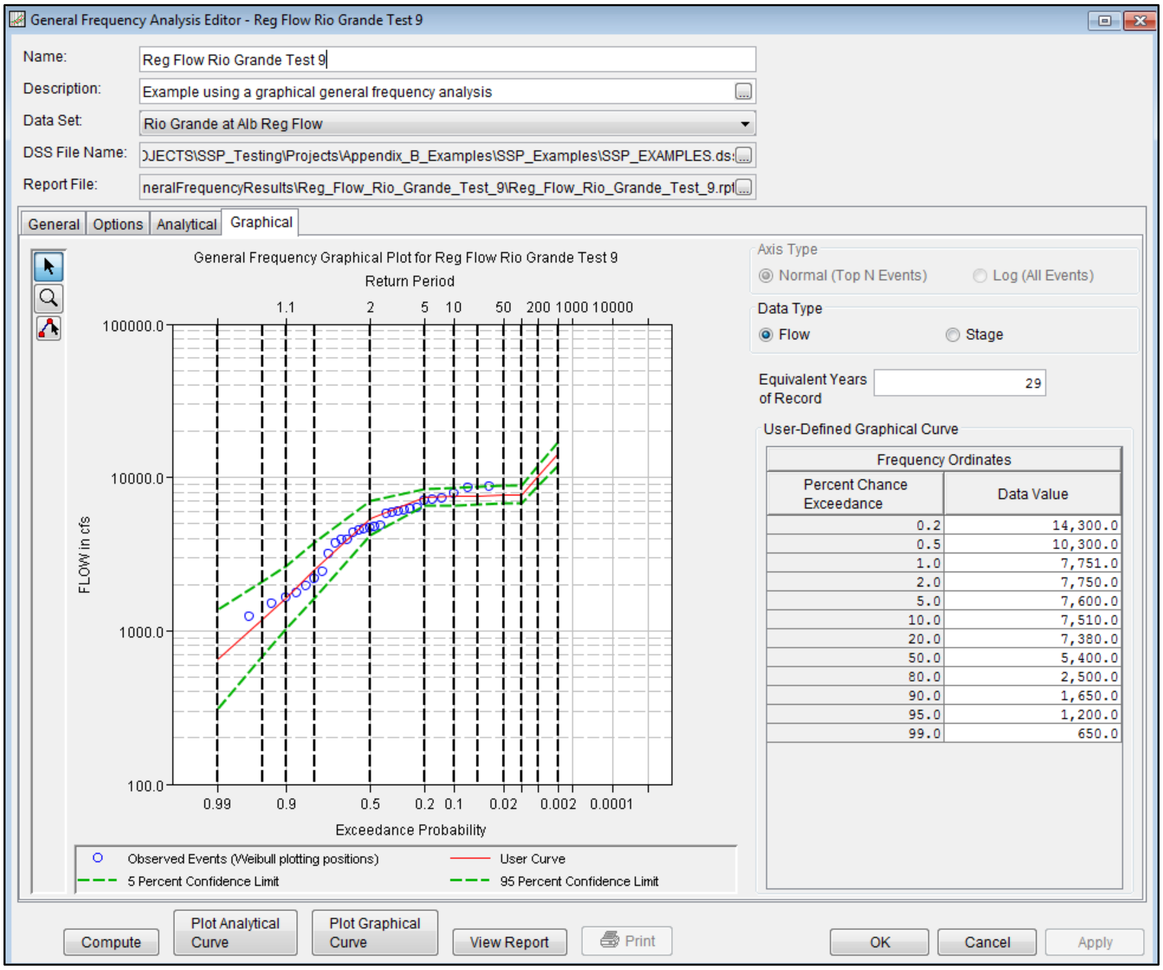


Figure 6-7. Graphical Tab of the General Frequency Analysis Editor.

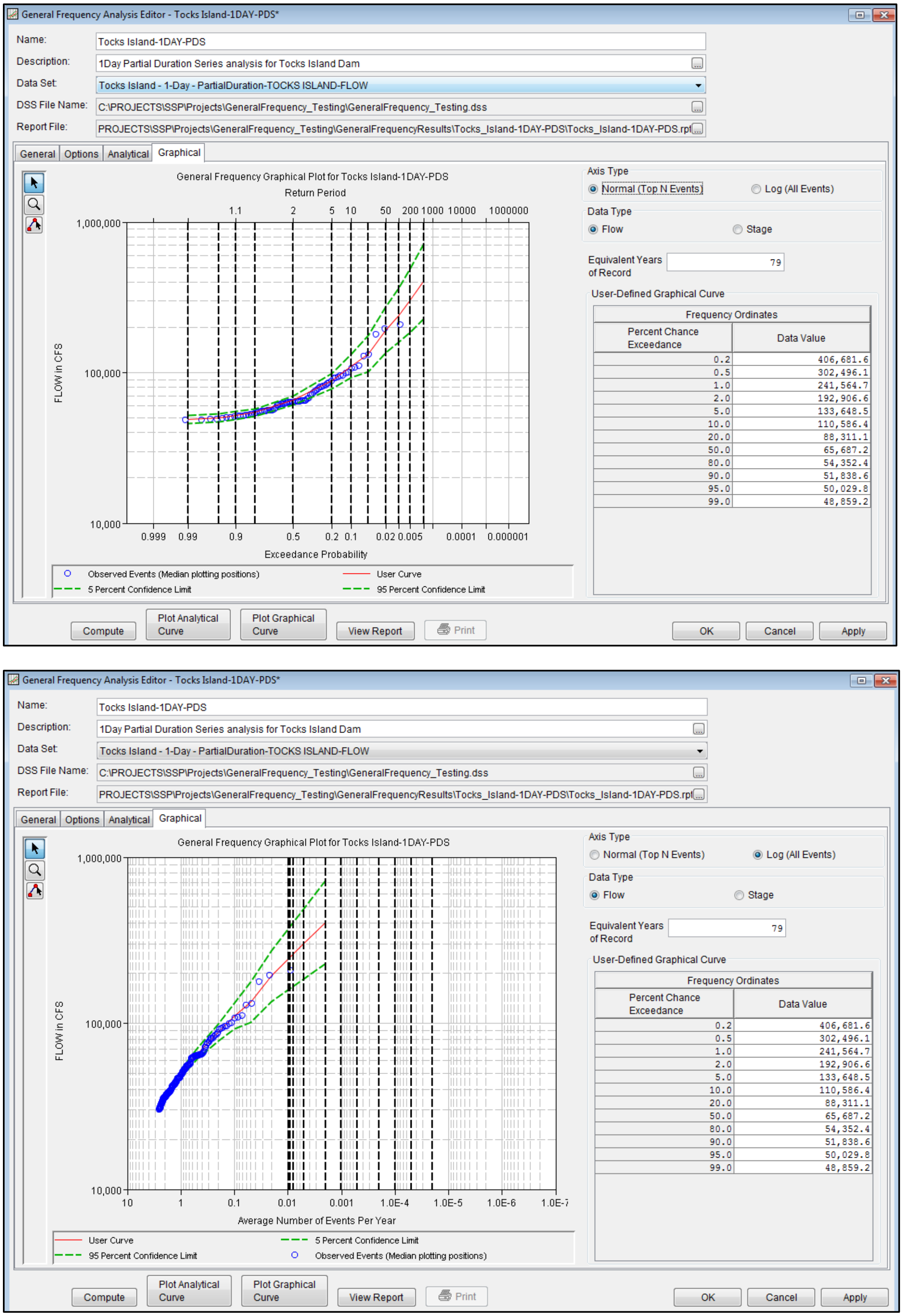


Figure 6-8. Axis Type Options on the Graphical Tab.

Viewing and Printing Results

The user can view output for the frequency analysis directly from the General Frequency Analysis editor (Tabular and Graphical output) or by using the plot and view buttons at the bottom of the editor. The output consists of tabular results, an analytical frequency curve plot, a graphical frequency curve plot, and a report documenting the data and computations performed.

Tabular Output

Once the computations for the analytical frequency analysis are completed, the user can view tabular output by selecting the **Tabular Results** tab under the **Analytical** analysis tab. The details of this table were discussed under the analytical analysis option above.

The tabular results can be printed by using the **Print** button at the bottom of the General Frequency Analysis editor. When the print button is pressed, a window will appear giving the user options for how they would like the table to be printed.

Graphical Output

Graphical output of the analytical frequency curve can be obtained by selecting either the **Plot** tab under the analytical analysis tab, or by pressing the button labeled **Plot Analytical Curve** at the bottom of the general frequency editor. When the Plot Analytical Curve button is pressed, a frequency curve plot will appear in a separate window as shown in Figure 6-9.

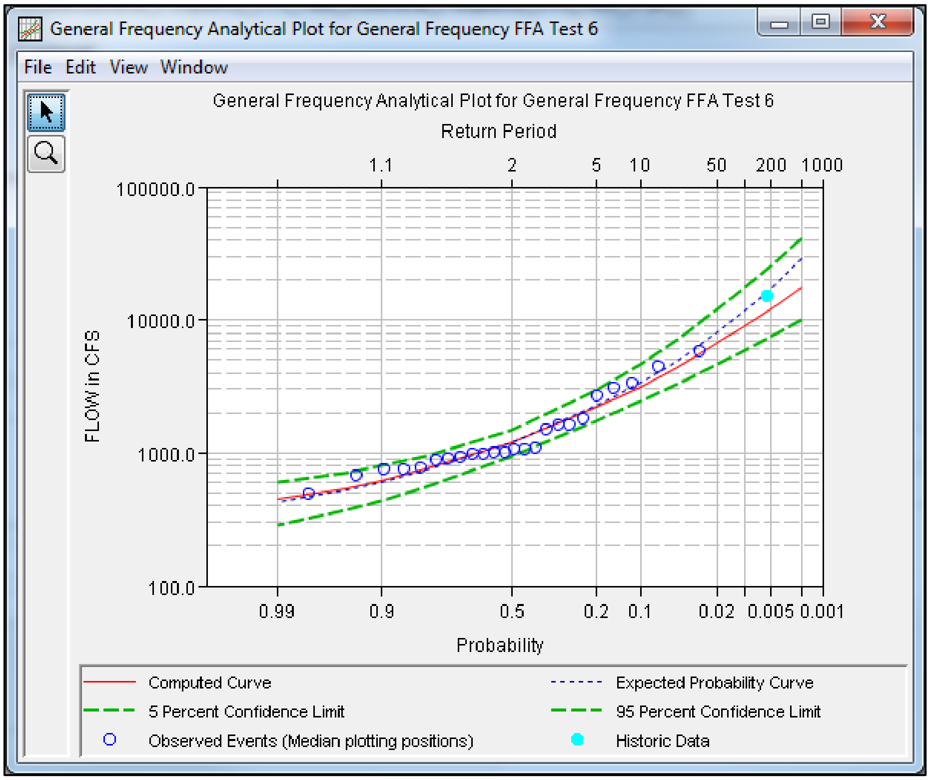


Figure 6-9. Analytical Analysis Frequency Curve Plot.

The analytical frequency curve plot can be sent to the printer by selecting the **Print** option from the **File** menu at the top of the window. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The graphic can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file. Currently four file formats are available for saving the graphic to disk: windows metafile, postscript, JPEG, and portable network graphic.

The data contained within the plot can also be tabulated by selecting **Tabulate** from the File menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the plot options as a template (**Save Template)** and applying previously saved templates to the current plot (**Apply Template**).

The **Edit** menu contains several options for customizing the graphic. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties. Also, a shortcut menu will appear with further customizing options when the user right-clicks on a line on the graph or the legend. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis. The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing plots in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User's Manual for details on customizing plots.

A plot of the graphical frequency curve can be obtained by pressing either the **Graphical** tab, or by pressing the button labeled **Plot Graphical Curve** at the bottom of the general frequency editor. When the Plot Graphical Curve button is pressed, a frequency curve plot will appear in a separate window as shown in Figure 6-10. All of the same options for tabulating, printing, and sending results to the windows clipboard are available for this plot as they are for the analytical frequency curve plot.

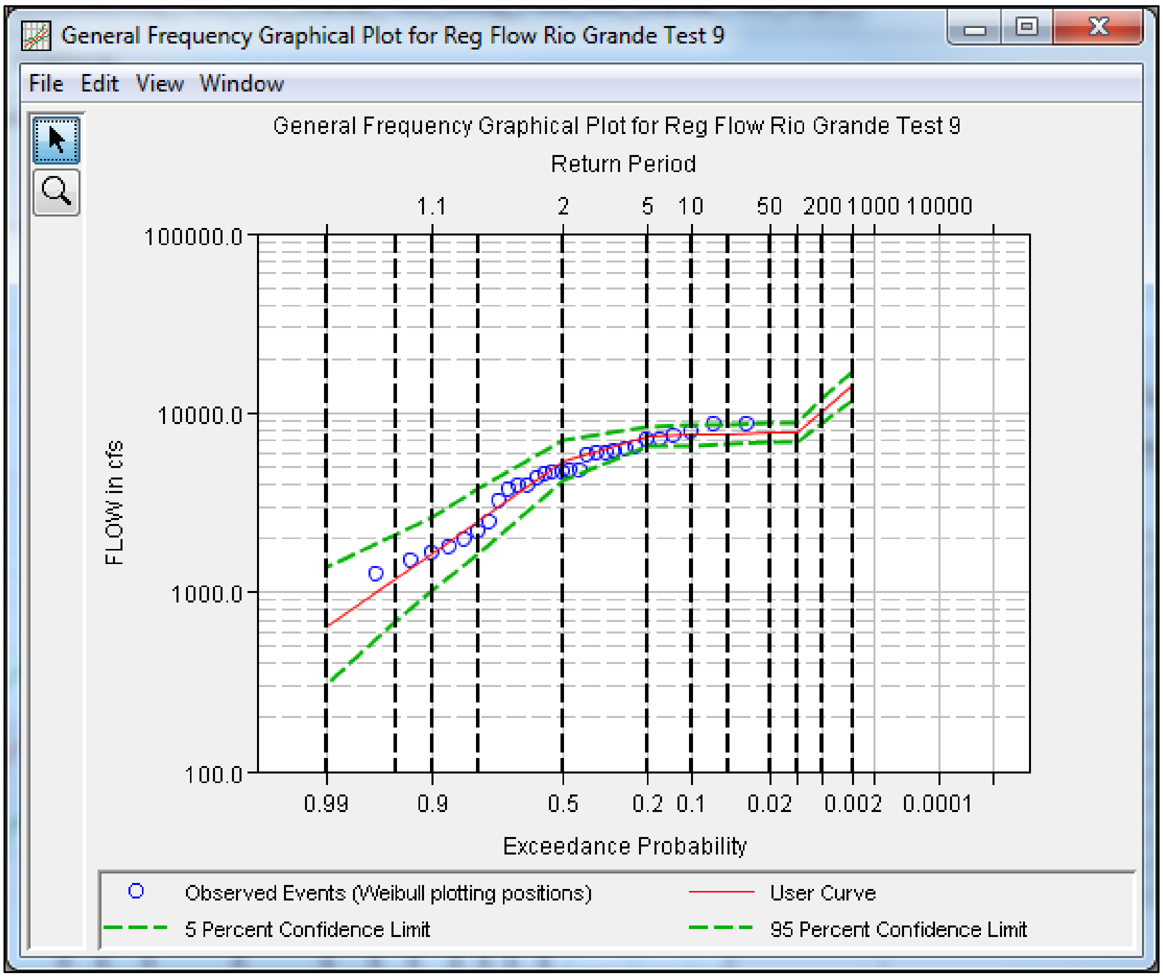
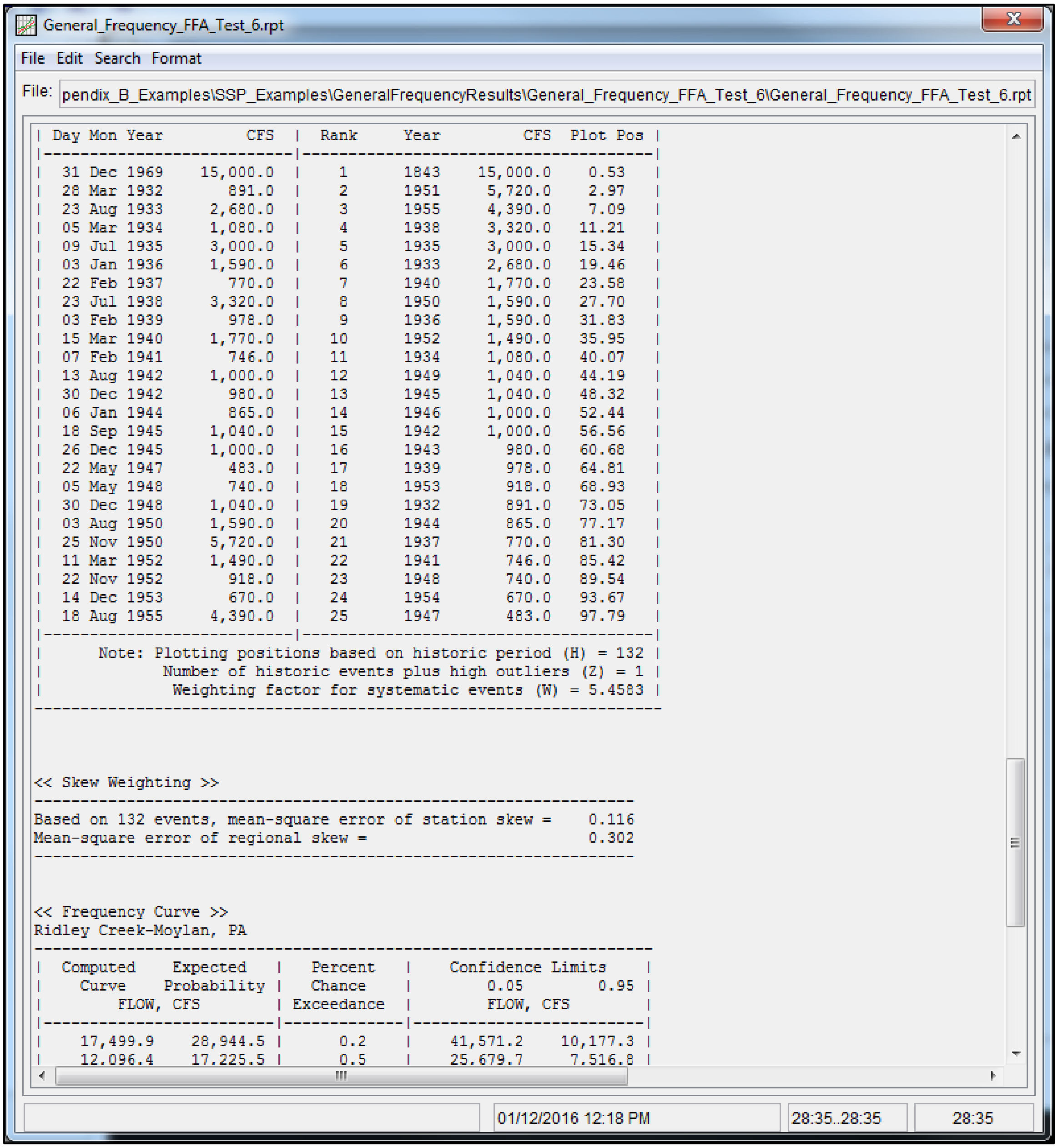


Figure 6-10. Graphical Analysis Frequency Curve Plot.

Viewing the Report File

When the General Frequency analysis computations are performed, a report file of the statistical computations is created. The report file lists all of the input data and user settings, plotting positions of the data points, intermediate results, each of the various statistical tests performed (i.e. high and low outliers, historical data, etc…), and the final results. This file is often useful for understanding and describing how the software arrived at the final frequency curve.

To view the report file press the **View Report** button at the bottom of the General Frequency analysis editor. When this button is pressed, a window will appear containing the report as shown in Figure 6-11.



General_Frequency_FFA_Test_6.rpt

File Edit Search Format

File: pendix_B_Examples\SSP_Examples\GeneralFrequencyResults\General_Frequency_FFA_Test_6\General_Frequency_FFA_Test_6.rpt

```
| Day Mon Year         CFS  |  Rank     Year         CFS  Plot Pos |
|---------------------------|---------------------------------------|
|  31 Dec 1969    15,000.0  |    1      1843    15,000.0    0.53    |
|  28 Mar 1932       891.0  |    2      1951     5,720.0    2.97    |
|  23 Aug 1933     2,680.0  |    3      1955     4,390.0    7.09    |
|  05 Mar 1934     1,080.0  |    4      1938     3,320.0   11.21    |
|  09 Jul 1935     3,000.0  |    5      1935     3,000.0   15.34    |
|  03 Jan 1936     1,590.0  |    6      1933     2,680.0   19.46    |
|  22 Feb 1937       770.0  |    7      1940     1,770.0   23.58    |
|  23 Jul 1938     3,320.0  |    8      1950     1,590.0   27.70    |
|  03 Feb 1939       978.0  |    9      1936     1,590.0   31.83    |
|  15 Mar 1940     1,770.0  |   10      1952     1,490.0   35.95    |
|  07 Feb 1941       746.0  |   11      1934     1,080.0   40.07    |
|  13 Aug 1942     1,000.0  |   12      1949     1,040.0   44.19    |
|  30 Dec 1942       980.0  |   13      1945     1,040.0   48.32    |
|  06 Jan 1944       865.0  |   14      1946     1,000.0   52.44    |
|  18 Sep 1945     1,040.0  |   15      1942     1,000.0   56.56    |
|  26 Dec 1945     1,000.0  |   16      1943       980.0   60.68    |
|  22 May 1947       483.0  |   17      1939       978.0   64.81    |
|  05 May 1948       740.0  |   18      1953       918.0   68.93    |
|  30 Dec 1948     1,040.0  |   19      1932       891.0   73.05    |
|  03 Aug 1950     1,590.0  |   20      1944       865.0   77.17    |
|  25 Nov 1950     5,720.0  |   21      1937       770.0   81.30    |
|  11 Mar 1952     1,490.0  |   22      1941       746.0   85.42    |
|  22 Nov 1952       918.0  |   23      1948       740.0   89.54    |
|  14 Dec 1953       670.0  |   24      1954       670.0   93.67    |
|  18 Aug 1955     4,390.0  |   25      1947       483.0   97.79    |
|---------------------------|---------------------------------------|
|      Note: Plotting positions based on historic period (H) = 132 |
|             Number of historic events plus high outliers (Z) = 1 |
|              Weighting factor for systematic events (W) = 5.4583 |
--------------------------------------------------------------------

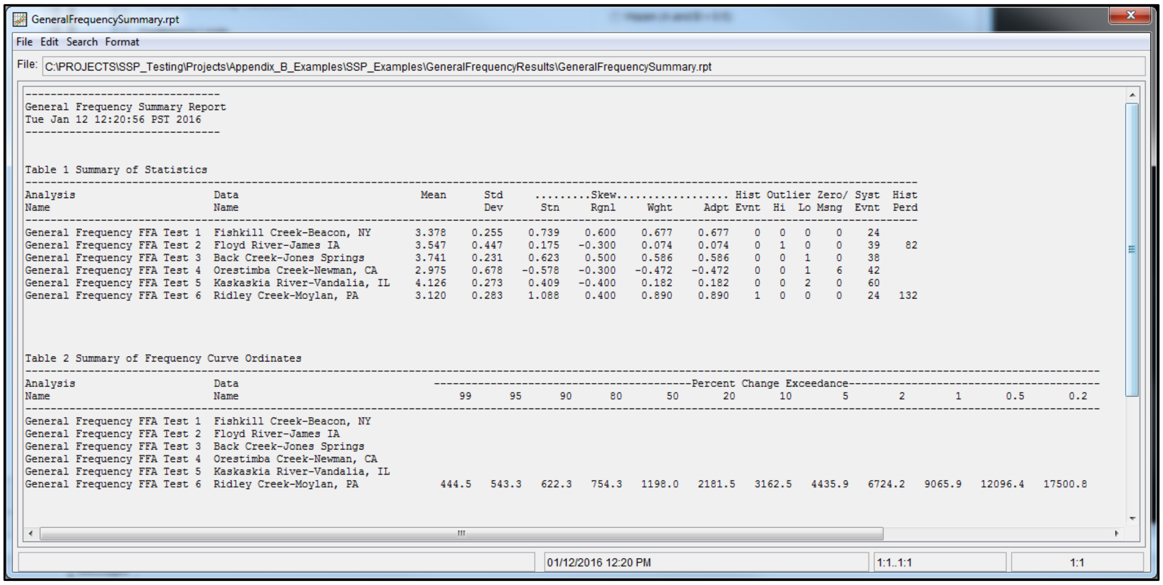

<< Skew Weighting >>
-----------------------------------------------------------------
Based on 132 events, mean-square error of station skew =    0.116
Mean-square error of regional skew =                        0.302
-----------------------------------------------------------------


<< Frequency Curve >>
Ridley Creek-Moylan, PA
-------------------------------------------------------------------
|  Computed    Expected   |   Percent   |   Confidence Limits    |
|    Curve     Probability |   Chance    |      0.05        0.95  |
|        FLOW, CFS        | Exceedance  |       FLOW, CFS        |
|-------------------------|-------------|------------------------|
|    17,499.9    28,944.5 |     0.2     |    41,571.2   10,177.3 |
|    12,096.4    17,225.5 |     0.5     |    25,679.7    7,516.8 |
```

01/12/2016 12:18 PM 28:35..28:35 28:35

Figure 6-11. General Frequency Analysis Report File.

Plots, tables, and reports can also be created by selecting menu options from the **Results** menu. At least one General Frequency analysis must be selected in the study explorer before selecting one of the menu options on the Results menu. Results from multiple analyses are combined in one graph if they are selected in the study explorer when the **Graph** menu option is selected. The **Results→Summary Report** menu option will create a summary table of statistics and frequency curve ordinates for the selected analyses as shown in Figure 6-12.



GeneralFrequencySummary.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\GeneralFrequencyResults\GeneralFrequencySummary.rpt

General Frequency Summary Report
Tue Jan 12 12:20:56 PST 2016

Table 1 Summary of Statistics

Analysis Name	Data Name	Mean	Std Dev	Skew Stn	Skew Rgnl	Skew Wght	Skew Adpt	Hist Evnt	Outlier Hi	Outlier Lo	Zero/ Msng	Syst Evnt	Hist Perd
General Frequency FFA Test 1	Fishkill Creek-Beacon, NY	3.378	0.255	0.739	0.600	0.677	0.677	0	0	0	0	24	
General Frequency FFA Test 2	Floyd River-James IA	3.547	0.447	0.175	-0.300	0.074	0.074	0	1	0	0	39	82
General Frequency FFA Test 3	Back Creek-Jones Springs	3.741	0.231	0.623	0.500	0.586	0.586	0	0	1	0	38	
General Frequency FFA Test 4	Orestimba Creek-Newman, CA	2.975	0.678	-0.578	-0.300	-0.472	-0.472	0	0	1	6	42	
General Frequency FFA Test 5	Kaskaskia River-Vandalia, IL	4.126	0.273	0.409	-0.400	0.182	0.182	0	0	2	0	60	
General Frequency FFA Test 6	Ridley Creek-Moylan, PA	3.120	0.283	1.088	0.400	0.890	0.890	1	0	0	0	24	132

Table 2 Summary of Frequency Curve Ordinates

Analysis Name	Data Name	Percent Change Exceedance 99	95	90	80	50	20	10	5	2	1	0.5	0.2
General Frequency FFA Test 1	Fishkill Creek-Beacon, NY												
General Frequency FFA Test 2	Floyd River-James IA												
General Frequency FFA Test 3	Back Creek-Jones Springs												
General Frequency FFA Test 4	Orestimba Creek-Newman, CA												
General Frequency FFA Test 5	Kaskaskia River-Vandalia, IL												
General Frequency FFA Test 6	Ridley Creek-Moylan, PA	444.5	543.3	622.3	754.3	1198.0	2181.5	3162.5	4435.9	6724.2	9065.9	12096.4	17500.8

01/12/2016 12:20 PM 1:1..1:1 1:1

Figure 6-12. Summary Table for Selected General Frequency Analyses.

CHAPTER 7

Performing a Volume Frequency Analysis

The current version of HEC-SSP allows the user to perform a volume frequency analysis of flow data. In this type of analysis, frequency curves are developed using daily average flows. Runoff volumes are expressed as average flows over a time duration. For example, the 3-day flow is the average flow over a three day period. The volume from the 3-day flow would be computed by multiplying the 3-day flow (in cfs) by 259,200 seconds (3-days). Typical volume frequency analyses would develop frequency curves for a number of volumes (flow-duration), like the 1, 3, 7, 15, 30, 60, 90, 120, and 180 day volumes. The user can choose between different analytical distributions as well as perform a graphical fit to the data. This chapter discusses in detail how to use the Volume Frequency Analysis editor in HEC-SSP.

Contents

Starting a New Volume Frequency Analysis

A volume frequency analysis can be started in two ways within the software, either by right clicking on the Volume Frequency Analysis folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **Volume-Frequency Analysis**. When a new volume frequency analysis is selected, the Volume Frequency Analysis editor will appear as shown in Figure 7-1.

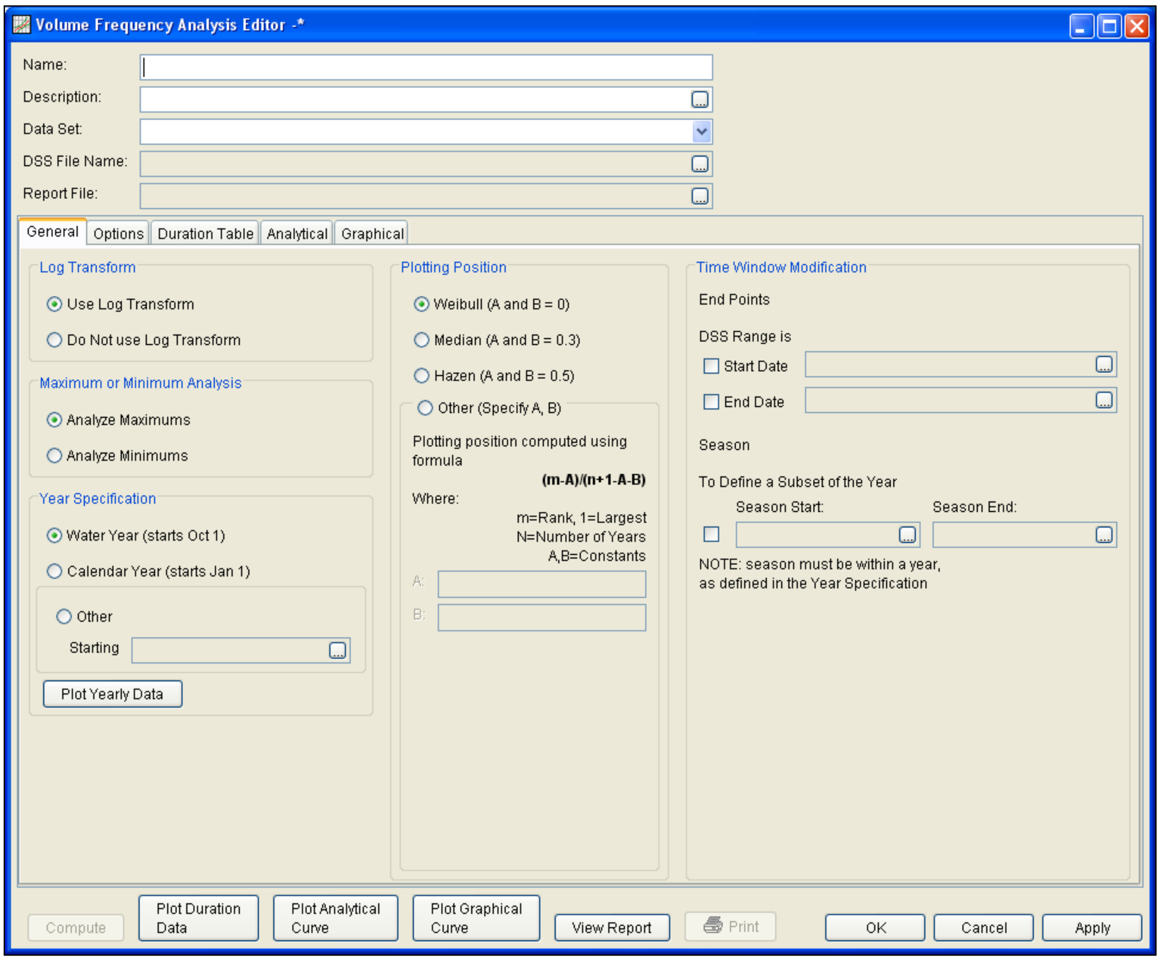


Figure 7-1. Volume Frequency Analysis Editor.

The user is required to enter a **Name** for the analysis; while a **Description** is optional. A data set must be selected from the available data sets stored in the current study DSS file (see Chapter 4 for importing daily flow data into the study). The list of data that can be selected for a volume frequency analysis will only include those data that have a regular interval, like 1HOUR and 1DAY (E-part pathname). Once a **Name** is entered and a data set is selected, the **DSS File Name** and **Report File** will automatically be filled out. The DSS filename is by default the same name as the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

General Settings and Options

Once the analysis name and data set are selected, the user can begin defining the analysis. Five tabs are contained on the Volume Frequency Analysis editor. The tabs are labeled **General**, **Options**, **Duration Table**, **Analytical**, and **Graphical**. This section of the manual explains the use of the General and Options tabs.

General Settings

The first tab contains general settings for performing the frequency analysis (Figure 7-1). These settings include:

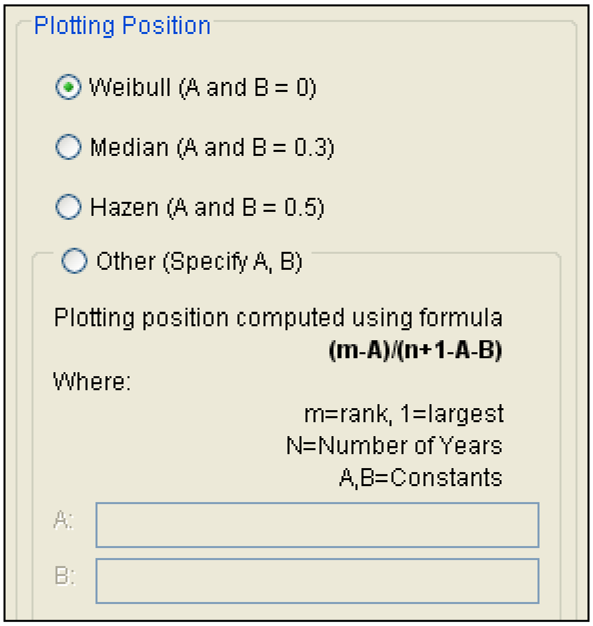
- Log Transforms
- Plotting Positions
- Maximum or Minimum Analysis
- Year Specification
- Time Window Modification

Log Transform

There are two options contained within the Log Transform setting: **Use Log Transform** and **Do not use Log Transform**. If the user selects **Use Log Transform**, then the logs of the data will be computed first, and the frequency analysis will be performed on the logs of the data. If the user selects **Do not use Log Transform**, then the frequency analysis will be performed on the raw data values without taking the logs of the data. The default setting is **Use Log Transform**.

Plotting Positions

Plotting positions are used for plotting the raw data points on the graph.



There are four options for plotting position within HEC-SSP: Weibull, Median, Hazen, and user entered coefficients. The default method is the Weibull plotting position method.

The generalized plotting position equation is:

$$P = \frac{(m - A)}{(n + 1 - A - B)}$$

where: m = rank of flood values with the largest equal to 1.

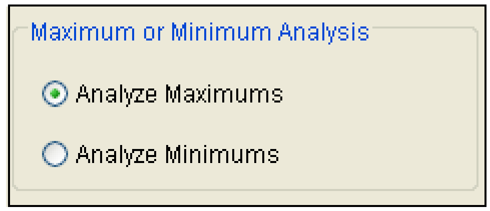
n = number of flood peaks in the data set.

A & B = constants dependent on which equation is used (Weibull A and B=0; Median A and B = 0.3; and Hazen A and B=0.5).

Plotting positions are estimates of the exceedance probability for each data point. Different methods can give different values for the probabilities of the highest and lowest points in the data set. The plotting of data on the graph by a plotting position method is only done as a guide to assist in evaluating the computed curve. The plotting position method selected does not have any impact on the computed curve.

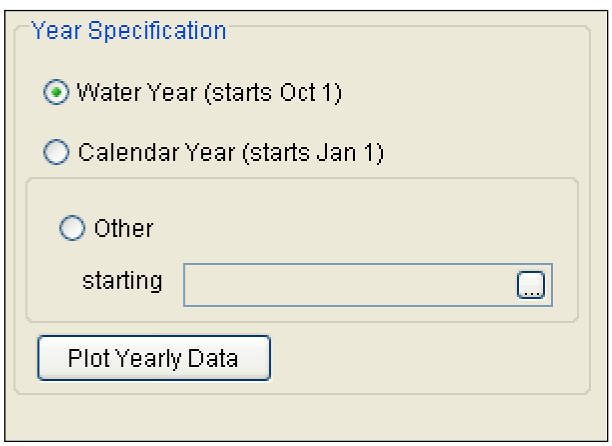
Maximum or Minimum Analysis

A volume frequency analysis can be performed using annual maximum or minimum flows. A maximum flow analysis could be used for determining the amount of reservoir storage required for a flood of specific frequency. A minimum flow, or low flow analysis, could be used determine if a river could supply a given demand. A low flow analysis could also be beneficial for water quality and reservoir storage projects. There are two options contained in the Maximum or Minimum Analysis section. If **Analyze Maximums** is selected, then the program will extract annual maximum volumes for all durations. The program will extract annual minimum volumes for all durations if **Analyze Minimums** is selected.



Year Specification

This option allows the user to define the beginning and ending date for what will be considered as the analysis year for extracting the data. These dates are used for extracting the annual maximum or minimum flows, in order to get one value for each analysis year. It is important to choose a start date that captures all flood events from a certain hydrologic regime. If high flows generally occur between November and May, then the year should not start between these months. This will minimize the possibility that the same flood event is used for consecutive years. There are three options contained in the Year Specification section. If **Water Year** is selected, the program uses a starting date of October 1 and an ending date of September 30. If **Calendar Year** is selected, the program uses a starting date of January 1 and an ending date of December 31. The **Other** option lets the user define the starting date. One way to determine when the year should begin is to plot each year of record on top of one another, as shown in Figure 7-2. The program will create a graph like the one shown in Figure 7-2 when the **Plot Yearly Data** button is pressed. This data set is from an area that experiences both snowmelt floods and summer/fall rain floods. Starting



the year on January 1 would be more appropriate for this data set because a few large flood events occurred around October 1.

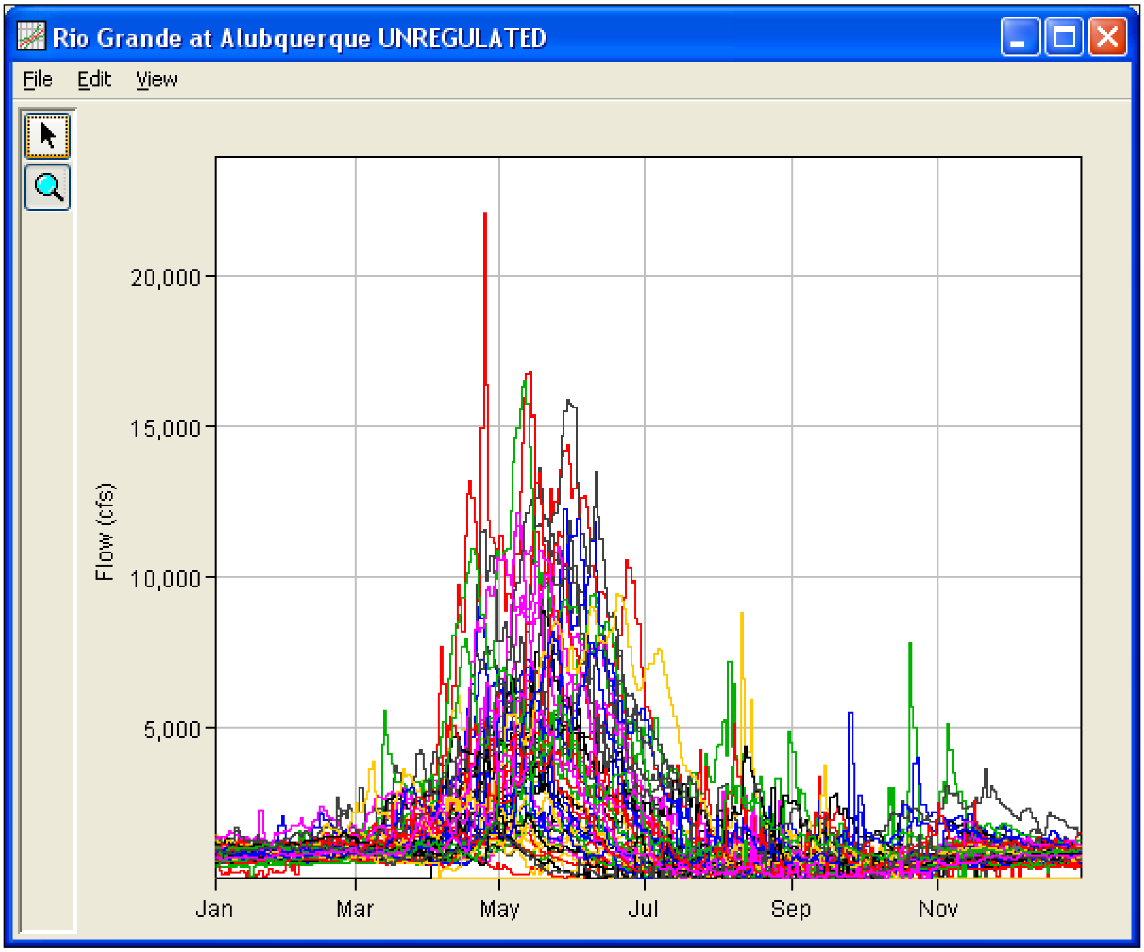
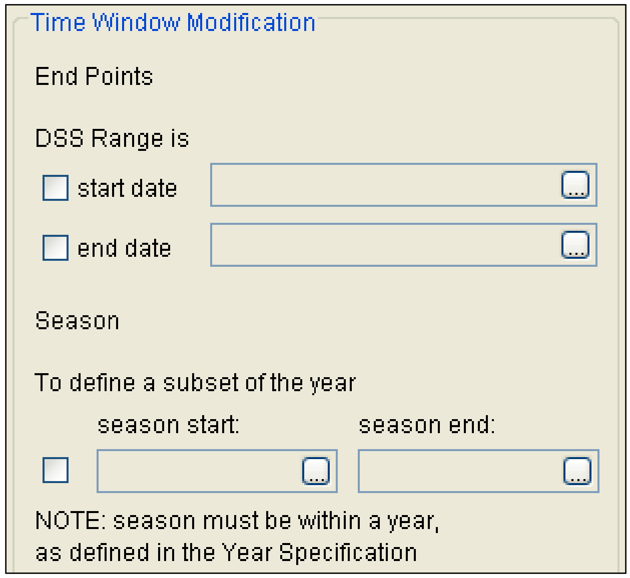


Figure 7-2. Plot Showing when Flood Events Typically Occur.

Time Window Modification

This option allows the user to narrow the time window used for the analysis. When left unchecked, the program will use all of the data contained in the selected data set. The user can enter either a start or end date or both a start and end date. If a start and/or end date are used, they must be dates that are included within the selected data set. The date range for the selected data set is shown in the editor just above the Start Date field.

An additional option at the bottom of the time window modification section allows the user to define a shorter duration, a **Season**, within the year in which the program extracts maximum or minimum flows. This option allows the user to analyze floods that typically occur during a specific season, like snowmelt floods. When left unchecked, the program will examine all flow records during the year. The season start and end dates must be entered using a two digit day followed by the month, example 15May. The season start and end dates must fall within a year as defined in the Year Specification. The user must enter both start and end dates to define the season subset.



Options

In addition to the general settings, there are also several options available to the user for modifying the computation of the volume-frequency curves. These options include:

- Flow-durations
- User-Specified Frequency Ordinates
- Output Labeling
- Low Outlier Threshold
- Historic Period Data

When the Options tab is selected, the Volume Frequency Analysis editor will appear as shown in Figure 7-3.

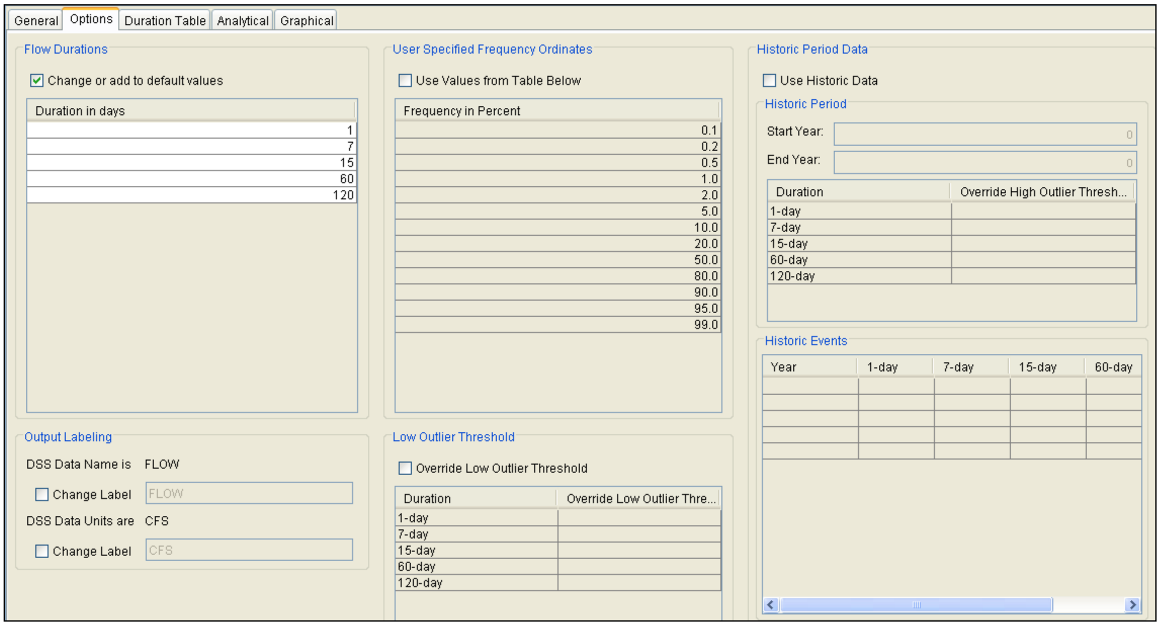
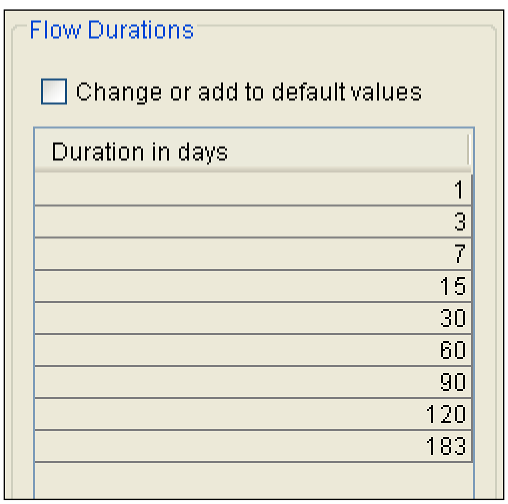


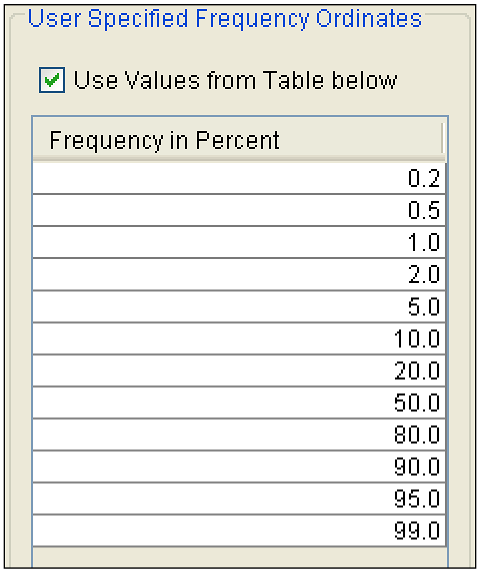
Figure 7-3. Volume Frequency Analysis Editor with Options Tab Selected.

Flow-Durations

This option lets the user define which durations are used in the volume frequency analysis. The program will extract annual maximum or minimum volumes based on the durations defined in this table. The default durations are 1, 3, 7, 15, 30, 60, 120, and 183 days. Check the box next to **Change or add to default values** to change or add additional durations to the analysis. Once this box is checked, the user can add/remove rows and edit the duration values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default durations, even if they are not contained in the table, when the **Change or add to default values** option is not checked.



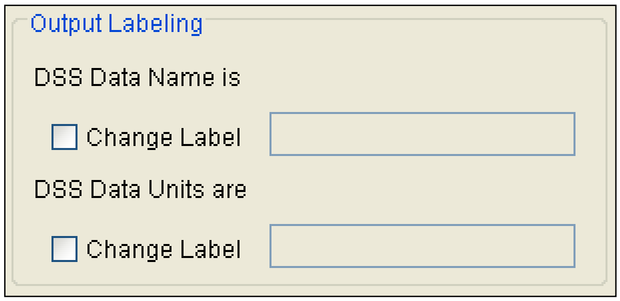
User Specified Frequency Ordinates



This option allows the user to change the frequency ordinates used for creating result tables and graphs. The default values listed in percent chance exceedance are 0.2, 0.5, 1, 2, 5, 10, 20, 50, 80, 90, 95, and 99. Check the box next to **Use Values from Table below** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the frequency values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Use Values from Table below** option is not checked. Finally, all values in the table must be between 0 and 100.

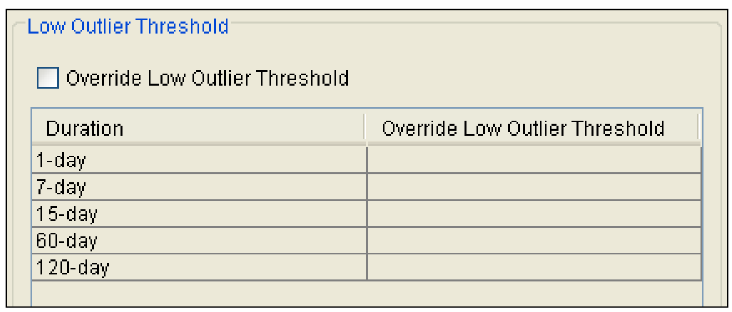
Output Labeling

This option allows the user to change the default labels for data contained in the output tables and plots. The user can change both the name of the data and how the units of the data are labeled.



Low Outlier Threshold

High and low outlier tests are based on the procedures outlined in Bulletin 17B, and are applied in the same manner in the Volume Frequency Analysis. The outlier magnitudes calculated by the Bulletin 17B procedure are used as default values for the high and low outlier thresholds in HEC-SSP. The user has the option to enter a different low outlier threshold for each duration. If a value is entered for the low outlier threshold, then this value will override the computed value from the Bulletin 17B methodology. When analyzing maximum flows, HEC-SSP will identify both high and low outliers. However, only low outliers will be removed from the data set when performing the analysis. If a high outlier is identified in the data set, the analyst should try to incorporate historical period information to extend the time period for which the high outlier(s) is considered to be the maximum value(s). Further discussion of outlier thresholds can be found in Bulletin 17B and the HEC-SSP Statistical Reference Guide. To use the low outlier threshold, simply check the box and enter a value for one duration or all durations.



When **Analyzing Minimums** is selected on the General tab, then the Low Outlier Threshold criteria becomes the High Outlier Threshold. When applying the outlier tests, HEC-SSP will identify both high and low outliers. However, only high outliers will be removed from the data set when performing the analysis. If a low outlier is identified in the data set, the analyst should try to incorporate historical period information to extend the time period for which the low outlier(s) is considered to be the minimum value(s).

Historic Period Data

All historic data that provides reliable estimates outside the systematic record should be used in order to improve the frequency computations. Information outside of the systematic record can often be used to extend the record of the largest events to a historic period much longer than that of the systematic record. HEC-SSP uses historic data as recommended in Bulletin 17B. This calculation is applied in the same manner in the Volume Frequency Analysis. To use historic data, check the box labeled **Use Historic Data**. The user can enter a starting year for the historic period, ending year for a historic period and a High Threshold value for each duration as shown in Figure 7-4. If the user enters a high threshold value, then any data in the systematic record greater than that value will also be treated as a historical annual maximum. The user can also enter historic data that are not contained in the systematic record. This is done in the table at the bottom labeled **Historic Events**. If a start year is not entered, then the assumed start year is the earliest year of the systematic record and any historical values that have been entered. If an end year is not entered, then the assumed end year is the latest year in the systematic record and any entered historic values. Further discussion of the use of historical data can be found in Bulletin 17B. If **Analyze Minimums** is selected on the General tab then the High Threshold becomes the Low Threshold. The program will treat systematic values that are lower than the low threshold as historic annual minimums.

Note: The program treats all data in the data set as systematic data. If historic events are included in the data set, then the user can define the analysis time window (General tab – Time Window Modification) so that it only bounds the systematic record. Then define the historic events in the Historic Events table. Instead of using the Time Window Modification option, another option is to enter a High Threshold value so that the historic data point(s) would be treated as historic data (rather than part of the systematic record).

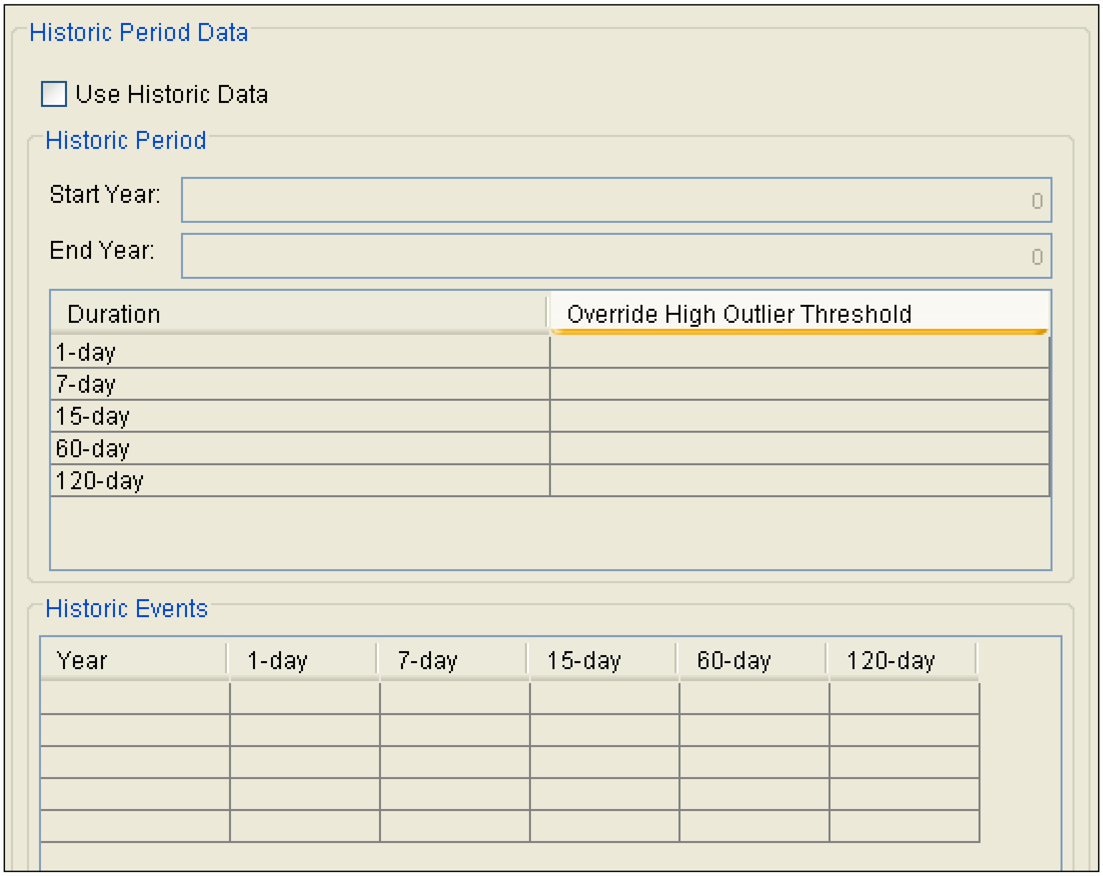


Figure 7-4. Historic Period Data on the Options Tab.

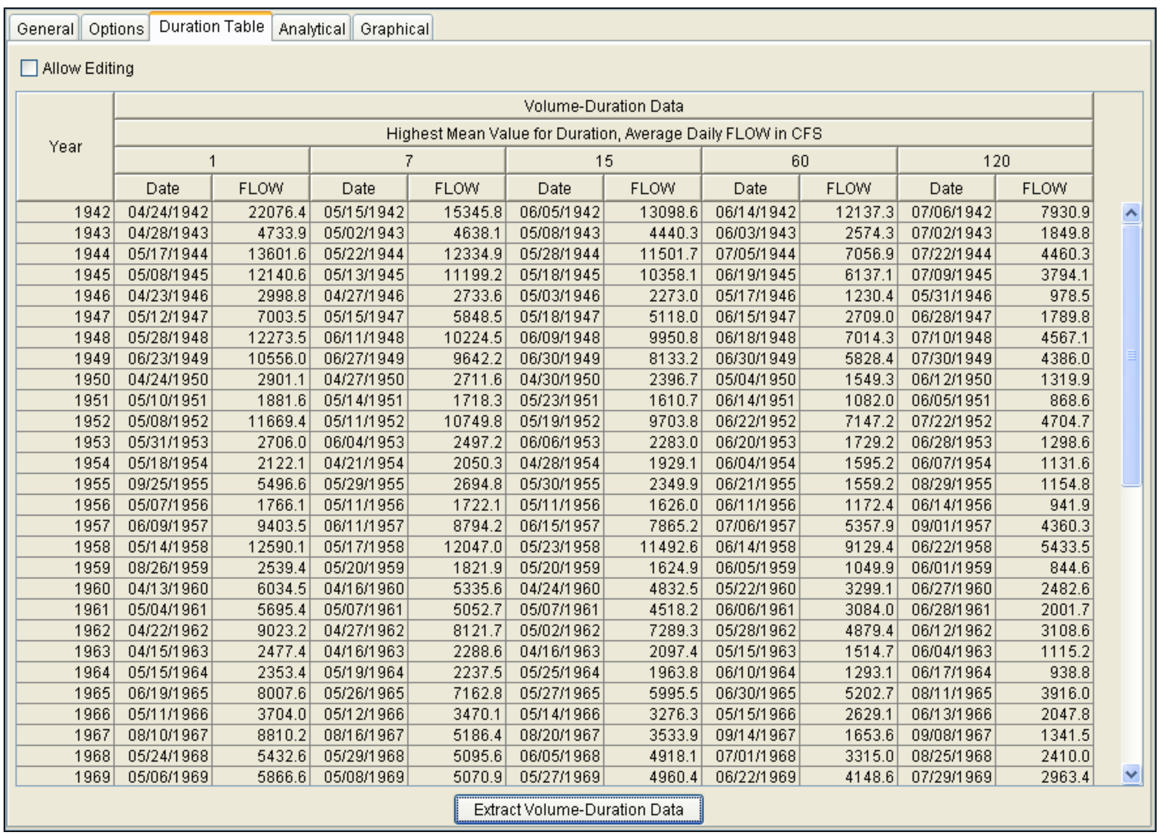
Extracting the Volume-Duration Data

The user can extract the volume-duration data once settings have been defined on the General and Options tabs. When the Duration Table tab is selected, the Volume Frequency Analysis editor will appear as shown in Figure 7-5. The program will compute the annual maximum or minimum average flows for the durations specified on the Options tab when the user presses the **Extract Volume-Duration Data** button at the bottom of the Duration Table.

The program computes the maximum/minimum flows by evaluating the flow record as one continuous record. For each duration, the program computes a time-series of average flow. These time-series are written to the study DSS file and can be viewed using HEC-DSSVue. Then the program extracts the annual maximum/minimum flows and populates the duration table. A similar procedure is followed when a Season has been defined within the Time Window Modification panel. The program will only extract the annual maximum from within the season.

The **Allow Editing** checkbox in the upper left portion of the Duration Table tab allows the user to manually edit values in the volume-duration table. The table becomes editable when the **Allow Editing** box is checked. Then the user can overwrite the extracted volume-duration data. In addition, the program will no longer extract volume-duration data during a compute and the **Extract Volume-Duration Data** button becomes inactive.

When computing the analysis, the program will issue a warning message if any of the maximum/minimum flows occur a specific number of days after the beginning of the year. The number of days is determined by the duration plus five days. For example, for a fifteen-day duration, the program issues a warning if the maximum/minimum is within twenty days after the beginning of the year. If water year is chosen, then the program issues a warning if the maximum/minimum occurs between October 1 – October 20. This warning is an attempt to let the user know if a maximum or minimum flow is generated by an event that began in the previous year. The goal is to prevent a scenario in which the same flow event causes maximum/minimum flows in consecutive years; this is why it is important to choose an appropriate annual starting date.



Year	Volume-Duration Data									
	Highest Mean Value for Duration, Average Daily FLOW in CFS									
	1		7		15		60		120	
	Date	FLOW	Date	FLOW	Date	FLOW	Date	FLOW	Date	FLOW
1942	04/24/1942	22076.4	05/15/1942	15345.8	06/05/1942	13098.6	06/14/1942	12137.3	07/06/1942	7930.9
1943	04/28/1943	4733.9	05/02/1943	4638.1	05/08/1943	4440.3	06/03/1943	2574.3	07/02/1943	1849.8
1944	05/17/1944	13601.6	05/22/1944	12334.9	05/28/1944	11501.7	07/05/1944	7056.9	07/22/1944	4460.3
1945	05/08/1945	12140.6	05/13/1945	11199.2	05/18/1945	10358.1	06/19/1945	6137.1	07/09/1945	3794.1
1946	04/23/1946	2998.8	04/27/1946	2733.6	05/03/1946	2273.0	05/17/1946	1230.4	05/31/1946	978.5
1947	05/12/1947	7003.5	05/15/1947	5848.5	05/18/1947	5118.0	06/15/1947	2709.0	06/28/1947	1789.8
1948	05/28/1948	12273.5	06/11/1948	10224.5	06/09/1948	9950.8	06/18/1948	7014.3	07/10/1948	4567.1
1949	06/23/1949	10556.0	06/27/1949	9642.2	06/30/1949	8133.2	06/30/1949	5828.4	07/30/1949	4386.0
1950	04/24/1950	2901.1	04/27/1950	2711.6	04/30/1950	2396.7	05/04/1950	1549.3	06/12/1950	1319.9
1951	05/10/1951	1881.6	05/14/1951	1718.3	05/23/1951	1610.7	06/14/1951	1082.0	06/05/1951	868.6
1952	05/08/1952	11669.4	05/11/1952	10749.8	05/19/1952	9703.8	06/22/1952	7147.2	07/22/1952	4704.7
1953	05/31/1953	2706.0	06/04/1953	2497.2	06/06/1953	2283.0	06/20/1953	1729.2	06/28/1953	1298.6
1954	05/18/1954	2122.1	04/21/1954	2050.3	04/28/1954	1929.1	06/04/1954	1595.2	06/07/1954	1131.6
1955	09/25/1955	5496.6	05/29/1955	2694.8	05/30/1955	2349.9	06/21/1955	1559.2	08/29/1955	1154.8
1956	05/07/1956	1766.1	05/11/1956	1722.1	05/11/1956	1626.0	06/11/1956	1172.4	06/14/1956	941.9
1957	06/09/1957	9403.5	06/11/1957	8794.2	06/15/1957	7865.2	07/06/1957	5357.9	09/01/1957	4360.3
1958	05/14/1958	12590.1	05/17/1958	12047.0	05/23/1958	11492.6	06/14/1958	9129.4	06/22/1958	5433.5
1959	08/26/1959	2539.4	05/20/1959	1821.9	05/20/1959	1624.9	06/05/1959	1049.9	06/01/1959	844.6
1960	04/13/1960	6034.5	04/16/1960	5335.6	04/24/1960	4832.5	05/22/1960	3299.1	06/27/1960	2482.6
1961	05/04/1961	5695.4	05/07/1961	5052.7	05/07/1961	4518.2	06/06/1961	3084.0	06/28/1961	2001.7
1962	04/22/1962	9023.2	04/27/1962	8121.7	05/02/1962	7289.3	05/28/1962	4879.4	06/12/1962	3108.6
1963	04/15/1963	2477.4	04/16/1963	2288.6	04/16/1963	2097.4	05/15/1963	1514.7	06/04/1963	1115.2
1964	05/15/1964	2353.4	05/19/1964	2237.5	05/25/1964	1963.8	06/10/1964	1293.1	06/17/1964	938.8
1965	06/19/1965	8007.6	05/26/1965	7162.8	05/27/1965	5995.5	06/30/1965	5202.7	08/11/1965	3916.0
1966	05/11/1966	3704.0	05/12/1966	3470.1	05/14/1966	3276.3	05/15/1966	2629.1	06/13/1966	2047.8
1967	08/10/1967	8810.2	08/16/1967	5186.4	08/20/1967	3533.9	09/14/1967	1653.6	09/08/1967	1341.5
1968	05/24/1968	5432.6	05/29/1968	5095.6	06/05/1968	4918.1	07/01/1968	3315.0	08/25/1968	2410.0
1969	05/06/1969	5866.6	05/08/1969	5070.9	05/27/1969	4960.4	06/22/1969	4148.6	07/29/1969	2963.4

Figure 7-5. Volume-Duration Table.

The user must **Compute** the analysis before viewing a frequency plot of the volume-duration data. The plot created by pressing the **Plot Duration Data** button, located at the bottom of a Volume Frequency Analysis editor, shows the annual maximum/minimum volumes plotted using the user specified plotting position method, as shown in Figure 7-6.

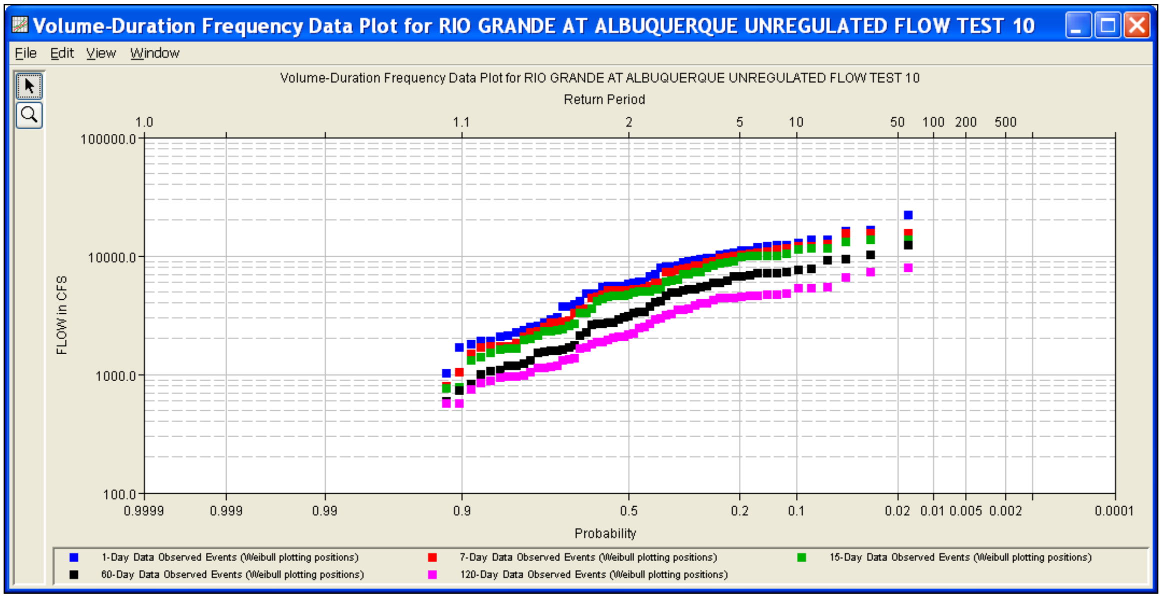


Figure 7-6. Plot of Volume-Duration Data.

Analytical Frequency Analysis

The user can choose between performing an Analytical Frequency Analysis or a Graphical Frequency Analysis once settings have been defined on the General and Options tabs. The Duration Data does not have to be extracted before computing an analysis. The program will automatically extract the duration data when the **Compute** button is pressed. This section of the manual describes how to compute and view results for an Analytical Frequency Analysis.

When the user selects the **Analytical** tab on the Volume Frequency Analysis editor, the window will appear as shown in Figure 7-7. As shown, four additional tabs will appear on the screen: Settings, Tabular Results, Plot, and Statistics.

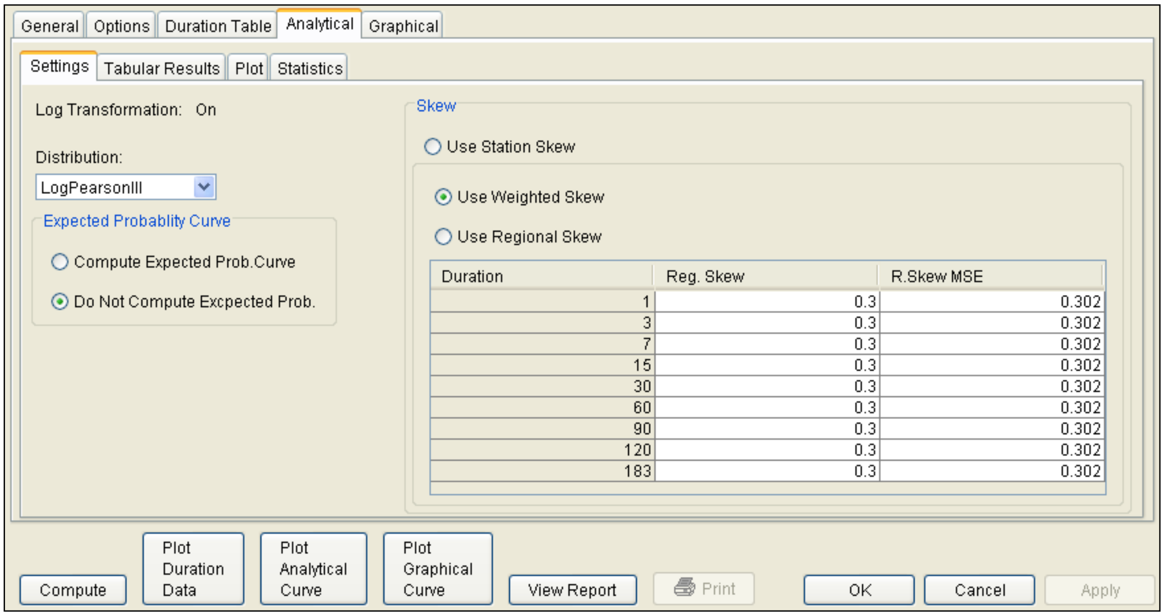


Figure 7-7. Analytical Tab of the Volume Frequency Analysis Editor.

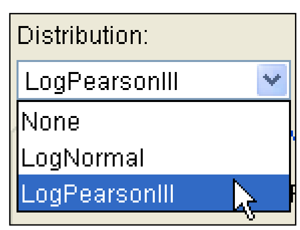
Settings

In addition to settings on the General and Options tabs, there are more options on the Settings tab the user must define in order to perform an Analytical Frequency analysis on the volume-duration data. These settings include:

- Distribution
- Expected Probability Curve
- Skew

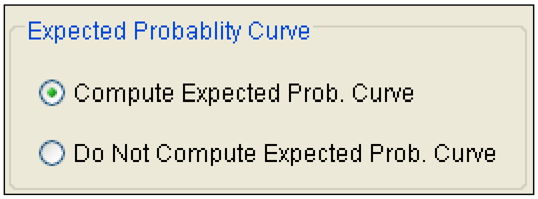
Distribution

This option allows the user to select a distribution to perform the frequency analysis. The current version of HEC-SSP contains five distribution choices: None, Normal, LogNormal, Pearson III, and LogPearson III. If the user has selected the **Use Log Transform** option, located on the General tab, then the available choices for distribution are None, LogNormal, and LogPearson III. If the user has selected the **Do not use Log Transform** option, located on the General tab, then the distribution choices are None, Normal, and Pearson III.



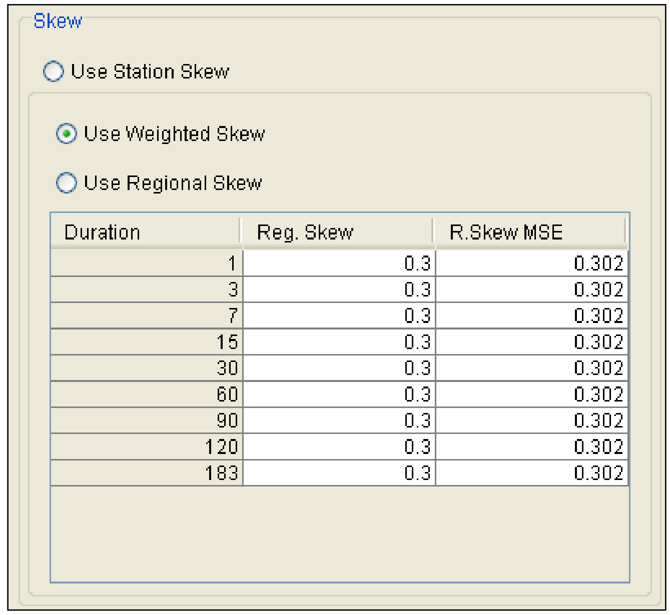
Expected Probability Curve

This setting has two options, **Compute Expected Prob. Curve** and **Do Not Compute Expected Prob. Curve**. The default setting is to have the expected probability curve computed. When computed, the expected probability curves will be shown in the report that is opened by pressing the **View Report** button at the bottom of the **Volume Frequency Analysis** editor. The expected probability curves are also saved to the study DSS file, along with the computed volume frequency curves and 5 and 95 percent confidence limits. The expected probability adjustment is a correction for bias in the computed frequency curve. The bias is caused by the skew in the uncertainty due to the shortness of the data record. The Method of Moments estimation of the Log Pearson III parameters produces a median estimate of each frequency curve quantile, and the adjustment changes to a mean (unbiased) estimate, which is different from the median because of a skewed uncertainty distribution. Please review the discussion in Bulletin 17B about the expected probability curve adjustment for an explanation of how and why it is computed. The use of the expected probability curve is a policy decision. It is most often used in establishing design flood criteria. The basic flood frequency curve without the expected probability adjustment is the curve used in computation of confidence limits, risk, and in obtaining weighted averages of independent estimates of flood frequency discharge (Interagency Advisory Committee on Water Data, 1982).



Skew

The skew option is only available whenever the analytical distribution is set to LogPearsonIII. There are three options contained within the skew setting, **Use Station Skew**, **Use Weighted Skew**, and **Use Regional Skew**. The default skew setting is **Use Station Skew**. With this setting, the skew of the computed curve will be based solely on computing a skew from the data points.



The **Use Weighted Skew** option requires the user to enter a generalized regional skew and a mean-square error (MSE) of the generalized regional skew. This option weights the computed station skew with the generalized regional skew.

The **Use Regional Skew** option requires the user to enter a generalized regional skew and a mean-square error (MSE) of the generalized regional skew. The program will ignore the computed station skew and use only the generalized regional skew.

Compute

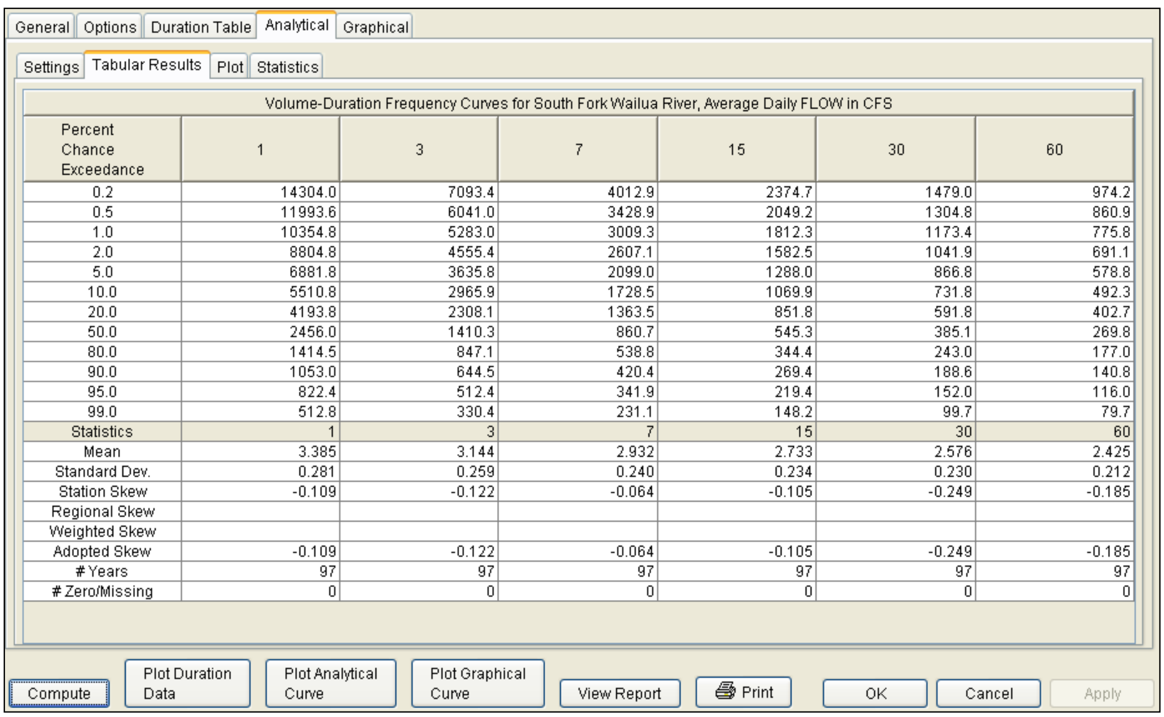
Press the **Compute** button, located at the bottom of the Volume Frequency Analysis editor, once options have been set on the General, Options, and Settings tabs. If the compute is successful, the user will receive a message that says **Compute Complete**. At this point, the user can review results from the analytical analysis by selecting the Tabular Results and Plot tabs.

Multiple Volume Frequency analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finishes computing the analyses.

Tabular Results

The **Tabular Results** tab contains a table of results for the analytical frequency analysis. An example of the results table is shown in Figure 7-8. The top portion of this table contains the analytical frequency curves for each duration. Data in the frequency curves can be re-sorted. Click the **Percent Chance Exceedance** column header (two mouse clicks are required the first time). The percent chance exceedance ordinates, along with the frequency curves, will sort so that the lowest values are on top or the highest values are on top. The statistics of the analytical frequency curves are contained below the frequency curve ordinates. The statistics include the mean, standard deviation, station skew, regional skew, weighted skew, adopted skew, number of years of record, and number of years with zero or missing flow.

User-adjusted statistics can be defined by the user on the **Statistics** tab. If the user has not entered statistics on the Statistics tab, then the results table will look similar to Figure 7-8. If the user does enter statistics on the Statistics tab, then the results table will include the adjusted mean, adjusted standard deviation, and adjusted skew. If specified by the user, the program will use the user-adjusted statistics when computing the analytical curves.



Volume-Duration Frequency Curves for South Fork Wailua River, Average Daily FLOW in CFS

Percent Chance Exceedance	1	3	7	15	30	60
0.2	14304.0	7093.4	4012.9	2374.7	1479.0	974.2
0.5	11993.6	6041.0	3428.9	2049.2	1304.8	860.9
1.0	10354.8	5283.0	3009.3	1812.3	1173.4	775.8
2.0	8804.8	4555.4	2607.1	1582.5	1041.9	691.1
5.0	6881.8	3635.8	2099.0	1288.0	866.8	578.8
10.0	5510.8	2965.9	1728.5	1069.9	731.8	492.3
20.0	4193.8	2308.1	1363.5	851.8	591.8	402.7
50.0	2456.0	1410.3	860.7	545.3	385.1	269.8
80.0	1414.5	847.1	538.8	344.4	243.0	177.0
90.0	1053.0	644.5	420.4	269.4	188.6	140.8
95.0	822.4	512.4	341.9	219.4	152.0	116.0
99.0	512.8	330.4	231.1	148.2	99.7	79.7
Statistics	1	3	7	15	30	60
Mean	3.385	3.144	2.932	2.733	2.576	2.425
Standard Dev.	0.281	0.259	0.240	0.234	0.230	0.212
Station Skew	-0.109	-0.122	-0.064	-0.105	-0.249	-0.185
Regional Skew						
Weighted Skew						
Adopted Skew	-0.109	-0.122	-0.064	-0.105	-0.249	-0.185
# Years	97	97	97	97	97	97
# Zero/Missing	0	0	0	0	0	0

Figure 7-8. Tabular Results for a Volume Frequency Analysis.

Plot

In addition to tabular results, a Plot tab is available for viewing results, as shown in Figure 7-9. The results graph includes the systematic annual maximum/minimum volumes, plotted using the specified plotting position method, and the analytical frequency curves. The analytical frequency curves are based on the computed statistics or user-adjusted statistics if they are defined on the Statistics tab.

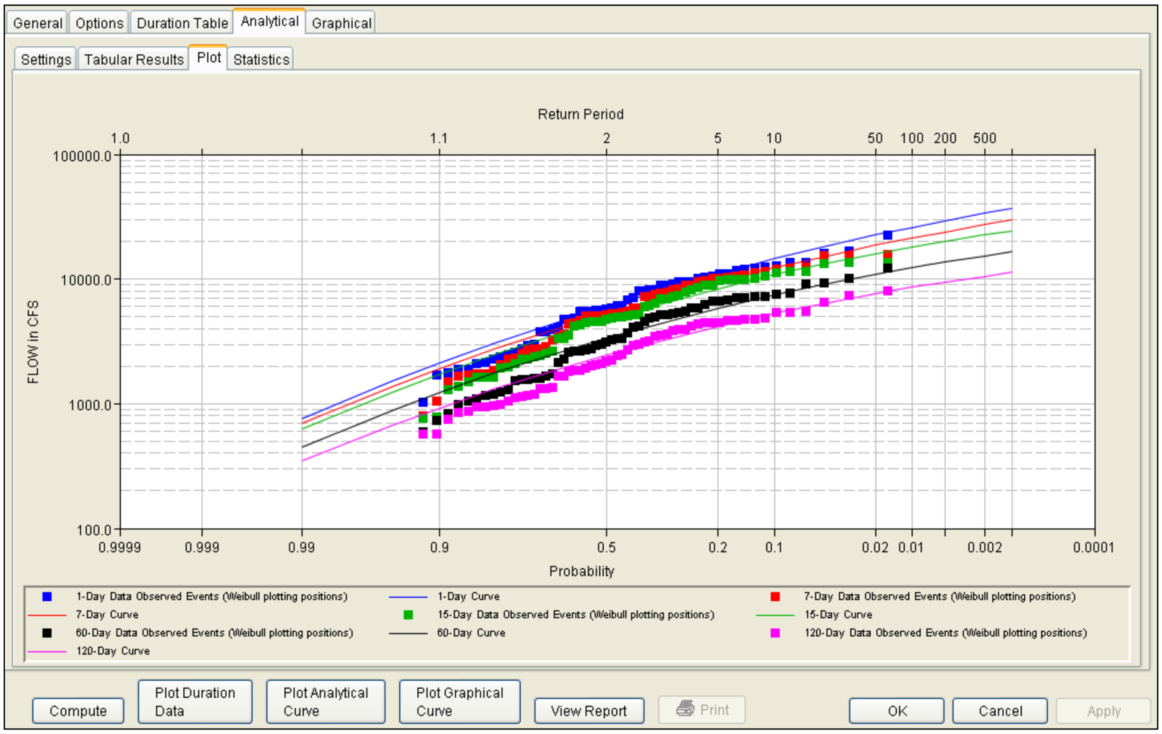


Figure 7-9. Plot of Analytical Results for a Volume Frequency Analysis.

Statistics

As discussed in EM 1110-2-1415, a necessary step in a volume-frequency analysis is to make sure the analytical frequency curves are consistent across all durations (USACE, 1993). In some situations, frequency curves from different durations might cross one another. The **Statistics** tab contains tools allowing the user to modify the mean, standard deviation, and skew to make sure frequency curves do not cross one another.

When the user selects the **Statistics** tab, the window will appear as shown in Figure 7-10. The upper portion of the Statistics tab contains a plot of the computed and user-adjusted statistics. The user has the option of choosing the parameter to be plotted in the comparison graph. Computed statistics are plotted as black data points and user-adjusted statistics are plotted as blue data points. The first table, **Sample Statistics**, contains the statistics computed from the systematic data. In addition, the adopted skew value in this table can be the station skew, weighted skew, or regional skew. The adopted skew is set by the user on the **Settings** tab. The lower table is where the user enters the adjusted statistics. Before entering adjusted statistics, the user must check the box in Column 1. User-adjusted statistics entered in this table are used when the program computes the analytical frequency curve.

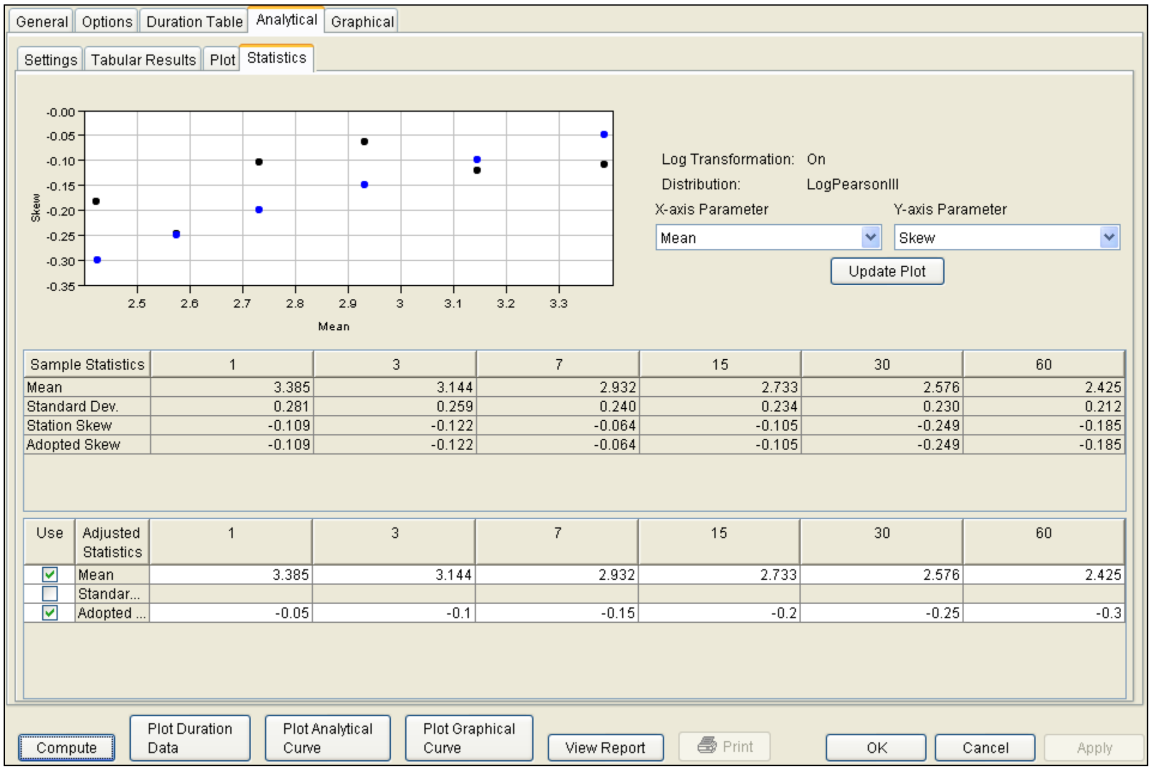


Figure 7-10. Statistics Tab in the Volume Frequency Analysis Editor.

Graphical Frequency Analysis

In addition to an analytical frequency analysis, which uses a statistical distribution to fit the data, the user has the option to graphically fit a frequency curve to the data. A graphical curve can be very useful when the available analytical distributions do not provide a good fit. One example of when a graphical frequency analysis is more appropriate is when plotting a frequency curve for flow data that is downstream of a flood control reservoir. Analytical frequency distributions are often not appropriate for fitting flow data that is significantly regulated by upstream reservoirs. In general, a portion of the flow frequency data for a highly regulated stream will be very flat in the zone in which upstream regulation can control the flow. This type of data lends itself to a graphical fit.

When the **Graphical** tab is selected on the Volume Frequency analysis editor, the window will appear as shown in Figure 7-11. As indicated, two additional tabs will appear on the screen, **Curve Input** and **Plot**.

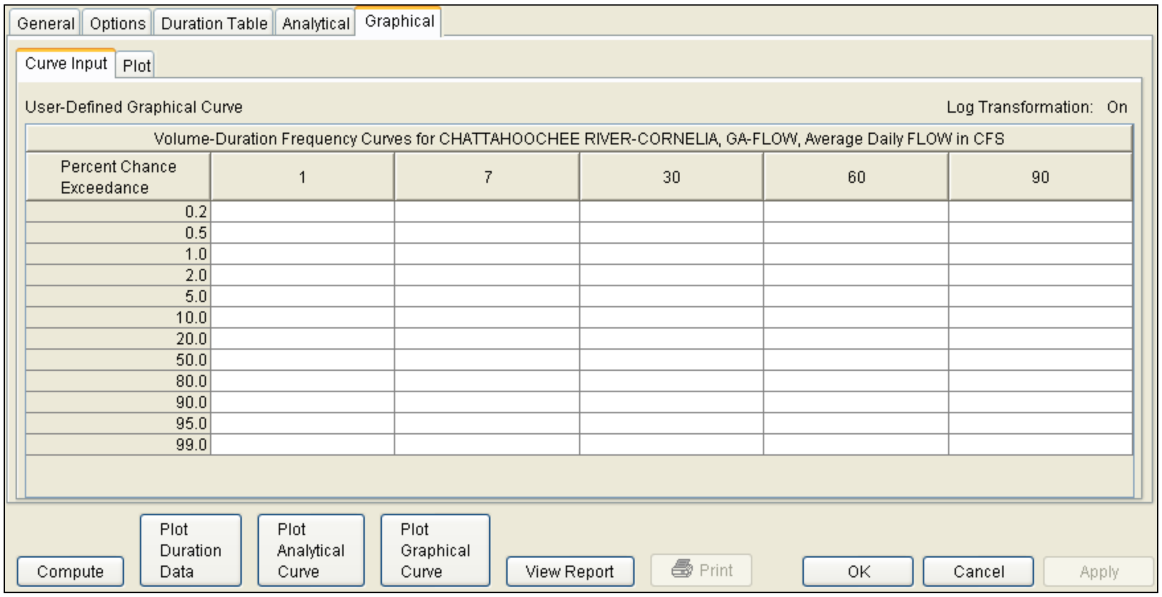


Figure 7-11. Graphical Curve Table for a Volume Frequency Analysis.

Curve Input

The user manually enters the frequency ordinates for all durations in the table on the **Curve Input** tab. As previously mentioned, the number of frequency ordinates and durations are set on the Options tab. The idea is to enter values in the table that will create a best fit line of the data, based on the user's judgment. Data entered in the graphical curve table will be plotted as a line in the graph on the **Plot** tab after the **Compute** button is pressed.

Plot

The graphical analysis **Plot** tab is available for viewing results, as shown in Figure 7-12. The results graph includes the historic annual maximum/minimum flows, plotted using the specified plotting position method, and the user-defined graphical curve, which was entered in the table on the **Curve Input** tab.

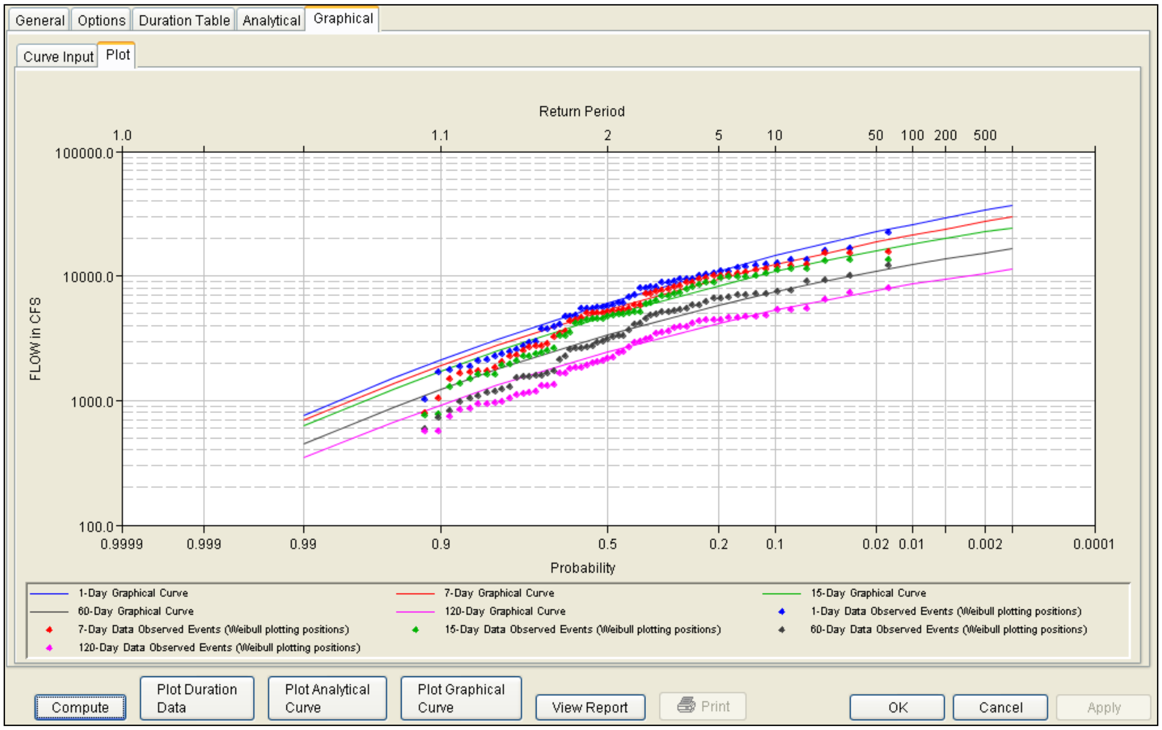


Figure 7-12. Plot Tab for a Graphical Analysis.

Viewing and Printing Results – Volume Frequency Analysis

The user can view output for the frequency analysis directly from the Volume Frequency Analysis editor (Tabular and Graphical output) or by using the plot and view report buttons at the bottom of the editor. The output consists of tabular results, an analytical frequency curve plot, a graphical frequency curve plot, and a report documenting the data and computations performed.

Tabular Output

Once the computations for the analytical frequency analysis are completed, the user can view tabular output by opening the **Tabular Results** tab under the **Analytical** analysis tab. The details of this table were discussed above. The tabular results can be printed by using the **Print** button at the bottom of the Volume Frequency Analysis editor. When the print button is pressed, a window will appear, giving the user options for how the table is to be printed.

Graphical Output

Graphical output can be opened by selecting one of the plot buttons at the bottom of the Volume Frequency Analysis editor or by selecting the **Plot** tab under the Analytical or Graphical tabs. There are three plot buttons at the bottom of the Volume Frequency Analysis editor, Plot Duration Data, Plot Analytical Curve, and Plot Graphical Curve. Pressing the Plot Duration Data button will open a new window containing a graph showing the systematic data plotted using the user-defined plotting position method. Pressing the Plot Analytical Curve button will open a new window containing a graph with both the systematic data and the computed analytical frequency curves, as shown in Figure 7-13. Pressing the Plot Graphical Curve button will open a new window containing a graph with both the systematic data and the user-defined frequency curves.

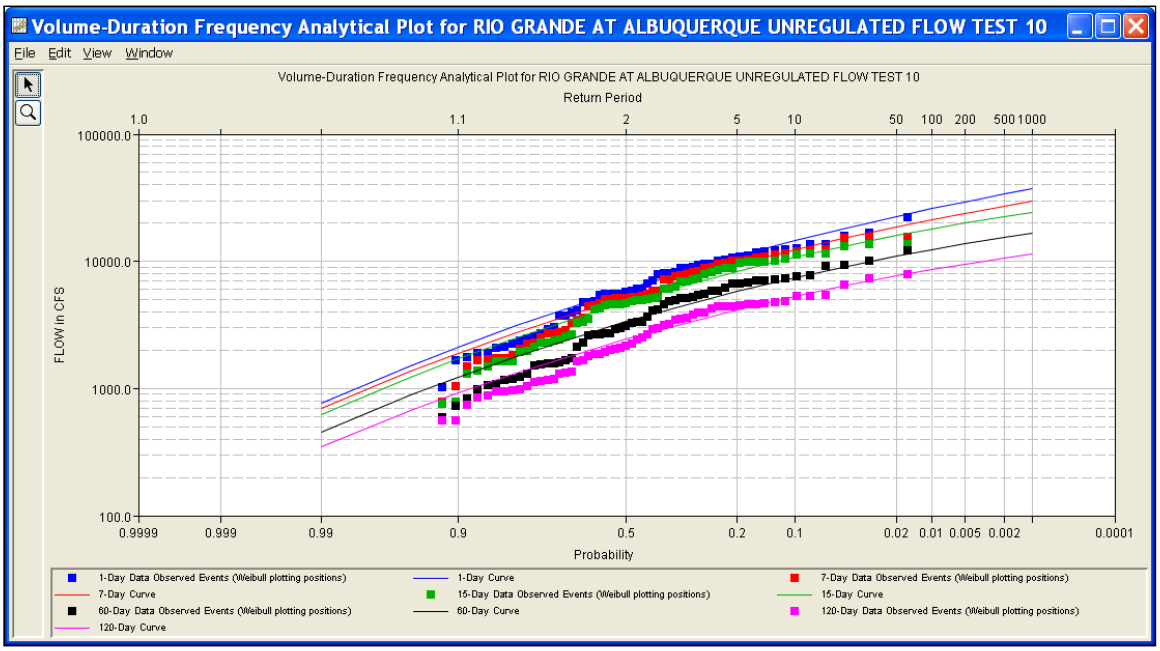


Figure 7-13. Plot of Systematic Data and Analytical Frequency Curves.

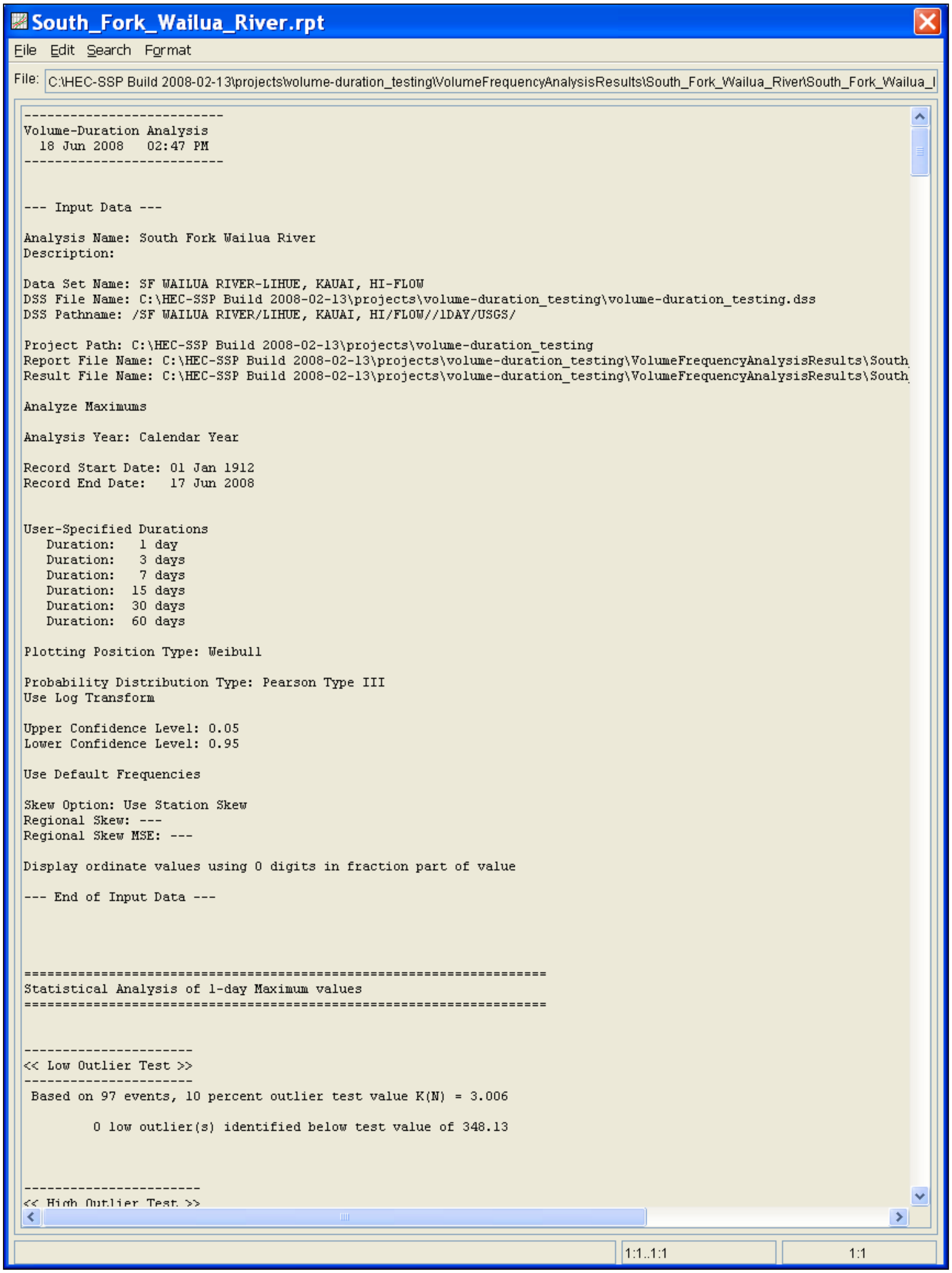
All plots opened by selecting one of the plot buttons at the bottom of the Volume Frequency Analysis editor contain menu options for printing, editing, and saving the plots.

Plots can be sent to the printer by selecting the **Print** option located on the **File** menu. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The plot can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file. Currently four file formats are available for saving the plot to disk: windows metafile, postscript, JPEG, and portable network graphic. The data contained within the plot can also be tabulated by selecting **Tabulate** from the File menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the plot properties as a template (**Save Template**) and applying previously saved templates to the current plot (**Apply Template**).

The **Edit** menu contains several options for customizing the plot properties. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties. Also, the user can right-click on a line or data point in the plot area or in the legend and a shortcut menu will open with customization options. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis. The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing plots in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User’s Manual for details on customizing plots.

Viewing the Report File

Computational results for a volume frequency analysis are written to a report file. The report file lists all of the input data and user settings, plotting positions of the data points, intermediate results, each of the various statistical tests performed (i.e. high and low outliers, historical data, etc…), and the final results. This file is often useful for understanding how the software arrived at the final frequency curves. Press the **View Report** button at the bottom of the Volume Frequency Analysis editor to open the report, as shown in Figure 7-14.



South_Fork_Wailua_River.rpt

File Edit Search Format

File: C:\HEC-SSP Build 2008-02-13\projects\volume-duration_testing\VolumeFrequencyAnalysisResults\South_Fork_Wailua_River\South_Fork_Wailua_I

```
-------------------------
Volume-Duration Analysis
  18 Jun 2008   02:47 PM
-------------------------


--- Input Data ---

Analysis Name: South Fork Wailua River
Description:

Data Set Name: SF WAILUA RIVER-LIHUE, KAUAI, HI-FLOW
DSS File Name: C:\HEC-SSP Build 2008-02-13\projects\volume-duration_testing\volume-duration_testing.dss
DSS Pathname: /SF WAILUA RIVER/LIHUE, KAUAI, HI/FLOW//1DAY/USGS/

Project Path: C:\HEC-SSP Build 2008-02-13\projects\volume-duration_testing
Report File Name: C:\HEC-SSP Build 2008-02-13\projects\volume-duration_testing\VolumeFrequencyAnalysisResults\South
Result File Name: C:\HEC-SSP Build 2008-02-13\projects\volume-duration_testing\VolumeFrequencyAnalysisResults\South

Analyze Maximums

Analysis Year: Calendar Year

Record Start Date: 01 Jan 1912
Record End Date:   17 Jun 2008


User-Specified Durations
   Duration:   1 day
   Duration:   3 days
   Duration:   7 days
   Duration:  15 days
   Duration:  30 days
   Duration:  60 days

Plotting Position Type: Weibull

Probability Distribution Type: Pearson Type III
Use Log Transform

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Use Default Frequencies

Skew Option: Use Station Skew
Regional Skew: ---
Regional Skew MSE: ---

Display ordinate values using 0 digits in fraction part of value

--- End of Input Data ---



====================================================================
Statistical Analysis of 1-day Maximum values
====================================================================


----------------------
<< Low Outlier Test >>
----------------------
 Based on 97 events, 10 percent outlier test value K(N) = 3.006

         0 low outlier(s) identified below test value of 348.13

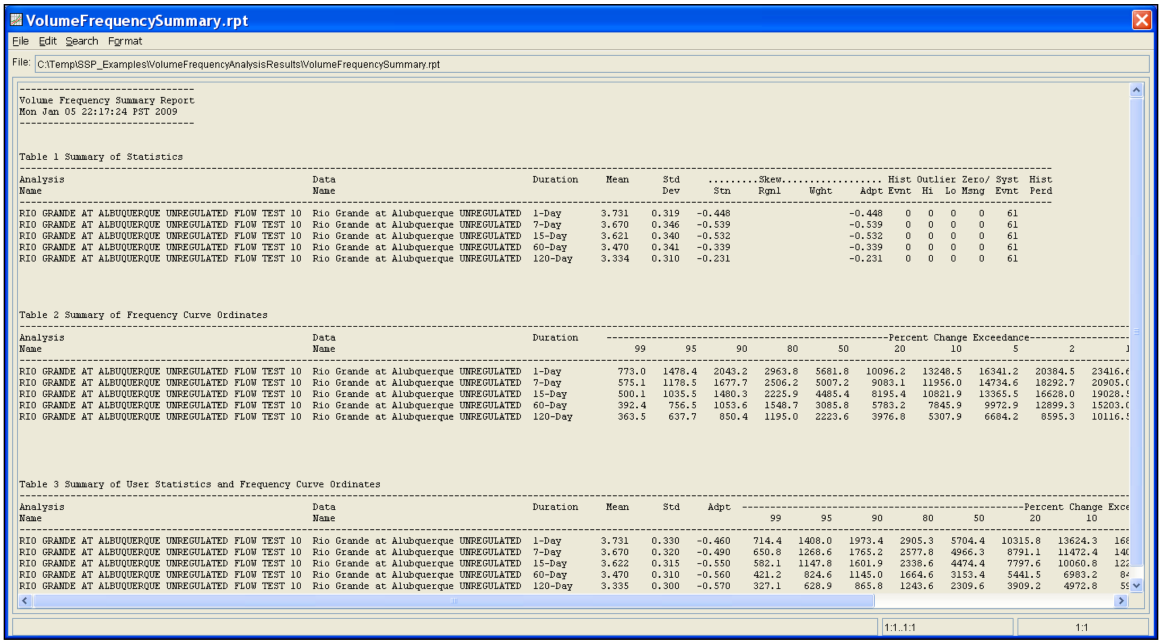


-----------------------
<< High Outlier Test >>
```

1:1..1:1 1:1

Figure 7-14. Volume Frequency Analysis Report.

Plots, tables and reports can also be created by selecting menu options from the **Results** menu. At least one volume frequency analysis must be selected in the study explorer before selecting one of the menu options on the Results menu. Results from multiple analyses are combined in one graph if they are selected in the study explorer when the **Graph** menu option is selected. The **Results→Summary Report** menu option will create a summary table of statistics and frequency curve ordinates for the selected analyses as shown in Figure 7-15.



VolumeFrequencySummary.rpt

File Edit Search Format

File: C:\Temp\SSP_Examples\VolumeFrequencyAnalysisResults\VolumeFrequencySummary.rpt

Volume Frequency Summary Report
Mon Jan 05 22:17:24 PST 2009

Table 1 Summary of Statistics

Analysis Name	Data Name	Duration	Mean	Std Dev	Skew Stn	Skew Rgnl	Skew Wght	Skew Adpt	Hist Evnt	Outlier Hi	Outlier Lo	Zero/ Msng	Syst Evnt	Hist Perd
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	1-Day	3.731	0.319	-0.448			-0.448	0	0	0	0	61	
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	7-Day	3.670	0.346	-0.539			-0.539	0	0	0	0	61	
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	15-Day	3.621	0.340	-0.532			-0.532	0	0	0	0	61	
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	60-Day	3.470	0.341	-0.339			-0.339	0	0	0	0	61	
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	120-Day	3.334	0.310	-0.231			-0.231	0	0	0	0	61	

Table 2 Summary of Frequency Curve Ordinates

Analysis Name	Data Name	Duration	Percent Change Exceedance 99	95	90	80	50	20	10	5	2	1
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	1-Day	773.0	1478.4	2043.2	2963.8	5681.8	10096.2	13248.5	16341.2	20384.5	23416.6
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	7-Day	575.1	1178.5	1677.7	2506.2	5007.2	9083.1	11956.0	14734.6	18292.7	20905.0
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	15-Day	500.1	1035.5	1480.3	2225.9	4485.4	8195.4	10821.9	13365.5	16628.0	19028.5
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	60-Day	392.4	756.5	1053.6	1548.7	3085.8	5783.2	7845.9	9972.9	12899.3	15203.0
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	120-Day	363.5	637.7	850.4	1195.0	2223.6	3976.8	5307.9	6684.2	8595.3	10116.5

Table 3 Summary of User Statistics and Frequency Curve Ordinates

Analysis Name	Data Name	Duration	Mean	Std	Adpt	Percent Change Exce 99	95	90	80	50	20	10	
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	1-Day	3.731	0.330	-0.460	714.4	1408.0	1973.4	2905.3	5704.4	10315.8	13624.3	168
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	7-Day	3.670	0.320	-0.490	650.8	1268.6	1765.2	2577.8	4966.3	8791.1	11472.4	140
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	15-Day	3.622	0.315	-0.550	582.1	1147.8	1601.9	2338.6	4474.4	7797.6	10060.8	122
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	60-Day	3.470	0.310	-0.560	421.2	824.6	1145.0	1664.6	3153.4	5441.5	6983.2	84
RIO GRANDE AT ALBUQUERQUE UNREGULATED FLOW TEST 10	Rio Grande at Alubquerque UNREGULATED	120-Day	3.335	0.300	-0.570	327.1	628.9	865.8	1243.6	2309.6	3909.2	4972.8	59

1:1..1:1 1:1

Figure 7-15. Summary Table for a Volume Frequency Analysis.

CHAPTER 8

Performing a Duration Analysis

This chapter discusses in detail how to use the Duration Analysis editor in HEC-SSP. A duration analysis can be performed on flow and stage data as well as other data types. All regular interval data can be used in a duration analysis and an option is included to manually define a duration curve.

Contents

Starting a New Analysis

A duration analysis can be started in two ways, either by right clicking on the Duration Analysis folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **Duration Analysis**. When a new duration analysis is selected, the Duration Analysis editor will appear as shown in Figure 8-1.

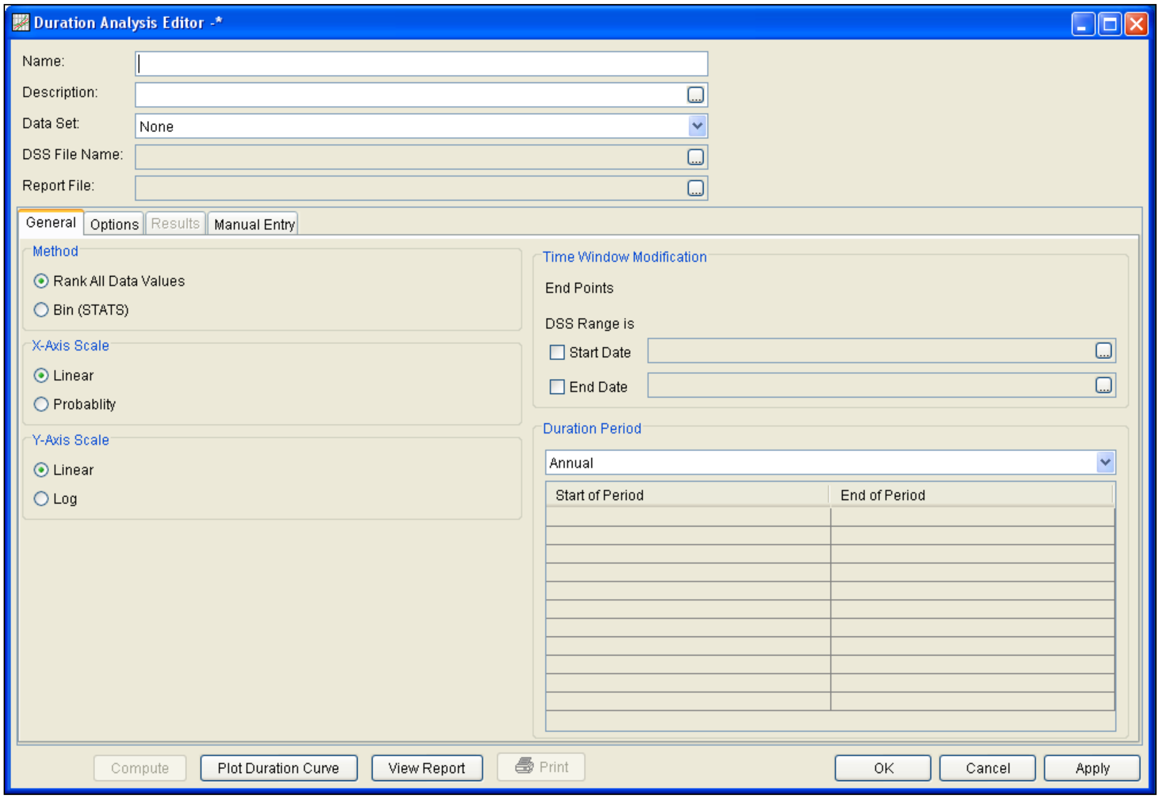


Figure 8-1. Duration Analysis Editor.

The user is required to enter a **Name** for the analysis, while a **Description** is optional. A data set (flow, stage, or other) can be selected from the available data sets stored in the current study DSS file (see Chapter 4 for importing data into the study). The list of data that can be selected for a duration analysis will only include those data that have a regular interval, like 1HOUR and 1DAY (E-part pathname). Choose “None” for the Data Set when defining the duration curve manually on the **Manual Entry** tab. Once a Name is entered and a data set is selected, the **DSS File Name** and **Report File** will automatically be filled out. The DSS filename is by default the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

General Settings and Options

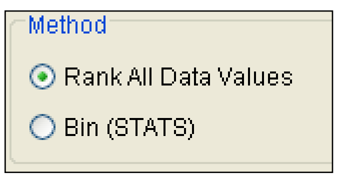
Once the analysis name and data set are selected, the user can begin to perform the analysis. Contained on the Duration Analysis editor are four tabs. The tabs are labeled **General**, **Options**, **Results**, and **Manual Entry**. This section of the manual explains the use of the General and Options tabs.

General

The first tab contains general settings for performing the duration analysis (Figure 8-1). These settings include:

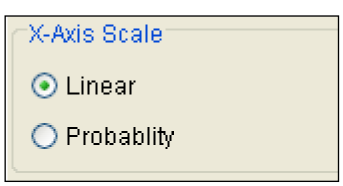
- Method
- X-Axis Scale
- Y-Axis Scale
- Time Window Modification
- Duration Period

Method



This option allows the user to choose the **Rank All Data Values** or **Bin (STATS)** method for computing the duration analysis; the rank all data values method is the preferred choice. This method computes the duration curve by sorting the data from largest to smallest, ranking the values from 1 to n, and using: $P = 100 * [M/(n+1)]$ where M is the ranked position and n is the number of events. The Bin method uses a similar procedure as in the STATS program for computing the duration curve (U.S. Army Corps of Engineers, 1996). The data is grouped into bins (classes) and the duration curve is computed using the number of data in each bin.

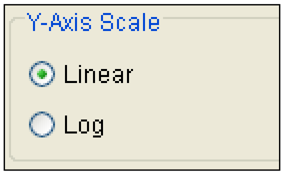
X-Axis Scale



This option allows the user to choose the scale of the x-axis. The options are **Linear** and **Probability**. This option will affect the x-axis scale in the duration curve plot and how the "interpolated" frequency curve is computed. The program will use a probability scale when interpolating the final duration curve to the user specified exceedance ordinates.

Y-Axis Scale

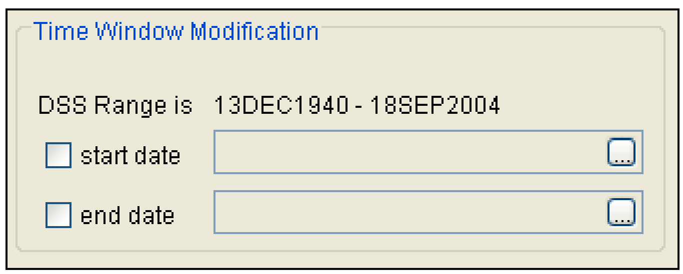
This option allows the user to choose the scale of the y-axis. The options are **Linear** and **Log**. This option will affect the y-axis scale in the



duration curve plot, how the program computes evenly spaced bins when the Bin (Stats) method is selected, and how the "interpolated" frequency curve is computed. One option for computing bins is to let the program define the bins at evenly spaced intervals between the minimum and maximum values from the selected data set. When **Log** is set as the y-axis scale, the program will convert the minimum and maximum values to log space before computing the evenly spaced bin limits. Also, the program will use log scale when interpolating the final duration curve to the user specified exceedance ordinates.

Time Window Modification

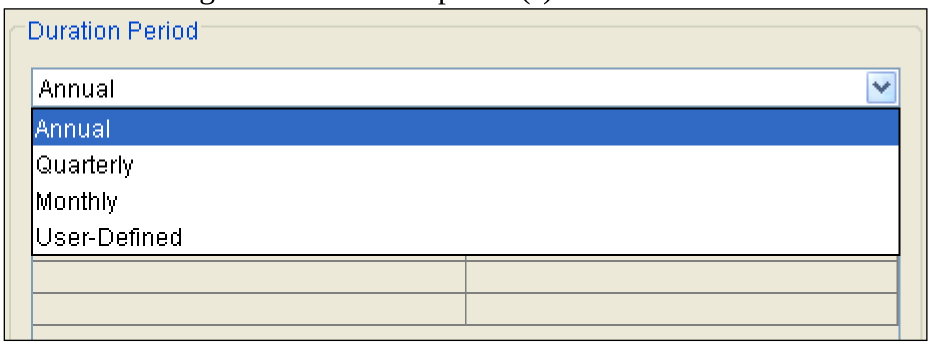
This option allows the user to narrow the time window used for the analysis. The default is to use all of the data contained in the selected data set. The user can enter either a start date and end date or both a start and end date. If a start and/or end date are used, they must be dates that are



contained within the data stored in the selected data set. The date range for the selected data set is shown in the editor just above the **Start Date** field.

Duration Period

This option allows the user to compute multiple duration curves for different time windows within the year. If **Annual** is selected, then the program uses all the data when computing the duration curve. If **Quarterly** is selected, then the program separates the data into quarters and computes a separate duration curve for each quarter. For example, a duration curve for the 1st quarter includes all data measured from Jan 1 – March 31. The program will compute a separate duration curve for each month of the year when the **Monthly** option is selected. The **User-Defined** option lets the user define one or multiple periods within the year. Then the program will perform the duration analysis using data only measured during the user-defined period(s).



Options

In addition to the general settings, there are also several options available to the user for modifying the computations of the duration curve. These options include:

- Output Labeling
- Plotting Position Formula
- User-Specified Exceedance Ordinates
- Bin Limits

When the Options tab is selected, the Duration Analysis editor will appear as shown in Figure 8-2.

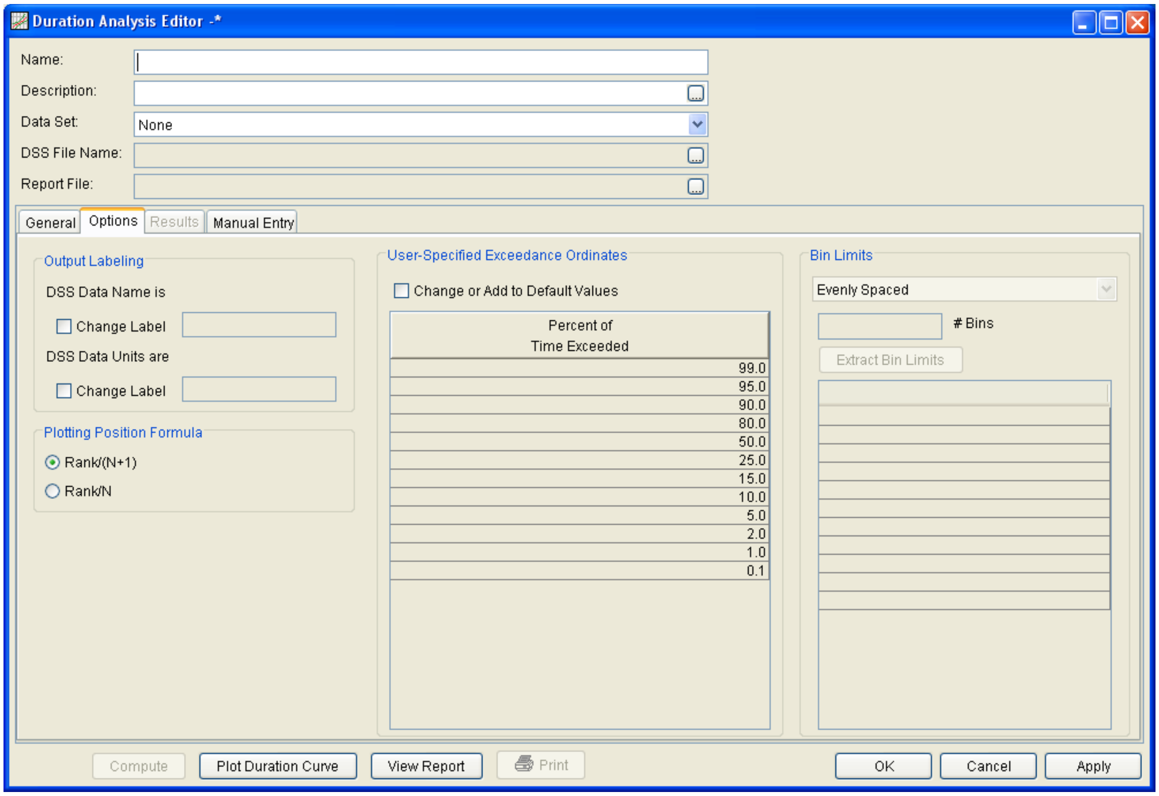
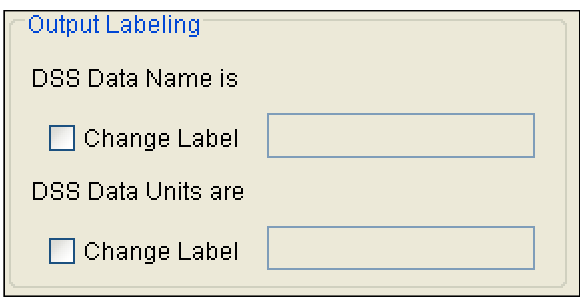


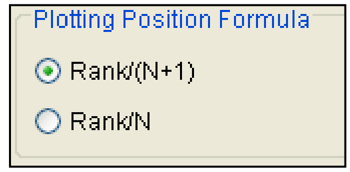
Figure 8-2. Duration Analysis Editor with Options Tab Selected.

Output Labeling

This option allows the user to change the default labels for data contained in the output tables and plots. The user can change both the name of the data as well as the units of the data. The output labeling does not result in the conversion of data from one unit system to another; it only affects what is displayed on table headings and the y-axis of the results plot.

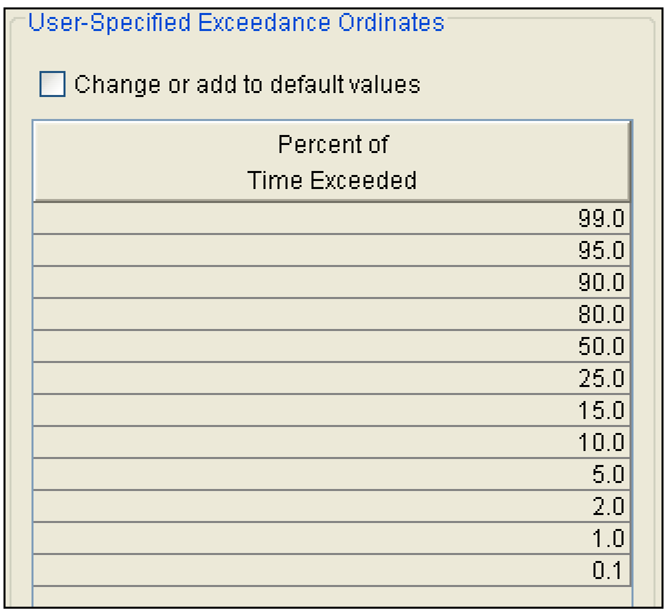


Plotting Position Formula



This option allows the user to choose how the duration curve is computed (this option is not available when the **Bin** method is selected). When **Rank/(N+1)** is selected the program will compute the duration curve using: $P = 100 * [M/(n+1)]$ where M is the ranked position and n is the number of events. When **Rank/N** is selected the program will compute the duration curve using: $P = 100 * [M/n]$ where M is the ranked position and n is the number of events.

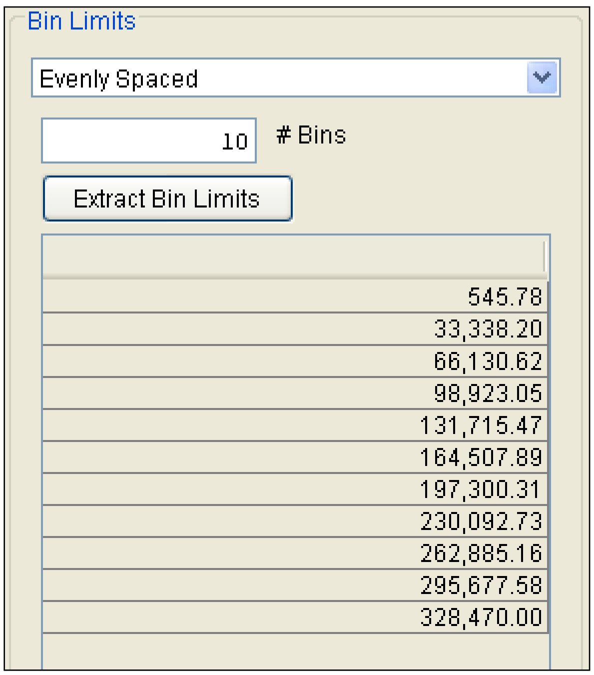
User-Specified Exceedance Ordinates



This option allows the user to change the ordinates used in computing the resulting duration curves. The default values listed in percent of time exceedance are 99, 95, 90, 80, 50, 25, 15, 10, 5, 2, 1, and 0.1. Check the box next to **Change or add to default values** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the ordinates. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Change or add to default values** option is not checked. Finally, all values in the table must be between 0 and 100.

Bin Limits

The **Bin Limits** panel is only active when the **Bin (STATS)** method is selected on the General tab. This option helps the user to define the limits, the minimum and maximum values, for each bin. There are two options; **Evenly Spaced** and **User-Defined**. When **Evenly Spaced** is selected the user must also enter the number of bins. The **Extract Bin Limits** button will automatically populate the bin limits table by first extracting the minimum and maximum values from the data set and then linearly interpolating evenly spaced bin limits. If Log is selected as the Y-axis scale on the General tab, then the program converts the minimum and maximum values to log space before computing the evenly spaced bin limits. The **User-Defined** option lets the user manually enter the bin limits. The user must ensure the minimum and maximum values from the data set are contained in the bin limits table. For example, if the minimum flow from the data set is 100.0 then the first row in the table must be less than or equal to 100.0. Additional rows can be added to the table. Place the mouse pointer on top of the table and click the right mouse button. Then select the **Insert Row(s)…** menu option to open an editor for specifying the number of rows to insert into the table.



Compute

Once the new analysis has been defined, and the user has all of the General and Options information selected the way they want, performing the computations is simply a matter of pressing the **Compute** button at the bottom of the Duration Analysis editor. If the computations are successful, the user will receive a message that says "Compute Complete". At this point, the user can begin to review the results.

Multiple Duration analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finished computing the analyses.

Results

This section of the manual describes results that are available for the Duration analysis. When the user selects the **Results** tab on the Duration Analysis editor, the window will appear as shown in Figure 8-3. As shown, two additional tabs will appear on the screen: **Tabular Results** and **Plot**.

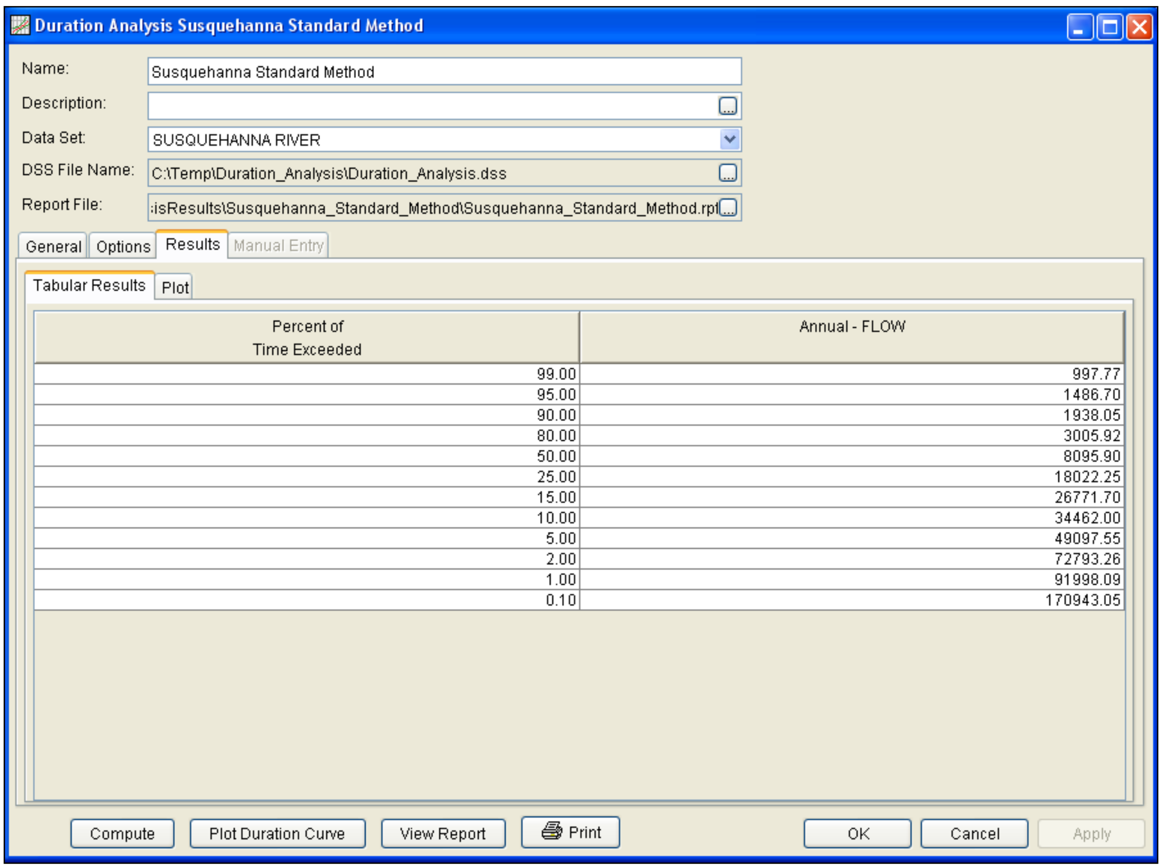
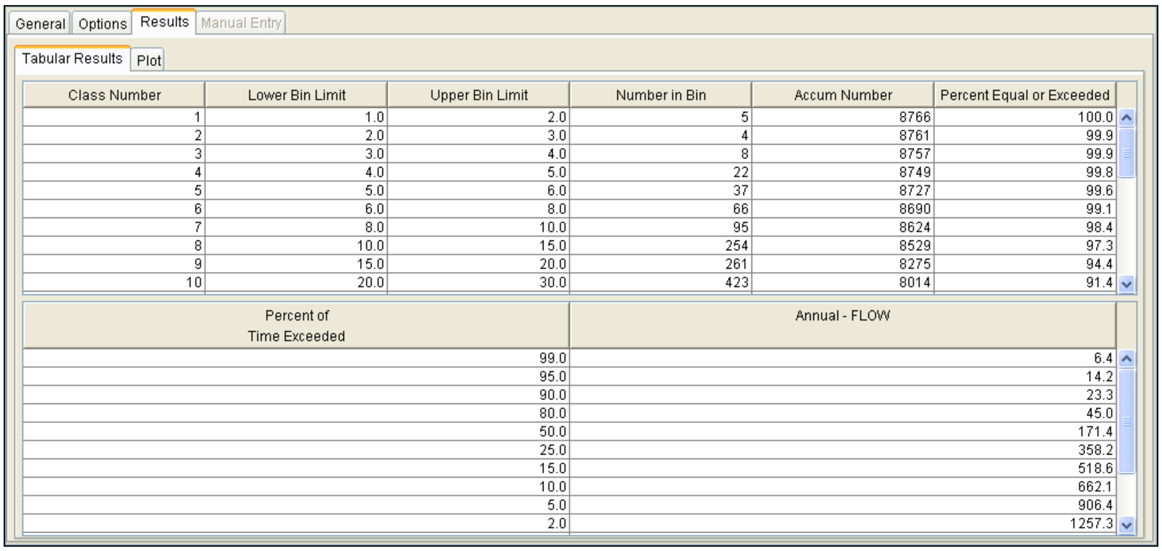


Figure 8-3. Results Tab of the Duration Analysis Editor.

Tabular Results

The **Tabular Results** tab will bring up a table of results for the duration analysis. The tabular results are different for the **Rank All Data Values** and **Bin (STATS)** methods. An example of tabular results for a **Rank All Data Values** analysis is shown in Figure 8-3. The results table will contain multiple duration curves if the Quarterly, Monthly, or the User Defined options are selected as the Duration Period. Data in the duration curve table can be re-sorted. Click the **Percent of Time Exceeded** column header (two mouse clicks are required the first time). The percent of time exceeded ordinates, along with the duration curve values, will sort so that the lowest values are on top or the highest values are on top.

The tabular results tab will look different when the **Bin (STATS)** method is used to compute the duration analysis. As shown in Figure 8-4, there are two tables. The first table contains summary information about the bins and the second table contains the interpolated duration curve.



Class Number	Lower Bin Limit	Upper Bin Limit	Number in Bin	Accum Number	Percent Equal or Exceeded
1	1.0	2.0	5	8766	100.0
2	2.0	3.0	4	8761	99.9
3	3.0	4.0	8	8757	99.9
4	4.0	5.0	22	8749	99.8
5	5.0	6.0	37	8727	99.6
6	6.0	8.0	66	8690	99.1
7	8.0	10.0	95	8624	98.4
8	10.0	15.0	254	8529	97.3
9	15.0	20.0	261	8275	94.4
10	20.0	30.0	423	8014	91.4

Percent of Time Exceeded	Annual - FLOW
99.0	6.4
95.0	14.2
90.0	23.3
80.0	45.0
50.0	171.4
25.0	358.2
15.0	518.6
10.0	662.1
5.0	906.4
2.0	1257.3

Figure 8-4. Results Tab for a Bin (STATS) analysis.

Plot

In addition to tabular results, a **Plot** tab is available for viewing a graphical plot of the duration curves. When the Plot tab is selected the window will change to what is shown in Figure 8-5. The plot contains the computed duration curve and the duration curve interpolated to the user-defined ordinates (defined on the Options tab). Multiple duration curves will be graphed if the Quarterly, Monthly, or User Defined options are selected as the duration period.

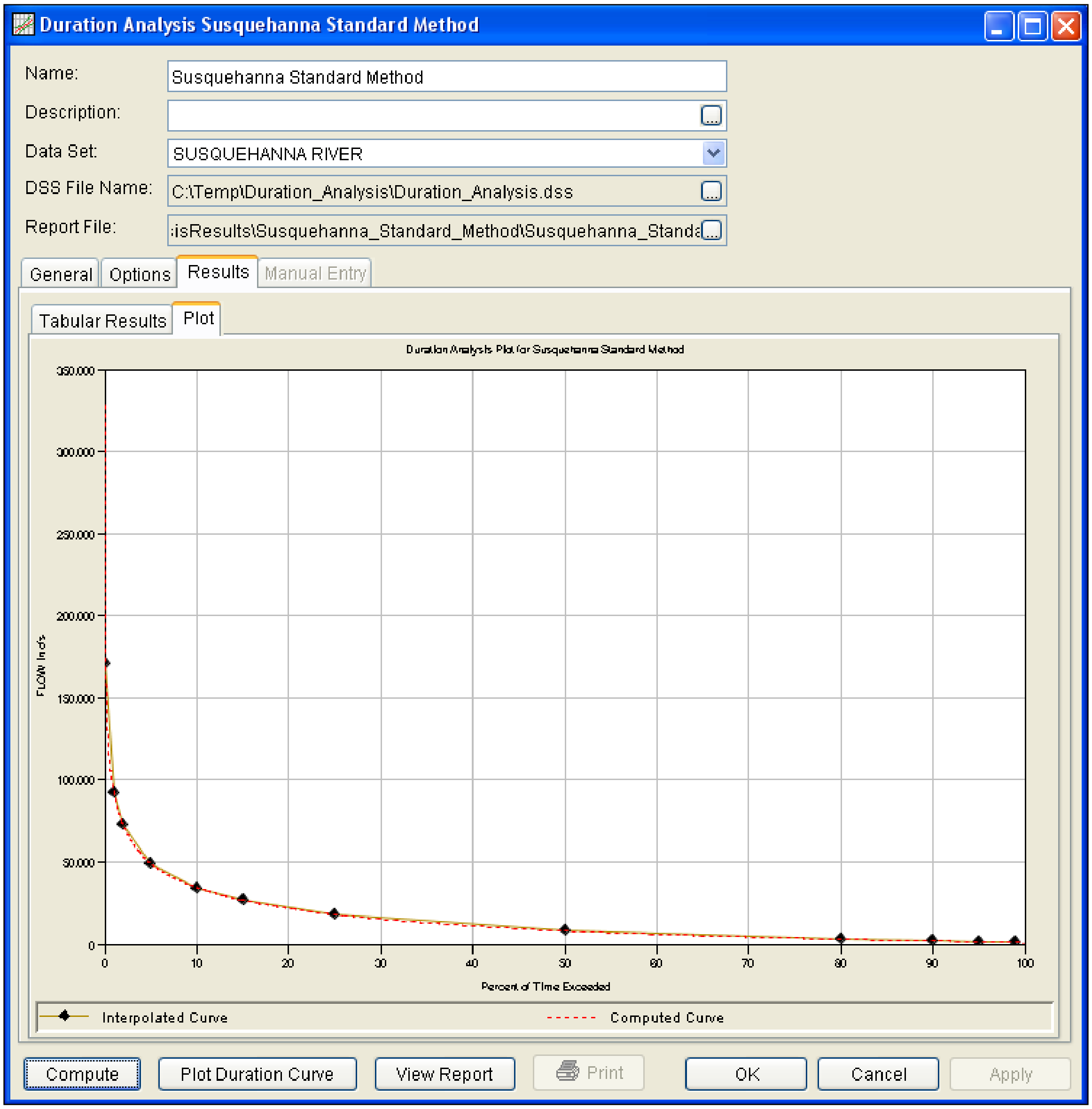


Figure 8-5. Plot Tab of the Duration Analysis.

Manual Duration Analysis

The user has the option to manually define a duration curve. This option would be used when a duration curve has been computed outside of HEC-SSP. The “None” data set must be selected in order to define a duration curve manually. When the **Manual Entry** tab is selected, the editor will display a plot and table as shown in Figure 8-6. The table allows the user to enter data values for the percent of time exceedance ordinates defined on the Options tab. When the user enters values in this table, those values will be plotted as a line on the plot after the **Compute** button is pressed.

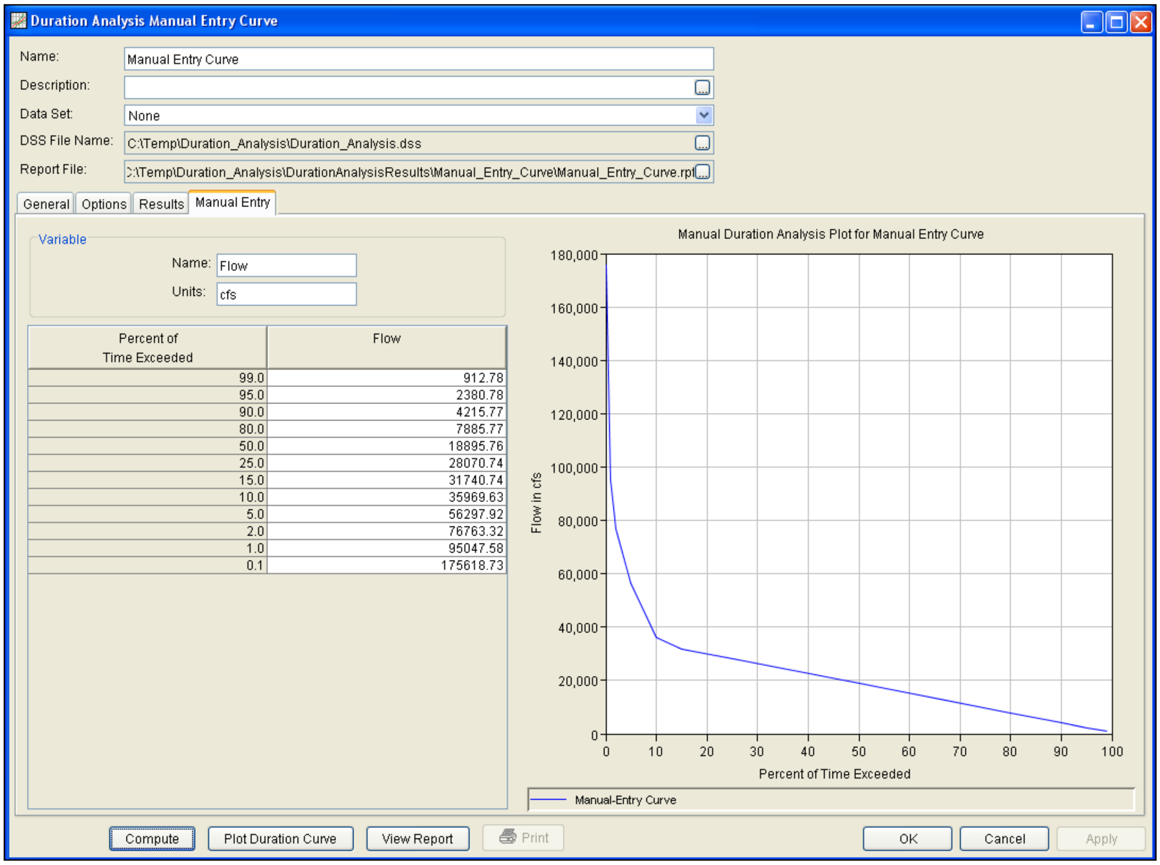


Figure 8-6. Manual Entry Tab of the Duration Analysis Editor.

Viewing and Printing Results

The user can view output for the duration analysis directly from the Duration Analysis editor (Tabular and Graphical output) or by using the buttons at the bottom of the editor. Results can also be opened by selecting the duration analysis in the study explorer and then choosing the **Graph**, **Table**, or **Report** option available from the **Results** menu.

Tabular Output

Once the computations for the duration analysis are completed, the user can view tabular output by selecting the **Tabular Results** tab under the **Results** tab. The details of this table were discussed above.

The tabular results can be printed by using the **Print** button at the bottom of the Duration Analysis editor. When the print button is pressed, a window will appear giving the user options for how they would like the table to be printed.

Graphical Output

Graphical output of the duration curve can be obtained by selecting either the **Plot** tab under the results tab, or by pressing the button labeled **Plot Duration Curve** at the bottom of the Duration Analysis editor. When the Plot Duration Curve button is pressed, a duration curve plot will appear in a separate window as shown in Figure 8-7.

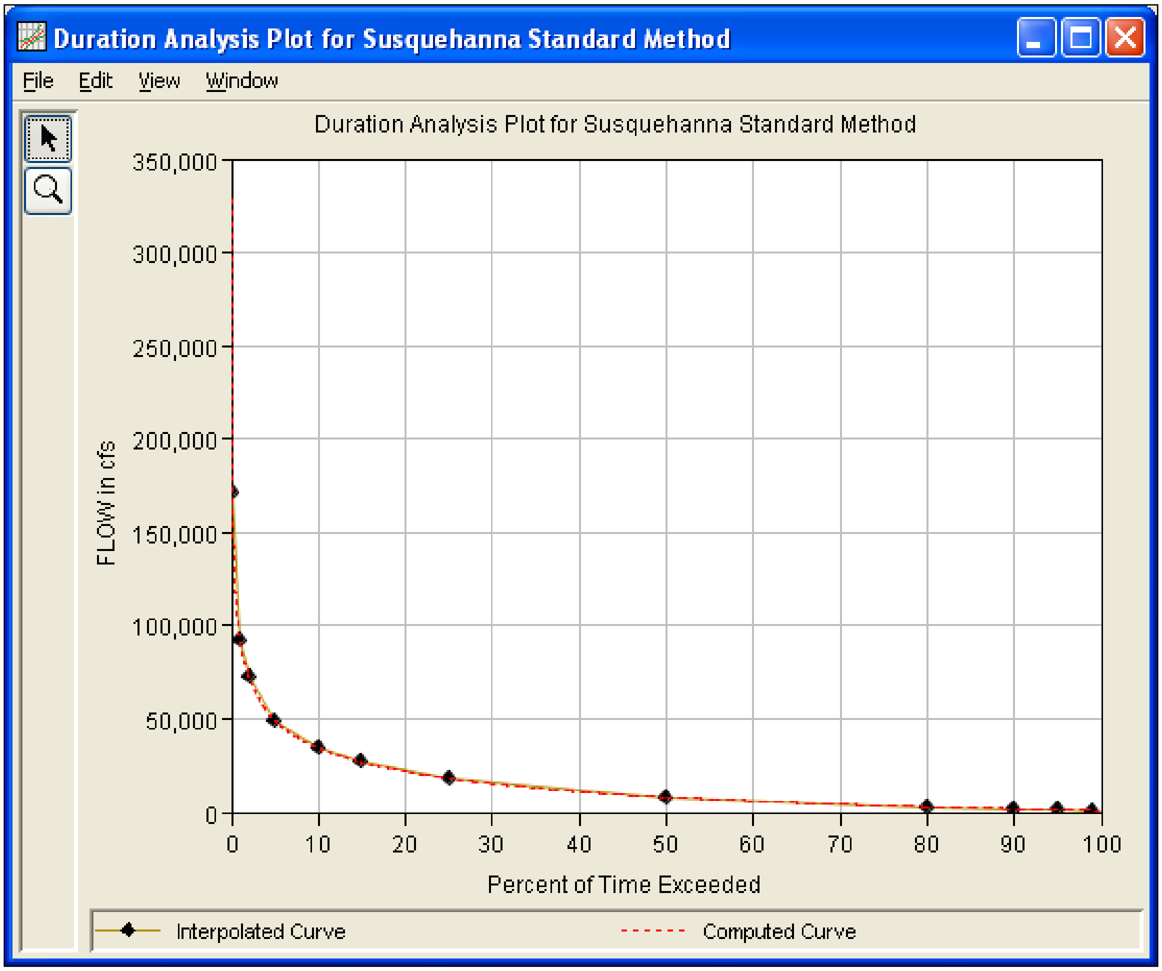


Figure 8-7. Duration Curve Plot.

The duration curve plot can be sent to the printer by selecting the **Print** option from the **File** menu at the top of the window. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The graphic can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file.

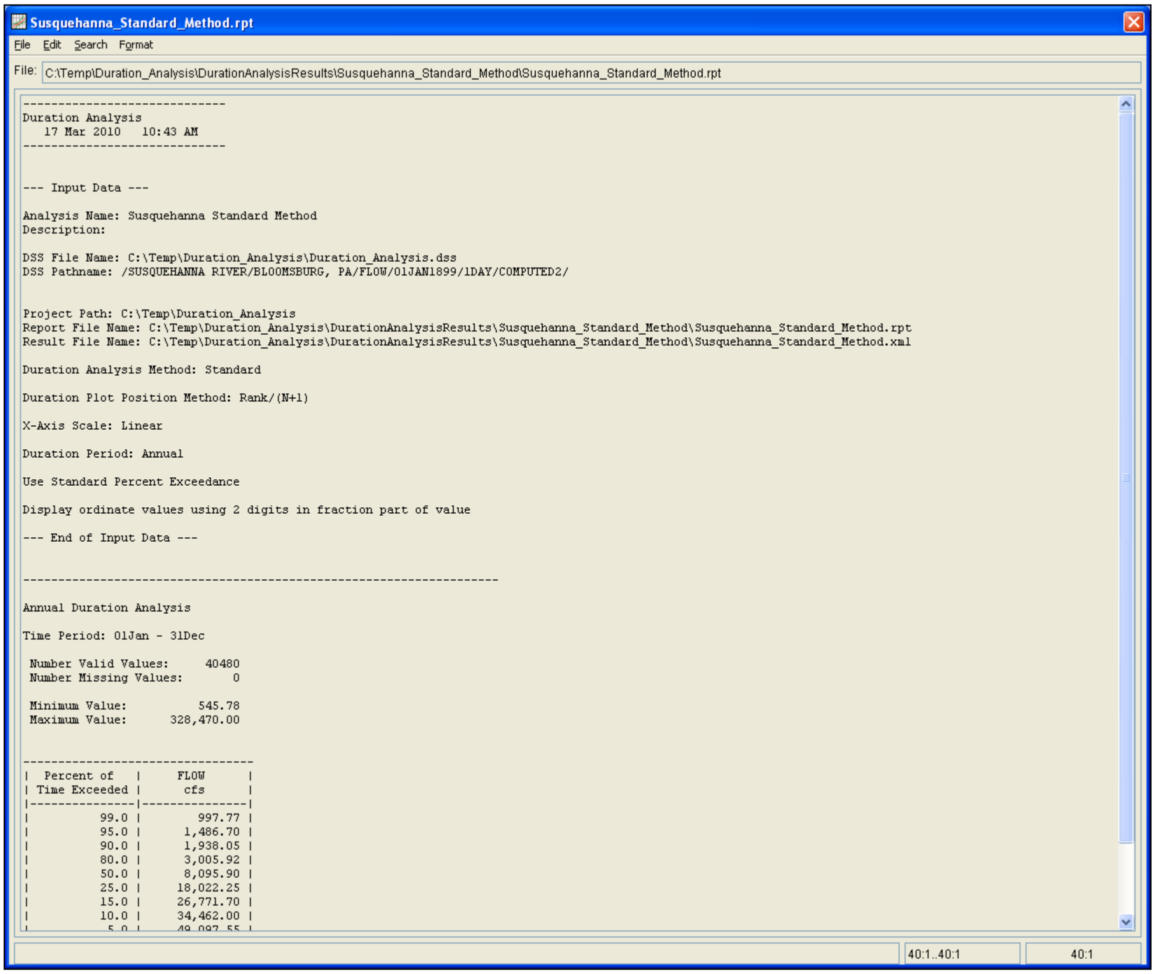
Currently four file formats are available for saving the graphic to disk: windows metafile, postscript, JPEG, and portable network graphic.

The data contained within the plot can also be tabulated by selecting **Tabulate** from the File menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the plot options as a template (**Save Template)** and applying previously saved templates to the current plot (**Apply Template**).

The **Edit** menu contains several options for customizing the graphic. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties. Also, a shortcut menu will appear with further customizing options when the user right-clicks on a line on the graph or the legend. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis. The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing plots in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User's Manual for details on customizing plots.

Viewing the Report File

A report file is created when the duration analysis computations are performed. The report file contains information about the duration analysis and the final results. To view the report file press the **View Report** button at the bottom of the Duration Analysis editor. When this button is pressed, a window will appear containing the report as shown in Figure 8-8.




```
----------------------------
Duration Analysis
   17 Mar 2010   10:43 AM
----------------------------


--- Input Data ---

Analysis Name: Susquehanna Standard Method
Description:

DSS File Name: C:\Temp\Duration_Analysis\Duration_Analysis.dss
DSS Pathname: /SUSQUEHANNA RIVER/BLOOMSBURG, PA/FLOW/01JAN1899/1DAY/COMPUTED2/


Project Path: C:\Temp\Duration_Analysis
Report File Name: C:\Temp\Duration_Analysis\DurationAnalysisResults\Susquehanna_Standard_Method\Susquehanna_Standard_Method.rpt
Result File Name: C:\Temp\Duration_Analysis\DurationAnalysisResults\Susquehanna_Standard_Method\Susquehanna_Standard_Method.xml

Duration Analysis Method: Standard

Duration Plot Position Method: Rank/(N+1)

X-Axis Scale: Linear

Duration Period: Annual

Use Standard Percent Exceedance

Display ordinate values using 2 digits in fraction part of value

--- End of Input Data ---


------------------------------------------------------------------

Annual Duration Analysis

Time Period: 01Jan - 31Dec

 Number Valid Values:     40480
 Number Missing Values:       0

 Minimum Value:          545.78
 Maximum Value:      328,470.00


--------------------------------
|  Percent of   |      FLOW     |
| Time Exceeded |       cfs     |
|---------------|---------------|
|          99.0 |        997.77 |
|          95.0 |      1,486.70 |
|          90.0 |      1,938.05 |
|          80.0 |      3,005.92 |
|          50.0 |      8,095.90 |
|          25.0 |     18,022.25 |
|          15.0 |     26,771.70 |
|          10.0 |     34,462.00 |
|           5.0 |     49,097.55 |
```

Figure 8-8. Duration Analysis Report File.

CHAPTER 9

Performing a Coincident Frequency Analysis

This chapter discusses in detail how to use the Coincident Frequency Analysis editor in HEC-SSP. A coincident frequency analysis can be performed on any data type; flow, stage, precipitation, wind, etc. The coincident frequency analysis requires both duration and frequency curves. These can be computed by existing analyses in the HEC-SSP study or they can be entered manually in the coincident frequency analysis editor.

The Coincident Frequency Analysis is designed following guidelines in EM 1110-2-1415. This analysis tool can be used to compute the exceedance frequency relationship for a variable that is a function of two other variables. An example is illustrated in Figure 9-1. In this example, the stage at the damage site on the tributary, variable C, is a function of stream flow from the tributary, variable A, and the stage in the mainstem river, variable B.

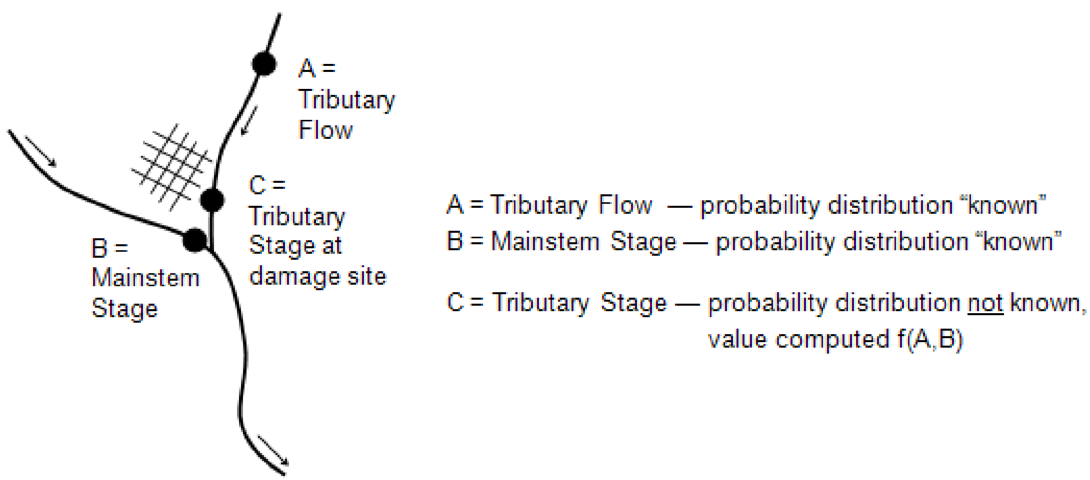


Figure 9-1. Example Application of the Coincident Frequency Analysis.

The general procedure for performing a coincident frequency analysis, using HEC-SSP is described below.

1) Develop a duration curve for variable B. This can be done using the Duration Analysis editor or it can be defined manually in the

Coincident Frequency Analysis editor. Then discretize the duration curve to determine index values for variable B. The index values should be defined so that the area under the discretized duration curve approximates the original duration curve. Figure 9-2 shows a flow duration curve that has been discretized using 9 index points. The index points are taken at the midpoint of each discrete segment and there are more index points along the steeper portion of the duration curve. The Coincident Frequency Analysis editor can be used to define the index points and to estimate the proportion of time for each index point. For example, the 9th index point in Figure 9-2 is taken at the midpoint for the discrete segment from 100 to 60 percent of time exceeded. The flow value at this point represents the variable B index occurring 40 percent of the time. The 8th index point is taken at the midpoint for the discrete segment from 60 to 40 percent of time exceeded. The flow value at this point represents the variable B index occurring 20 percent of the time. The proportion of time assigned to each index point will be used to compute the variable C frequency curve.

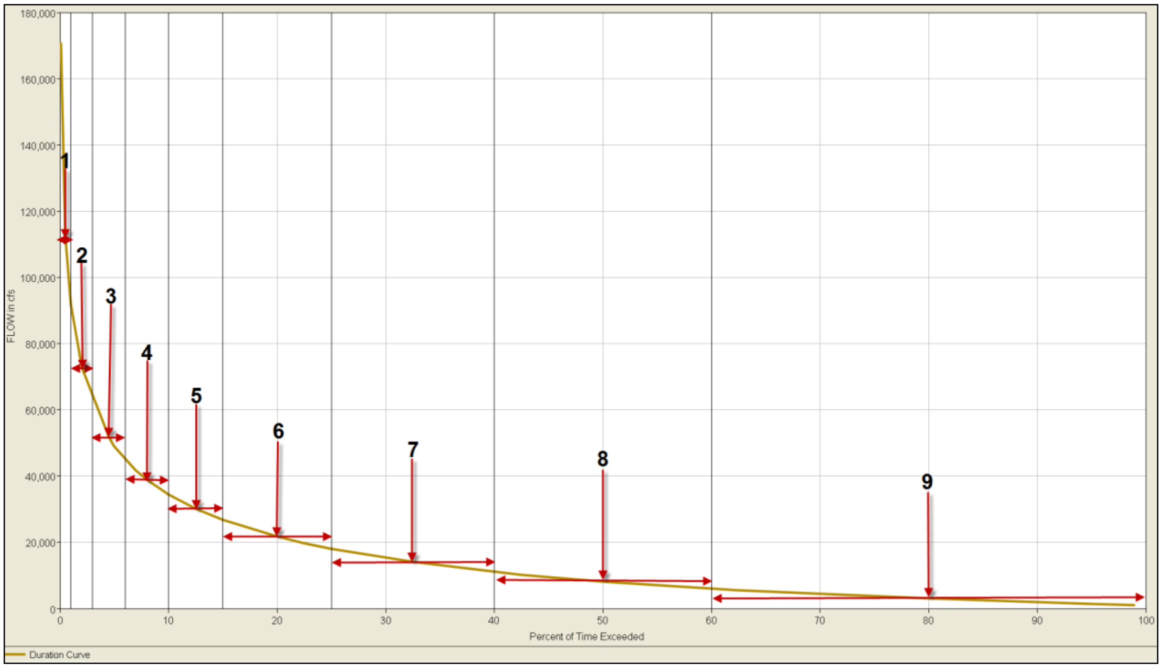
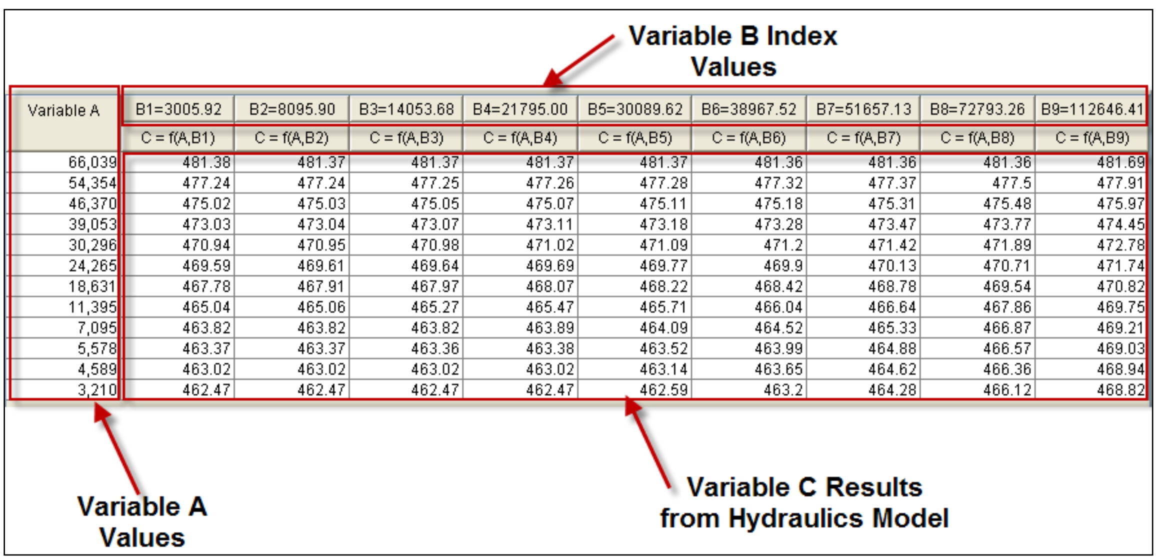


Figure 9-2. Variable B Duration Curve Divided into Discrete Segments.

2) Different procedures are required depending on whether variables A and B are independent or not independent of one another. When variables A and B are assumed independent of one another, develop a frequency curve of variable A. The frequency curve can come from an existing Bulletin 17 or General Frequency analysis or it can be defined

manually in the Coincident Frequency Analysis editor. If variables A and B are not independent of one another, then develop a frequency curve of variable A for each variable B index value. In this case, the variable A frequency curves must be defined manually in the Coincident Frequency Analysis editor. This involves extracting annual peak values for variable A that occur for each discrete range identified on the variable B duration curve and performing a separate frequency analysis on each set of variable A data.

3) Develop the response of variable C for combinations of variable A and variable B. This could be done using a hydrologic or hydraulic model. For the example shown in Figure 9-1, a flow value from the variable A frequency curve would be applied to the tributary and the index flow (or stage) from the variable B duration curve would be applied to the mainstem. The hydrologic or hydraulic model would be used to compute the variable C stage at some reference point on the tributary. This model simulation would be computed for many combinations of variable A and variable B. Figure 9-3 shows example output from a hydraulic model. The model was used to generate output from multiple combinations of variable A and B values. In this example, there were 12 variable A values and 9 index values from variable B. This resulted in 108 simulation results. The table shown in Figure 9-3 is referred to as the Response Curves table in HEC-SSP and these values must be entered by the user.



Variable A	B1=3005.92	B2=8095.90	B3=14053.68	B4=21795.00	B5=30089.62	B6=38967.52	B7=51657.13	B8=72793.26	B9=112646.41
	C = f(A,B1)	C = f(A,B2)	C = f(A,B3)	C = f(A,B4)	C = f(A,B5)	C = f(A,B6)	C = f(A,B7)	C = f(A,B8)	C = f(A,B9)
66,039	481.38	481.37	481.37	481.37	481.37	481.36	481.36	481.36	481.69
54,354	477.24	477.24	477.25	477.26	477.28	477.32	477.37	477.5	477.91
46,370	475.02	475.03	475.05	475.07	475.11	475.18	475.31	475.48	475.97
39,053	473.03	473.04	473.07	473.11	473.18	473.28	473.47	473.77	474.45
30,296	470.94	470.95	470.98	471.02	471.09	471.2	471.42	471.89	472.78
24,265	469.59	469.61	469.64	469.69	469.77	469.9	470.13	470.71	471.74
18,631	467.78	467.91	467.97	468.07	468.22	468.42	468.78	469.54	470.82
11,395	465.04	465.06	465.27	465.47	465.71	466.04	466.64	467.86	469.75
7,095	463.82	463.82	463.82	463.89	464.09	464.52	465.33	466.87	469.21
5,578	463.37	463.37	463.36	463.38	463.52	463.99	464.88	466.57	469.03
4,589	463.02	463.02	463.02	463.02	463.14	463.65	464.62	466.36	468.94
3,210	462.47	462.47	462.47	462.47	462.59	463.2	464.28	466.12	468.82

Figure 9-3. Response of Variable C for Combinations of Variable A and Variable B.

4) The program computes the variable C frequency curve by first using the response curves to compute conditional frequency curves of variable C.

This is done by assigning the same frequency from the variable A value to the corresponding variable C value. Then for a selected value of variable C, the frequency value from each conditional frequency curve is multiplied by the corresponding proportion of time (probability) from the variable B index value. The values are summed to obtain the frequency of the selected value of variable C. This is done for a number of values of variable C until a complete frequency curve is created.

Contents

Starting a New Analysis

A coincident frequency analysis can be started in two ways, either by right clicking on the Coincident Frequency Analysis folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **Coincident Frequency Analysis**. When a new coincident frequency analysis is selected, the Coincident Frequency Analysis editor will appear as shown in Figure 9-4.

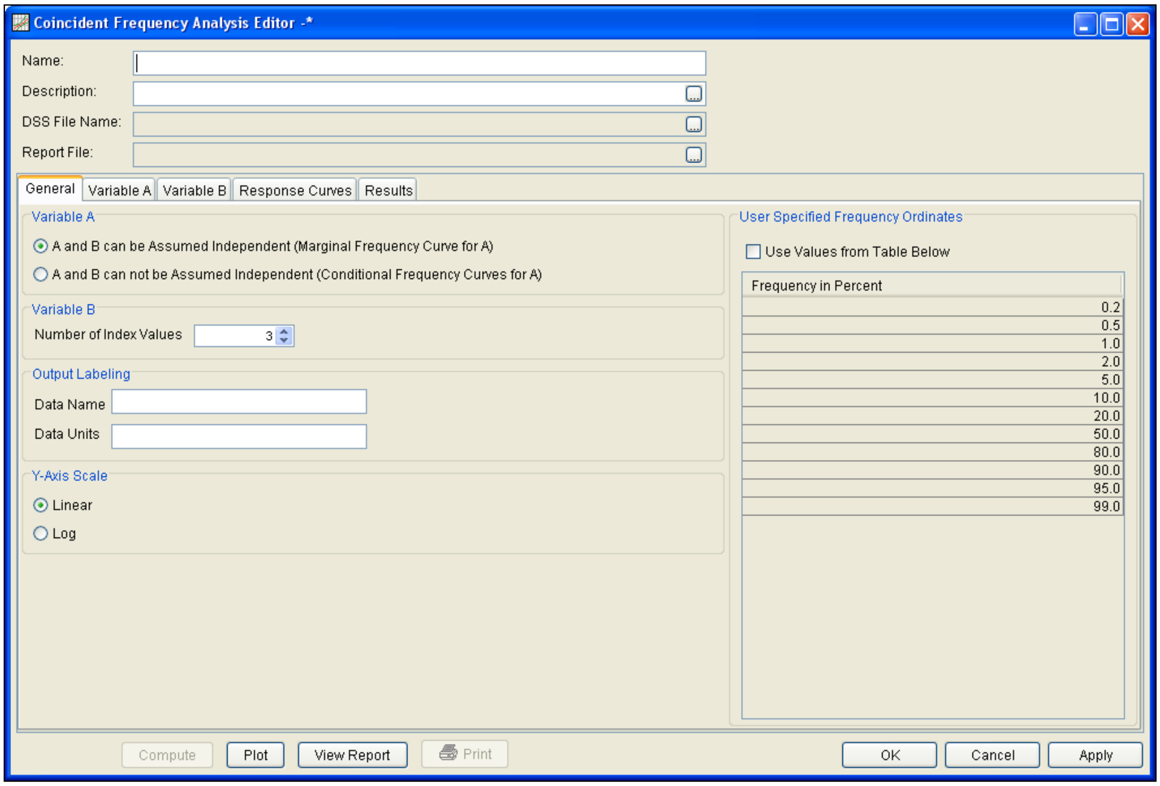


Figure 9-4. Coincident Frequency Analysis Editor.

The user is required to enter a **Name** for the analysis, while a **Description** is optional. Once a Name is entered, the **DSS File Name** and **Report File** will automatically be filled out. The DSS filename is by default the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

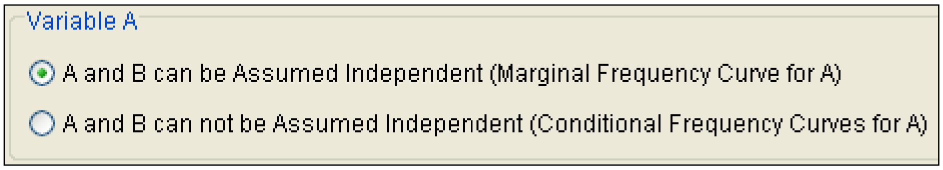
General Settings

Once the analysis name has been entered, the user can begin to perform the computations. Contained on the Coincident Frequency Analysis editor are five tabs. The tabs are labeled **General**, **Variable A**, **Variable B**, **Response Curves**, and **Results**. The first tab contains general settings for performing the coincident frequency analysis (Figure 9-4). These settings include:

- Variable A
- Variable B
- Output Labeling
- Y-Axis Scale
- User Specified Frequency Ordinates

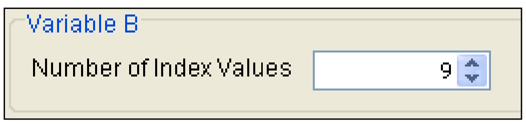
Variable A

This option allows the user to choose whether the coincident frequency analysis assumes variables A and B are independent or dependent. When variables A and B can be assumed independent, there will be only one frequency curve for variable A. A conditional variable A frequency curve assumes variables A and B are not independent, so there will be a separate variable A frequency curve for each variable B index value.



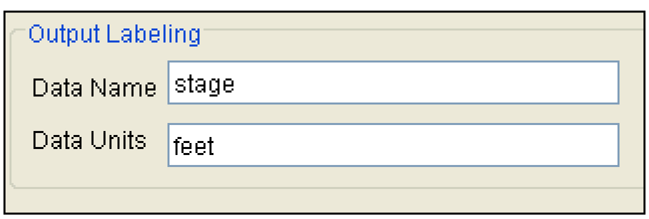
Variable B

This option allows the user to define the number of index values for variable B. The index points are used to discretize the duration curve. A probability, or a proportion of time, will be assigned to each index point.



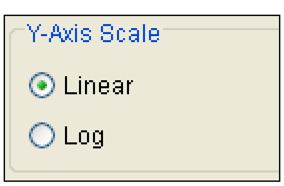
Output Labeling

This option allows the user to enter labels for data contained in the output tables and plots. The user must enter the name of the data as well as the data units. The output labeling does not result in the conversion of data from one unit system to another; it only affects what is displayed on table headings and the y-axis of the results plot.

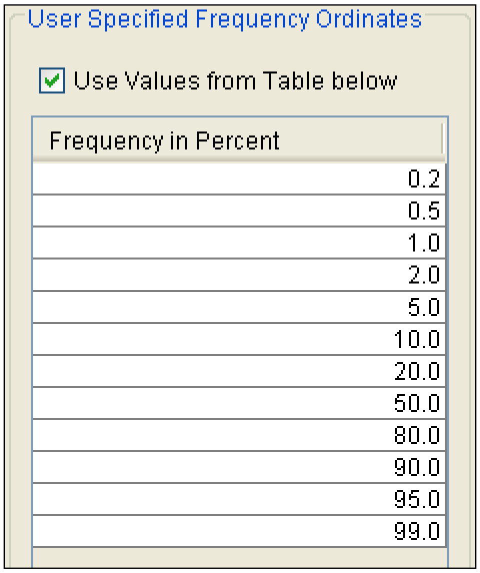


Y-Axis Scale

This option allows the user to choose the scale of the y-axis. The options are **Linear** and **Log**. This option will affect the y-axis scale in the coincident frequency curve plot.



User Specified Frequency Ordinates



This option allows the user to change the frequency ordinates used for creating result tables and graphs. The default values listed in percent chance exceedance are 0.2, 0.5, 1, 2, 5, 10, 20, 50, 80, 90, 95, and 99. Check the box next to **Use Values from Table below** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the frequency values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Use Values from Table below** option is not checked. Finally, all values in the table must be between 0 and 100.

Variable A

The **Variable A** tab is used to define the frequency curve for variable A. This tab will look different based on the user’s selection on the General Tab. The Variable A tab will look like Figure 9-5 when “A and B can be Assumed Independent” is selected on the General tab. Since variables A and B are independent, there will only be one frequency curve for variable A.

As shown in Figure 9-5, the user can choose to define the curve manually or select an existing study analysis. When the **Manual Entry** option is selected, the user must define the **Data Name** and **Data Units**. Then the user must enter the frequency curve for variable A. A frequency curve value must be defined for each percent chance exceedance ordinate in the table. When the **Existing Study Analysis** option is selected, the dropdown list will be active and the user can choose any Bulletin 17B or General Frequency analysis in the HEC-SSP study. The variable A frequency curve table will be populated with the frequency curve when an analysis is selected. The program uses the statistics from the selected analysis and computes the frequency curve that populates the table.

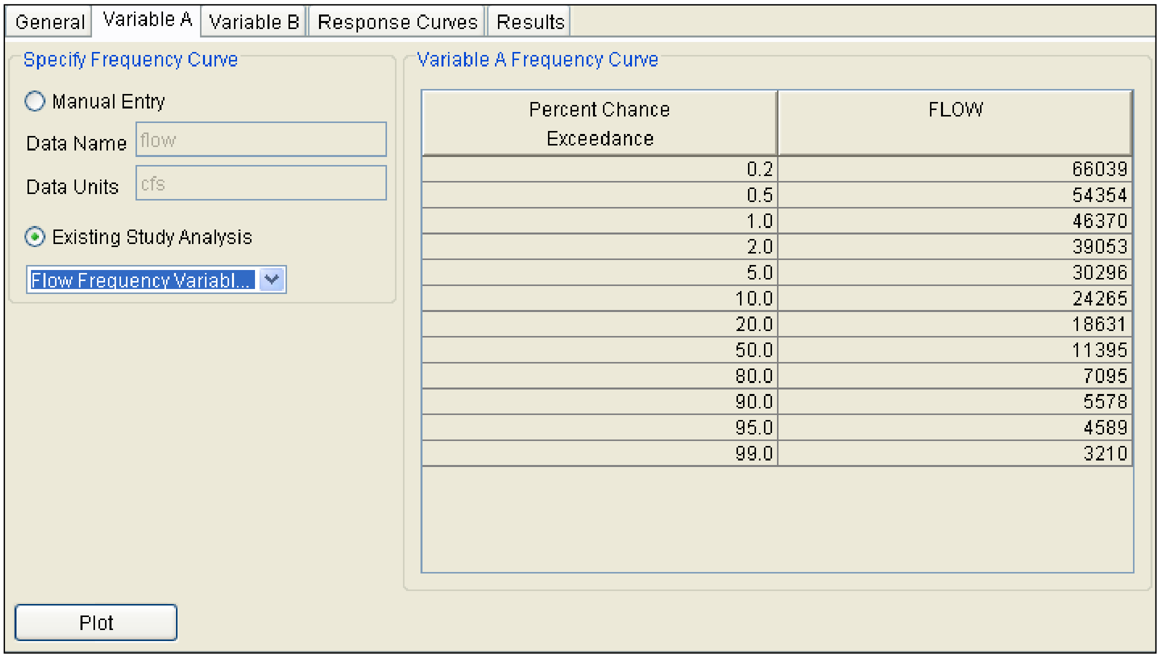
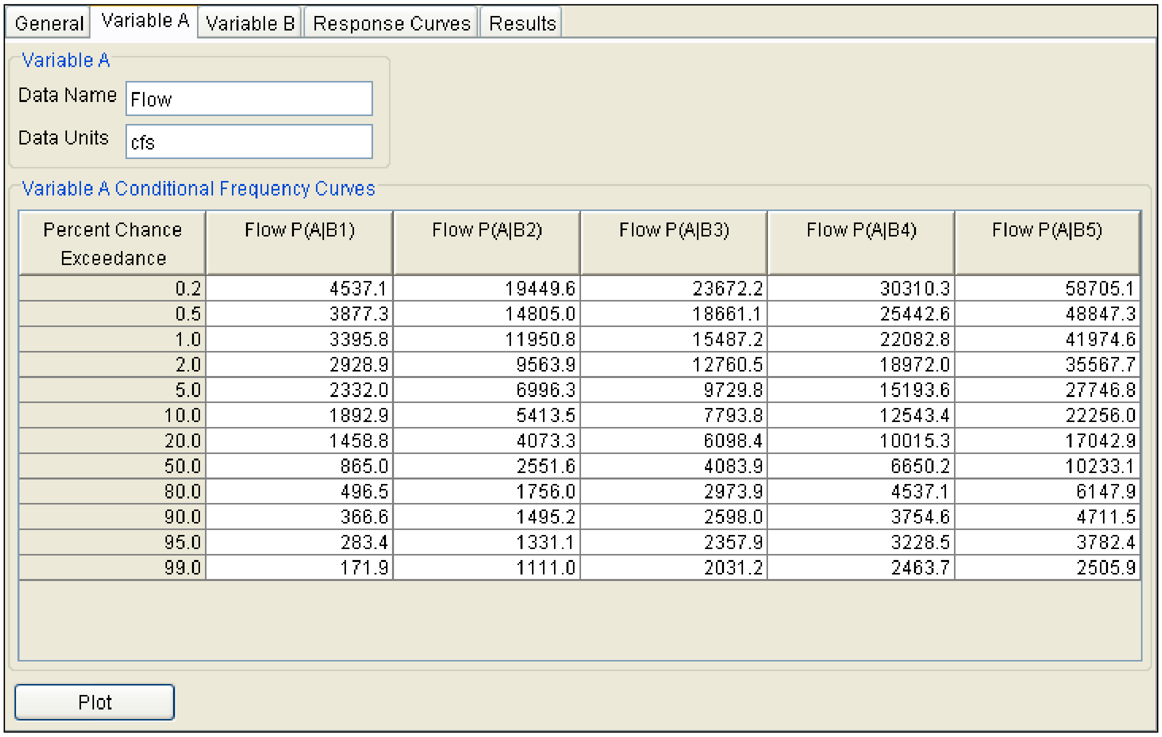


Figure 9-5. Variable A Tab when Variable A and B are Independent.

The Variable A tab will look like Figure 9-6 when "A and B can not be Assumed Independent" is selected on the General tab. A conditional variable A frequency curve assumes variables A and B are not independent, so there will be a separate variable A frequency curve for each variable B index value.

As shown in Figure 9-6, the user must define the **Data Name** and **Data Units**. Then the user must manually enter the variable A frequency curve for each index value of variable B. This involves extracting the annual peak values for variable A that occur for each discrete range identified on the variable B duration curve and performing a separate frequency analysis on each set of variable A data. Also, a frequency curve value must be defined for each Percent Chance Exceedance ordinate in the table.



Percent Chance Exceedance	Flow P(A|B1)	Flow P(A|B2)	Flow P(A|B3)	Flow P(A|B4)	Flow P(A|B5)
0.2	4537.1	19449.6	23672.2	30310.3	58705.1
0.5	3877.3	14805.0	18661.1	25442.6	48847.3
1.0	3395.8	11950.8	15487.2	22082.8	41974.6
2.0	2928.9	9563.9	12760.5	18972.0	35567.7
5.0	2332.0	6996.3	9729.8	15193.6	27746.8
10.0	1892.9	5413.5	7793.8	12543.4	22256.0
20.0	1458.8	4073.3	6098.4	10015.3	17042.9
50.0	865.0	2551.6	4083.9	6650.2	10233.1
80.0	496.5	1756.0	2973.9	4537.1	6147.9
90.0	366.6	1495.2	2598.0	3754.6	4711.5
95.0	283.4	1331.1	2357.9	3228.5	3782.4
99.0	171.9	1111.0	2031.2	2463.7	2505.9

Figure 9-6. Variable A Tab when Variable A and B are not Independent.

Press the **Plot** button located at the lower left corner of the Variable A tab to open a plot of the variable A frequency curve(s).

Variable B

The **Variable B** tab is used to define the duration curve for variable B and the index points with an associated probability. The index points will be used by the user when developing the response curves (response of variable C to each combination of variables A and B). The associated probability represents the proportion of time that each index point can be expected to occur.

As shown in Figure 9-7, the left side of the variable B tab is used to select the duration curve from an existing Duration Curve analysis. Once selected, the program populates the duration curve table. Press the **Plot** button located at the lower left corner of the Variable B tab to open a plot of the variable B duration curve.

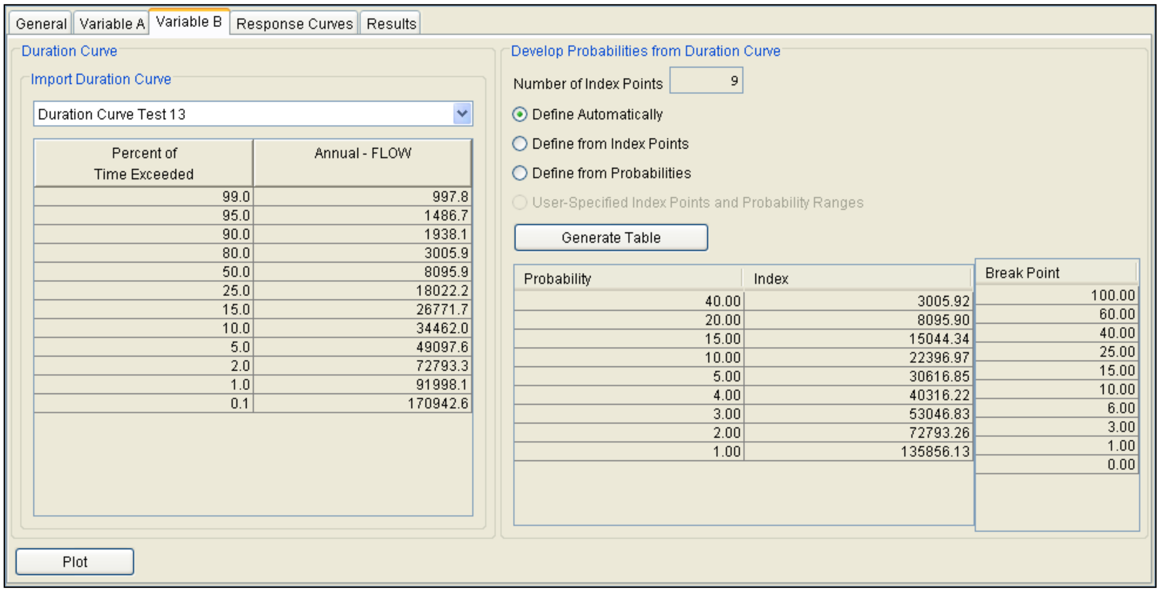


Figure 9-7. Variable B Tab.

After the duration curve has been selected, the right side of the variable B tab is used to define the index points and associated probabilities used to discretize the duration curve. The number of index points is defined on the General tab and is included on the Variable B tab to let the user know how many index points must be defined in the table. There are 4 methods for defining the index values and the associated probabilities. The user selects one of the methods, edits the table, and then clicks the **Generate Table** button in order for the program to finish populating the table. The following text describes each method.

Define Automatically. The program will use a predefined pattern of probability ranges when this option is selected, as contained in Table 9-1, to populate the **Probability** column. The pattern is dependent on the number of index points and the default probability patterns do not extend beyond nine index points. If more than nine index points have been selected for the analysis, then use one of the other methods for defining the index points and associated probabilities. The program will compute the **Index** and **Break Point** columns when the **Generate Table** button is pressed. The **Break Point** column is computed using the probability pattern. The first row in this column is always 100. The second break point is computed by subtracting the first probability value from the first break point value. The third break point is computed by subtracting the second probability value from the second break point value. This procedure is followed until the last break point is computed; it should always have a value of 0. The **Index** values are taken from the duration curve at the midpoint between each break point range. For example, if the first break point was 100 and the second was 60 then the first **Index** value would be the value from the duration curve at 80 percent time exceeded.

Table 9-1. Default Probability Patterns.

	Number of Index Points						
Index	3	4	5	6	7	8	9
1	20	15	45	35	35	35	40
2	60	35	40	30	25	20	20
3	10	35	10	20	20	15	15
4		15	4	10	10	10	10
5			1	4	6	10	5
6				1	3	6	4
7					1	3	3
8						1	3
9							1

Define from Index Points. The number of rows is set by the number of index points. In this case, the **Index** column is edited by the user; the user must enter an index value in each row. When the **Generate Table** button is pressed, the program will compute the **Break Point** and the **Probability** values. First, the program will use the selected duration curve and interpolate a percent of time exceeded for each user-defined index value. Then break points are computed so that they are half way between the percent of time exceeded values (the first and last break points will be 100 and 0). The probability values are computed based on the break points. For example, the first probability value is computed by subtracting the second break point value from the first. The second probability value is computed by subtracting the third break point value from the second. This procedure is followed until the last probability value is computed.

Define from Probabilities. The number of rows is set by the number of index points. In this case, the **Probability** column is edited by the user; the user must enter a probability value in each row (the probability values should add up to 100). When the **Generate Table** button is pressed, the **Break Point** column is computed using the user-entered probability pattern. For example, the first row in the break point column is 100; therefore, the second break point is computed by subtracting the first probability value from the first break point value. The third break point is computed by subtracting the second probability value from the second break point value. This procedure is followed until the last break point is computed; it should always have a value of 0. The **Index** values are taken from the duration curve at the midpoint between each break point range. For example, if the first break point was 100 and the second was 60 then the first **Index** value would be the value from the duration curve at 80 percent time exceeded.

User-Specified Index Points and Probability Ranges. This option can only be selected when the user does not select an existing Duration Curve to import. This would be applicable for the case where the user developed the duration curve outside of HEC-SSP and developed the index points and associated probabilities. As shown in Figure 9-8, the user must specify both the **Probability** and **Index** values; the user must enter values in each row. When the **Generate Table** button is pressed, the **Break Point** column is computed using the user-entered probability pattern. For example, the first row in the break point column is 100; therefore, the second break point is computed by subtracting the first probability value from the first break point value. The third break point is computed by subtracting the second probability value from the second break point value. This procedure is followed until the last break point is computed; it should always have a value of 0.

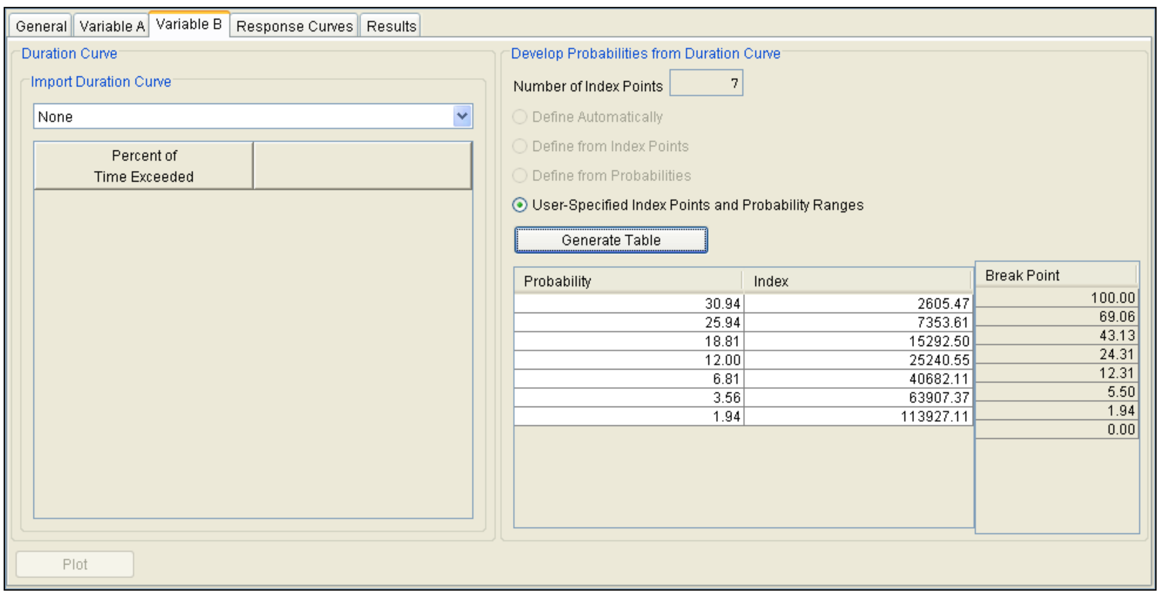


Figure 9-8. User-Specified Option to Define Index Points and Probability Ranges.

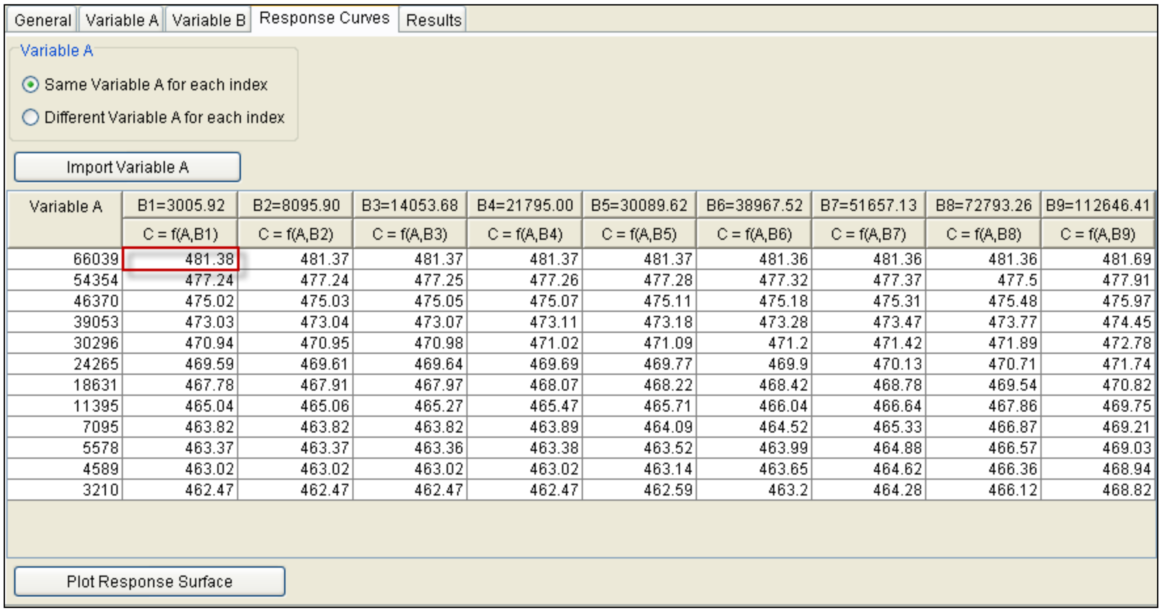
Response Curves

The Response Curves tab is used to define the response of variable C to each combination of variable A and variable B. This analysis is performed outside of HEC-SSP. For example, a hydraulics model could be used to apply flow values from the variable A frequency curve to the tributary and the index flow (or stage) from the variable B duration curve would be applied to the mainstem. The hydraulics model would be used to compute the variable C stage at some reference point on the tributary for multiple combinations of variable A and variable B. The peak variable C stage is the value to input into the Response Curves table.

As shown in Figure 9-9, there are two options for the Response Curves table; **Same Variable A for each index** or **Different Variable A for each index**. When the **Same Variable A for each index** option is selected, there is only one **Variable A** column in the response curves table. The user can manually fill in the values for Variable A or press the **Import Variable A** button. When the button is pressed, the program will import the values on the Variable A tab. The user can edit the Variable A values after they are imported. When the **Different Variable A for each index** option is selected, there is a separate **Variable A** column for each variable B index value, as shown in Figure 9-10. The user can manually fill in the values for Variable A or press the **Import Variable A** button. When the button is pressed, the program will import the values from the Variable A tab. The user can edit the Variable A values after they are imported. In most cases, the Different Variable A for each index options will be used when performing a conditional analysis (variables A and B can not be assumed independent). In this case, a separated variable A frequency curve was defined for each variable B index value; therefore, when the **Import Variable A** button is pressed the program will import the corresponding frequency curve into the response curves table.

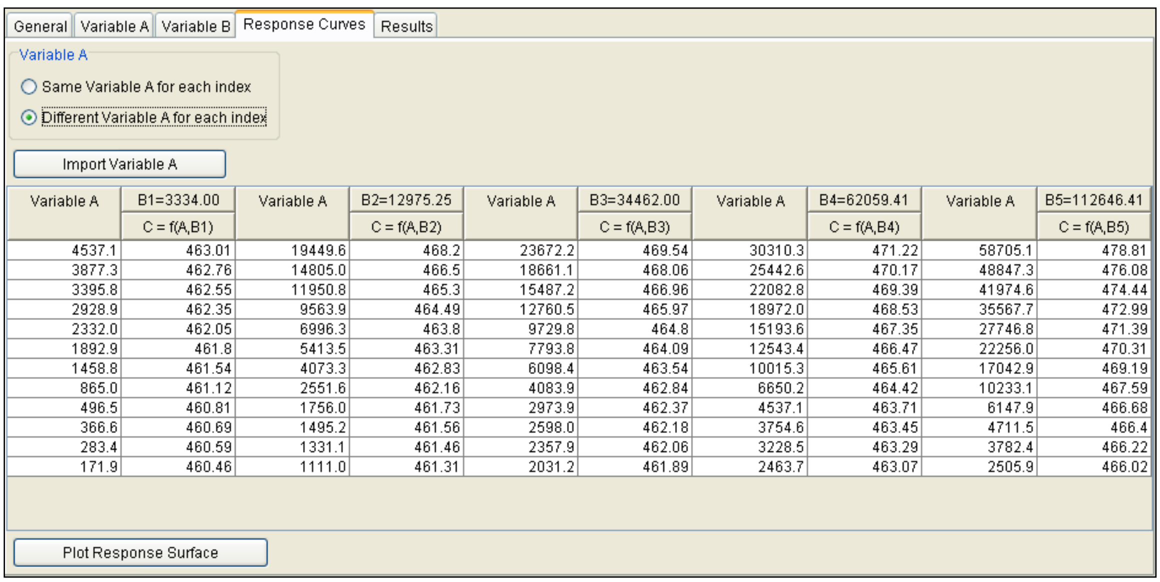
The user must compute the variable C value given the combinations of variables A and B. Figure 9-9 contains 12 values of variable A and 9 index values for variable B. Therefore, the user would have 108 combinations of variables A and B to compute values of variable C. Once computed, the user would manually enter the variable C values into the response curves table. For example, the first value in the first variable C column in Figure 9-9 is 481.38. This was computed using a variable A value of 66039 and a variable B value of 3005.92.

The **Plot Response Surface** button will open a plot similar to the one shown in Figure 9-11. Each line in the response surface plot shows the variable C versus variable A relationship for a given variable B index value.



Variable A	B1=3005.92	B2=8095.90	B3=14053.68	B4=21795.00	B5=30089.62	B6=38967.52	B7=51657.13	B8=72793.26	B9=112646.41
	C = f(A,B1)	C = f(A,B2)	C = f(A,B3)	C = f(A,B4)	C = f(A,B5)	C = f(A,B6)	C = f(A,B7)	C = f(A,B8)	C = f(A,B9)
66039	481.38	481.37	481.37	481.37	481.37	481.36	481.36	481.36	481.69
54354	477.24	477.24	477.25	477.26	477.28	477.32	477.37	477.5	477.91
46370	475.02	475.03	475.05	475.07	475.11	475.18	475.31	475.48	475.97
39053	473.03	473.04	473.07	473.11	473.18	473.28	473.47	473.77	474.45
30296	470.94	470.95	470.98	471.02	471.09	471.2	471.42	471.89	472.78
24265	469.59	469.61	469.64	469.69	469.77	469.9	470.13	470.71	471.74
18631	467.78	467.91	467.97	468.07	468.22	468.42	468.78	469.54	470.82
11395	465.04	465.06	465.27	465.47	465.71	466.04	466.64	467.86	469.75
7095	463.82	463.82	463.82	463.89	464.09	464.52	465.33	466.87	469.21
5578	463.37	463.37	463.36	463.38	463.52	463.99	464.88	466.57	469.03
4589	463.02	463.02	463.02	463.02	463.14	463.65	464.62	466.36	468.94
3210	462.47	462.47	462.47	462.47	462.59	463.2	464.28	466.12	468.82

Figure 9-9. Response Curves Tab for Same Variable A for Each Variable B Index.



Variable A	B1=3334.00	Variable A	B2=12975.25	Variable A	B3=34462.00	Variable A	B4=62059.41	Variable A	B5=112646.41
	C = f(A,B1)		C = f(A,B2)		C = f(A,B3)		C = f(A,B4)		C = f(A,B5)
4537.1	463.01	19449.6	468.2	23672.2	469.54	30310.3	471.22	58705.1	478.81
3877.3	462.76	14805.0	466.5	18661.1	468.06	25442.6	470.17	48847.3	476.08
3395.8	462.55	11950.8	465.3	15487.2	466.96	22082.8	469.39	41974.6	474.44
2928.9	462.35	9563.9	464.49	12760.5	465.97	18972.0	468.53	35567.7	472.99
2332.0	462.05	6996.3	463.8	9729.8	464.8	15193.6	467.35	27746.8	471.39
1892.9	461.8	5413.5	463.31	7793.8	464.09	12543.4	466.47	22256.0	470.31
1458.8	461.54	4073.3	462.83	6098.4	463.54	10015.3	465.61	17042.9	469.19
865.0	461.12	2551.6	462.16	4083.9	462.84	6650.2	464.42	10233.1	467.59
496.5	460.81	1756.0	461.73	2973.9	462.37	4537.1	463.71	6147.9	466.68
366.6	460.69	1495.2	461.56	2598.0	462.18	3754.6	463.45	4711.5	466.4
283.4	460.59	1331.1	461.46	2357.9	462.06	3228.5	463.29	3782.4	466.22
171.9	460.46	1111.0	461.31	2031.2	461.89	2463.7	463.07	2505.9	466.02

Figure 9-10. Response Curves Tab for Different Variable A for Each Variable B Index.

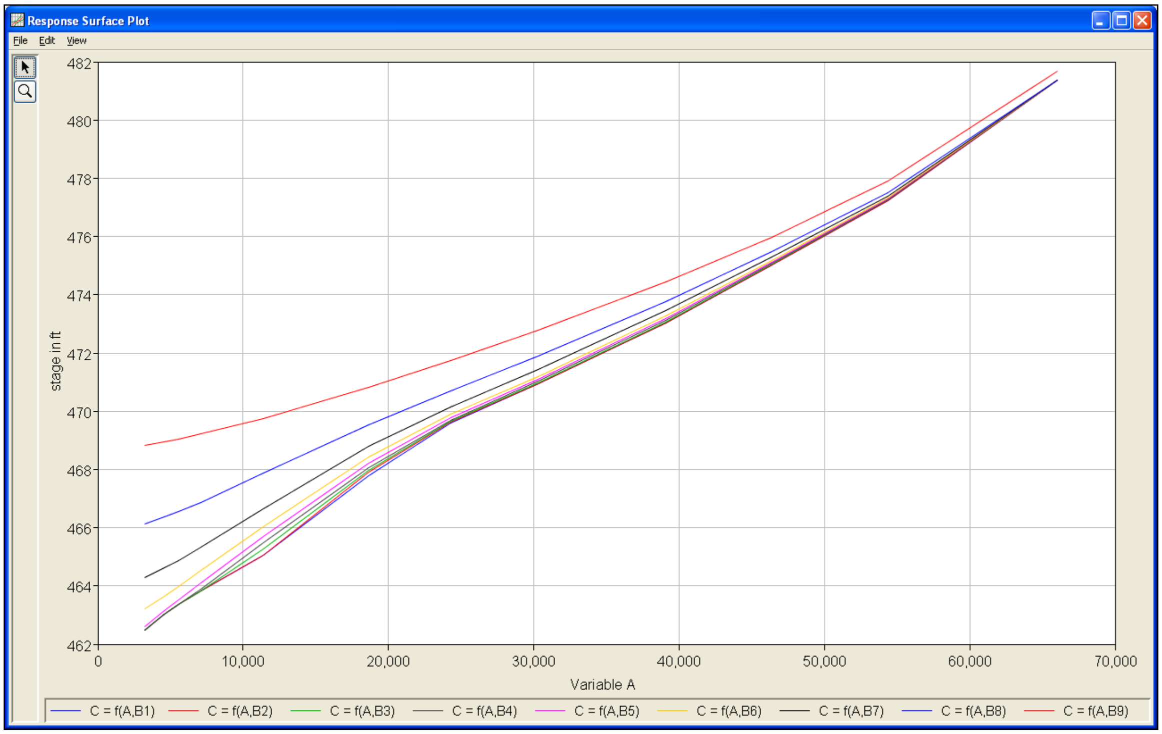


Figure 9-11. Plot of Response Curves.

Compute

Once the new analysis has been defined, and the user has all of the information defined on the General, Variable A, Variable B, Response Curves tabs, performing the computations is simply a matter of pressing the **Compute** button at the bottom of the Coincident Frequency Analysis editor. If the computations are successful, the user will receive a message that says "Compute Complete". At this point, the user can begin to review the results.

The following describes how the variable C coincident frequency curve is computed.

1) The program uses the variable A frequency curve(s) and the variable A values in the response curves table to assign a frequency of exceedance to each variable C value in the response curves table.

2) The program finds the minimum and maximum values of variable C in the response curves table.

3) The program defines 100 evenly spaced values of variable C in-between the minimum and maximum values (100 values include the minimum and maximum values).

4) For each variable C from step 3, the program will look-up the exceedance frequency value from each response curve in step 1 and multiply by the corresponding proportion of time (using the probability defined on the Variable B tab) obtained from the variable B index value. These “weighted” values from each response curve are summed to compute the variable C frequency curve.

5) The curve is interpolated to the selected exceedance ordinates defined on the General tab.

Multiple coincident frequency analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finishes computing the analyses.

Results

This section of the manual describes results that are available for the Coincident Frequency analysis. When the user selects the **Results** tab on the Coincident Frequency Analysis editor, the window will appear as shown in Figure 9-12. Both tabular and graphical results are included. The percent chance exceedance ordinates are the same as those defined on the General tab. In addition, the Data Name and Data Units defined on the General tab are used in the column header in the results table and the y-axis label in the plot.

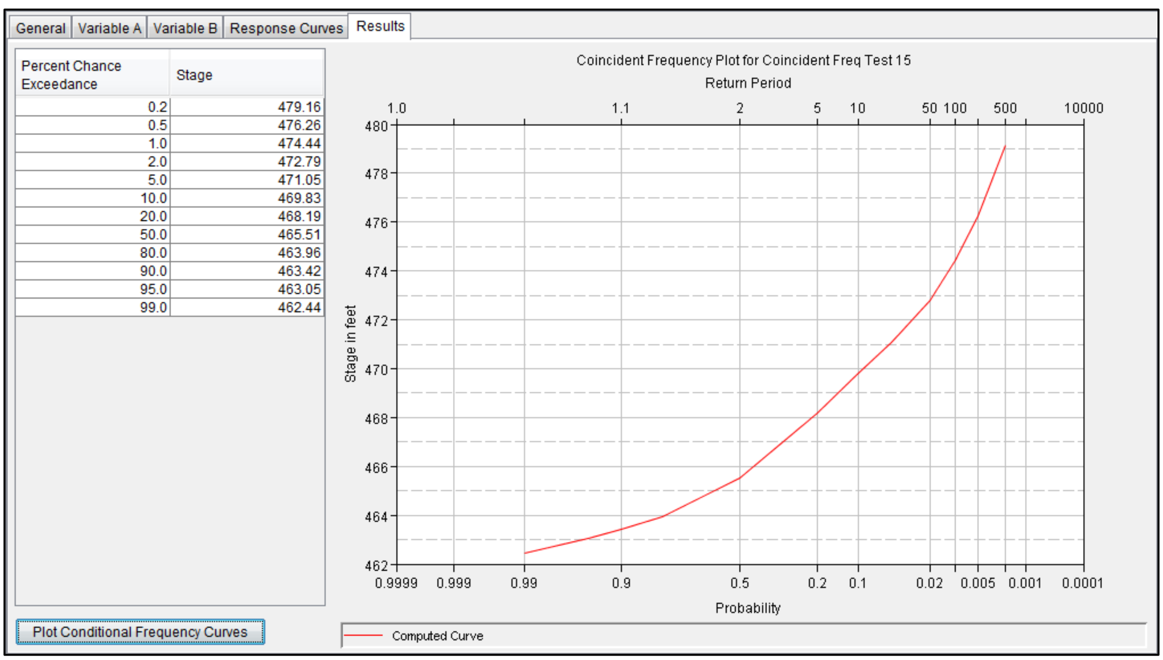


Figure 9-12. Results Tab of the Coincident Frequency Analysis Editor.

By pressing the **Plot Condition Frequency Curves**, the user can plot the response curves entered on the **Response Curves** tab along with the computed curve and the upper and lower accurate limits.

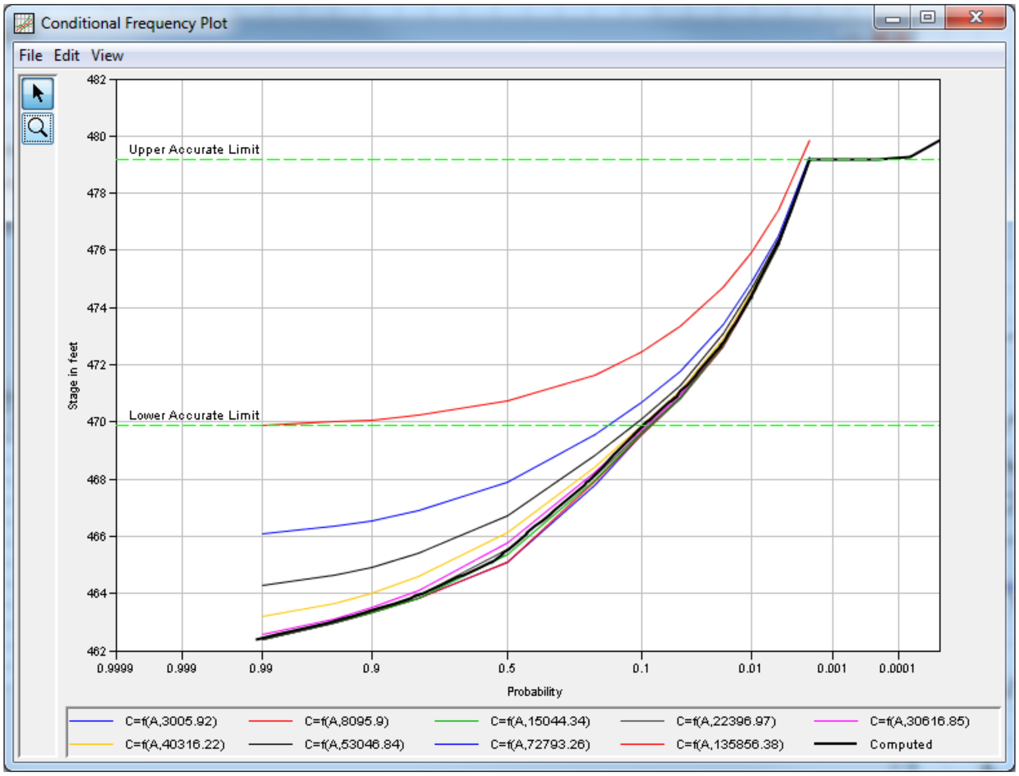


Figure 9-13. Plot of Conditional Frequency Curves.

Data in the frequency curve table can be re-sorted. Click the **Percent Chance Exceedance** column header (two mouse clicks are required the first time). The percent chance exceedance ordinates, along with frequency values, will sort so that the lowest values are on top or the highest values are on top.

Viewing and Printing Results

The user can view output for the coincident frequency analysis directly from the Coincident Frequency Analysis editor (tabular and graphical output) or by using the buttons at the bottom of the editor.

Tabular Output

Once the computations for the coincident frequency analysis are completed, the user can view tabular output by selecting the **Results** tab. The tabular results can be printed by using the **Print** button at the bottom of the coincident frequency analysis editor. When the print button is pressed, a window will appear giving the user options for how they would like the table to be printed. Result tables can also be created from the **Results** menu. At least one coincident frequency analysis must be selected in the study explorer before selecting the **Results→Table** option.

Graphical Output

Graphical output of the coincident frequency analysis can be obtained by selecting either the **Results** tab, or by pressing the **Plot** button at the bottom of the coincident frequency analysis editor. When the Plot button is pressed, a frequency curve plot will appear in a separate window as shown in Figure 9-14. Result graphs can also be created from the **Results** menu. At least one coincident frequency analysis must be selected in the study explorer before selecting the **Results→Graph** option. Results will be graphed in the same plot if multiple coincident frequency analyses are selected in the study explorer when opening a graph from the **Results** menu.

The coincident frequency curve plot can be sent to the printer by selecting the **Print** option from the **File** menu at the top of the window. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The graphic can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file. Currently four file formats are available for saving the graphic to disk: windows metafile, postscript, JPEG, and portable network graphic.

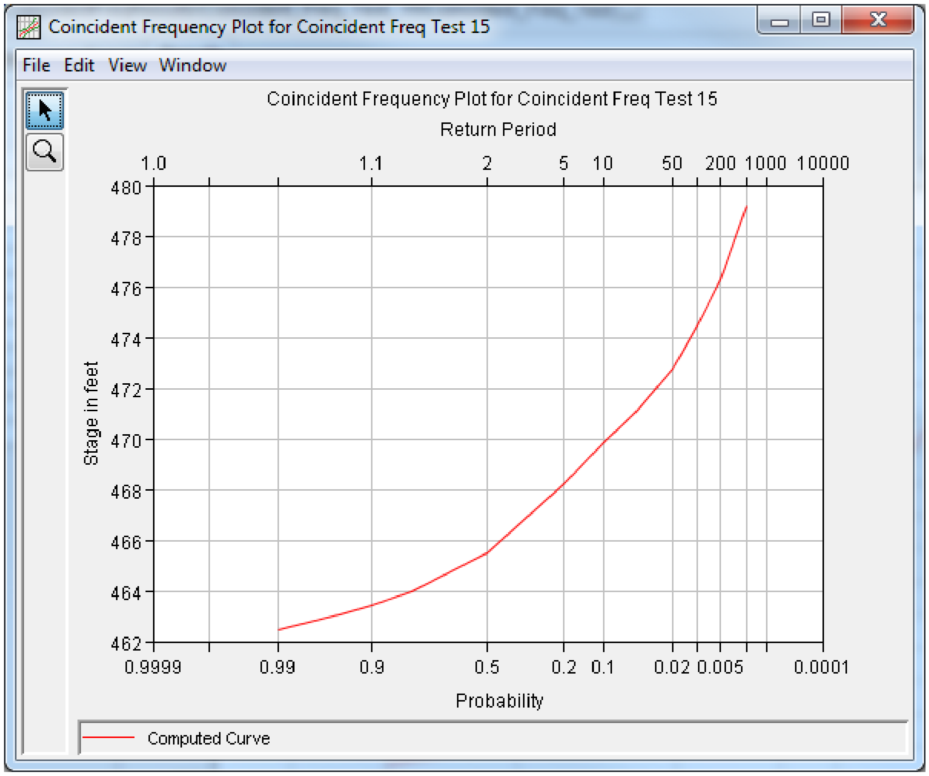


Figure 9-14. Coincident Frequency Analysis Plot.

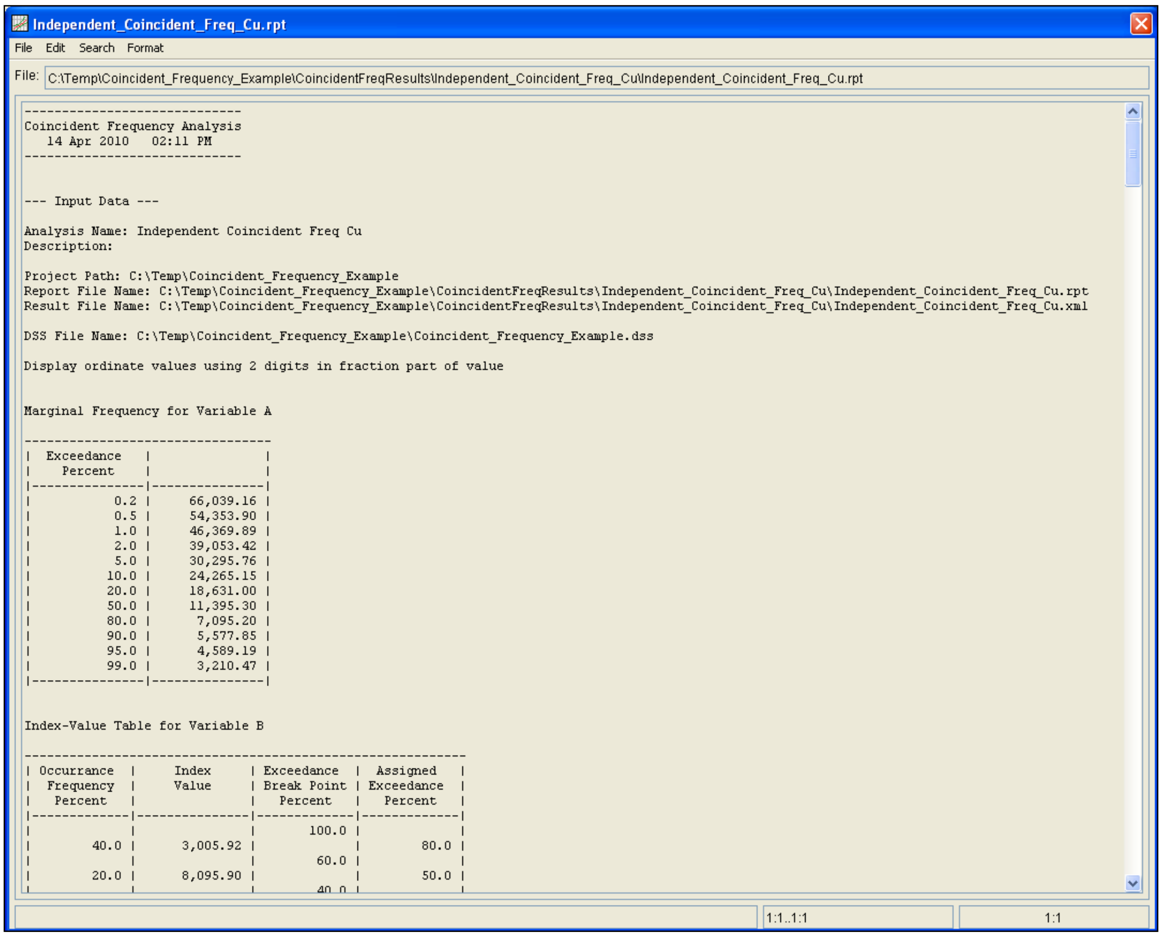
The data contained within the plot can also be tabulated by selecting **Tabulate** from the File menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the plot options as a template (**Save Template)** and applying previously saved templates to the current plot (**Apply Template**).

The **Edit** menu contains several options for customizing the graphic. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties. Also, a shortcut menu will appear with further customizing options when the user right-clicks on a line on the graph or the legend. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis. The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing plots in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User’s Manual for details on customizing plots.

Viewing the Report File

A report file is created when the coincident frequency analysis computations are performed. The report file lists the input data, user settings, and the final results. This file is often useful for understanding how the software arrived at the final frequency curve.

To view the report file press the **View Report** button at the bottom of the Coincident Frequency Analysis editor. When this button is pressed, a window will appear containing the report as shown in Figure 9-15.



```
Independent_Coincident_Freq_Cu.rpt
File  Edit  Search  Format
File: C:\Temp\Coincident_Frequency_Example\CoincidentFreqResults\Independent_Coincident_Freq_Cu\Independent_Coincident_Freq_Cu.rpt

-----------------------------
Coincident Frequency Analysis
   14 Apr 2010    02:11 PM
-----------------------------


--- Input Data ---

Analysis Name: Independent Coincident Freq Cu
Description:

Project Path: C:\Temp\Coincident_Frequency_Example
Report File Name: C:\Temp\Coincident_Frequency_Example\CoincidentFreqResults\Independent_Coincident_Freq_Cu\Independent_Coincident_Freq_Cu.rpt
Result File Name: C:\Temp\Coincident_Frequency_Example\CoincidentFreqResults\Independent_Coincident_Freq_Cu\Independent_Coincident_Freq_Cu.xml

DSS File Name: C:\Temp\Coincident_Frequency_Example\Coincident_Frequency_Example.dss

Display ordinate values using 2 digits in fraction part of value


Marginal Frequency for Variable A

---------------------------------
|  Exceedance   |               |
|    Percent    |               |
|---------------|---------------|
|           0.2 |     66,039.16 |
|           0.5 |     54,353.90 |
|           1.0 |     46,369.89 |
|           2.0 |     39,053.42 |
|           5.0 |     30,295.76 |
|          10.0 |     24,265.15 |
|          20.0 |     18,631.00 |
|          50.0 |     11,395.30 |
|          80.0 |      7,095.20 |
|          90.0 |      5,577.85 |
|          95.0 |      4,589.19 |
|          99.0 |      3,210.47 |
|---------------|---------------|


Index-Value Table for Variable B

-----------------------------------------------------------
| Occurrance  |     Index      | Exceedance  |  Assigned   |
|  Frequency  |     Value      | Break Point | Exceedance  |
|   Percent   |                |   Percent   |   Percent   |
|-------------|----------------|-------------|-------------|
|             |                |       100.0 |             |
|        40.0 |       3,005.92 |             |        80.0 |
|             |                |        60.0 |             |
|        20.0 |       8,095.90 |             |        50.0 |
|             |                |        40.0 |             |

1:1..1:1        1:1
```

Figure 9-15. Coincident Frequency Analysis Report File.

CHAPTER 10

Performing a Balanced Hydrograph Analysis

The current version of HEC-SSP allows the user to compute balanced hydrographs. In this type of analysis, observed data, flow, and volume-frequency curves are used to create a hypothetical hydrograph that "balances" flow rates, volumes, and frequency. Within a balanced hydrograph, the flow and/or volume across multiple durations satisfies the relation between flow/volume and duration for a given frequency. For example, a 5-day 0.2 percent annual chance exceedance (ACE) balanced hydrograph would have individual hydrograph ordinates arranged in such a way that the flow volumes for the 1-hr, 1-day, …, 5-day durations would each equal the 0.2 percent ACE flow rates and/or volumes. Although such hydrographs do not necessarily preserve the random character of natural hydrographs, use of balanced hydrographs ensures an appropriate flow rate and/or volume (in terms of frequency), regardless of the characteristics of a particular watershed or location. This chapter discusses in detail how to use the Balanced Hydrograph Analysis editor within HEC-SSP.

Contents

Starting a New Analysis

A balanced hydrograph analysis can be started in two ways, either by right clicking on the Balanced Hydrograph Analysis folder in the study explorer and selecting **New**, or by going to the **Analysis** menu and selecting **New** and then **Balanced Hydrograph Analysis**. When a new balanced hydrograph analysis is selected, the Balanced Hydrograph Analysis Editor will appear as shown in Figure 10-1.

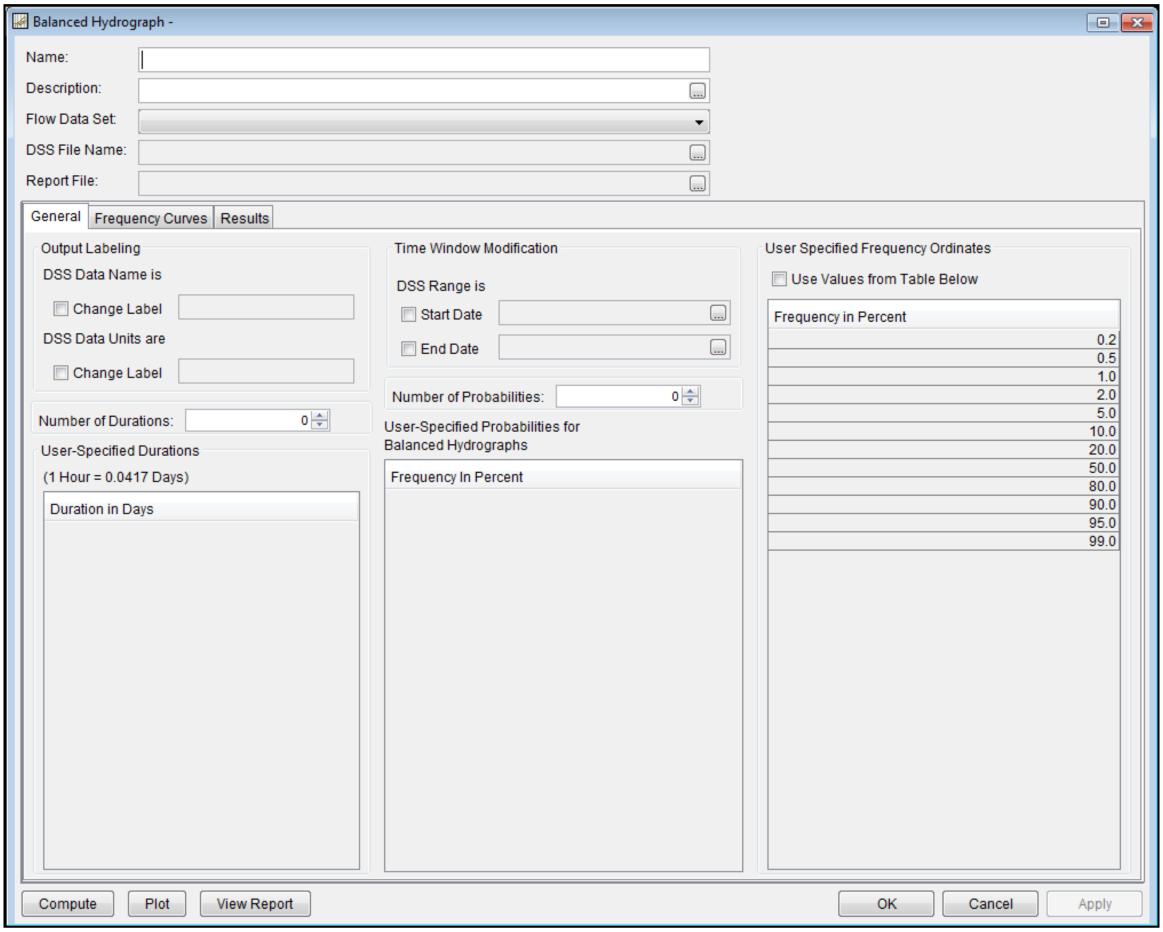


Figure 10-1. Balanced Hydrograph Analysis Editor.

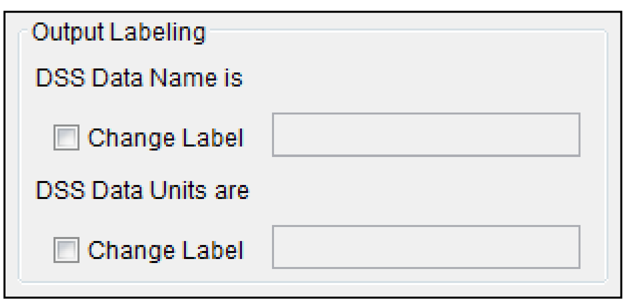
The user is required to enter a **Name** for the analysis, while a **Description** is optional. A **Flow Data Set** must be selected from the available datasets stored within the current study DSS file. This flow data set could be comprised of daily measurements or those of a shorter duration. Generally speaking, shorter duration datasets (such as 1HOUR or 15MIN) should be used in lieu of daily durations (see Chapter 4 for importing flow data into the study). The list of data that can be selected for a balanced hydrograph analysis will only include those data that have a regular interval, like 15MIN, 1HOUR, or 1DAY (E-Part pathname). Once a Name is entered, the **DSS File Name** and **Report File** will automatically be filled out. The DSS filename is by default the study DSS file. The report file is given the same name as the analysis with the extension ".rpt".

General Settings

Once the analysis name has been entered, the user can begin to perform the analysis. Contained on the Balanced Hydrograph Analysis editor are three tabs. The tabs are labeled **General**, **Frequency Curves**, and **Results**. The first tab contains general settings for performing the balanced hydrograph analysis (Figure 10-1). These settings include:

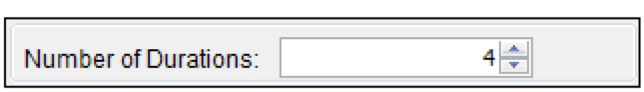
- Output Labeling
- Number of Durations
- User-Specified Durations
- Time Window Modification
- Number of Probabilities
- User-Specified Probabilities for Balanced Hydrographs
- User Specified Frequency Ordinates

Output Labeling



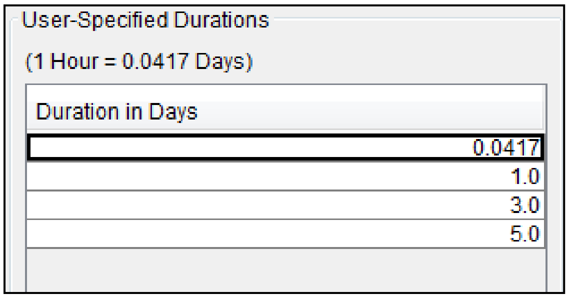
This option allows the user to change the default labels for data contained in the output tables and plots. The user can change both the name of the data as well as the units of the data. The output labeling does not result in the conversion of data from one unit system to another; it only affects what is displayed on table headings and the y-axis of the results plot.

Number of Durations



This option allows the user to set the number of frequency curve durations that will be used to construct the balanced hydrographs. The number entered will modify the number of rows contained within the User-Specified

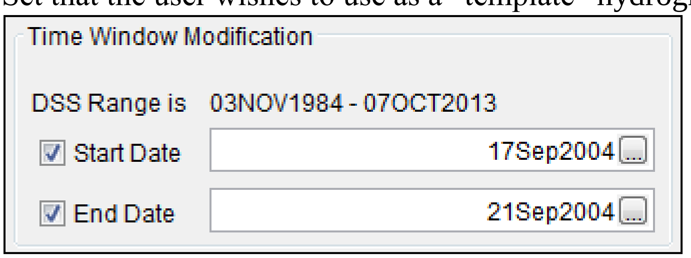
Durations. Typically, balanced hydrographs are constructed using more than one duration. However, as the number of durations is increased, the resulting hydrographs will preserve less of the random character of natural hydrographs. At a minimum, the number of durations must be set equal to one.



The **User-Specified Durations** table automatically adjusts the number of rows based on the defined number of durations. After the user sets the number of durations, the user must input the durations for which the balanced hydrographs will be created. The program will arrange hydrograph ordinates to "balance" the flow-durations (i.e. volumes) using the durations defined within this table. Note that the units for each duration is days. For example, a one hour duration is equivalent to 0.0417 days.

There are no default durations. A typical listing of durations includes both shorter and longer durations. Durations should be listed in descending order with shorter durations listed first followed by longer durations. The smallest duration should be equal to or greater than the time step of the input flow data set. For example, a 1DAY flow data set cannot be used in conjunction with a specified duration of 0.0417 days.

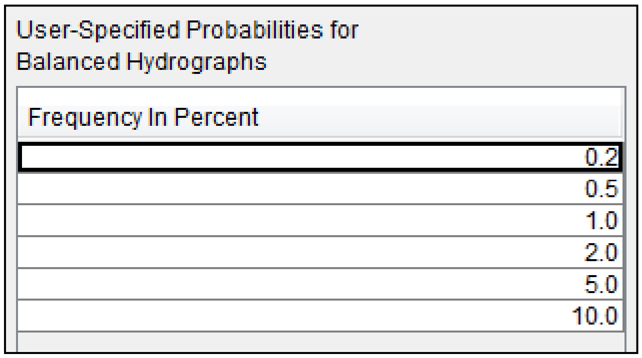
Time Window Modification



This option allows the user to define a time window used for the analysis. The time window should correspond to the period within the Flow Data Set that the user wishes to use as a "template" hydrograph shape. The default is to use all of the data contained within the selected data set. If the default time window is used, HEC-SSP will identify the event with the greatest peak flow rate within the selected flow data set and use that as the "template" hydrograph shape. If a start and/or end date are used, they must be dates that are contained within the data stored in the selected data set. The date range for the selected data set is shown in the editor just above the **Start Date** field.

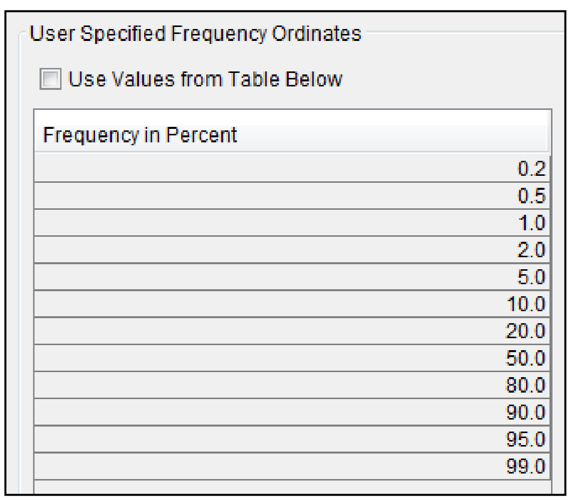
Number of Probabilities

This option lets the user choose the number of probabilities that will be used to construct the balanced hydrographs. The default setting is “1” probability. Using the default will result in the creation of a single balanced hydrograph.



The **User-Specified Probabilities** table automatically adjusts the number of rows based on the defined number of probabilities. After the user sets the number of probabilities, the user must input the probabilities for the balanced hydrograph analysis. This listing should be entered in ascending order (i.e. 0.2, 0.5, 1.0, etc). The input listing cannot use frequencies outside of the User Specified Frequency Ordinates. The input frequencies should have units of percent.

User Specified Frequency Ordinates



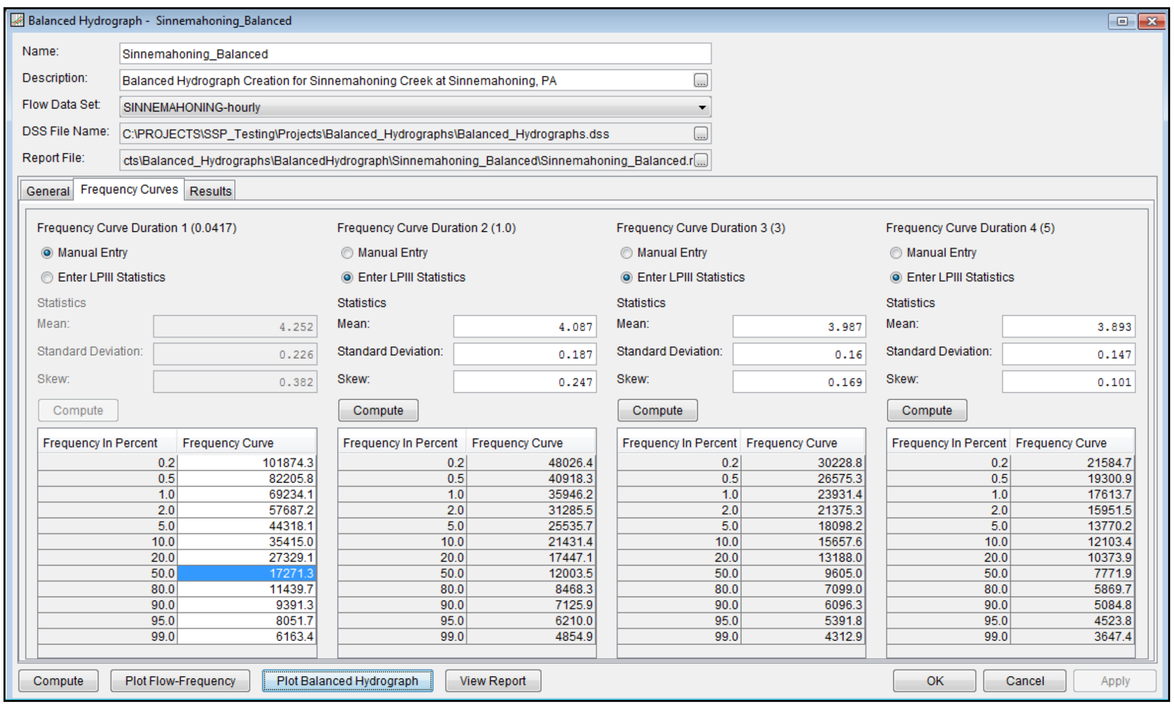
This option allows the user to change the frequency ordinates used for creating result tables and graphs. The default values listed in percent chance exceedance are 0.2, 0.5, 1, 2, 5, 10, 20, 50, 80, 90, 95, and 99. Check the box next to **Use Values from Table below** to change or add additional values. Once this box is checked, the user can add/remove rows and edit the frequency values. To add or remove a row from the table, select the row(s), place the mouse over the highlighted row(s) and click the right mouse button. The shortcut menu contains options to **Insert Row(s)** and **Delete Row(s)**. The program will use the default values, even if they are not contained in the table, when the **Use Values from Table below** option is not checked. Finally, all values in the table must be between 0 and 100.

Frequency Curves

The Frequency Curves tab is used to define the flow- frequency curves for the User-Specified Durations. As shown in Figure 10-2, the Frequency Curves tab contains a panel for each frequency curve; the number of frequency curves is defined in the General tab. Two options are available to define these flow-frequency curves. First, the user can input the flow-frequency information for *all* of the frequency ordinates. Second, the user can input the Log-Pearson III statistics (mean, standard deviation, and skew). Both forms of input can be determined using pre-determined flow- and/or volume-frequency analyses (i.e. Bulletin 17B, Bulletin 17C, Volume-Frequency, etc).

The **Plot Flow-Frequency** 

button will open a graph showing all flow-frequency curves defined on the frequency curves tab as well as the Flow Data Set, as show in Figure 10-3.



Frequency In Percent	Duration 1 Frequency Curve	Duration 2 Frequency Curve	Duration 3 Frequency Curve	Duration 4 Frequency Curve
0.2	101874.3	48026.4	30228.8	21584.7
0.5	82205.8	40918.3	26575.3	19300.9
1.0	69234.1	35946.2	23931.4	17613.7
2.0	57687.2	31285.5	21375.3	15951.5
5.0	44318.1	25535.7	18098.2	13770.2
10.0	35415.0	21431.4	15657.6	12103.4
20.0	27329.1	17447.1	13188.0	10373.9
50.0	17271.3	12003.5	9605.0	7771.9
80.0	11439.7	8468.3	7099.0	5869.7
90.0	9391.3	7125.9	6096.3	5084.8
95.0	8051.7	6210.0	5391.8	4523.8
99.0	6163.4	4854.9	4312.9	3647.4

Figure 10-2. Balanced Hydrograph Analysis Frequency Curves Tab.

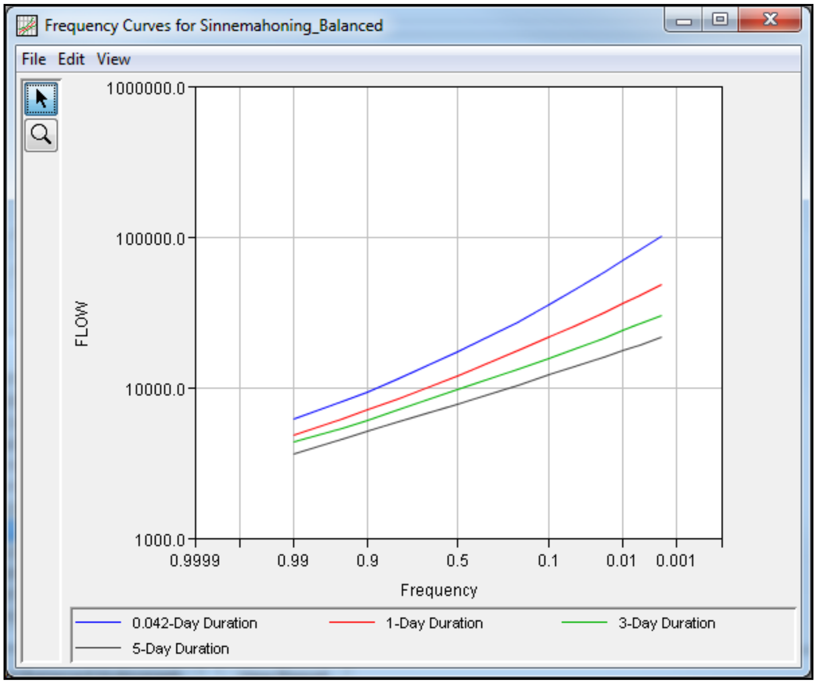


Figure 10-3. Plot of Frequency Curves Defined in the Frequency Curves Tab.

Compute

Press the **Compute** button, located at the bottom of the Balanced Hydrograph Analysis editor, once options have been set on the General and Frequency Curves tabs. If the compute is successful, the user will receive a message that says **Compute Complete**. At this point, the user can begin to review the results.

Multiple Balanced Hydrograph analyses can be computed using the **Compute Manager**. Select the **Analysis→Compute Manager** menu option to open the Compute Manager. Select the analyses to be computed and then press the **Compute** button. Close the compute dialogs and Compute Manager when the program finishes computing the analyses.

Results

This section describes results that are available for the Balanced Hydrograph analysis. When the user selects the **Results** tab on the Balanced Hydrograph Analysis editor, the window will appear as shown in Figure 10-4. Both tabular and graphical results are included. The durations and probabilities for the balanced hydrographs are the same as those defined on the **General** tab. In addition, when the Data Name and Data Units are defined on the General tab they are used in the y-axis label in the plot.

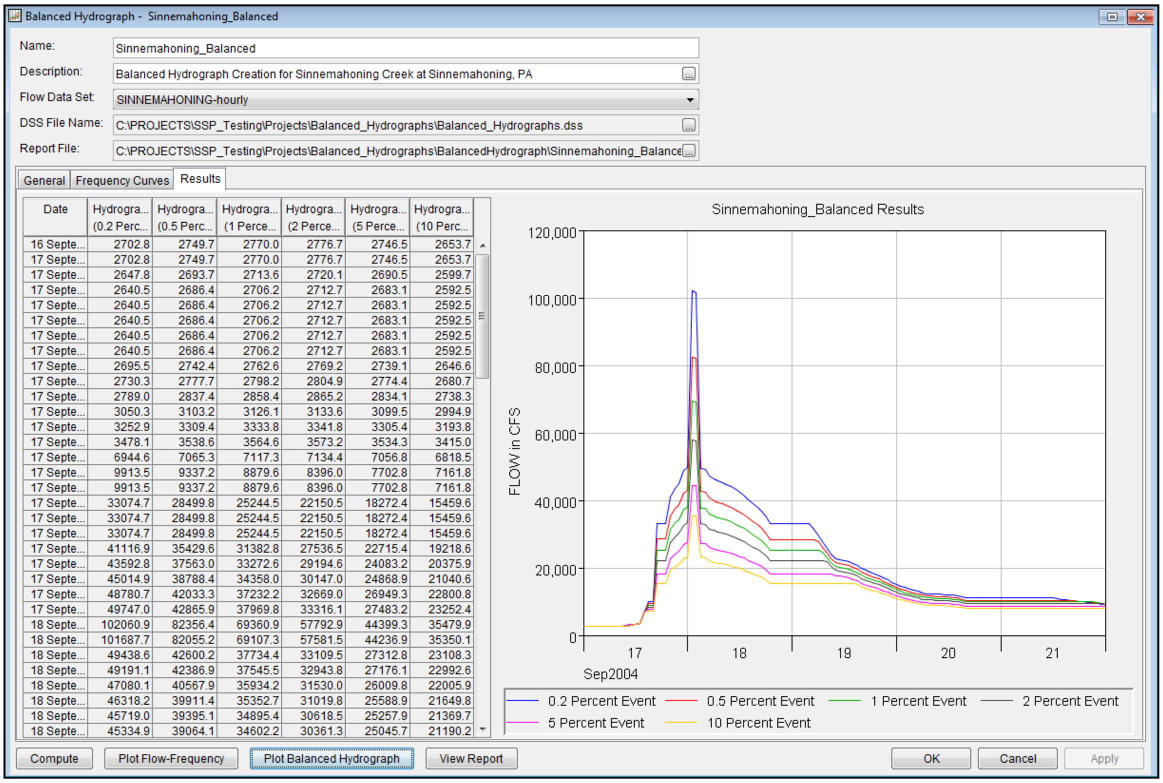


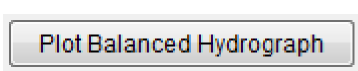
Figure 10-4. Results Tab of the Balanced Hydrograph Analysis Editor.

Viewing and Printing Results

The user can view the output for the balanced hydrograph analysis directly from the Balanced Hydrograph Analysis editor (tabular and graphical output) or by using the buttons at the bottom of the editor.

Tabular Output

Once the computations for the balanced hydrograph analysis are completed, the user can view the tabular output by selecting the **Results** tab. Tabular results can be opened after clicking the **Plot Balanced Hydrograph** button and selecting **File→Tabulate** or by double clicking on the balanced hydrograph plot in the **Results** tab and in the opened plot selecting **File→Tabulate**. The balanced hydrograph table can



also be printed once opened in a new window using the **File→Print** option. An additional printing option available from the File menu is Print Preview. The table can also be exported by selecting **Export…** from the File menu. When the Export option is selected, a window will appear allowing the user to select the Field Delimiter and additional Table Export Options. Currently five field delimiter formats are available for exporting the table: **TAB**, **SPACE**, **COMMA**, **COLON** and **SEMI-COLON**.

Graphical Output

Graphical output of the balanced hydrograph analysis can be obtained by selecting either the **Results** tab, or by pressing the **Plot Balanced Hydrograph** button at the bottom of the balanced hydrograph analysis editor. When the Plot Balanced Hydrograph button is pressed, a balanced hydrograph plot will appear in a separate window as shown in Figure 10-5. The example balanced hydrograph plot in Figure 10-5 was created after modifying the Time-Window (in the **General** tab). The user can modify the Time-Window to obtain balanced hydrographs for a specific maximum peak in the dataset.

The balanced hydrograph plot can be sent to the printer by selecting the **Print** option from the **File** menu at the top of the window. Additional printing options available from the File menu are Page Setup, Print Preview, and Print Multiple (used for printing multiple graphs on the same page). The graphic can also be sent to the Windows Clipboard by selecting **Copy to Clipboard** from the File menu. Additionally, the plot can be saved to a file by selecting the **Save As** option from the File menu. When the Save As option is selected, a window will appear allowing the user to select a directory, enter a filename, and select the format for saving the file. Currently four file formats are available for saving the graphic to disk: **windows metafile**, **postscript**, **JPEG**, and **portable network graphic**.

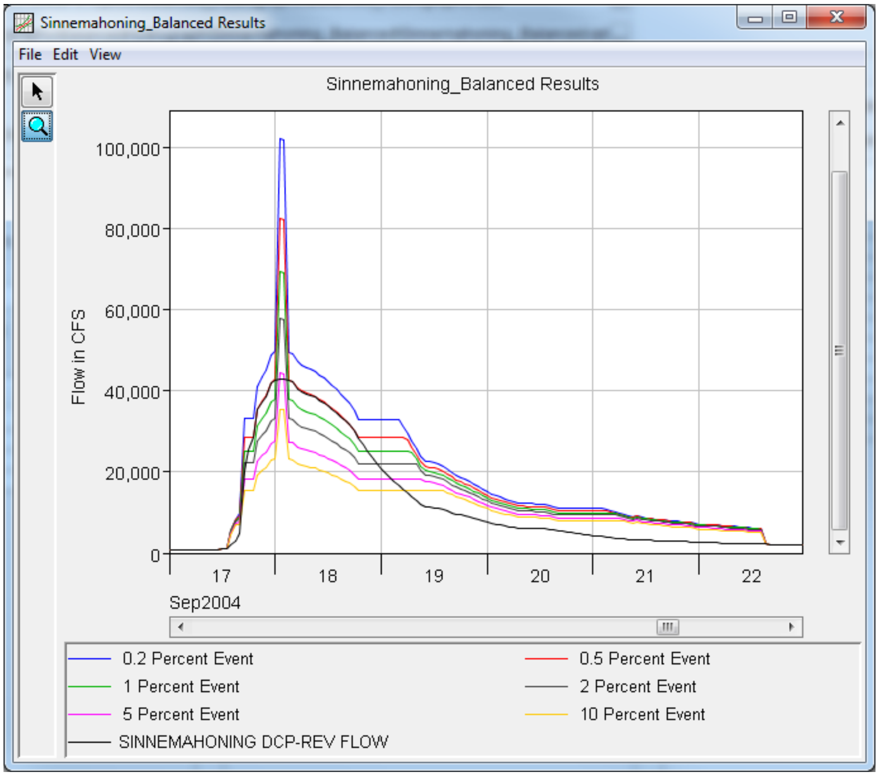


Figure 10-5. Balanced Hydrograph Analysis Plot.

As explained previously, the data contained within the plot can also be tabulated by selecting **Tabulate** from the File menu. When this option is selected, a separate window will appear with the data tabulated. Additional options are available from the File menu for saving the plot options as a template (**Save Template)** and applying previously saved templates to the current plot (**Apply Template**).

The **Edit** menu contains several options for customizing the graphic. These options include Plot Properties, Configure Plot Layout, Default Line Styles, and Default Plot Properties. Also, a shortcut menu will appear with further customizing options when the user right-clicks on a line on the graph or the legend. Both the Y and X-axis properties can be edited by placing the mouse on top of axis and clicking the right mouse button. Then select the **Edit Properties** menu option in the shortcut menu. For example, the user can turn on minor tic marks for the y-axis and modify the minimum and maximum scale for the x-axis. The graphic customizing capabilities within HEC-SSP are very powerful, but are also somewhat complex to use. The code used in developing the plots in HEC-SSP is the same code that is used for developing plots in HEC-DSSVue and several other HEC software programs. Please refer to the HEC-DSSVue User's Manual for details on customizing plots.

Viewing the Report File

A report file is created when the balanced hydrograph analysis computations are performed. The report file lists the input data, user settings, and the final results. This file is often useful for understanding how the software arrived at the balanced hydrograph.

To view the report file press the **View Report** button at the bottom of the Balanced Hydrograph Analysis editor. When this button is pressed, a window will appear containing the report as shown in Figure 10-6.

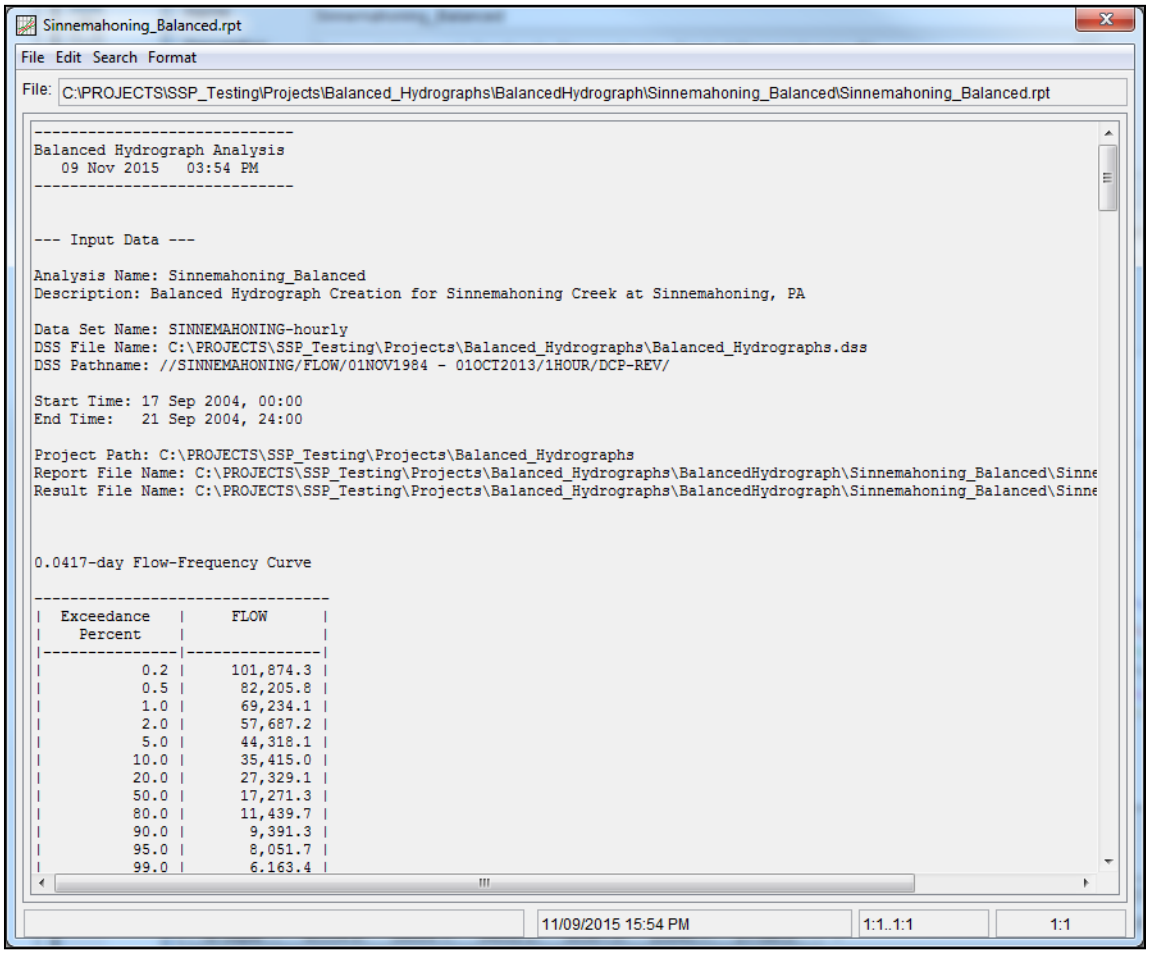


Figure 10-6. Balanced Hydrograph Analysis Report File.

The computations that were used to create the balanced hydrographs are contained within the **Report** output. Specifically, the base, required, and final flow-duration values are detailed along with the percent error for each duration and frequency. Additionally, the balanced hydrograph report can be opened using the **Results→Report** option in the Results dropdown menu at the top of the SSP window.

APPENDIX A

References

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APPENDIX B

Example Data Sets

The input and output for eleven example data sets are provided to illustrate the use of selected options and to assist in verifying the correct execution of the program.

The first six example data sets are the same examples that were found in the HEC-FFA program documentation. The first six examples were duplicated with a Bulletin 17B and General Frequency analysis. This manual only shows these examples using the Bulletin 17B analysis; however, the example data sets show that results are the same whether a Bulletin 17B or General Frequency analysis was performed. As shown in the example data sets, the HEC-SSP software produces the same results as HEC-FFA for these six data sets. All of these examples are provided with the software as a single HEC-SSP study labeled "SSP Examples". You can install this study on your computer by selecting the **Help→Install Example Data** menu option. After opening this study for the first time on your computer, you must compute each example before viewing tabular and graphical results.

A brief description of each example is provided. In most cases the weighted skew option was selected, and a regional skew value was entered from the generalized skew map of the United States provided within Bulletin 17B (Plate 1).

The example problems shown in this section are entitled:

1. Fitting the Log-Pearson Type III Distribution.
2. Analysis with High Outliers.
3. Testing and Adjusting for a Low Outlier.
4. Zero Flood Years.
5. Confidence Limits and Low Threshold Discharge.
6. Use of Historic Data and Median Plotting Positions.
7. Analyzing Stage Data.
8. Using User-Adjusted Statistics.

9. General Frequency - Graphical Analysis.
10. Volume Frequency Analysis, Maximum Flows.
11. Volume Frequency Analysis, Minimum Flows.
12. Duration Analysis, Bin (STATS) Method.
13. Duration Analysis, Rank All Data Method.
14. Duration Analysis, Manual Entry.
15. Coincident Frequency Analysis, A and B can be Assumed Independent.
16. Coincident Frequency Analysis, A and B cannot be Assumed Independent.
17. Balanced Hydrograph Analysis, Using an Historical Event Hydrograph.
18. Balanced Hydrograph Analysis, Using a Triangular-shaped Hydrograph.

When the "SSP Examples" study file is open, the screen will appear as shown in Figure B-1. There are six Bulletin 17B analyses, nine General Frequency analyses, two Volume Frequency analyses, three Duration analyses, two Coincidence Frequency analyses, and two Balanced Hydrograph analyses in this study. The following sections document each of the example data sets. Appendix C details six additional examples which make use of the Expected Moments Algorithm and Bulletin 17C procedures.

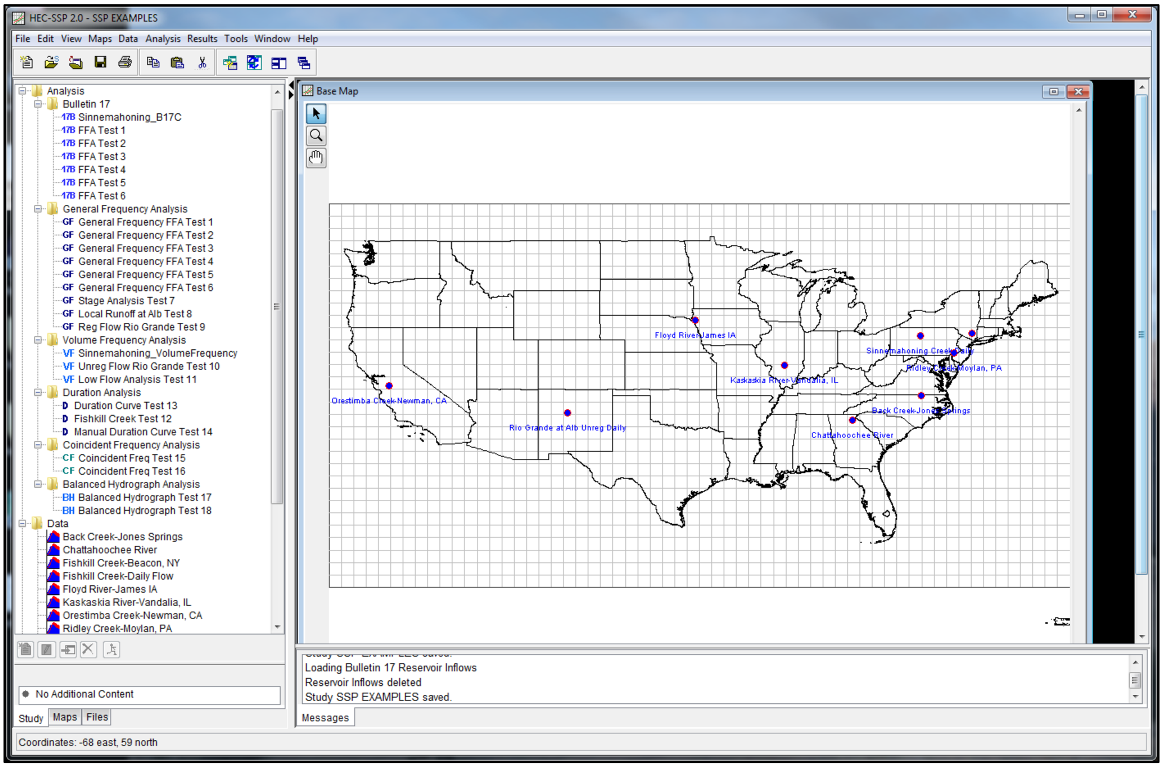
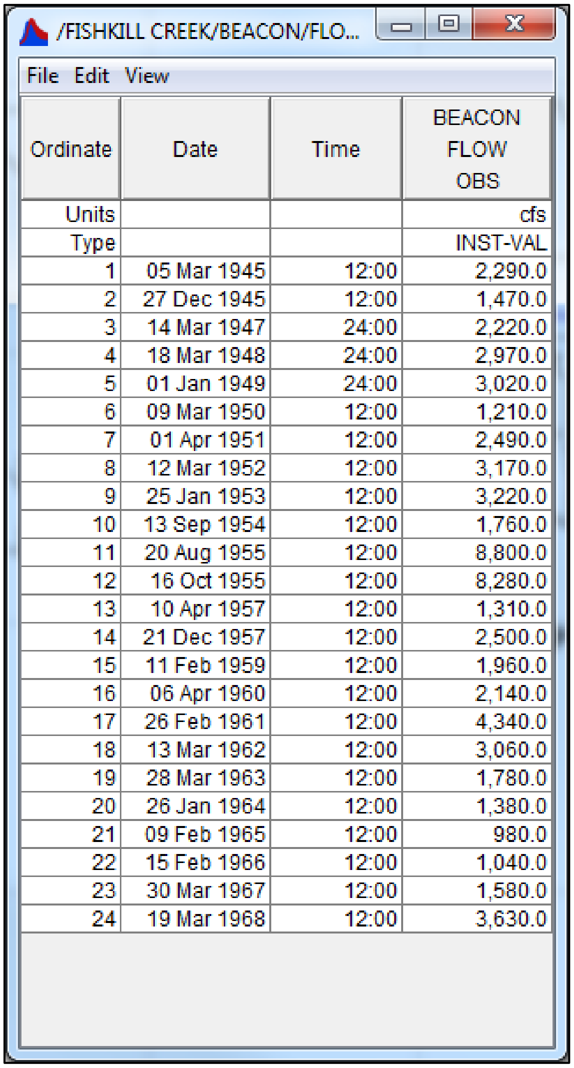


Figure B-1. SSP Examples Study.

Example 1: Fitting the Log-Pearson Type III Distribution

The input data for **FFA Test 1** is the same as that for Example 1 in Appendix 12, Guidelines for Determining Flood Flow Frequency, Water Resources Council Bulletin 17B. Example 1 illustrates the routine computation of a frequency curve by the Bulletin 17B methodology.

The data for this example is from Fishkill Creek in Beacon, New York. The period of record used for this example is from 1945 to 1968. To view the data from HEC-SSP, right-click on the data record labeled "**Fishkill Creek-Beacon, NY**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-2.



Ordinate	Date	Time	BEACON FLOW OBS
Units			cfs
Type			INST-VAL
1	05 Mar 1945	12:00	2,290.0
2	27 Dec 1945	12:00	1,470.0
3	14 Mar 1947	24:00	2,220.0
4	18 Mar 1948	24:00	2,970.0
5	01 Jan 1949	24:00	3,020.0
6	09 Mar 1950	12:00	1,210.0
7	01 Apr 1951	12:00	2,490.0
8	12 Mar 1952	12:00	3,170.0
9	25 Jan 1953	12:00	3,220.0
10	13 Sep 1954	12:00	1,760.0
11	20 Aug 1955	12:00	8,800.0
12	16 Oct 1955	12:00	8,280.0
13	10 Apr 1957	12:00	1,310.0
14	21 Dec 1957	12:00	2,500.0
15	11 Feb 1959	12:00	1,960.0
16	06 Apr 1960	12:00	2,140.0
17	26 Feb 1961	12:00	4,340.0
18	13 Mar 1962	12:00	3,060.0
19	28 Mar 1963	12:00	1,780.0
20	26 Jan 1964	12:00	1,380.0
21	09 Feb 1965	12:00	980.0
22	15 Feb 1966	12:00	1,040.0
23	30 Mar 1967	12:00	1,580.0
24	19 Mar 1968	12:00	3,630.0

Figure B-2. Tabulation of the Peak Flow Data for Fishkill Creek.

To plot the data for this example, right-click on the data record again and then select **Plot**. A plot of the data will appear as shown in Figure B-3.

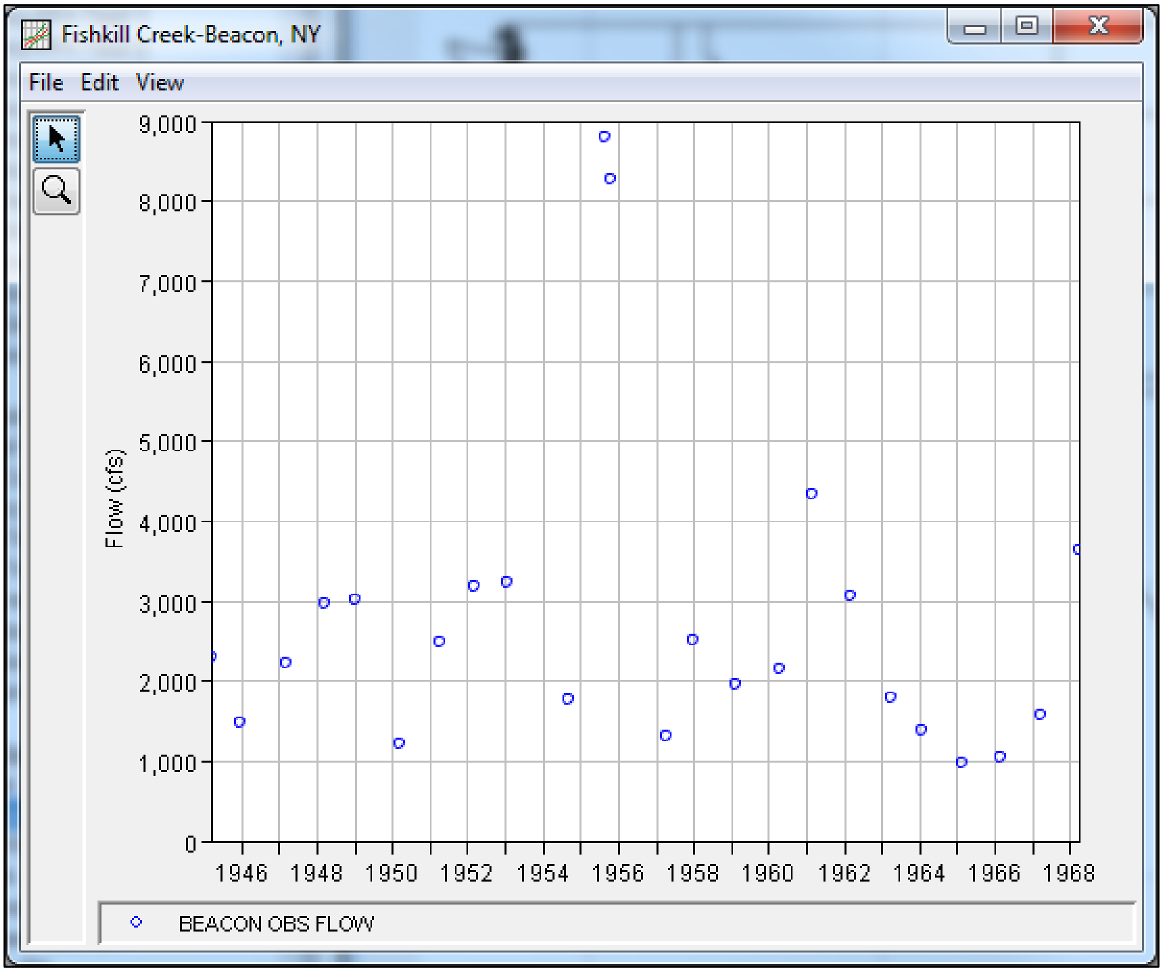


Figure B-3. Plot of the Fishkill Creek Data.

A Bulletin 17B and a General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for Example 1, either double-click on the analysis labeled **FFA Test 1** from the Study Explorer, or from the **Analysis** menu select open, then select **FFA Test 1** from the list of available analyses. When **FFA Test 1** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-4.

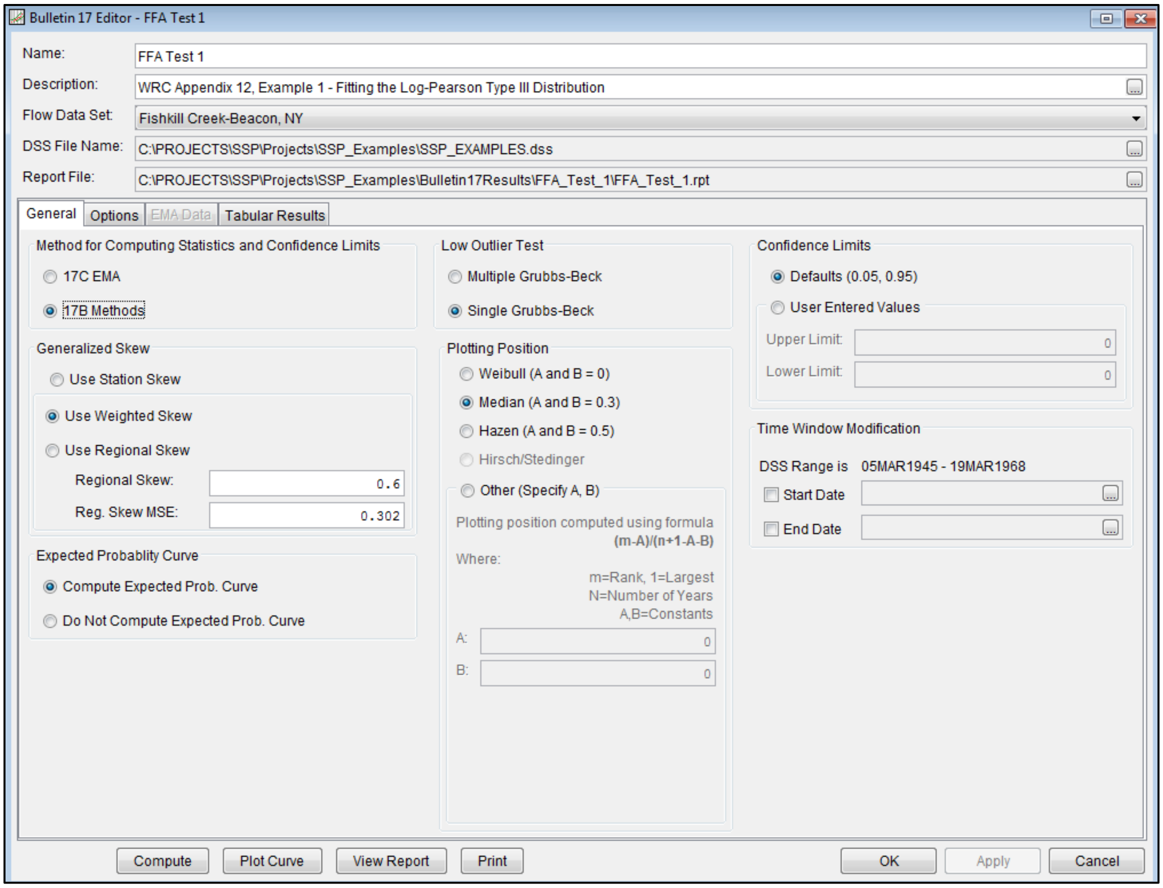


Figure B-4. Bulletin 17B Analysis Editor with FFA Test 1 Data Set.

Shown in Figure B-4 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example a value of 0.6 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The **Weibull** plotting position method was selected, as well as the default **Confidence Limits** of 0.05 (5 percent chance exceedance) and 0.95 (95% chance exceedance). Shown in Figure B-5 is the Bulletin 17B editor with the **Options Tab** selected.

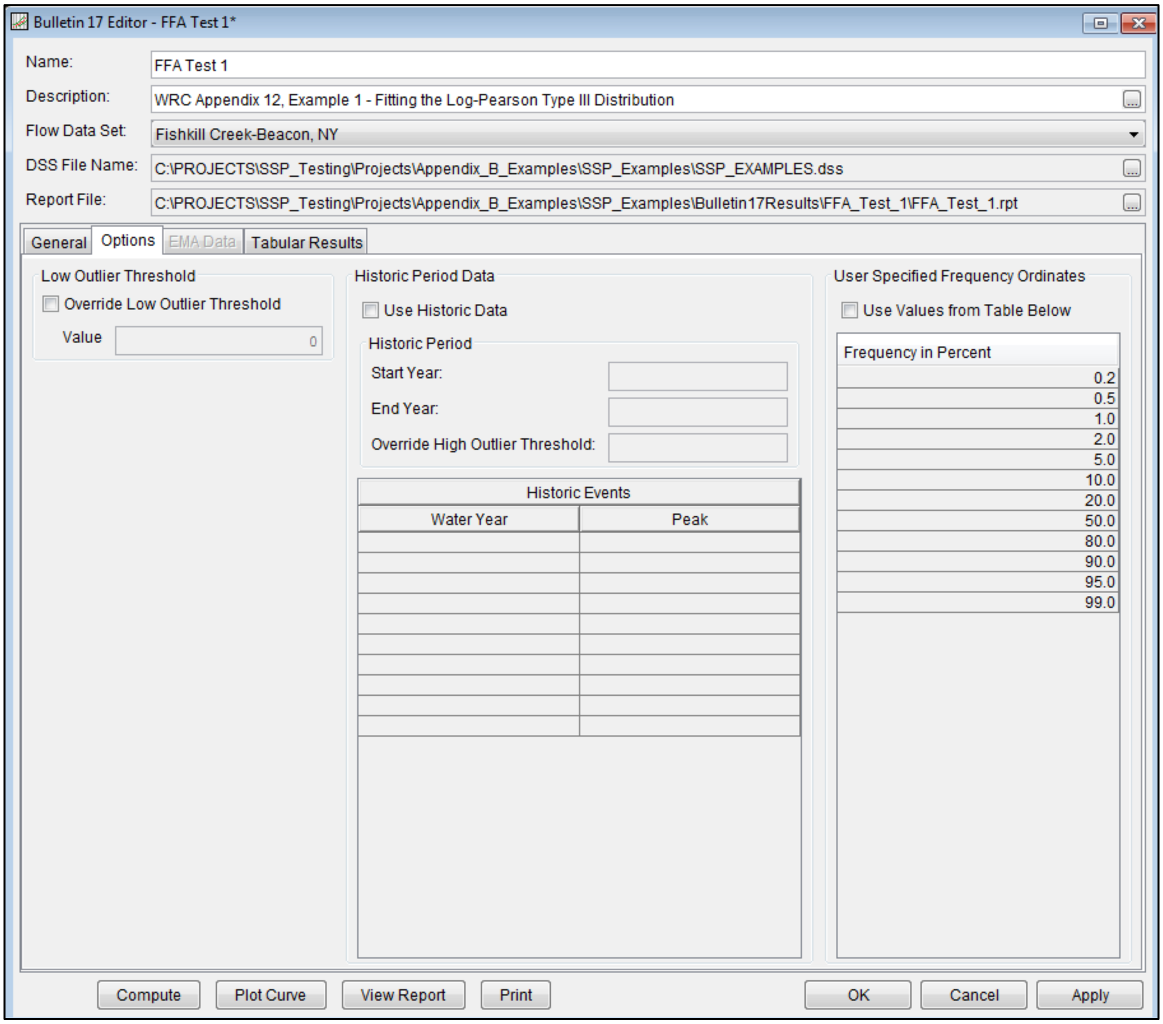


Figure B-5. Bulletin 17B Editor with Options Tab Selected for FFA Test 1.

As shown in Figure B-5, none of the available options for modifying the frequency analysis were selected for this example. These options include changing the **Low Outlier Threshold** and using **Historic Data**. Additionally, the option to override the default **Frequency Ordinates** was not selected.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure B-6.

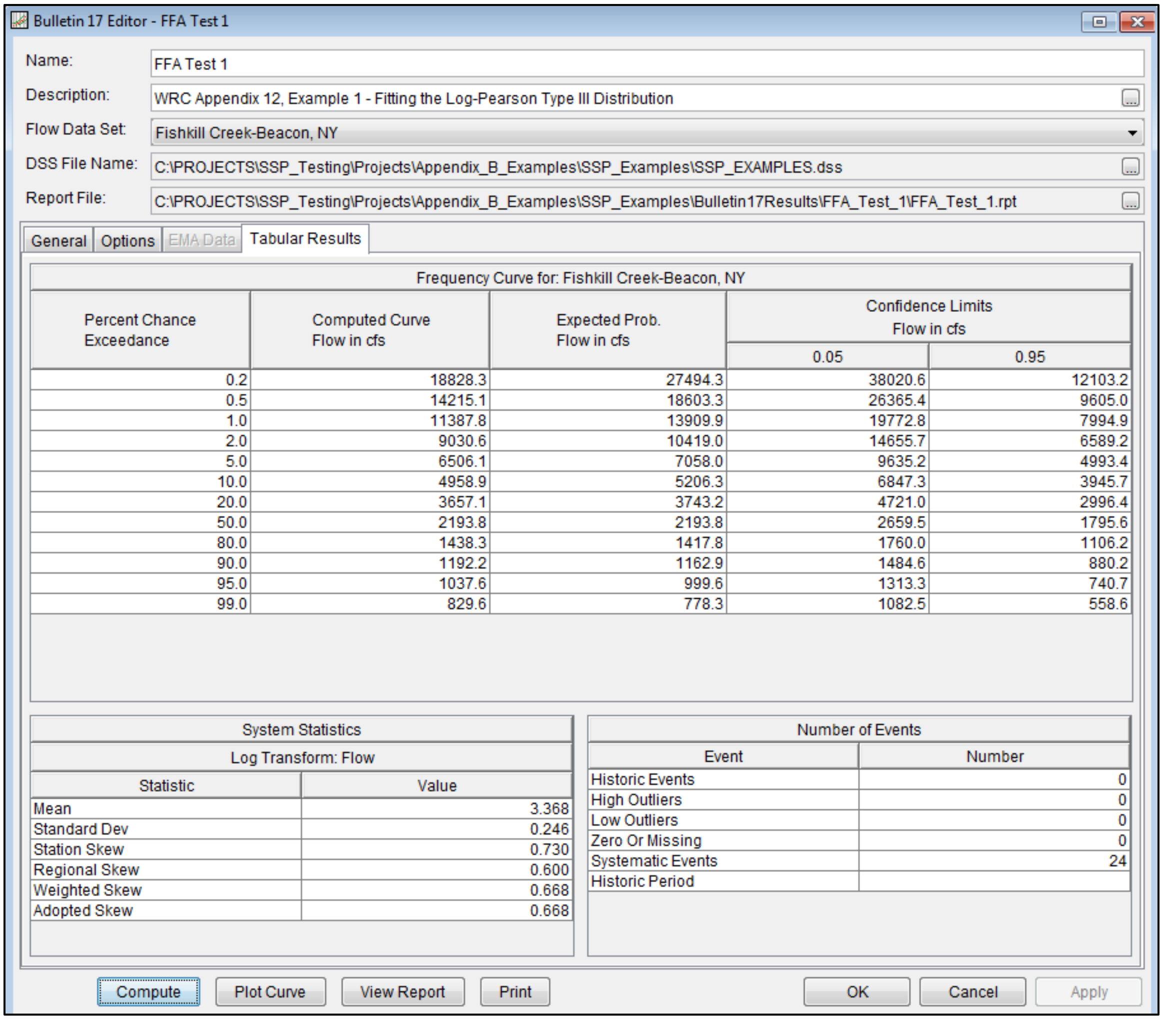


Figure B-6. Bulletin 17B Analysis Window with Results Tab Shown for FFA Test 1.

As shown in Figure B-6, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (5% and 95% chance exceedance curves)

On the bottom, left side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom, right side of the results tab is a Number of Events table showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-7.

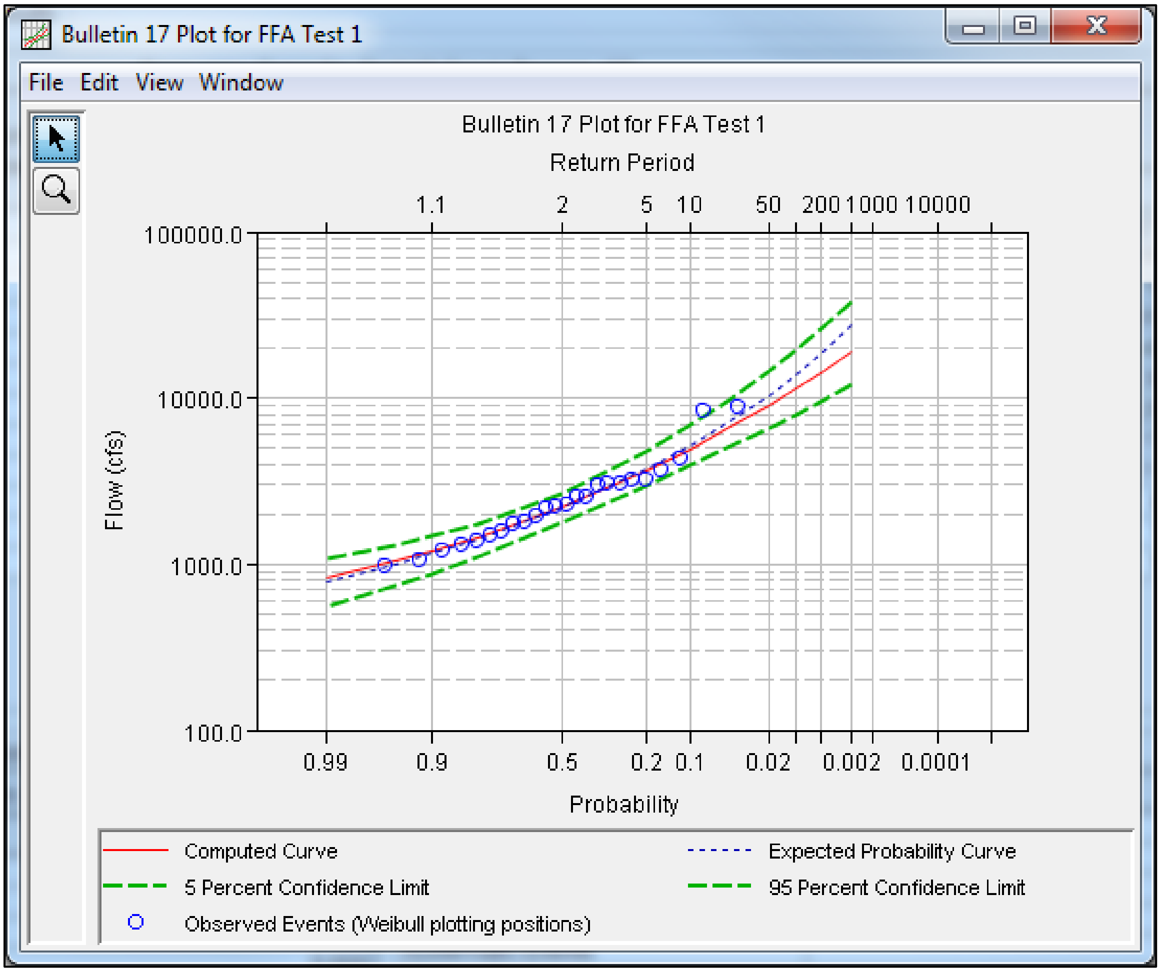


Figure B-7. Plotted Frequency Curves for FFA Test 1.

The tabular and graphical results can be sent to the printer or the Windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the Windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-8 is the report file for FFA Test 1.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis. The user should review the report file to understand how HEC-SSP performed the Bulletin 17B frequency curve calculations.

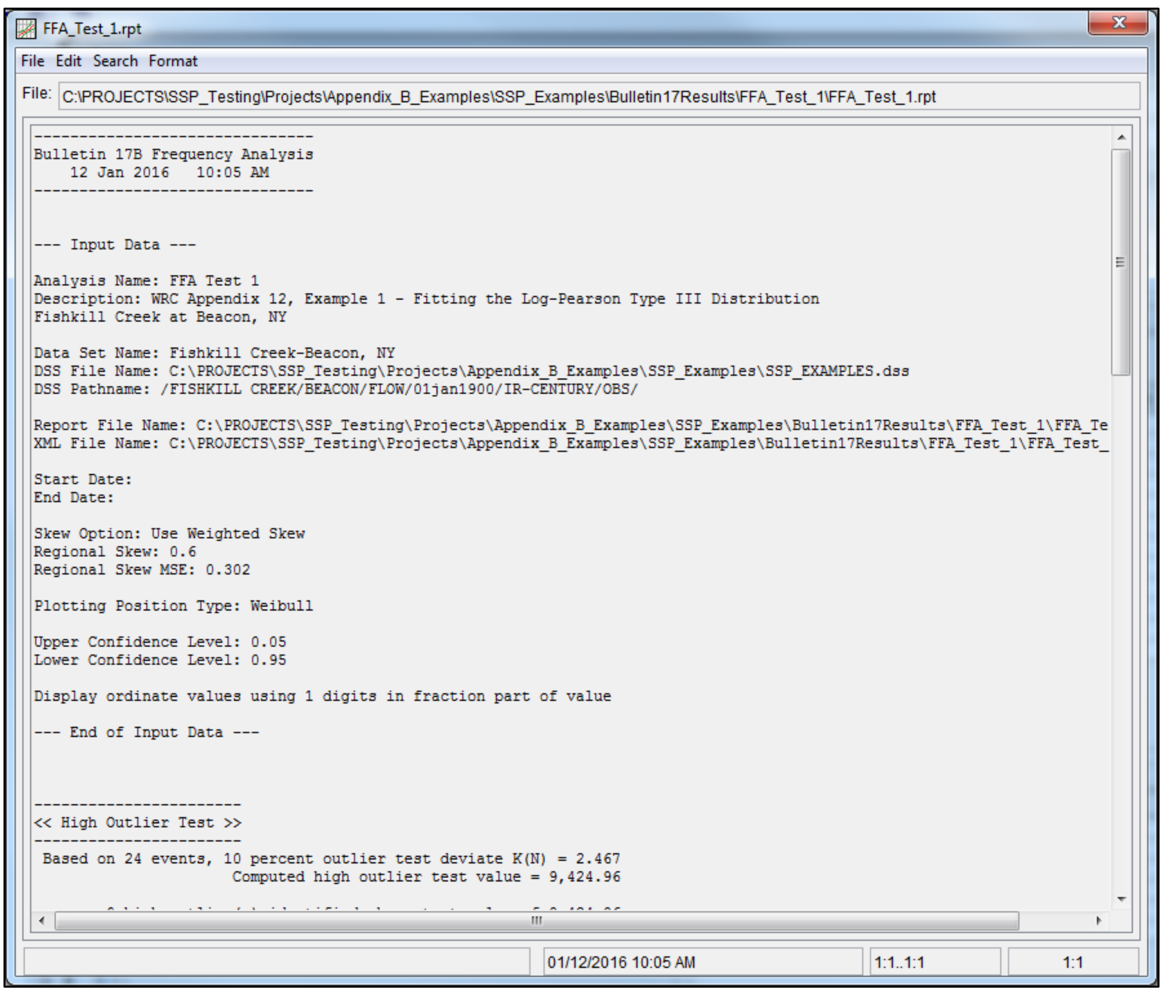


Figure B-8. FFA Test 1 Report File.

Example 2: Analysis with High Outliers

The input data for **FFA Test 2** is the same as that for Example 2 in Appendix 12, Guidelines for Determining Flood Flow Frequency, Water Resources Council Bulletin 17B. Example 2 illustrates the application to data with a high outlier.

The data for this example is from Floyd River in James, Iowa. The period of record used is from 1935 to 1973. To view the data from HEC-SSP, right-click on the data record labeled "**Floyd River-James IA**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-9.

/FLOYD RIVER/JAMES IA/FLOW/...

File Edit View

Ordina...	Date	Time	JAMES IA FLOW OBS
10	13 May 1944	12:00	7,440
11	12 Mar 1945	12:00	5,320
12	01 Mar 1946	12:00	1,400
13	25 Jun 1947	12:00	3,240
14	17 Mar 1948	12:00	2,710
15	05 Mar 1949	12:00	4,520
16	19 Jun 1950	12:00	4,840
17	28 Mar 1951	12:00	8,320
18	31 Mar 1952	12:00	13,900
19	08 Jun 1953	12:00	71,500
20	22 Jun 1954	12:00	6,250
21	10 Jul 1955	12:00	2,260
22	13 Jul 1956	12:00	318
23	05 Jul 1957	12:00	1,330
24	01 Jul 1958	12:00	970
25	01 Jun 1959	12:00	1,920
26	29 Mar 1960	12:00	15,100
27	02 Mar 1961	12:00	2,870
28	29 Mar 1962	12:00	20,600
29	02 Jun 1963	12:00	3,810
30	09 Sep 1964	12:00	726
31	02 Apr 1965	12:00	7,500
32	10 Feb 1966	12:00	7,170
33	19 Jun 1967	12:00	2,000
34	21 Jul 1968	12:00	829
35	05 Apr 1969	12:00	17,300
36	04 Mar 1970	12:00	4,740
37	01 Jan 1971	12:00	13,400
38	01 Jan 1972	12:00	2,940
39	01 Jan 1973	12:00	5,660

Figure B-9. Tabulation of the Peak Flow Data for the Floyd River.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-10.

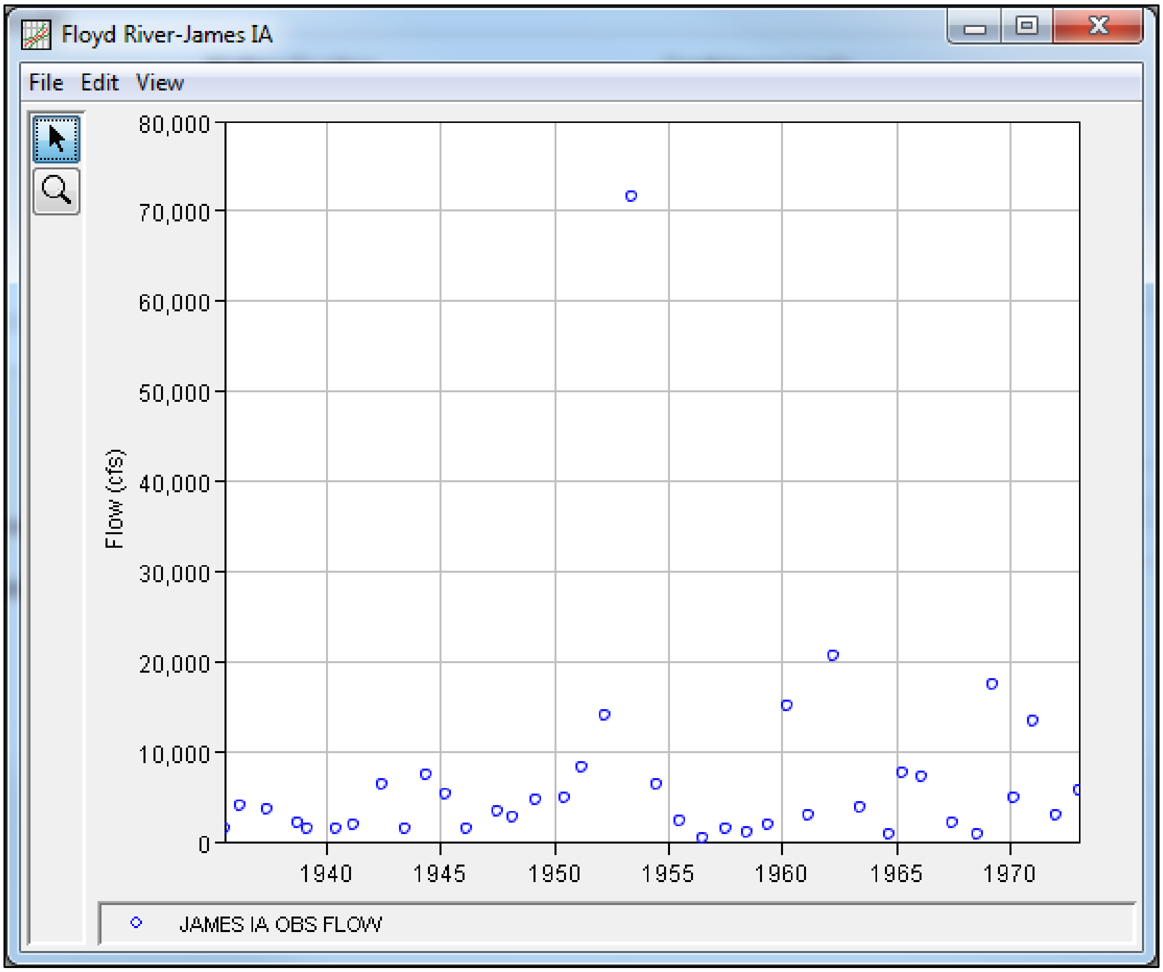


Figure B-10. Plot of Floyd River Data

A Bulletin 17B and General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for **FFA Test 2**, either double-click on the analysis labeled **FFA Test 2** from the study pane, or from the **Analysis** menu select open and then select **FFA Test 2** from the list of available analyses. When **FFA Test 2** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-11.

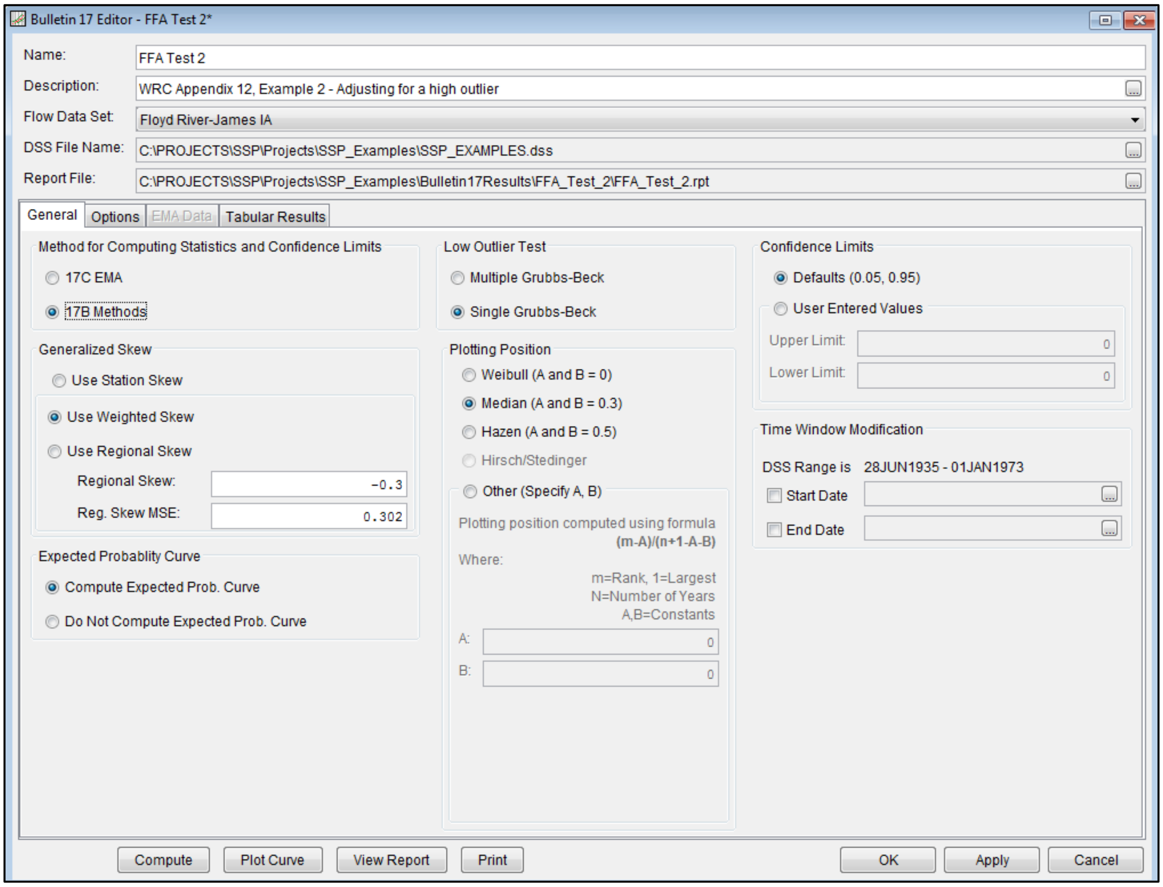


Figure B-11. Bulletin 17B Analysis Editor with FFA Test 2 Data Set.

Shown in Figure B-11 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example a value of -0.3 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The **Weibull** plotting position method was selected, as well as the default **Confidence Limits** of 0.05 (5 percent chance exceedance) and 0.95 (95% chance exceedance). Shown in Figure B-12 is the Bulletin 17B editor with the **Options Tab** selected.

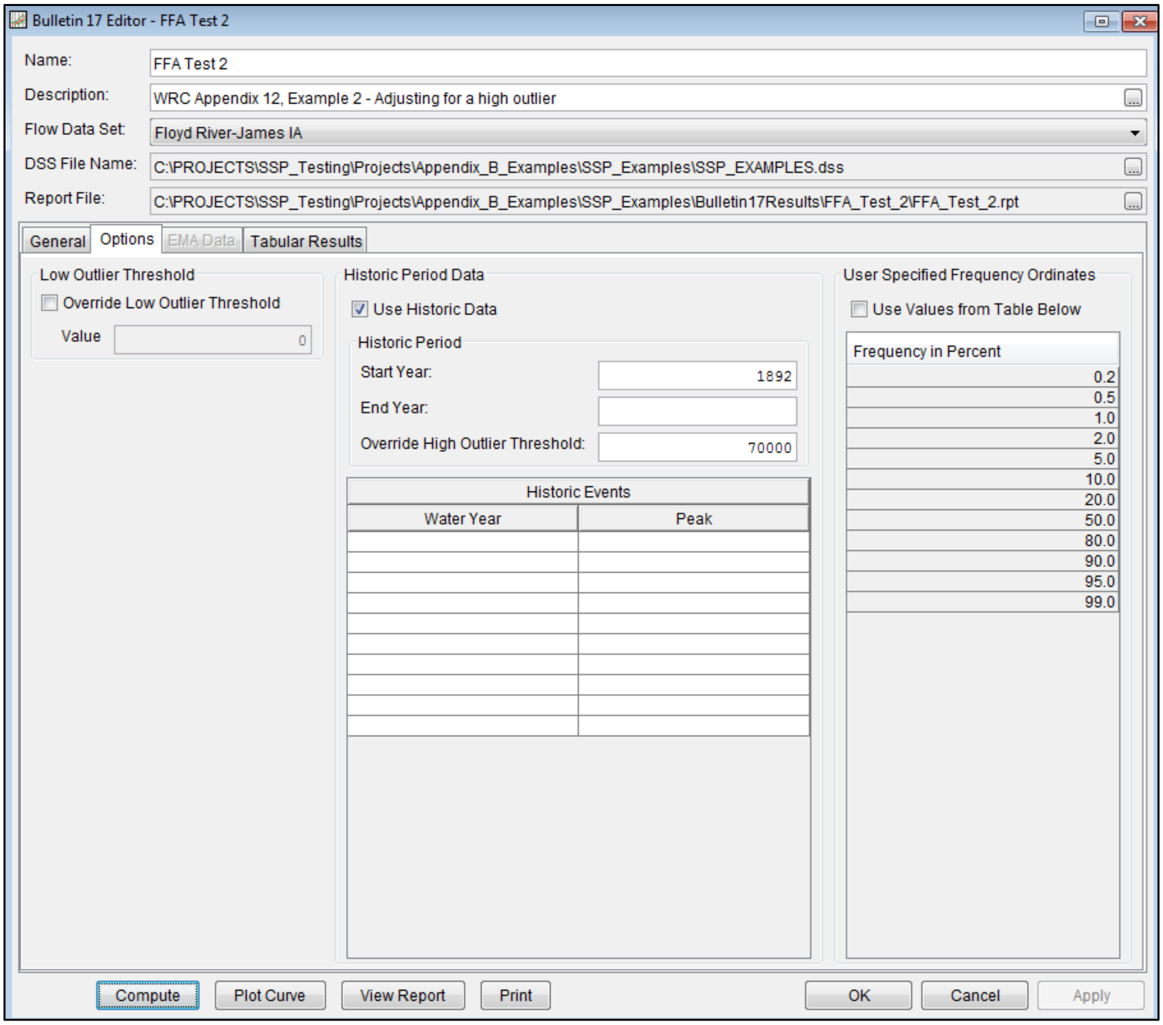
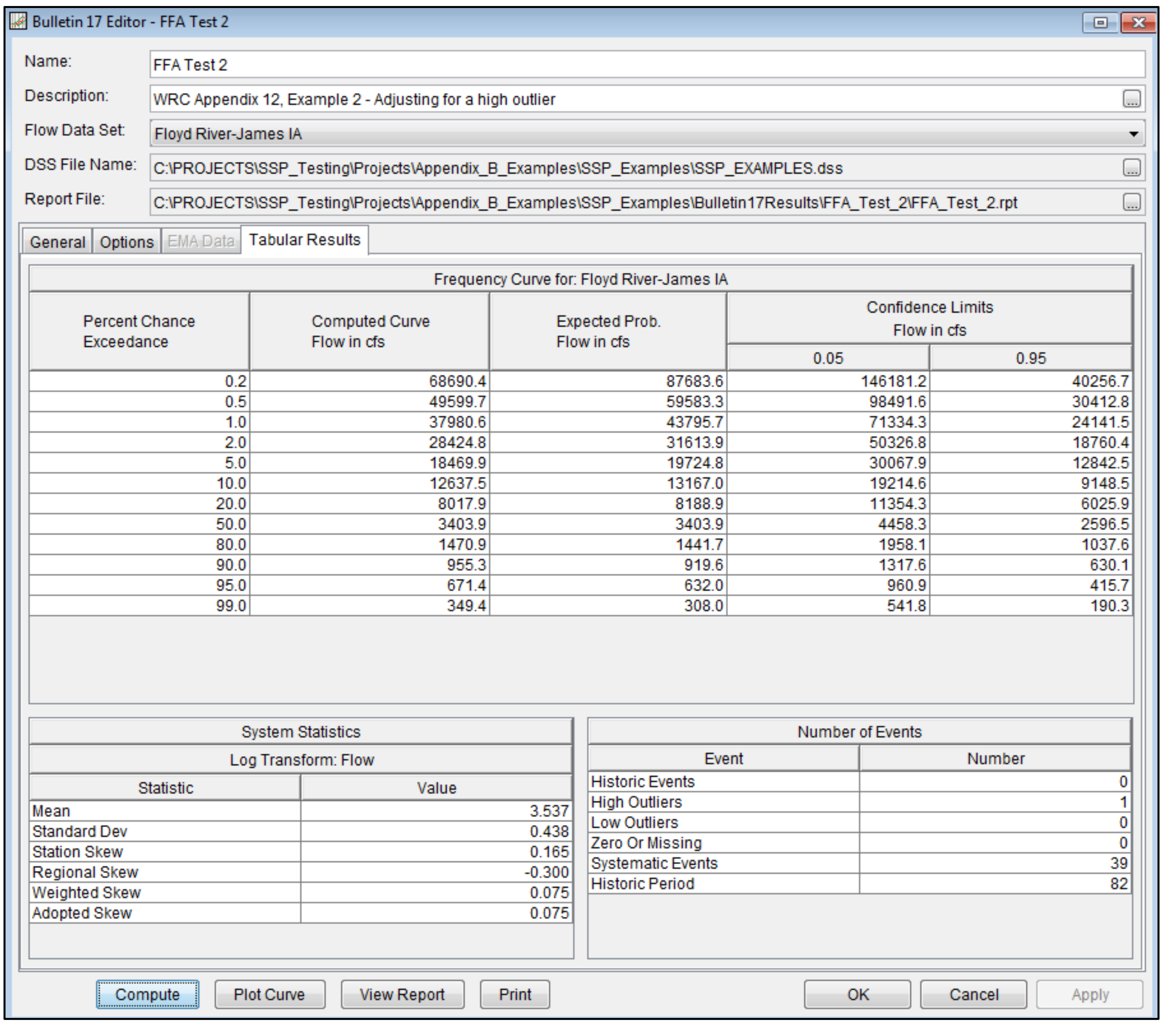


Figure B-12. Bulletin 17B Editor with Options Tab Selected for FFA Test 2.

As shown in Figure B-12, the **Historic Period Data** option has been selected to reflect the fact that the 1953 flood peak of 71,500 cfs is known to be the largest flood since 1892. When the analysis was originally performed on this data set, the 1953 event was found to be a high outlier. (The reader may replicate this result by un-checking the "Use Historic Data" box, hitting the Compute button, and reviewing the Tabular Results tab.) High outliers should not be eliminated from an analysis, as they are valuable pieces of the flow record. However, when a high outlier is found in a data set, it suggests that the event might actually be the largest in a much longer period of record. The analyst should always try to locate and incorporate historic information to define a longer record and improve the quality of the frequency analysis. Since it was known that the 1953 event was the largest value since 1892, the year 1892 is entered as the **Start Year** for the historic period. Additionally, a **High Threshold Value** of 70,000 cfs was entered. By entering the High Threshold Value of 70,000 cfs, the 1953 flood of 71,500 cfs was removed from the systematic record and treated as a historic data value during the historic data adjustment calculations performed by HEC-SSP and outlined in Bulletin 17B, Appendix 6. Since no End Year was entered for the historic period, the last year of the systematic data set will be used as the End Year.

Other features on this tab include the **Low Outlier Threshold** and the option to override the default **Frequency Ordinates,** neither of which are selected in this example.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure B-13.



Frequency Curve for: Floyd River-James IA

Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Confidence Limits Flow in cfs 0.05	Confidence Limits Flow in cfs 0.95
0.2	68690.4	87683.6	146181.2	40256.7
0.5	49599.7	59583.3	98491.6	30412.8
1.0	37980.6	43795.7	71334.3	24141.5
2.0	28424.8	31613.9	50326.8	18760.4
5.0	18469.9	19724.8	30067.9	12842.5
10.0	12637.5	13167.0	19214.6	9148.5
20.0	8017.9	8188.9	11354.3	6025.9
50.0	3403.9	3403.9	4458.3	2596.5
80.0	1470.9	1441.7	1958.1	1037.6
90.0	955.3	919.6	1317.6	630.1
95.0	671.4	632.0	960.9	415.7
99.0	349.4	308.0	541.8	190.3

System Statistics — Log Transform: Flow

Statistic	Value
Mean	3.537
Standard Dev	0.438
Station Skew	0.165
Regional Skew	-0.300
Weighted Skew	0.075
Adopted Skew	0.075

Number of Events

Event	Number
Historic Events	0
High Outliers	1
Low Outliers	0
Zero Or Missing	0
Systematic Events	39
Historic Period	82

Figure B-13. Bulletin 17B Editor with Results Tab Selected for FFA Test 2.

As shown in Figure B-13, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (5% and 95% chance exceedance curves)

On the bottom left-hand side of the results tab is the Statistics table for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is the Number of Events table showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-14.

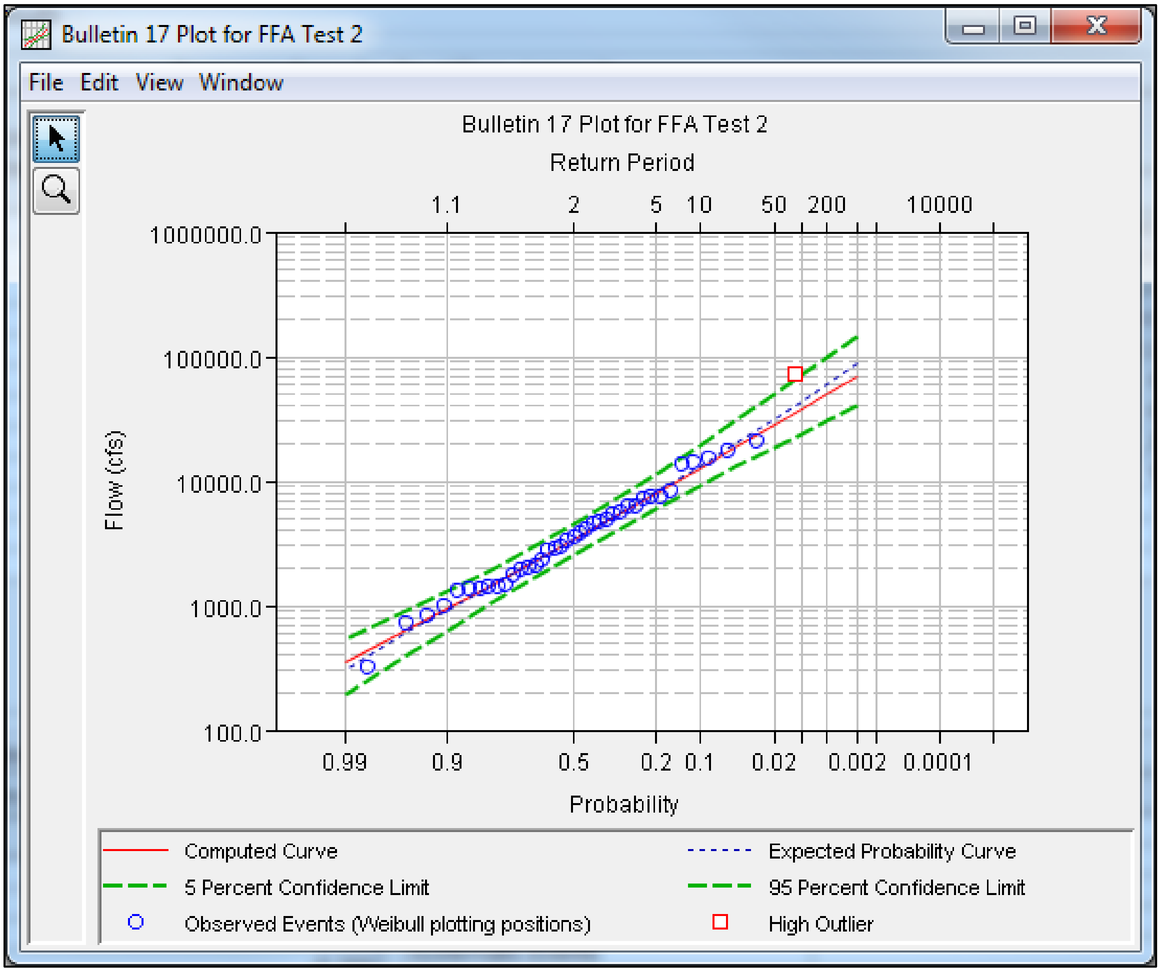


Figure B-14. Plotted Frequency Curves for FFA Test 2.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-15 is the report file for **FFA Test 2**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis. The user should review the report file to understand how HEC-SSP performed the frequency curve calculations.

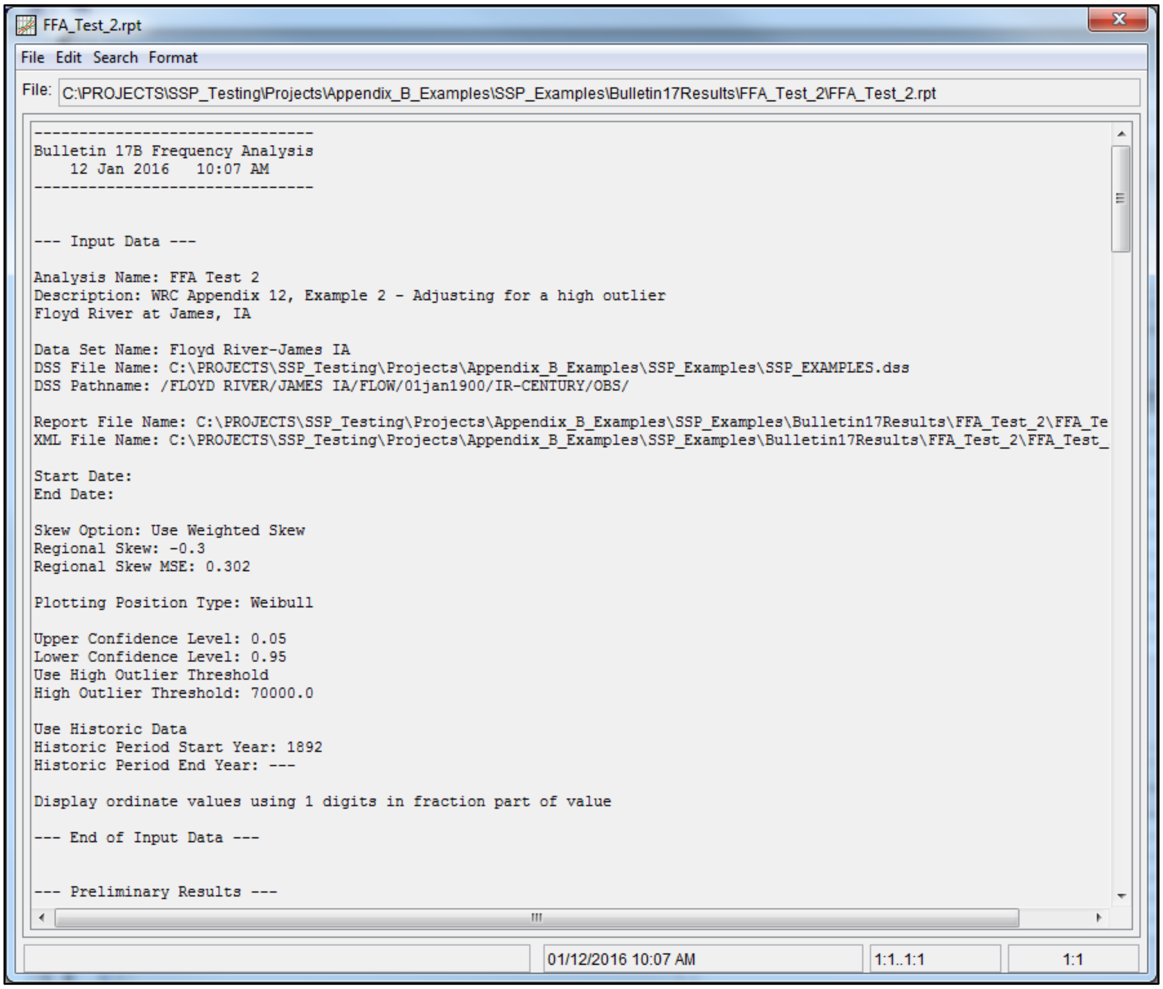
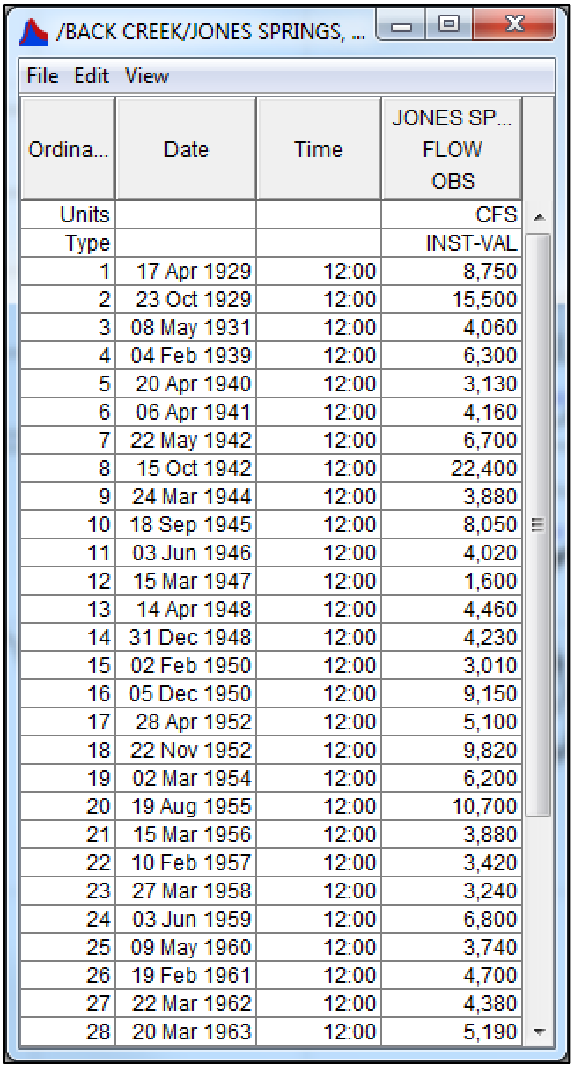


Figure B-15. FFA Test 2 Report File.

Example 3: Testing and Adjusting for a Low Outlier

The input data for **FFA Test 3** are the same as that for Example 3 in Appendix 12 of the WRC Guidelines. **FFA Test 3** illustrates the application to data with a low outlier. Note that the program automatically screens for low outliers and, if low outliers are found, outputs the preliminary results in the report file in order to allow for comparison with the final results.

The data for this example is from Back Creek in Jones Springs, West Virginia. The period of record used for this example is from 1929 to 1973. To view the data, right-click on the data record labeled "**Back Creek-Jones Springs**" in the study pane and then select **Tabulate**. The data will appear as shown in Figure B-16.



Ordina...	Date	Time	JONES SP... FLOW OBS
Units			CFS
Type			INST-VAL
1	17 Apr 1929	12:00	8,750
2	23 Oct 1929	12:00	15,500
3	08 May 1931	12:00	4,060
4	04 Feb 1939	12:00	6,300
5	20 Apr 1940	12:00	3,130
6	06 Apr 1941	12:00	4,160
7	22 May 1942	12:00	6,700
8	15 Oct 1942	12:00	22,400
9	24 Mar 1944	12:00	3,880
10	18 Sep 1945	12:00	8,050
11	03 Jun 1946	12:00	4,020
12	15 Mar 1947	12:00	1,600
13	14 Apr 1948	12:00	4,460
14	31 Dec 1948	12:00	4,230
15	02 Feb 1950	12:00	3,010
16	05 Dec 1950	12:00	9,150
17	28 Apr 1952	12:00	5,100
18	22 Nov 1952	12:00	9,820
19	02 Mar 1954	12:00	6,200
20	19 Aug 1955	12:00	10,700
21	15 Mar 1956	12:00	3,880
22	10 Feb 1957	12:00	3,420
23	27 Mar 1958	12:00	3,240
24	03 Jun 1959	12:00	6,800
25	09 May 1960	12:00	3,740
26	19 Feb 1961	12:00	4,700
27	22 Mar 1962	12:00	4,380
28	20 Mar 1963	12:00	5,190

Figure B-16. Tabulation of the Peak Flow Data for Back Creek.

To plot the data for this example, right-click on the data record and select **Plot**. A plot of the data will appear as shown in Figure B-17.

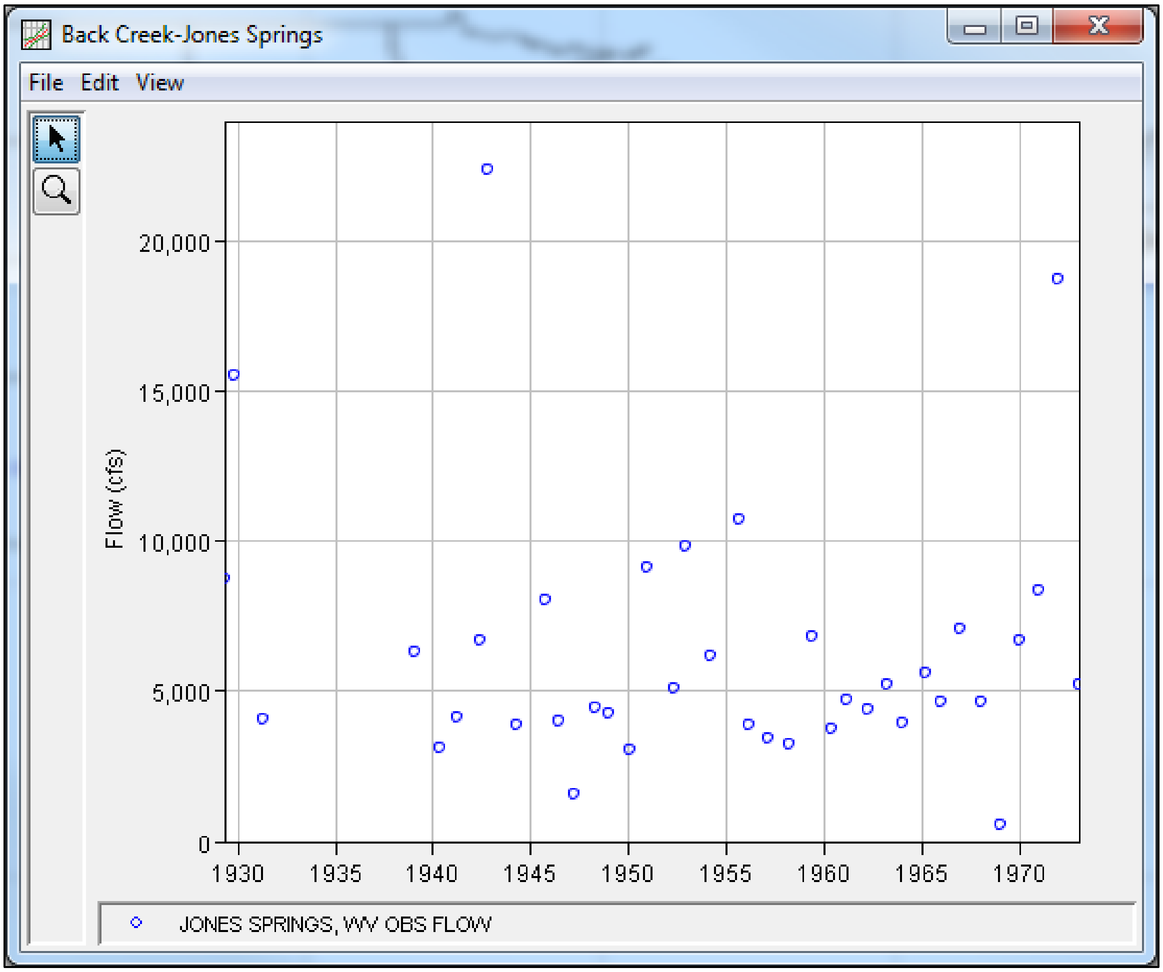


Figure B-17. Plot of Back Creek Data.

A Bulletin 17B and General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for **FFA Test 3**, either double-click on the analysis labeled **FFA Test 3** from the study explorer, or from the **Analysis** menu select open and then select **FFA Test 3** from the list of available analyses. When **FFA Test 3** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-18.

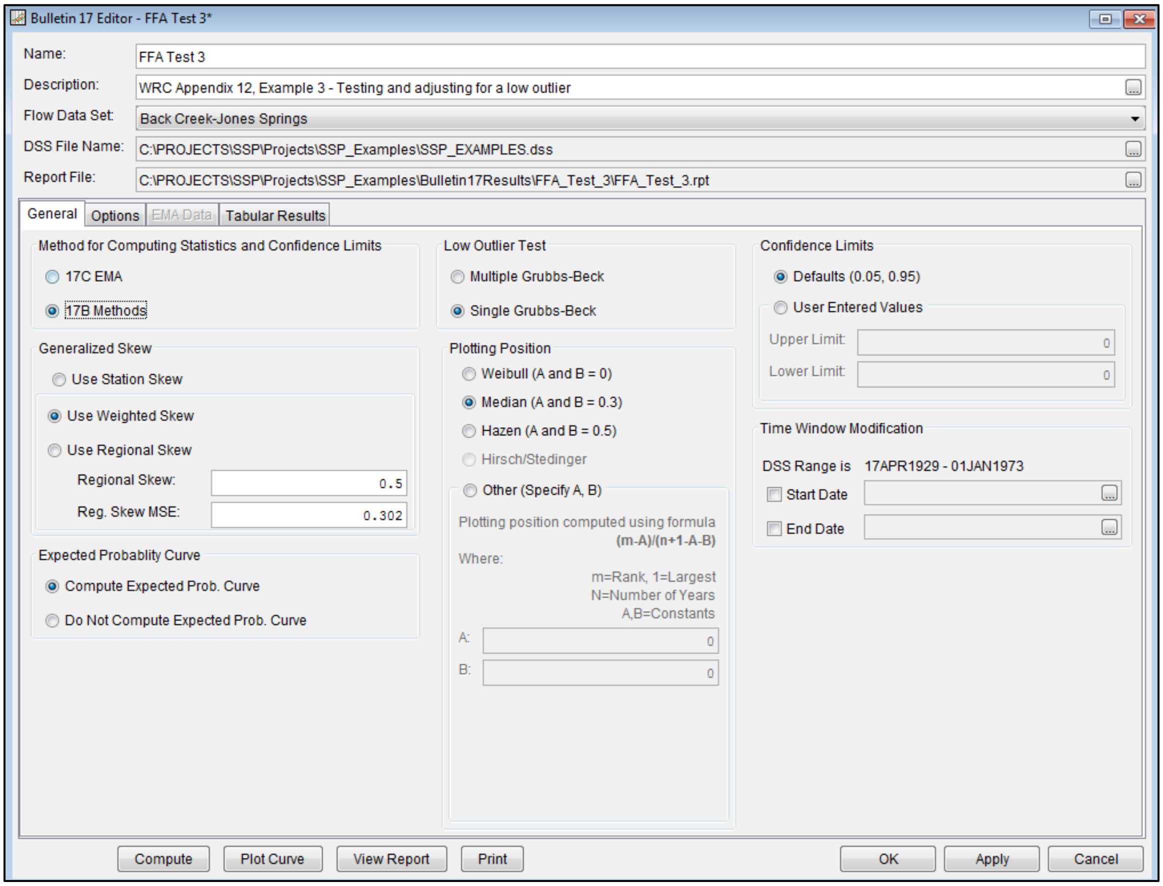


Figure B-18. Bulletin 17B Analysis Editor with FFA Test 3 Data Set.

Shown in Figure B-18 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example, a value of 0.5 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The **Weibull** plotting position method was selected, as well as the default **Confidence Limits** of 0.05 (5 percent chance exceedance) and 0.95 (95% chance exceedance). Shown in Figure B-19 is the Bulletin 17B editor with the **Options Tab** selected.

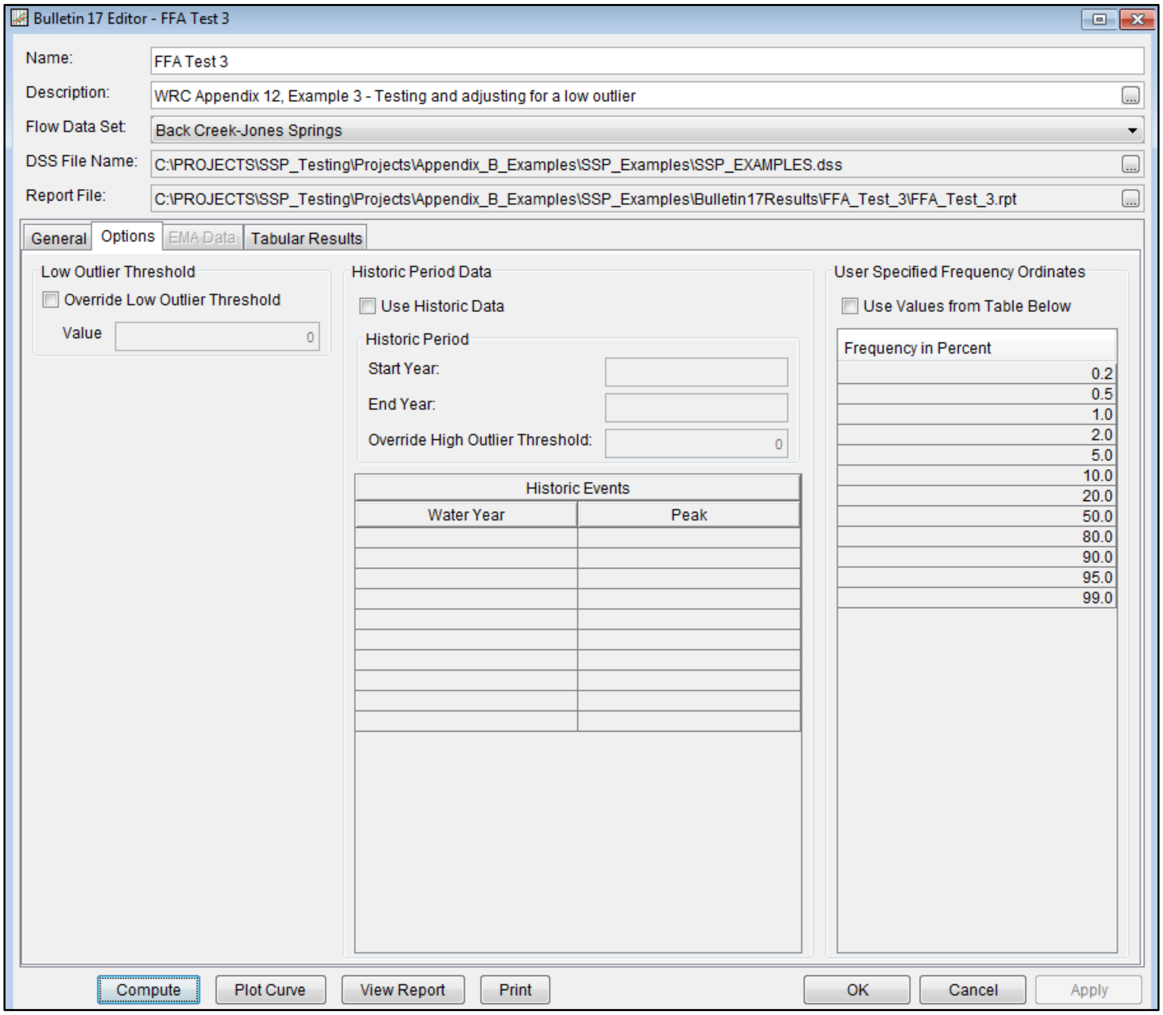
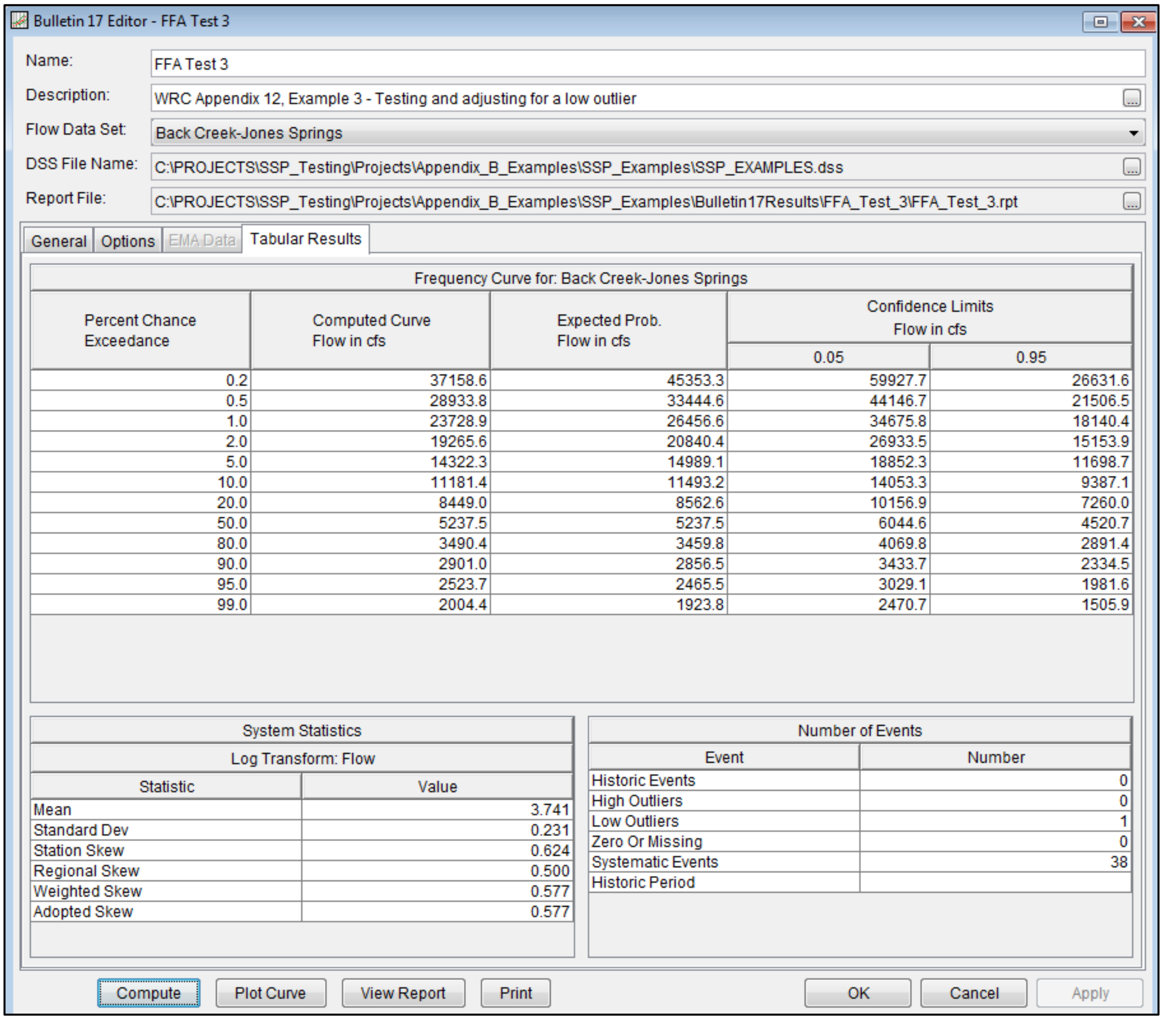


Figure B-19. Bulletin 17B Editor with the Options Tab Selected for FFA Test 3.

As shown in Figure B-19, none of the available options for modifying the frequency curve were selected for this test example. These options include the **Low Outlier Threshold** and **Historic Period Data**. Additionally, the option to override the default **Frequency Ordinates** was not selected.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed a message window will open stating **Compute Complete.** Close this window and select the **Tabular Results** tab. The analysis window should look like Figure B-20.



Frequency Curve for: Back Creek-Jones Springs

Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Confidence Limits Flow in cfs 0.05	Confidence Limits Flow in cfs 0.95
0.2	37158.6	45353.3	59927.7	26631.6
0.5	28933.8	33444.6	44146.7	21506.5
1.0	23728.9	26456.6	34675.8	18140.4
2.0	19265.6	20840.4	26933.5	15153.9
5.0	14322.3	14989.1	18852.3	11698.7
10.0	11181.4	11493.2	14053.3	9387.1
20.0	8449.0	8562.6	10156.9	7260.0
50.0	5237.5	5237.5	6044.6	4520.7
80.0	3490.4	3459.8	4069.8	2891.4
90.0	2901.0	2856.5	3433.7	2334.5
95.0	2523.7	2465.5	3029.1	1981.6
99.0	2004.4	1923.8	2470.7	1505.9

System Statistics

Log Transform: Flow

Statistic	Value
Mean	3.741
Standard Dev	0.231
Station Skew	0.624
Regional Skew	0.500
Weighted Skew	0.577
Adopted Skew	0.577

Number of Events

Event	Number
Historic Events	0
High Outliers	0
Low Outliers	1
Zero Or Missing	0
Systematic Events	38
Historic Period	

Figure B-20. Bulletin 17B Editor with the Results Tab Selected for FFA Test 3.

As shown in Figure B-20, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (5% and 95% chance exceedance curves)

On the bottom left-hand side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is a table of Number of Events showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

In this analysis, the software detected one low outlier in the systematic record. As recommended in Bulletin 17B, if a low outlier is detected, then that data point will be removed and the Conditional Probability Adjustment will be used to recalculate the frequency curve and then the statistics without that point. Review the report file to see the original statistics, computed curves, the low outlier test, and recomputed curves.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-21.

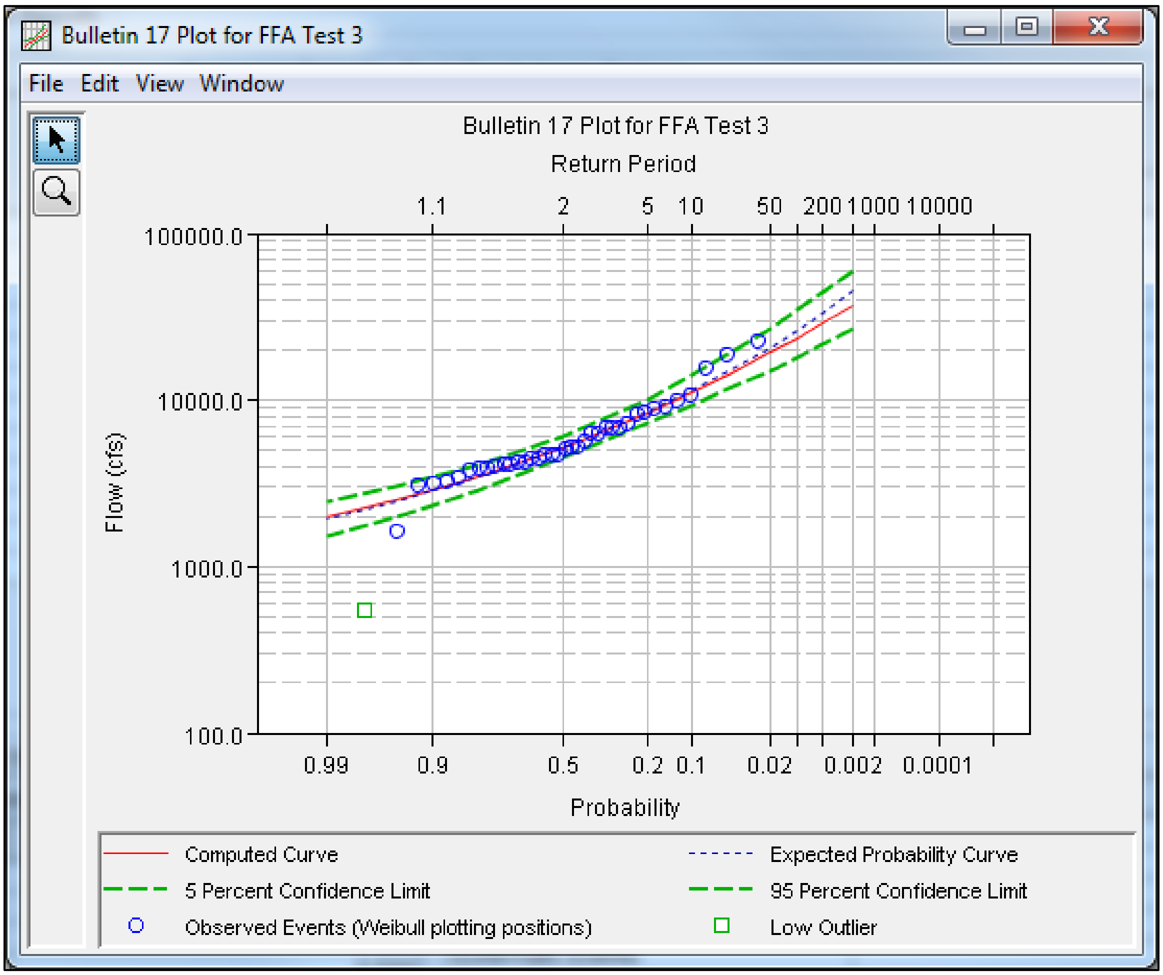
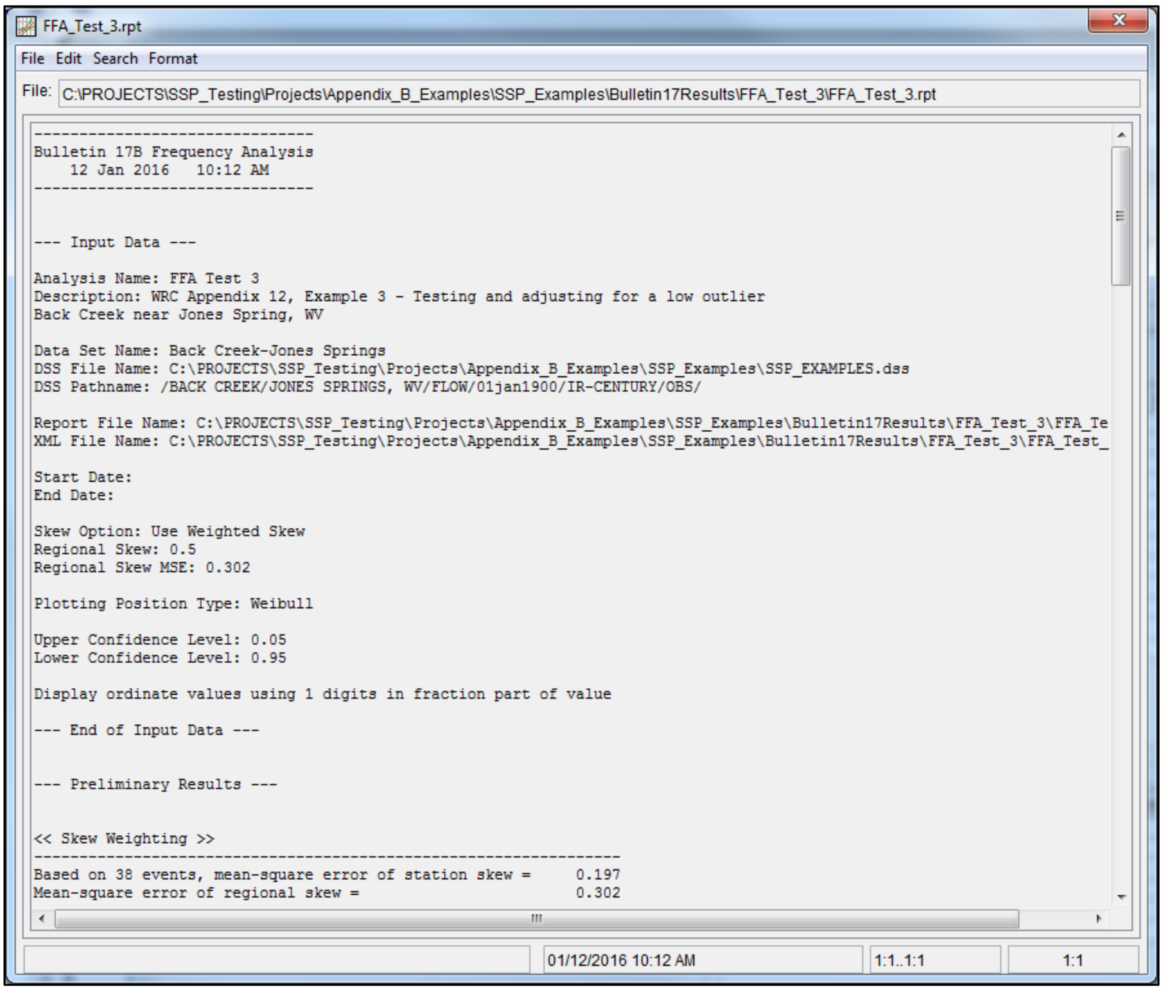


Figure B-21. Pot for FFA Test 3.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-22 is the report file for **FFA Test 3**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.



FFA_Test_3.rpt
File Edit Search Format
File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_3\FFA_Test_3.rpt

```
------------------------------
Bulletin 17B Frequency Analysis
    12 Jan 2016   10:12 AM
------------------------------


--- Input Data ---

Analysis Name: FFA Test 3
Description: WRC Appendix 12, Example 3 - Testing and adjusting for a low outlier
Back Creek near Jones Spring, WV

Data Set Name: Back Creek-Jones Springs
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss
DSS Pathname: /BACK CREEK/JONES SPRINGS, WV/FLOW/01jan1900/IR-CENTURY/OBS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_3\FFA_Te
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_3\FFA_Test_

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: 0.5
Regional Skew MSE: 0.302

Plotting Position Type: Weibull

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---


<< Skew Weighting >>
-----------------------------------------------------------------
Based on 38 events, mean-square error of station skew =     0.197
Mean-square error of regional skew =                        0.302
```

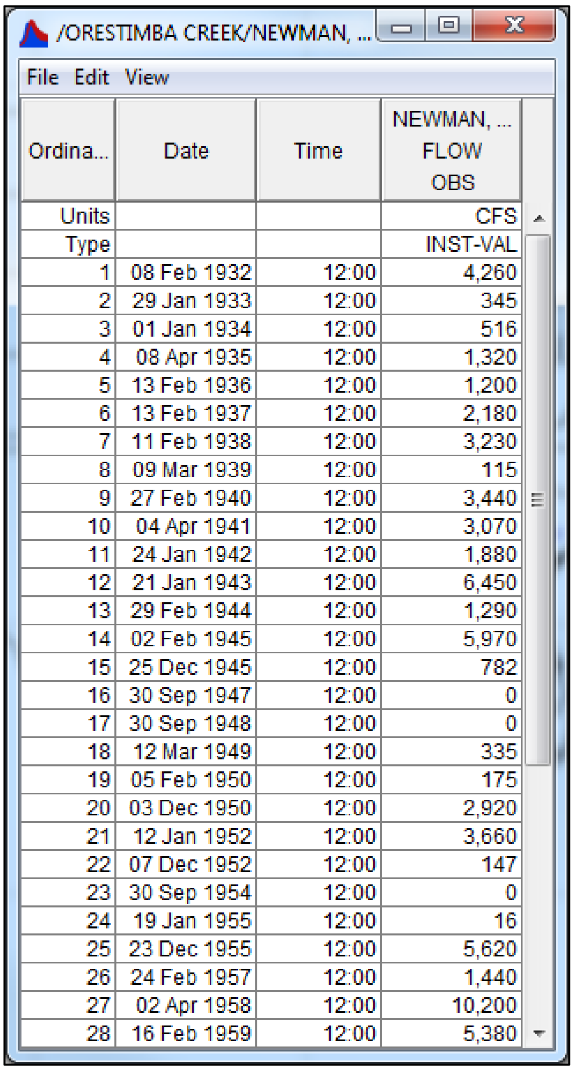
01/12/2016 10:12 AM | 1:1..1:1 | 1:1

Figure B-22. Report File for FFA Test 3.

Example 4: Zero-Flood Years

The input data for **FFA Test 4** are the same as that for Example 4 in Appendix 12 of the WRC Guidelines. **FFA Test 4** illustrates the application to data that includes several zero flow years.

The data for this example is from Orestimba Creek in Newman, California. The period of record used for this example is from 1932 to 1973. To view the data from HEC-SSP, right-click on the data record labeled "**Orestimba Creek-Newman, CA**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-23.



Ordina...	Date	Time	NEWMAN, ... FLOW OBS
Units			CFS
Type			INST-VAL
1	08 Feb 1932	12:00	4,260
2	29 Jan 1933	12:00	345
3	01 Jan 1934	12:00	516
4	08 Apr 1935	12:00	1,320
5	13 Feb 1936	12:00	1,200
6	13 Feb 1937	12:00	2,180
7	11 Feb 1938	12:00	3,230
8	09 Mar 1939	12:00	115
9	27 Feb 1940	12:00	3,440
10	04 Apr 1941	12:00	3,070
11	24 Jan 1942	12:00	1,880
12	21 Jan 1943	12:00	6,450
13	29 Feb 1944	12:00	1,290
14	02 Feb 1945	12:00	5,970
15	25 Dec 1945	12:00	782
16	30 Sep 1947	12:00	0
17	30 Sep 1948	12:00	0
18	12 Mar 1949	12:00	335
19	05 Feb 1950	12:00	175
20	03 Dec 1950	12:00	2,920
21	12 Jan 1952	12:00	3,660
22	07 Dec 1952	12:00	147
23	30 Sep 1954	12:00	0
24	19 Jan 1955	12:00	16
25	23 Dec 1955	12:00	5,620
26	24 Feb 1957	12:00	1,440
27	02 Apr 1958	12:00	10,200
28	16 Feb 1959	12:00	5,380

Figure B-23. Tabulation of the Peak Flow Data for Orestimba Creek.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-24. The years with peak flows measuring zero are visible.

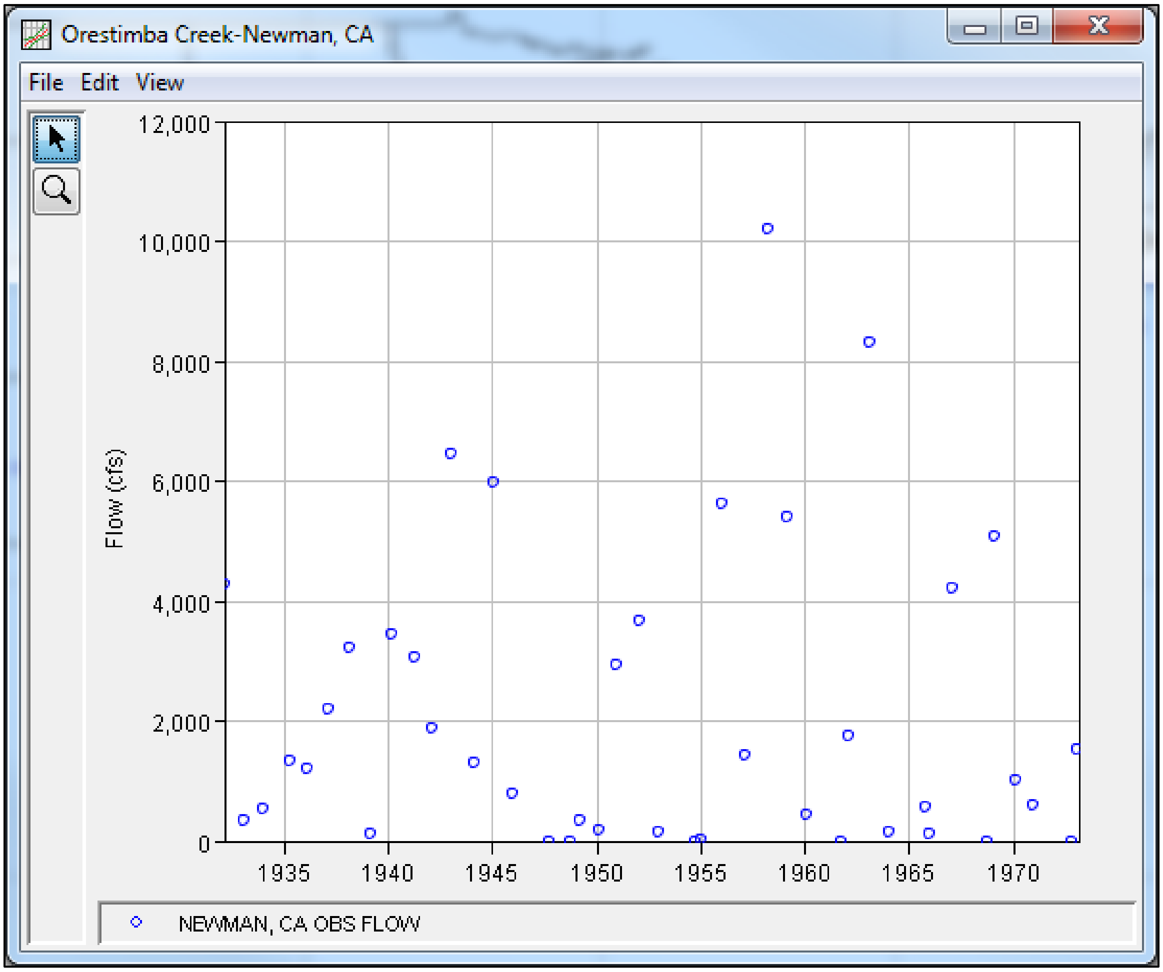


Figure B-24. Plot of Orestimba Creek Data.

A Bulletin 17B and General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for **FFA Test 4**, either double-click on the analysis labeled **FFA Test 4** from the study explorer, or from the **Analysis** menu select open, then select **FFA Test 4** from the list of available analyses. When **FFA Test 4** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-25.

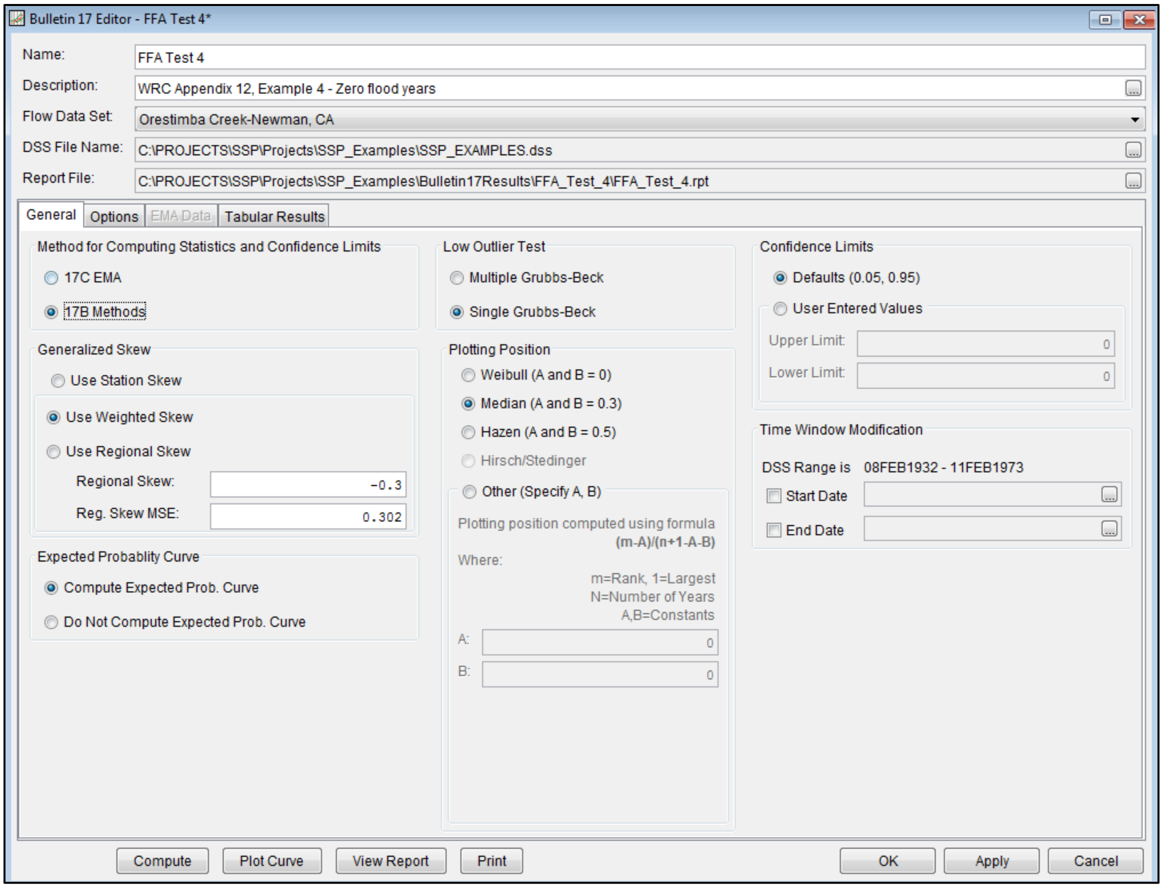


Figure B-25. Bulletin 17B Analysis Editor with FFA Test 4 Data Set.

Shown in Figure B-25 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example a value of -0.3 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The **Weibull** plotting position method was selected, as well as the default **Confidence Limits** of 0.05 (5 percent chance exceedance) and 0.95 (95% chance exceedance). Shown in Figure B-26 is the Bulletin 17B editor with the **Options Tab** selected.

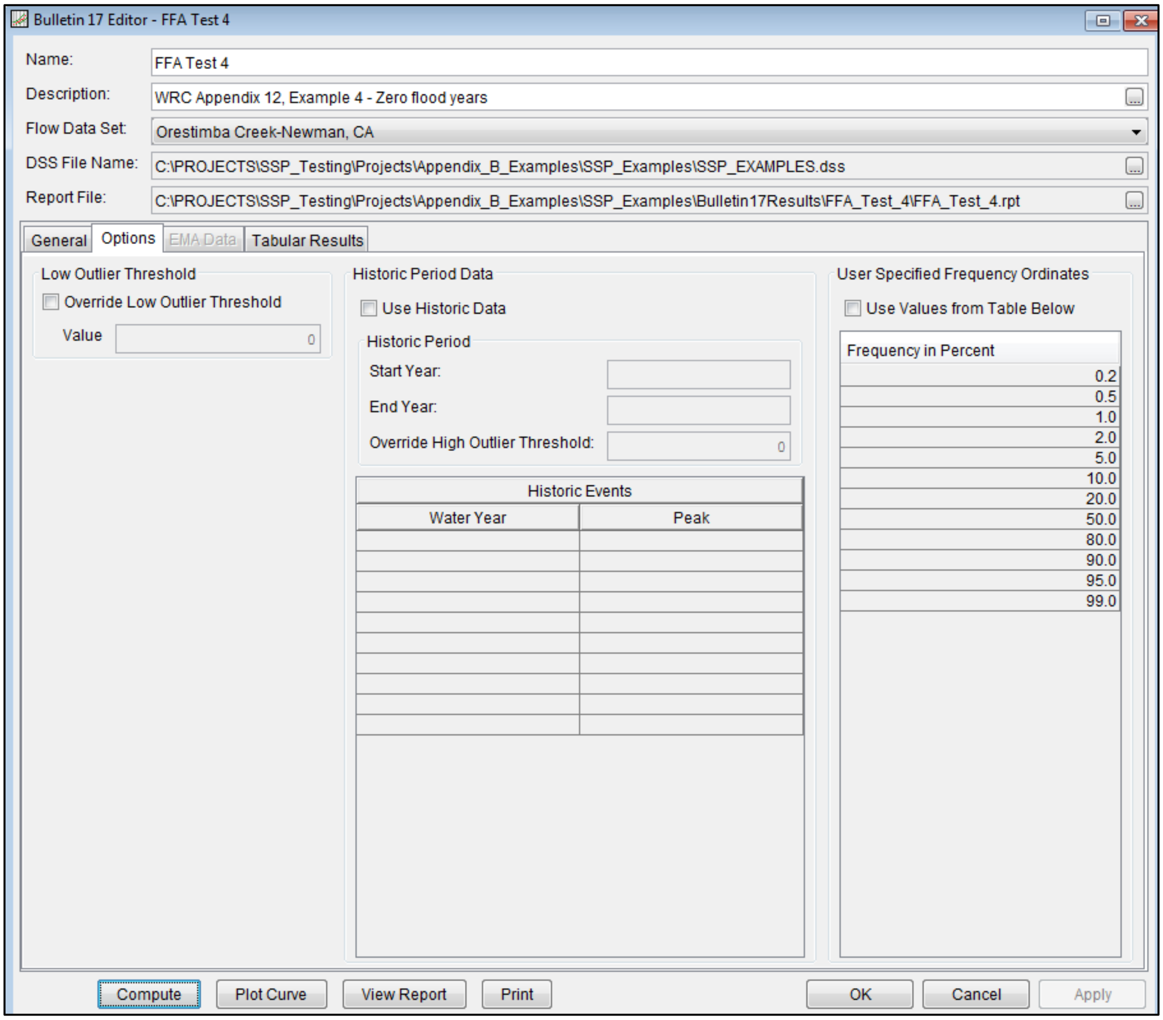
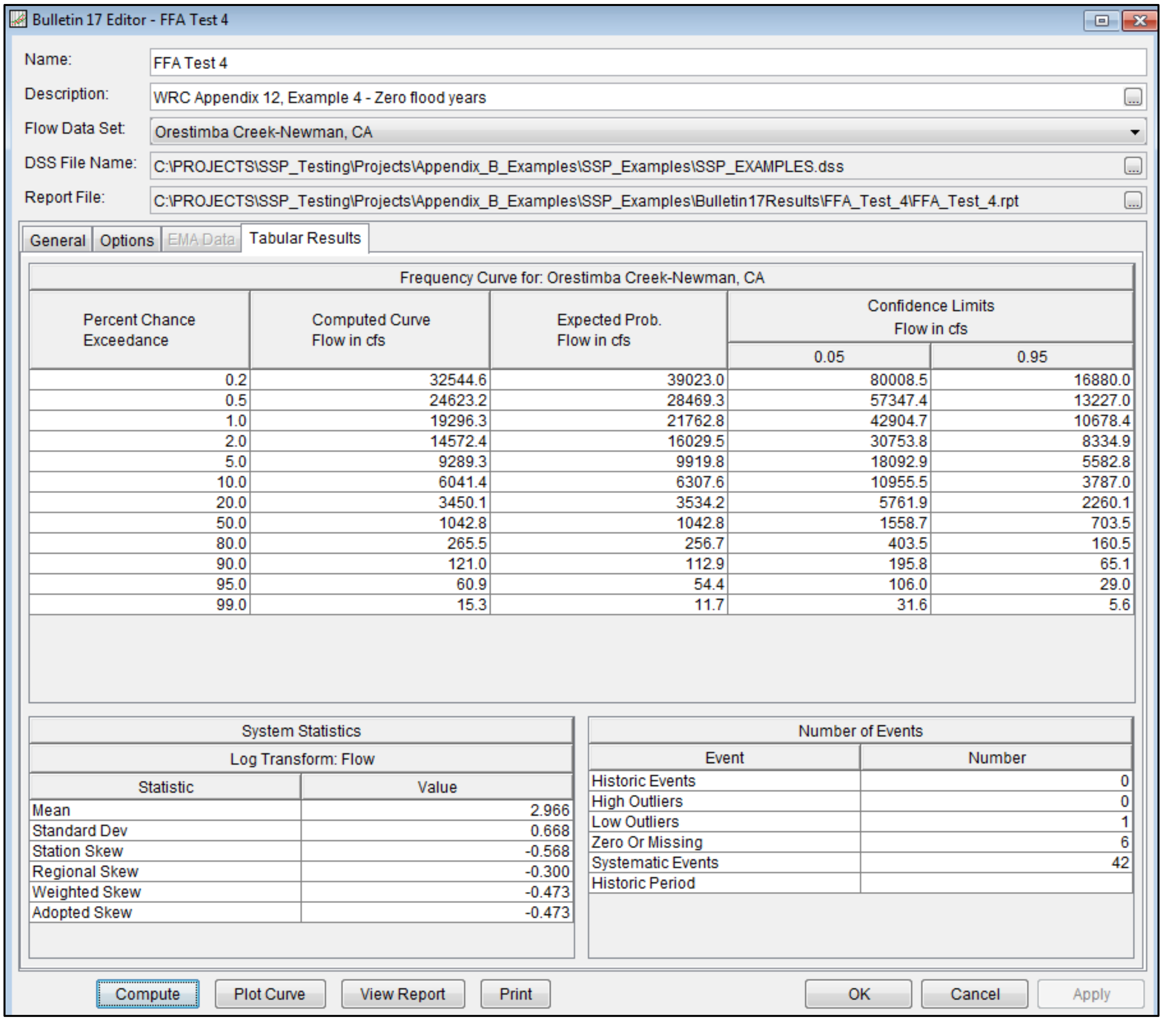


Figure B-26. Bulletin 17B Editor with the Options Tab Selected for FFA Test 4.

As shown in Figure B-26, none of the available options for modifying the frequency curve were selected for this test example. These options include the **Low Outlier Threshold** and **Historic Period Data**. Additionally, the option to override the default **Frequency Ordinates** was not selected.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab. The analysis window should look Figure B-27.



Bulletin 17 Editor - FFA Test 4

Name: FFA Test 4

Description: WRC Appendix 12, Example 4 - Zero flood years

Flow Data Set: Orestimba Creek-Newman, CA

DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss

Report File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_4\FFA_Test_4.rpt

General | Options | EMA Data | Tabular Results

Frequency Curve for: Orestimba Creek-Newman, CA

Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Confidence Limits Flow in cfs	
			0.05	0.95
0.2	32544.6	39023.0	80008.5	16880.0
0.5	24623.2	28469.3	57347.4	13227.0
1.0	19296.3	21762.8	42904.7	10678.4
2.0	14572.4	16029.5	30753.8	8334.9
5.0	9289.3	9919.8	18092.9	5582.8
10.0	6041.4	6307.6	10955.5	3787.0
20.0	3450.1	3534.2	5761.9	2260.1
50.0	1042.8	1042.8	1558.7	703.5
80.0	265.5	256.7	403.5	160.5
90.0	121.0	112.9	195.8	65.1
95.0	60.9	54.4	106.0	29.0
99.0	15.3	11.7	31.6	5.6

System Statistics

Log Transform: Flow

Statistic	Value
Mean	2.966
Standard Dev	0.668
Station Skew	-0.568
Regional Skew	-0.300
Weighted Skew	-0.473
Adopted Skew	-0.473

Number of Events

Event	Number
Historic Events	0
High Outliers	0
Low Outliers	1
Zero Or Missing	6
Systematic Events	42
Historic Period	

Compute | Plot Curve | View Report | Print | OK | Cancel | Apply

Figure B-27. Bulletin 17B Editor with the Results Tab Selected for FFA Test 4.

As shown in Figure B-27, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (5% and 95% chance exceedance curves)

On the bottom left-hand side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is a table of Number of Events showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

As noted earlier, there were six zero values in this record, and also a low outlier. A zero value causes difficulty because the first step in fitting a Log Pearson III distribution is computing the base-10 log of each flow value, which is undefined for zero. Bulletin 17B recommends removing the zero values (and the low outlier) from the systematic record to compute a preliminary frequency curve, and then adjusting that curve with the Conditional Probability Adjustment. The final frequency curve and statistics are shown in the table, and the preliminary calculations can be reviewed in the report file.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-28.

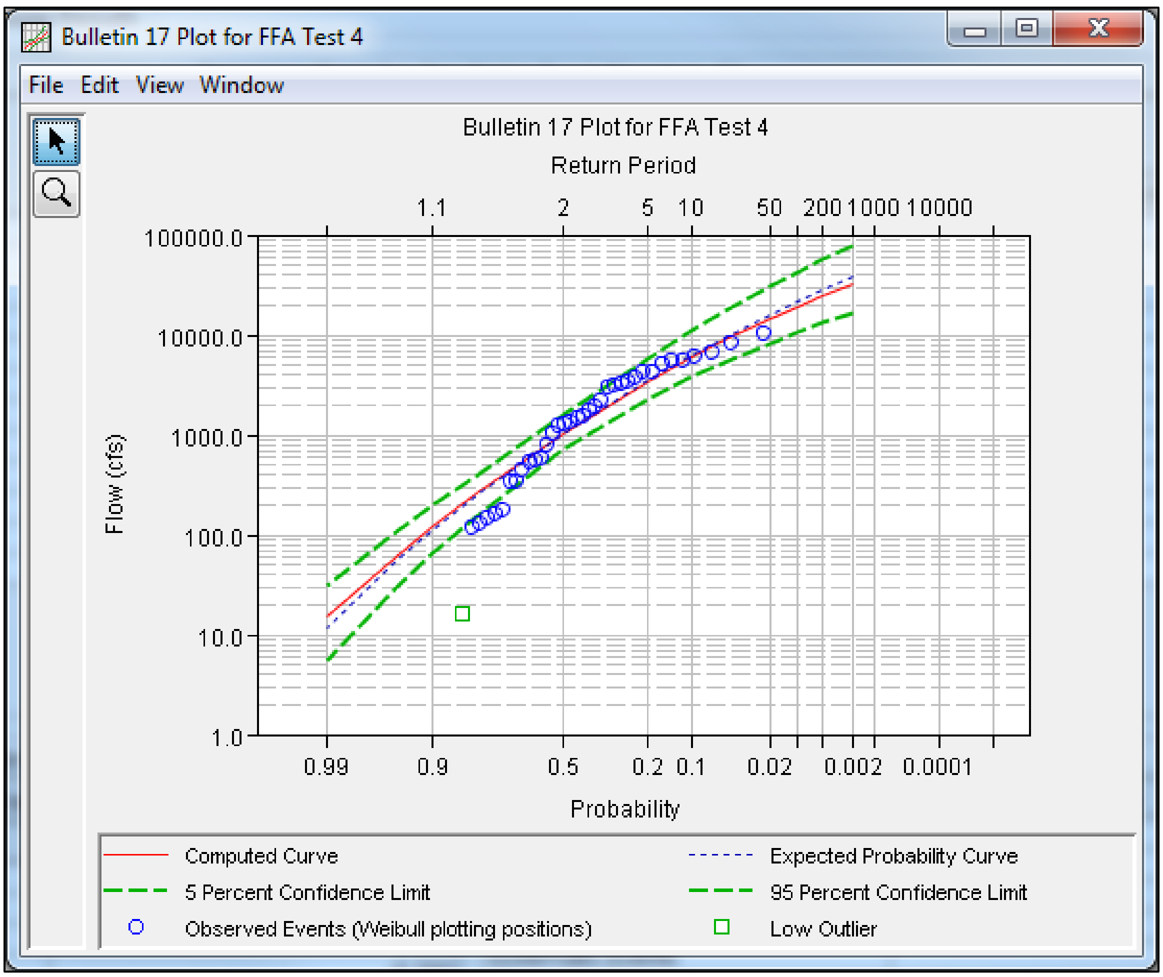
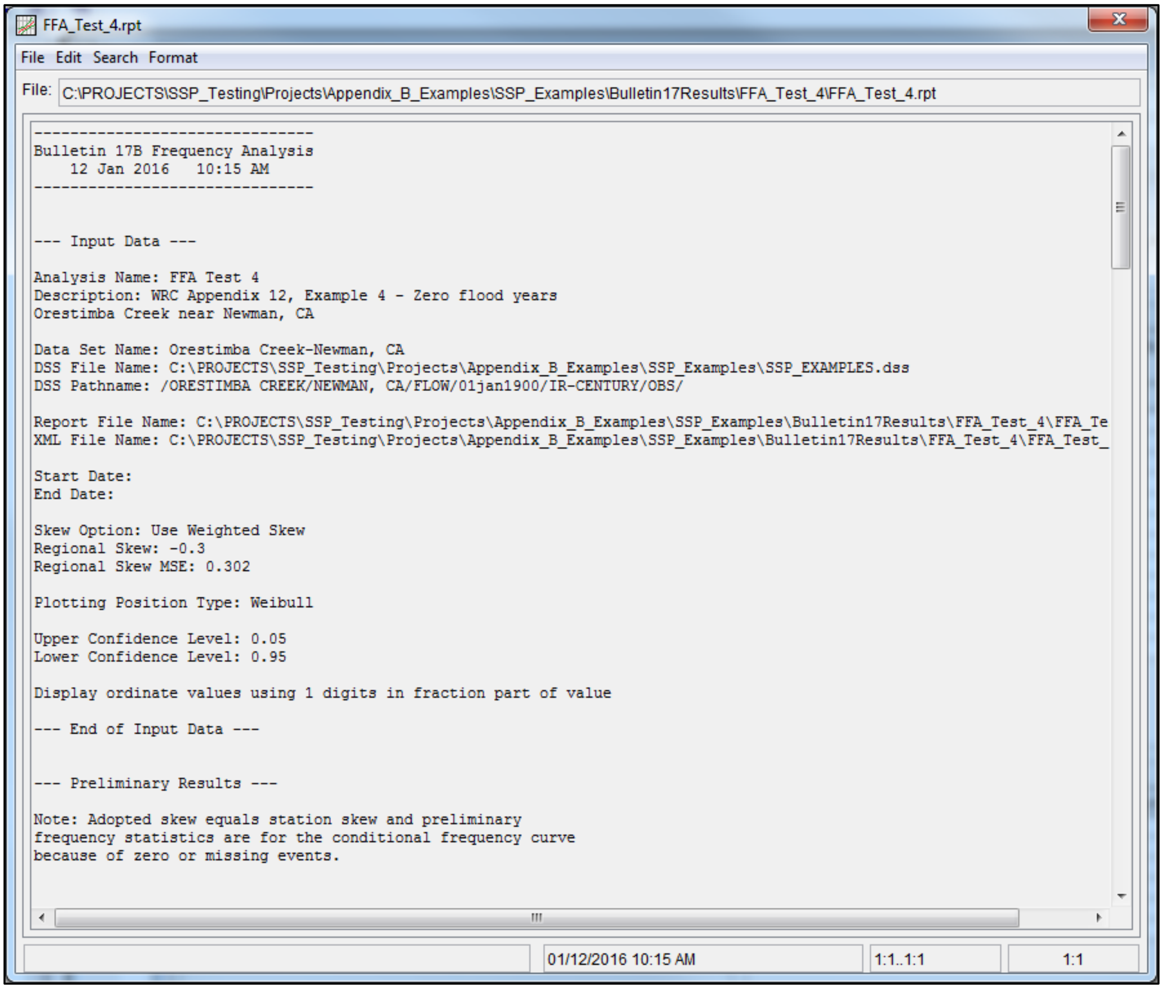


Figure B-28. Plot of FFA Test 4 Results.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-29 is the report file for **FFA Test 4**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.




```
-------------------------------
Bulletin 17B Frequency Analysis
    12 Jan 2016   10:15 AM
-------------------------------


--- Input Data ---

Analysis Name: FFA Test 4
Description: WRC Appendix 12, Example 4 - Zero flood years
Orestimba Creek near Newman, CA

Data Set Name: Orestimba Creek-Newman, CA
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss
DSS Pathname: /ORESTIMBA CREEK/NEWMAN, CA/FLOW/01jan1900/IR-CENTURY/OBS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_4\FFA_Te
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_4\FFA_Test_

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: -0.3
Regional Skew MSE: 0.302

Plotting Position Type: Weibull

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
```

Figure B-29. HEC-SSP Report File for FFA Test 4.

Example 5: Confidence Limits and Low Threshold Discharge

This example illustrates the use of user-entered confidence limits. Probabilities of .01 and .99 were entered for the computed confidence limit curves. This data set also includes two very low values, the higher of which is just above the default low outlier threshold. This example therefore also demonstrates the use of a user-entered low outlier threshold set to be higher than both values.

The data for this example is from Kaskaskia River in Vandalia, Illinois. The period of record used for this example is from 1908 to 1970. To view the data from HEC-SSP, right-click on the data record labeled "**Kaskaskia River-Vandalia, IL**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-30.

/KASKASKIA RIVER/VANDALIA, I...

File Edit View

Ordina...	Date	Time	VANDALIA, IL FLOW OBS
31	12 Jun 1941	12:00	4,560
32	12 Jul 1942	12:00	13,600
33	18 May 1943	12:00	52,200
34	24 Apr 1944	12:00	31,000
35	10 Jun 1945	12:00	21,500
36	04 May 1946	12:00	13,000
37	10 Jun 1947	12:00	12,300
38	28 Mar 1948	12:00	19,000
39	16 Feb 1949	12:00	25,000
40	04 Jan 1950	12:00	51,300
41	29 Jun 1951	12:00	31,000
42	15 Apr 1952	12:00	10,500
43	05 Mar 1953	12:00	5,680
44	19 Apr 1954	12:00	505
45	25 Apr 1955	12:00	5,000
46	27 Feb 1956	12:00	7,840
47	29 Jun 1957	12:00	62,700
48	04 Aug 1958	12:00	12,400
49	12 Feb 1959	12:00	17,200
50	30 Jun 1960	12:00	11,800
51	10 Apr 1961	12:00	34,400
52	25 Mar 1962	12:00	17,100
53	22 May 1963	12:00	9,000
54	04 May 1964	12:00	8,500
55	04 May 1965	12:00	5,350
56	19 May 1966	12:00	11,900
57	10 Dec 1966	12:00	27,000
58	23 Dec 1967	12:00	20,800
59	31 Jan 1969	12:00	20,700
60	16 Jun 1970	12:00	30,000

Figure B-30. Tabulation of the Peak Flow Data for Kaskaskia River.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-31.

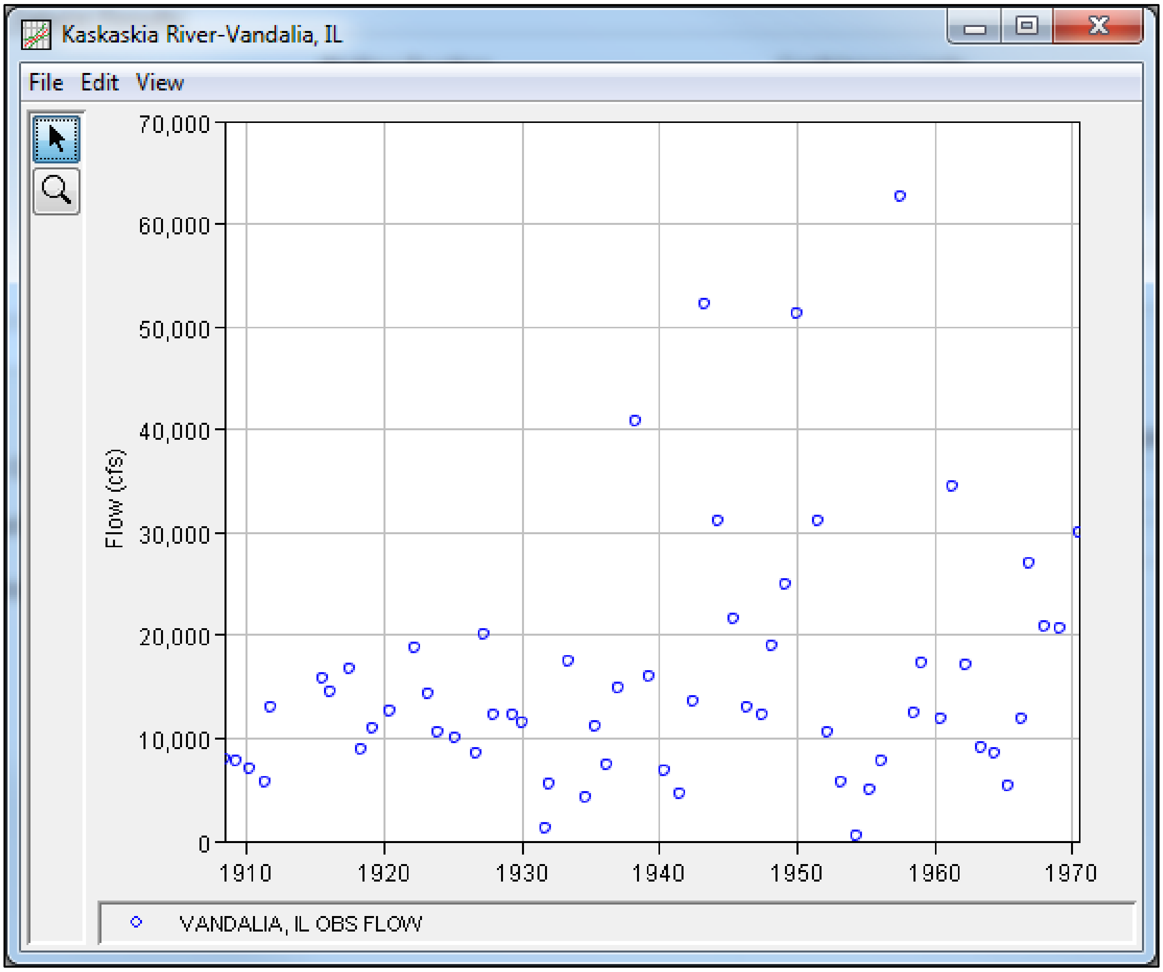


Figure B-31. HEC-SSP Plot of the Kaskaskia River Data.

A Bulletin 17B and General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for **FFA Test 5**, either double-click on the analysis labeled **FFA Test 5** from the study explorer, or from the **Analysis** menu select **Open** and then select **FFA Test 5** from the list of available analyses. When **FFA Test 5** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-32.

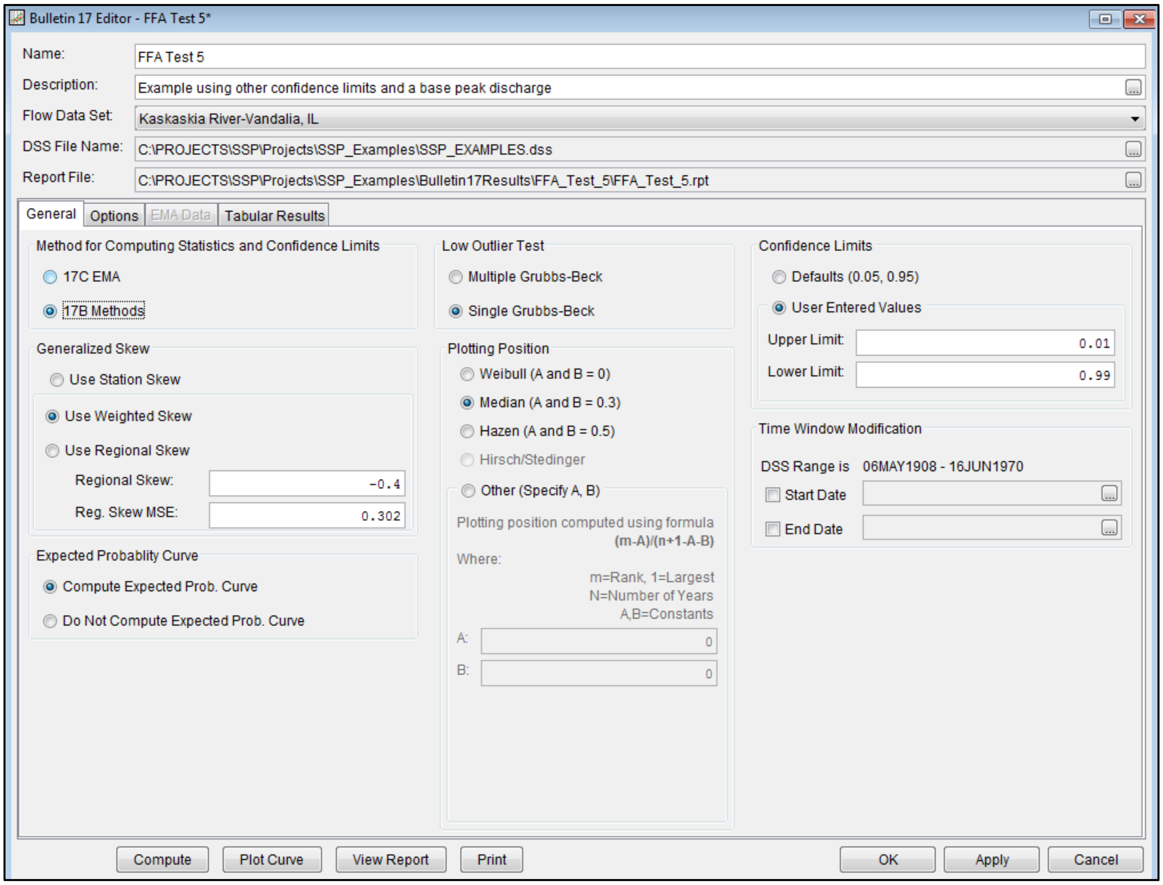


Figure B-32. Bulletin 17B Analysis Editor for FFA Test 5.

Shown in Figure B-32 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example a value of -0.4 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The default method of **Weibull** plotting positions was selected. The default values for confidence limits (.05 and .95) were changed to 0.01 (1 percent chance exceedance) and 0.99 (99% chance exceedance). Shown in Figure B-33 is the Bulletin 17B editor with the **Options Tab** selected.

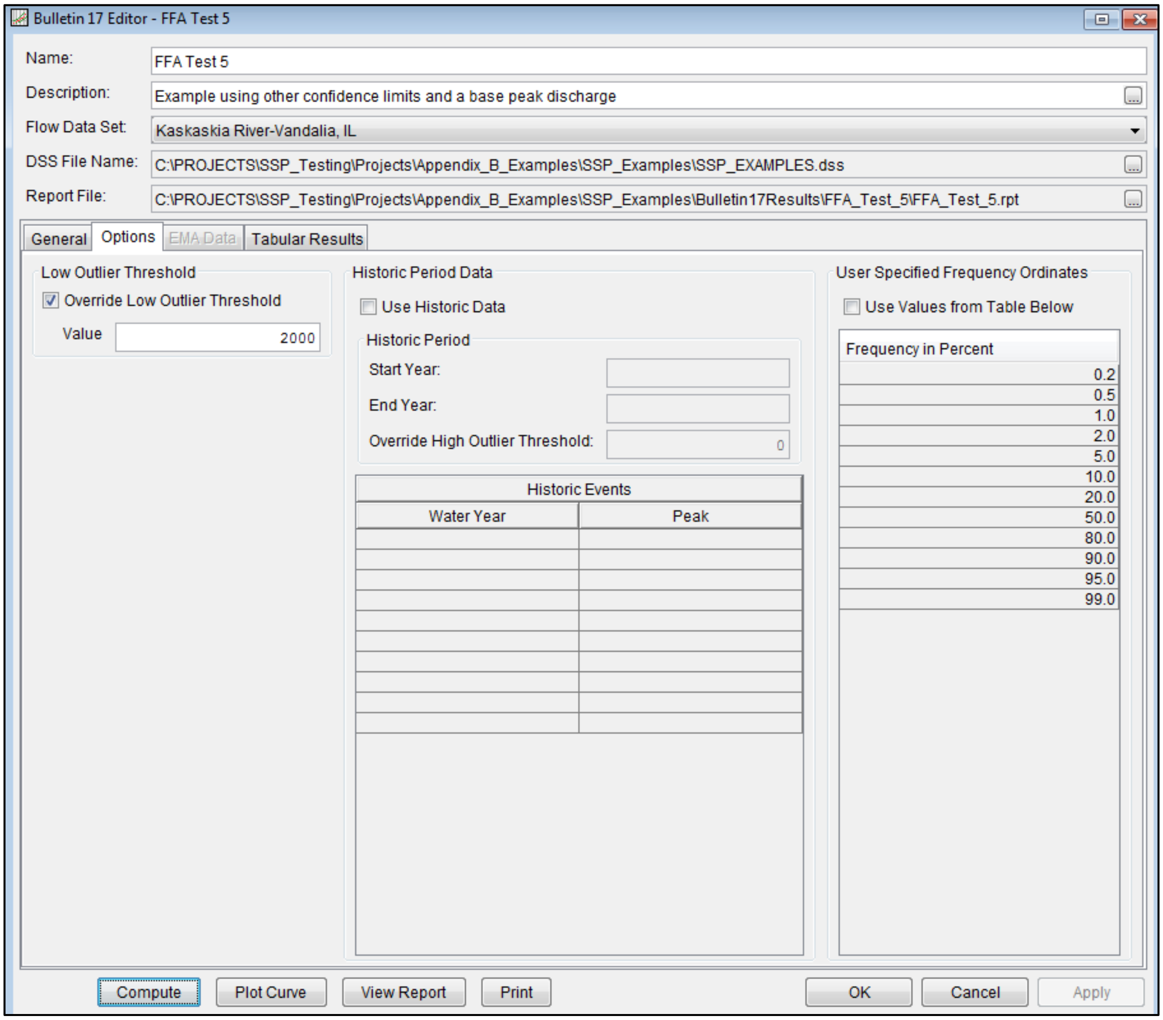
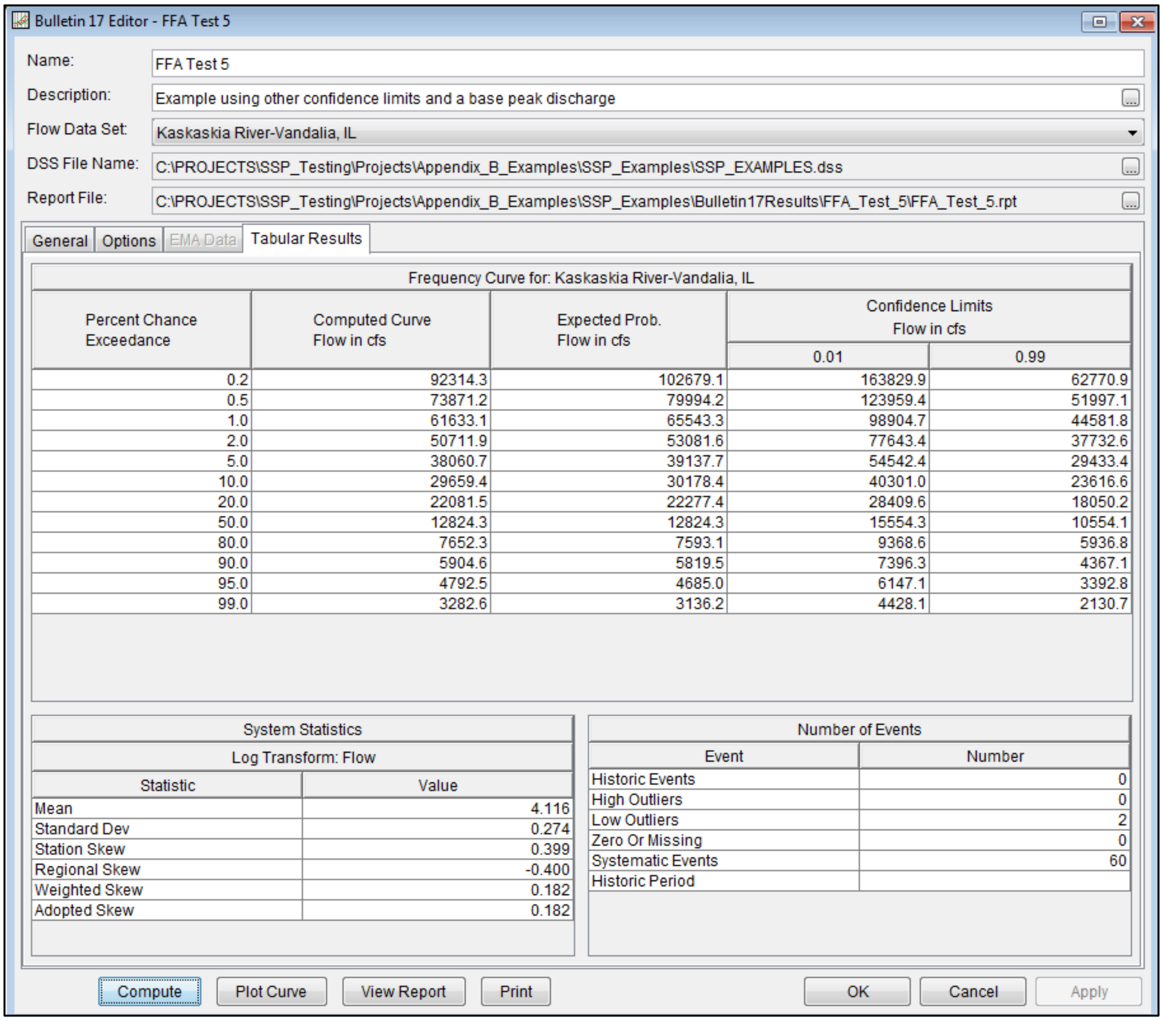


Figure B-33. Bulletin 17B Editor with the Options Tab Shown for FFA Test 5.

As shown in Figure B-33, a **Low Outlier Threshold** of 2000 cfs was entered. In the initial computation with this data (which the reader can reproduce by Computing without the "Use Low Outlier Threshold" box checked), the default low outlier threshold was 1,253 cfs, just below the second lowest value of 1,270 cfs. A look at the statistics and computed frequency curve from that run shows that the 1,270 cfs value is well below the computed curve and with a station skew of -0.21 the frequency curve does not fit the upper data well. By choosing to also censor the 1,270 cfs value with a threshold of 2000 cfs, the fit is improved. None of the other available options, such as **Historic Period Data** and the option to override the default **Frequency Ordinates** were selected for this test example.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed a message window will open stating

Compute Complete. Close this window and then select the **Tabular Results** tab from the analysis window. The analysis window should look Figure B-34.



Percent Chance Exceedance	Computed Curve Flow in cfs	Expected Prob. Flow in cfs	Confidence Limits Flow in cfs 0.01	0.99
0.2	92314.3	102679.1	163829.9	62770.9
0.5	73871.2	79994.2	123959.4	51997.1
1.0	61633.1	65543.3	98904.7	44581.8
2.0	50711.9	53081.6	77643.4	37732.6
5.0	38060.7	39137.7	54542.4	29433.4
10.0	29659.4	30178.4	40301.0	23616.6
20.0	22081.5	22277.4	28409.6	18050.2
50.0	12824.3	12824.3	15554.3	10554.1
80.0	7652.3	7593.1	9368.6	5936.8
90.0	5904.6	5819.5	7396.3	4367.1
95.0	4792.5	4685.0	6147.1	3392.8
99.0	3282.6	3136.2	4428.1	2130.7

Statistic	Value
Mean	4.116
Standard Dev	0.274
Station Skew	0.399
Regional Skew	-0.400
Weighted Skew	0.182
Adopted Skew	0.182

Event	Number
Historic Events	0
High Outliers	0
Low Outliers	2
Zero Or Missing	0
Systematic Events	60
Historic Period	

Figure B-34. Bulletin 17B Editor with the Results Tab Selected for FFA Test 5.

As shown in Figure B-34, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (1% and 99% chance exceedance curves)

On the bottom left-hand side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is a table of Number of Events showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (only if historic data was entered).

With the user-defined low-outlier threshold of 2000 cfs, there are two low-outliers detected. The analysis report shows the program omitted these values and used the Conditional Probability Adjustment to recompute the resulting frequency curve and statistics. The report file (described below) includes the preliminary computation before removal of outliers and the default and user-defined outlier thresholds, as well as the final frequency curve and statistics.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-35.

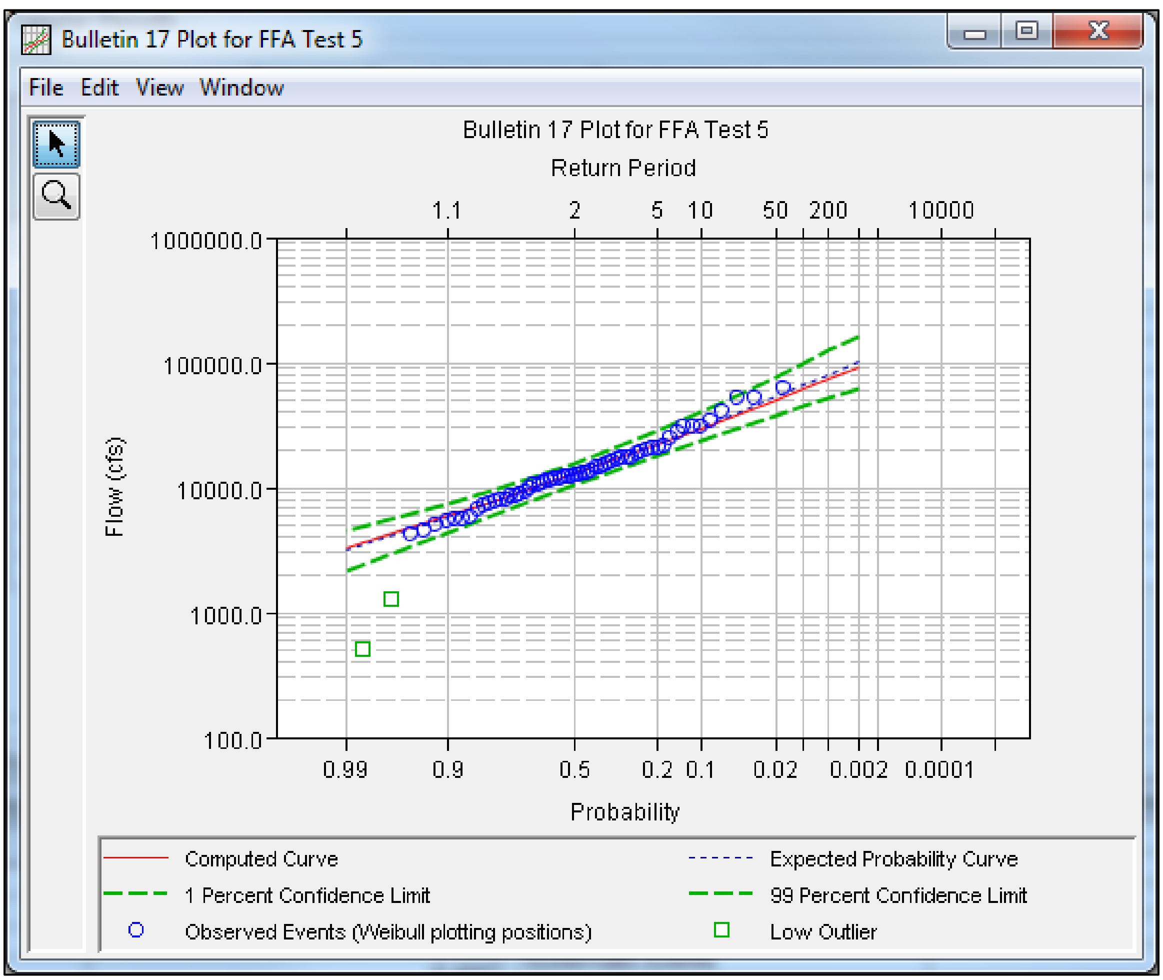
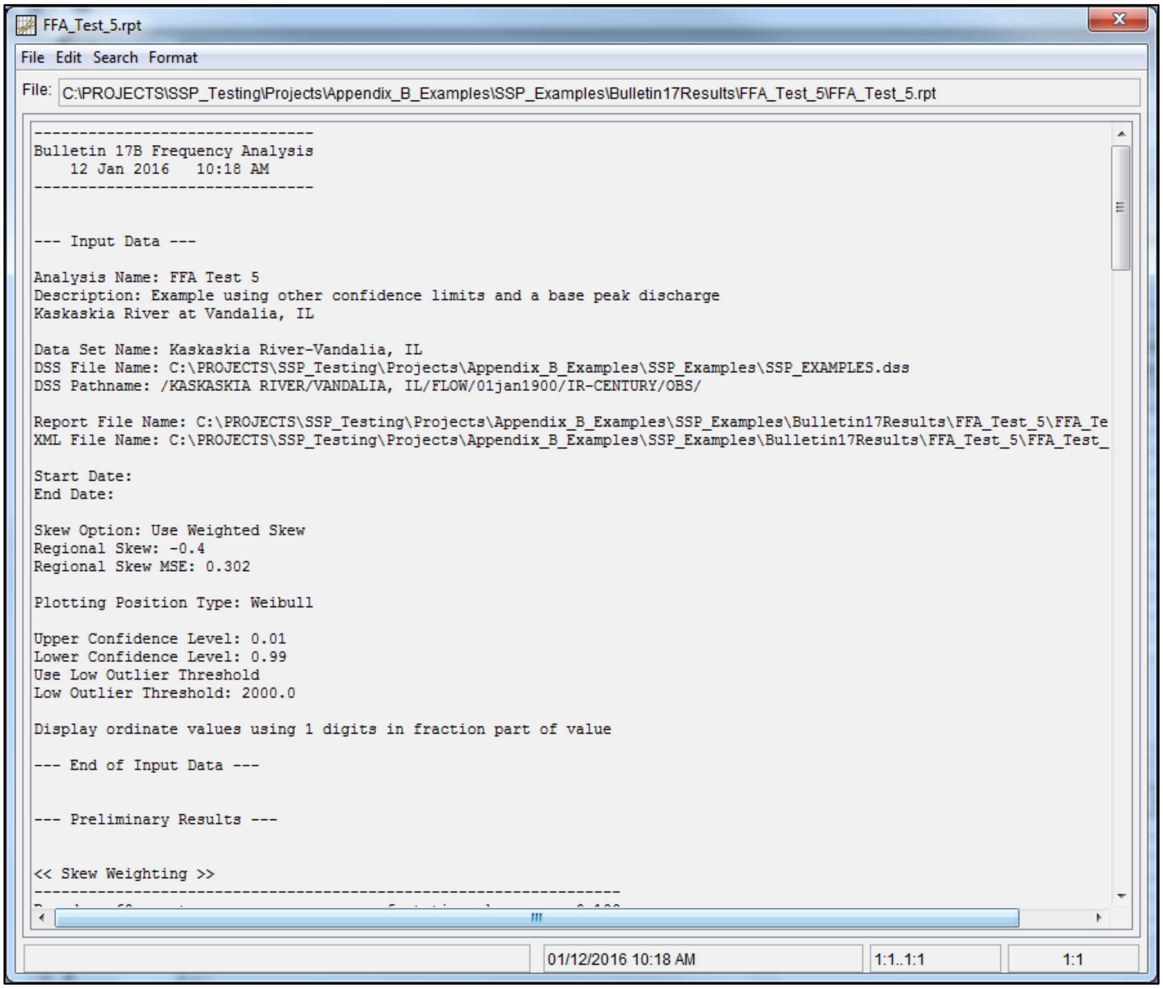


Figure B-35. Plot of the Frequency Curve Results for FFA Test 5.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-36 is the report file for **FFA Test 5**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.




```
------------------------------
Bulletin 17B Frequency Analysis
    12 Jan 2016   10:18 AM
------------------------------


--- Input Data ---

Analysis Name: FFA Test 5
Description: Example using other confidence limits and a base peak discharge
Kaskaskia River at Vandalia, IL

Data Set Name: Kaskaskia River-Vandalia, IL
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss
DSS Pathname: /KASKASKIA RIVER/VANDALIA, IL/FLOW/01jan1900/IR-CENTURY/OBS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_5\FFA_Te
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_5\FFA_Test_

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: -0.4
Regional Skew MSE: 0.302

Plotting Position Type: Weibull

Upper Confidence Level: 0.01
Lower Confidence Level: 0.99
Use Low Outlier Threshold
Low Outlier Threshold: 2000.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---


<< Skew Weighting >>
-----------------------------------------------------------------
```

Figure B-36. Report File for FFA Test 5.

Example 6: Use of Historic Data and Median Plotting Position

This example demonstrates how to use historic information to improve a flow frequency analysis. A historic flood peak of 15,000 cfs which occurred in 1843 is included in the analysis. This value is the highest known value up to the present time (1974 for this example), even though the systematic record stopped in 1955.

The data for this example is from Ridley Creek in Moylan, Pennsylvania. The period of record used for this example is from 1932 to 1955. To view the data from HEC-SSP, right-click on the data record labeled "**Ridley Creek-Moylan, PA**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-37.

/RIDLEY CREEK/MOYLAN, PA/FL...

File Edit View

Ordinate	Date	Time	MOYLAN, PA FLOW OBS
Units			CFS
Type			INST-VAL
1	28 Mar 1932	12:00	891.0
2	23 Aug 1933	12:00	2,680.0
3	05 Mar 1934	12:00	1,080.0
4	09 Jul 1935	12:00	3,000.0
5	03 Jan 1936	12:00	1,590.0
6	22 Feb 1937	12:00	770.0
7	23 Jul 1938	12:00	3,320.0
8	03 Feb 1939	12:00	978.0
9	15 Mar 1940	12:00	1,770.0
10	07 Feb 1941	12:00	746.0
11	13 Aug 1942	12:00	1,000.0
12	30 Dec 1942	12:00	980.0
13	06 Jan 1944	12:00	865.0
14	18 Sep 1945	12:00	1,040.0
15	26 Dec 1945	12:00	1,000.0
16	22 May 1947	12:00	483.0
17	05 May 1948	12:00	740.0
18	30 Dec 1948	12:00	1,040.0
19	03 Aug 1950	12:00	1,590.0
20	25 Nov 1950	12:00	5,720.0
21	11 Mar 1952	12:00	1,490.0
22	22 Nov 1952	12:00	918.0
23	14 Dec 1953	12:00	670.0
24	18 Aug 1955	12:00	4,390.0

Figure B-37. Tabulation of the Peak Flow Data for Ridley Creek.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-38.

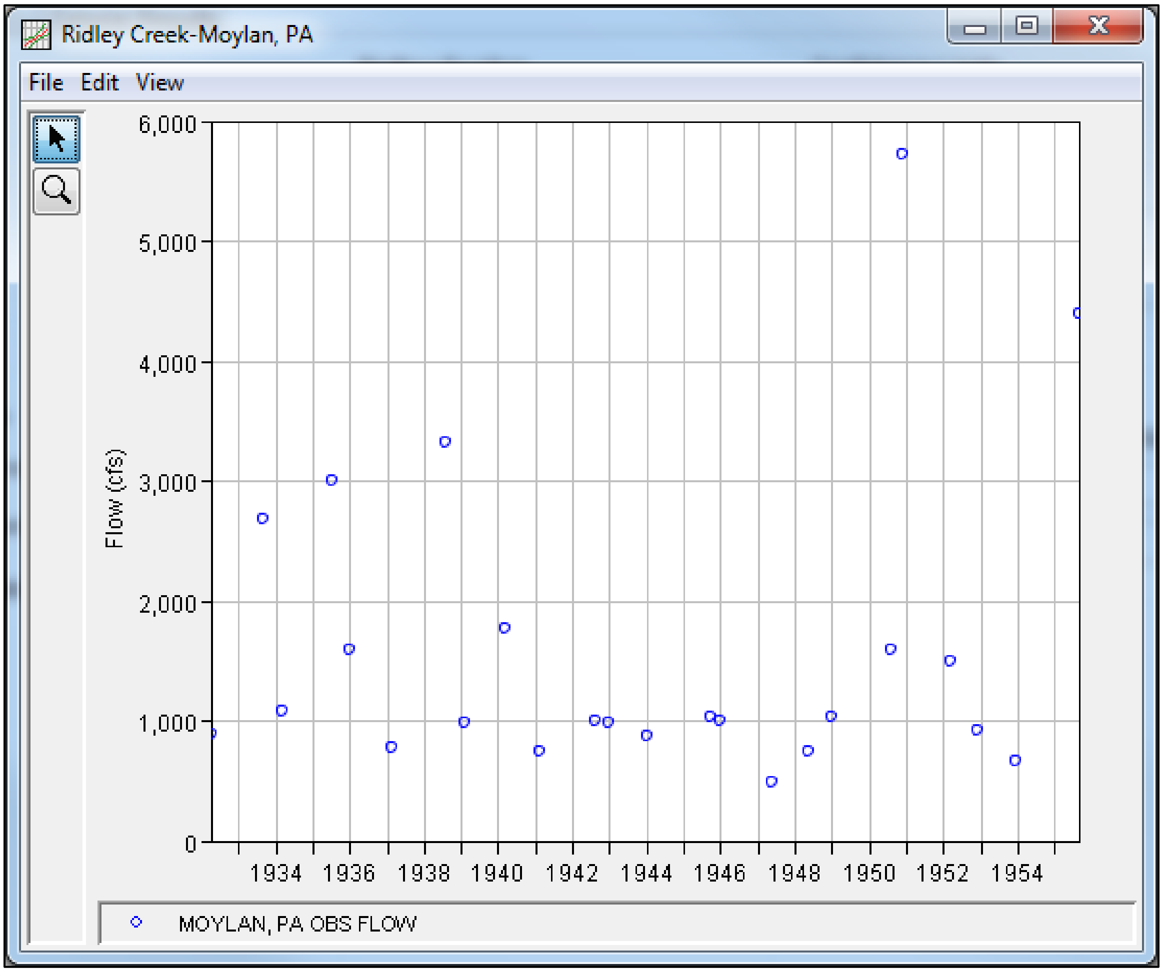


Figure B-38. Plot of the Ridley Creek Data.

A Bulletin 17B and General Frequency analysis have been developed for this example. To open the Bulletin 17B analysis editor for **FFA Test 6**, either double-click on the analysis labeled **FFA Test 6** from the study explorer, or from the **Analysis** menu select open, then select **FFA Test 6** from the list of available analyses. When **FFA Test 6** is selected, the Bulletin 17B analysis editor will appear as shown in Figure B-39.

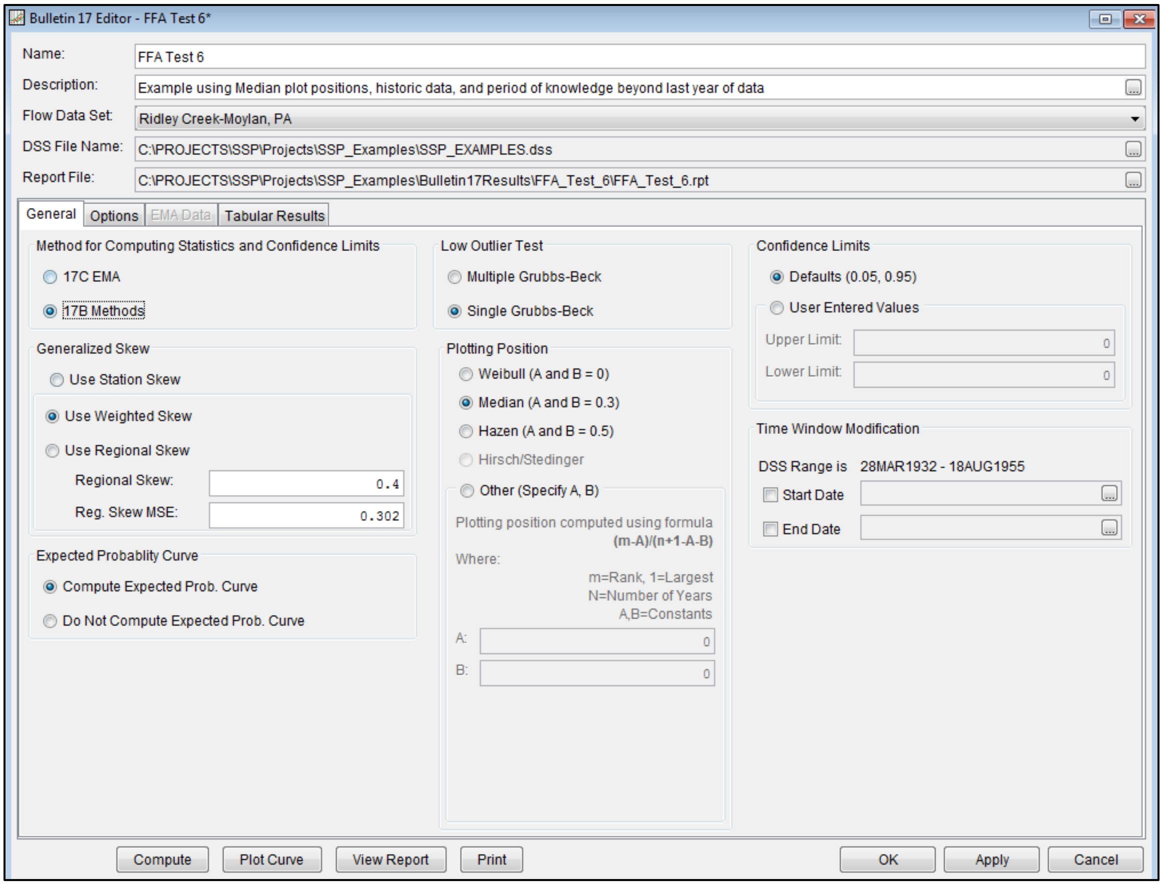


Figure B-39. Bulletin 17B Analysis Editor for FFA Test 6.

Shown in Figure B-39 are the general settings that were used to perform this frequency analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error (MSE). This selection requires the user to either look up a value from the generalized skew map of the United States, which is provided with Bulletin 17B, or develop a value from a regional analysis of nearby gages. In this example a value of 0.4 was taken from the generalized skew map of the U.S. from Bulletin 17B. Bulletin 17B suggests using a Regional Skew MSE of 0.302 whenever regional skew values are taken from the map.

Also for this example, the **Expected Probability Curve** option was selected to be computed in addition to the Log Pearson III computed curve. The **Median** plotting position method was selected, as well as the default **Confidence Limits** of 0.05 (5 percent chance exceedance) and 0.95 (95% chance exceedance). Shown in Figure B-40 is the Bulletin 17B editor with the **Options Tab** selected.

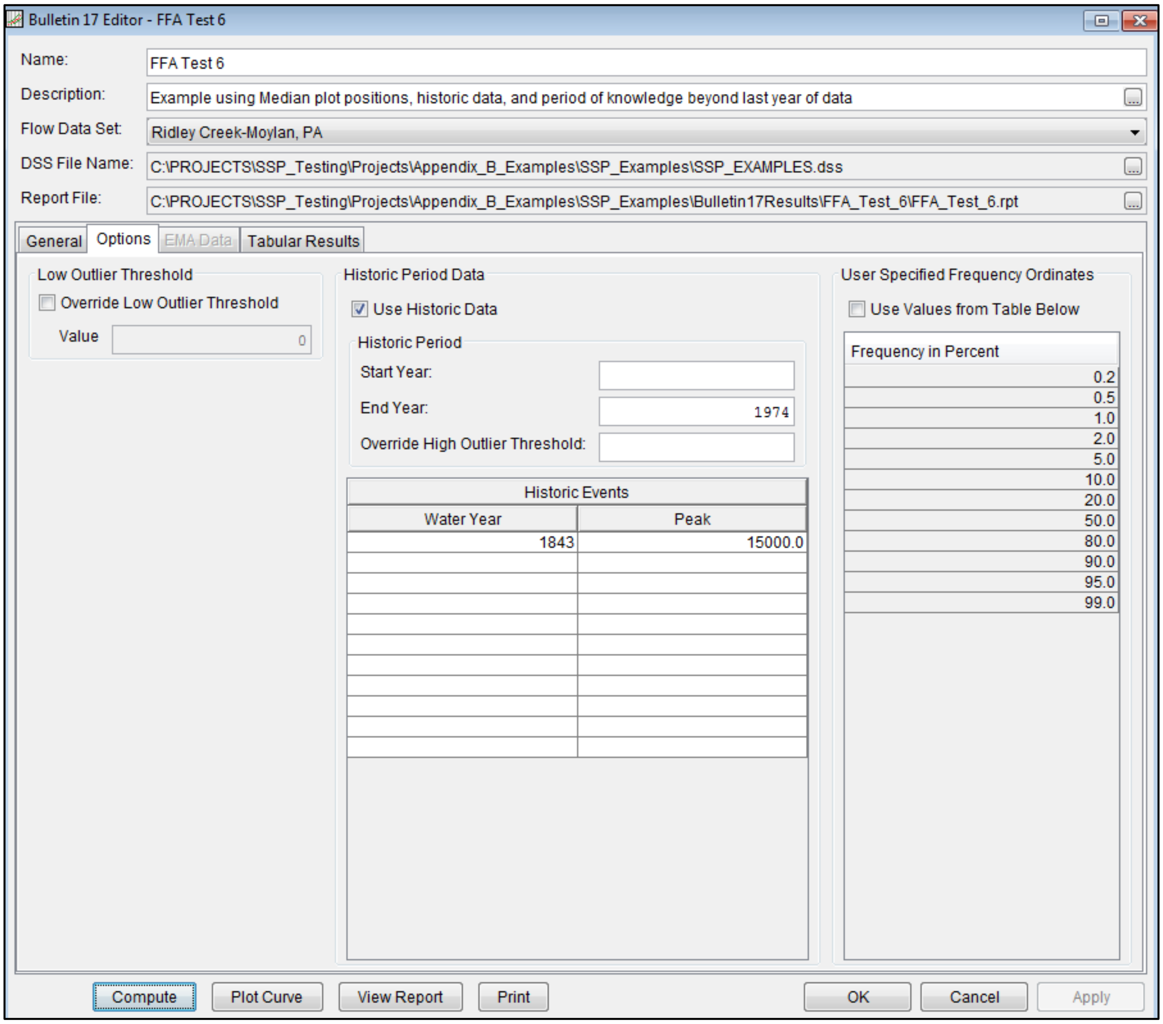


Figure B-40. Bulletin 17B Analysis Editor with Options Tab Shown for FFA Test 6.

As shown in Figure B-40, the **Historic Period Data** option has been selected to reflect a historical flood event of 15,000 cfs in 1843 and an analysis period from 1843 to 1974. Historic data is used to account for historic flood events large enough to be relevant to the analysis and not contained in the systematic data record. The additional information provided by historic data can improve the flood frequency analysis, especially when the data collection period for a given area is relatively short. Information for a **Historic Flood Peak** has been entered to account for a peak flow of 15,000 cfs in the 1843 water year. The Historic Period **Start Year** has been left blank. By default this value will be the earliest year found in the historic flood peak data or the systematic record. Therefore for this example, 1843 will automatically be used for the Start Year of the Historic Period. An **End Year** of 1974 has been entered. The systematic record for the gage ended in 1955, however when this analysis was performed in 1974, no other flood peaks of consequence had been observed between 1955 and 1974. Therefore, 1974 is set as the End Year for the historic period analysis.

Other features on this tab include the **Low Outlier Threshold** and the option to override the default **Frequency Ordinates**. Neither option is selected in this example.

Once all of the General and Optional settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab from the analysis window. The analysis window should look Figure B-41.

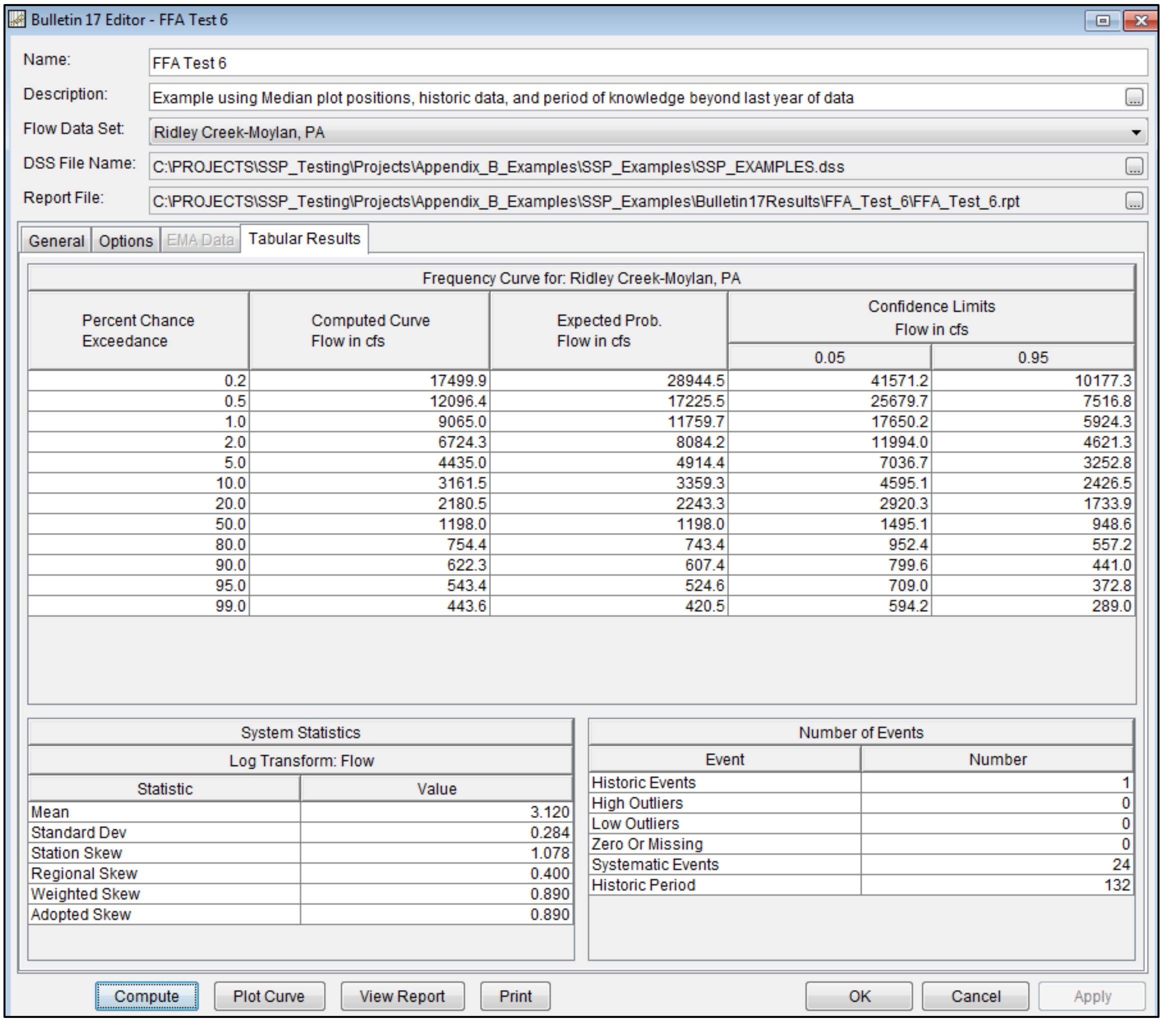


Figure B-41. Bulletin 17B Editor with the Results Tab Selected for FFA Test 6.

As shown in Figure B-41, the Frequency Curve table contains the following results:

Percent Chance Exceedance

Computed Curve (Log-Pearson III results)

Expected Probability Curve

Confidence Limits (5% and 95% chance exceedance curves)

On the bottom left-hand side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is a table of Number of Events showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

This example reports one historical flood event, and a historical period of 132 years, between 1843 and 1974. The reported statistics reflect the use of the historical data adjustment outlined in Bulletin 17B Appendix 6. The report file (described below) shows the initial computation of the statistics and frequency curve before the historical data was used, and the resulting statistics and frequency curve after the historical data is taken into account.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-42.

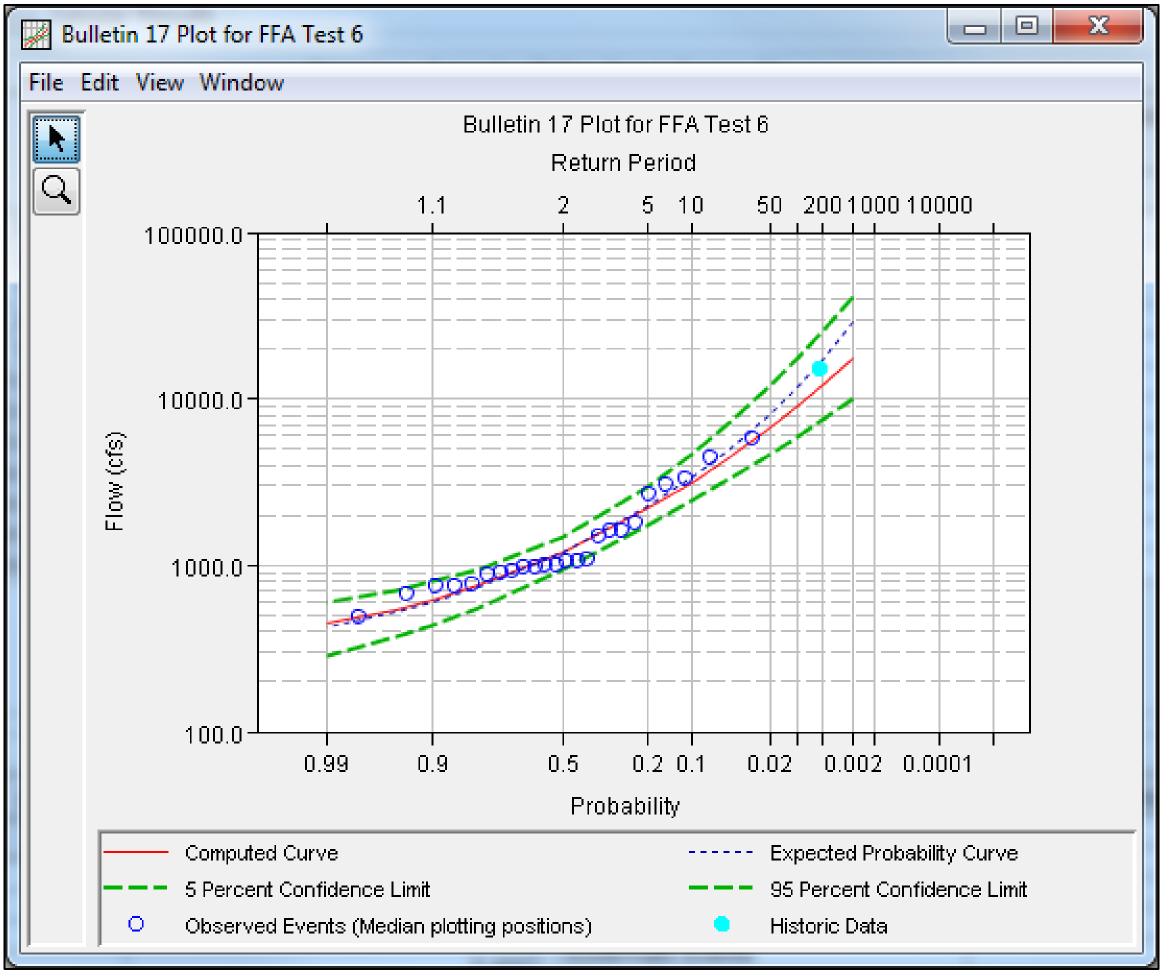
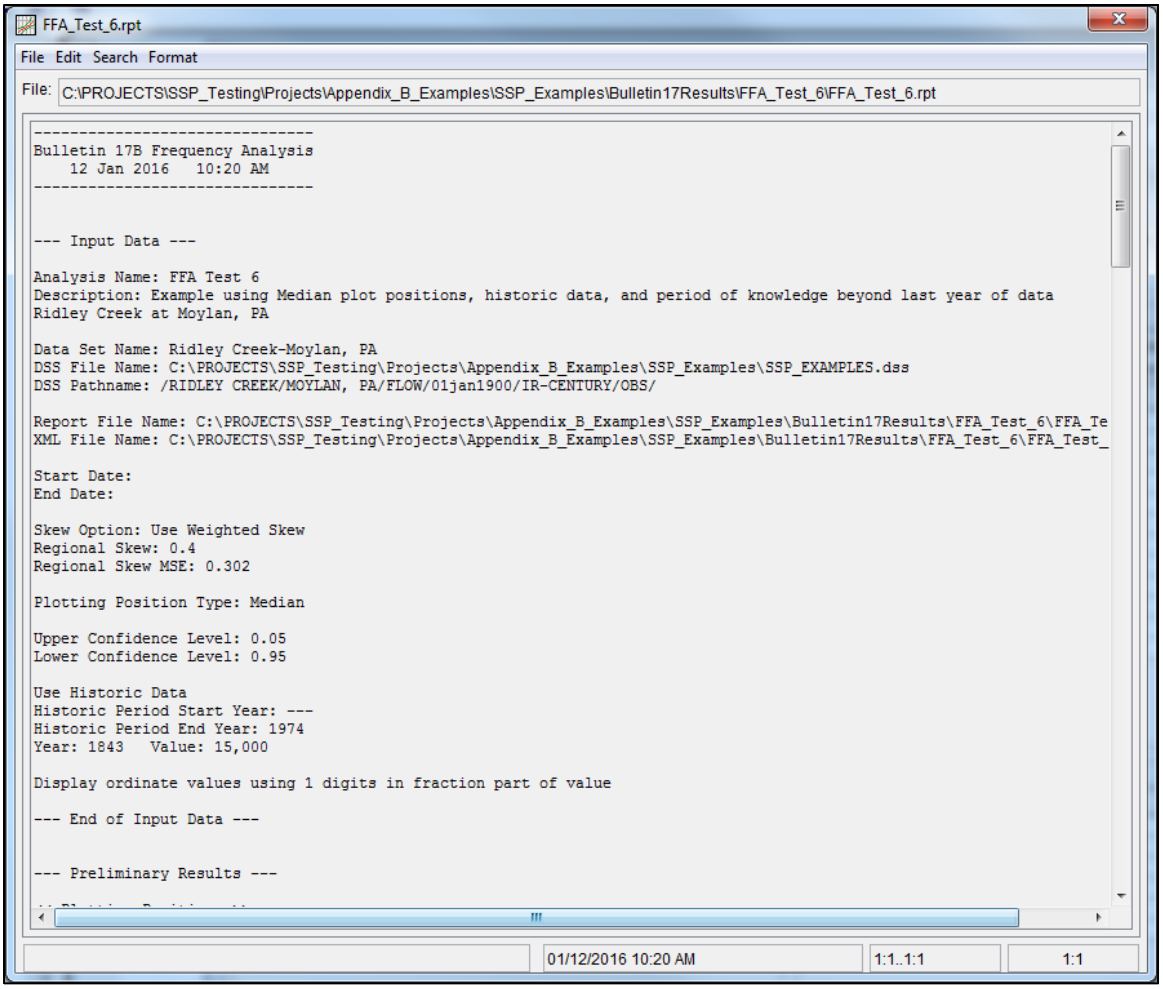


Figure B-42. Plot of the Frequency Curve Results for FFA Test 6.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-43 is the report file for **FFA Test 6**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.




```
-------------------------------
Bulletin 17B Frequency Analysis
    12 Jan 2016   10:20 AM
-------------------------------


--- Input Data ---

Analysis Name: FFA Test 6
Description: Example using Median plot positions, historic data, and period of knowledge beyond last year of data
Ridley Creek at Moylan, PA

Data Set Name: Ridley Creek-Moylan, PA
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss
DSS Pathname: /RIDLEY CREEK/MOYLAN, PA/FLOW/01jan1900/IR-CENTURY/OBS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_6\FFA_Te
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\Bulletin17Results\FFA_Test_6\FFA_Test_

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: 0.4
Regional Skew MSE: 0.302

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Use Historic Data
Historic Period Start Year: ---
Historic Period End Year: 1974
Year: 1843   Value: 15,000

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---
```

Figure B-43. HEC-SSP Report File for FFA Test 6.

Example 7: Analyzing Stage Data

This example demonstrates how to use the General Frequency analysis to analyze stage data. The data for this example is annual maximum stage data for a reservoir. The period of record used for this example is from 1948 to 2004. To view the data, right-click on the data record labeled "**Reservoir Stage**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-44.

/BE CREEK/RESERVOIR/STAGE/0...

File Edit View

Ordina...	Date	Time	RESERVOIR STAGE OBSERVED
Units			feet
Type			INST-VAL
1	01 Jan 1948	12:00	631.88
2	01 Jan 1949	12:00	630.17
3	01 Jan 1950	12:00	647.47
4	01 Jan 1951	12:00	631.82
5	01 Jan 1952	12:00	632.88
6	01 Jan 1953	12:00	655.37
7	01 Jan 1954	12:00	647.63
8	01 Jan 1955	12:00	638.09
9	01 Jan 1956	12:00	640.65
10	01 Jan 1957	12:00	634.51
11	01 Jan 1958	12:00	634.49
12	01 Jan 1959	12:00	637.49
13	01 Jan 1960	12:00	632.36
14	01 Jan 1961	12:00	638.02
15	01 Jan 1962	12:00	630.59
16	01 Jan 1963	12:00	626.77
17	01 Jan 1964	12:00	630.28
18	01 Jan 1965	12:00	630.12
19	01 Jan 1966	12:00	630.79
20	01 Jan 1967	12:00	637.63
21	01 Jan 1968	12:00	632.21
22	01 Jan 1969	12:00	632.10
23	01 Jan 1970	12:00	623.00
24	01 Jan 1971	12:00	630.40
25	01 Jan 1972	12:00	658.40
26	01 Jan 1973	12:00	630.80
27	01 Jan 1974	12:00	631.60
28	01 Jan 1975	12:00	638.40

Figure B-44. Tabulation of the Peak Stage Data for Example 7.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-45.

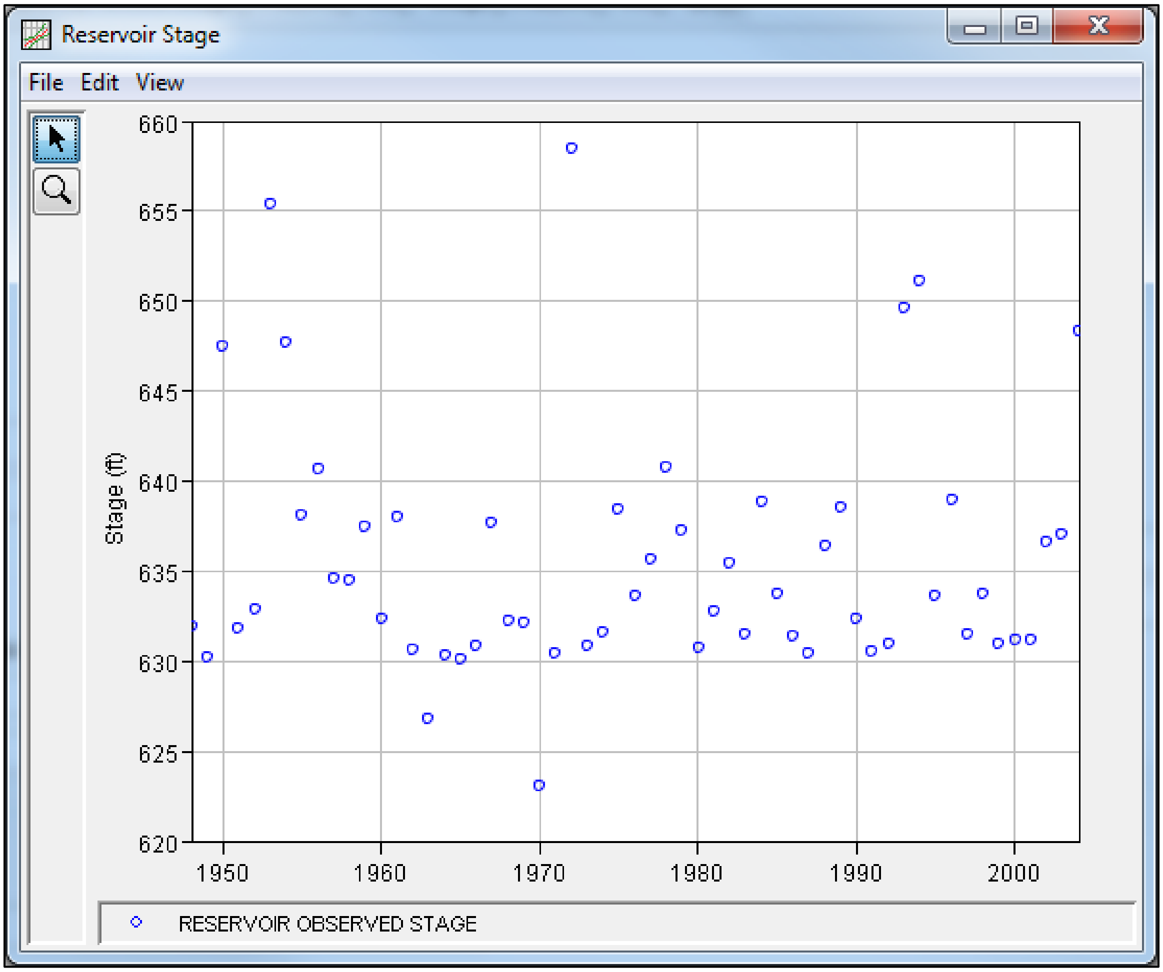


Figure B-45. Plot of the Reservoir Stage Data.

A General Frequency analysis has been developed for this example. To open the General Frequency analysis editor for this example, either double-click on the analysis labeled **Stage Analysis Test 7** from the study explorer, or from the **Analysis** menu select open, then select **Stage Analysis Test 7** from the list of available analyses. When test 7 is opened, the General Frequency analysis editor will appear as shown in Figure B-46. For this analysis, the **Do Not Use Log Transform** option was selected, the **Weibull** plotting position method was selected, the default **Confidence Limits** were selected, and no modification was made to the time window.

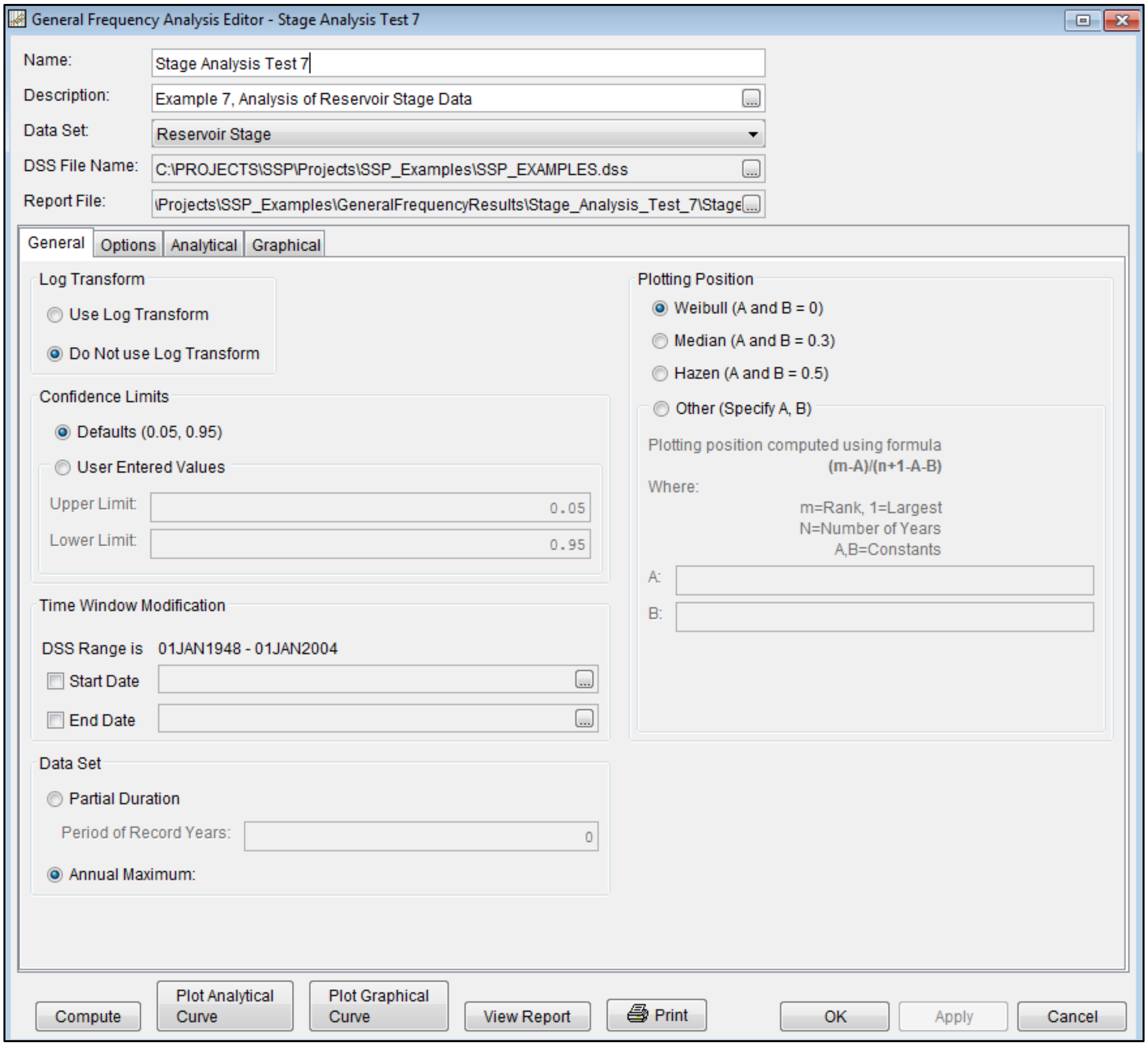


Figure B-46. General Frequency Analysis Editor for Stage Analysis Test 7.

Shown in Figure B-47 is the General Frequency analysis editor with the **Options Tab** selected. Features on this tab include the **Low Outlier Threshold**, adding **Historic Date** to the analysis, an option to override the default **Frequency Ordinates**, and **Output Labeling**. The 0.1 percent frequency ordinate was added to the **User Specified Frequency Ordinates** table.

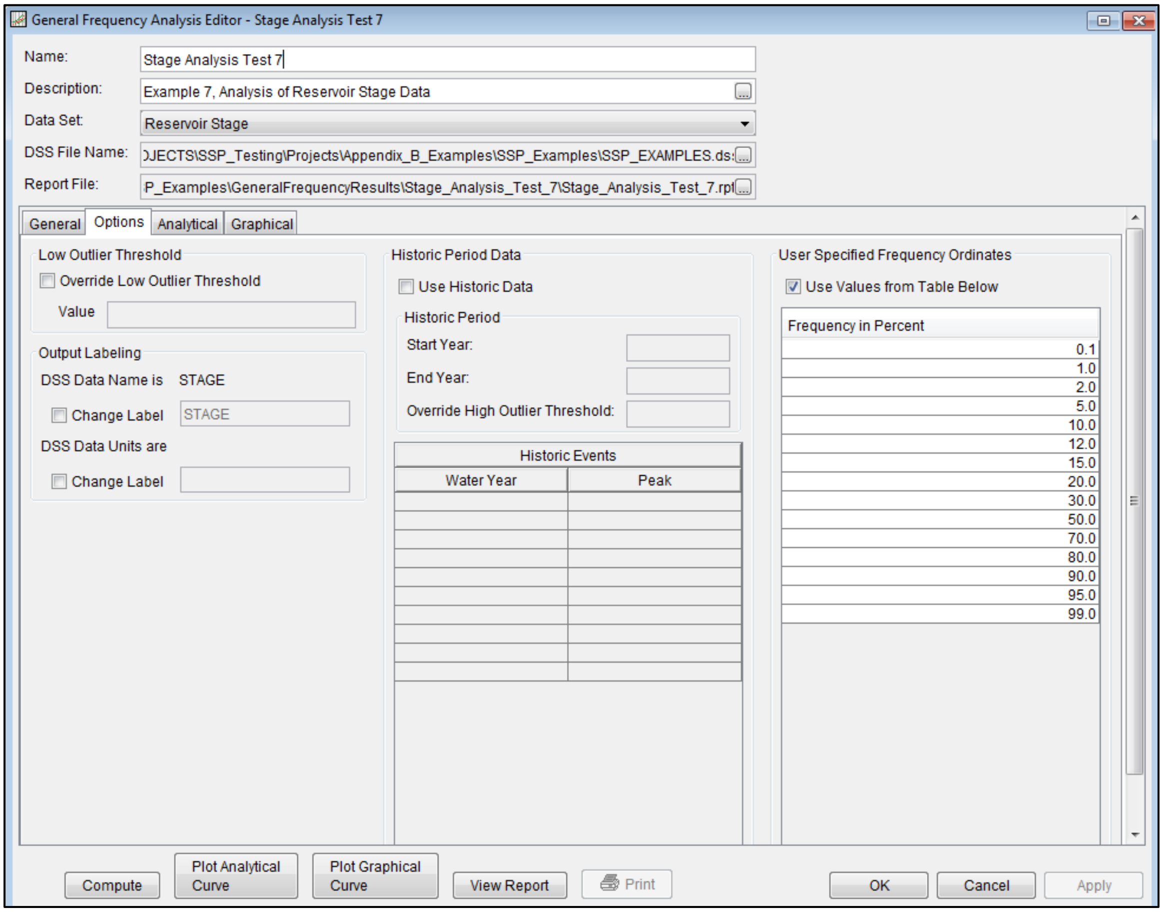


Figure B-47. General Frequency Analysis Editor with Options Tab Shown for Stage Analysis Test 7.

Once all of the General and Optional settings are set or selected, the user can choose to perform an Analytical or Graphical analysis. In this example, a graphical analysis was performed on the peak stage data. Shown in Figure B-48 is the **Graphical** tab. The frequency curve was entered manually into the **User-Defined Graphical Curve** table. When the **Compute** button is pressed, the program plots the graphical frequency curve along with the annual maximum peak stage values.

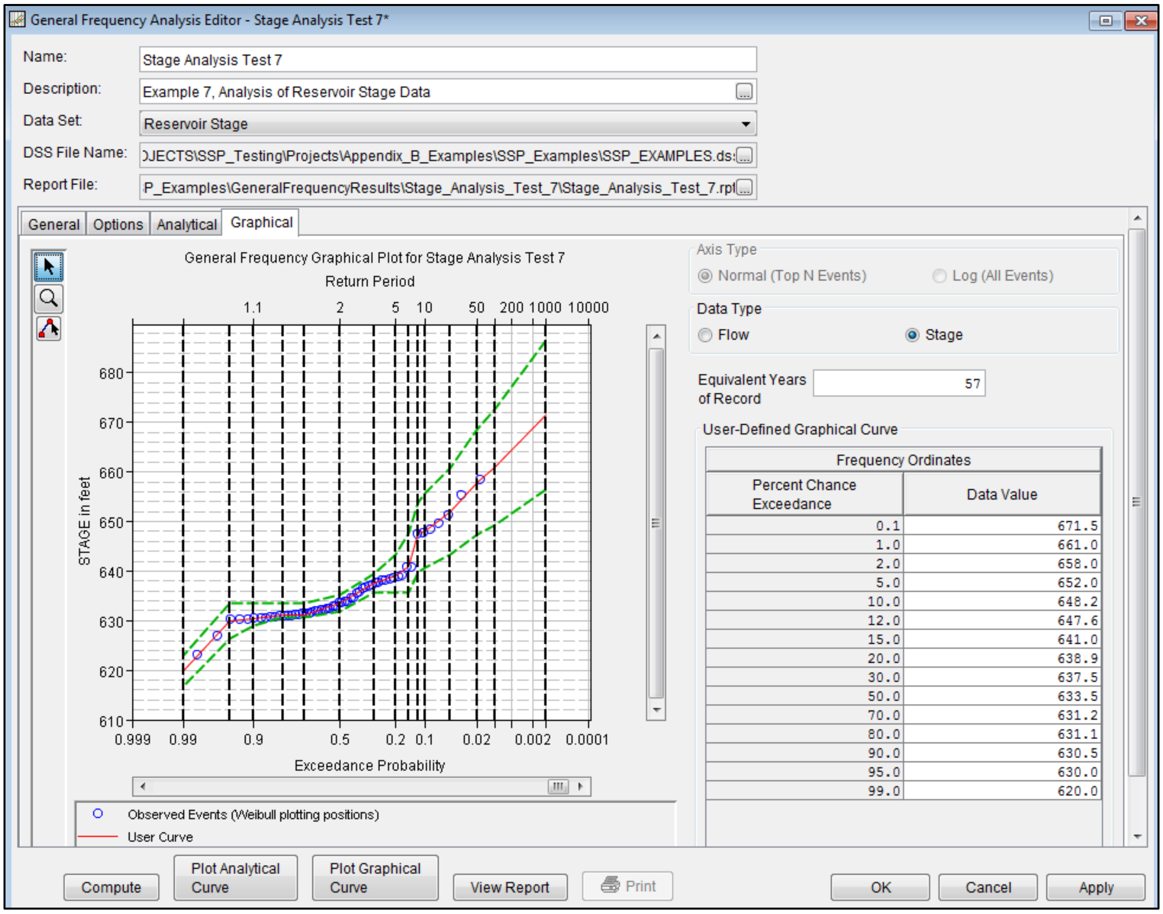


Figure B-48. General Frequency Graphical Tab Shown for Stage Analysis Test 7.

In addition to the table and plot available on the Graphical tab, a plot of the graphical frequency curves can be obtained by pressing the **Plot Graphical Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-49.

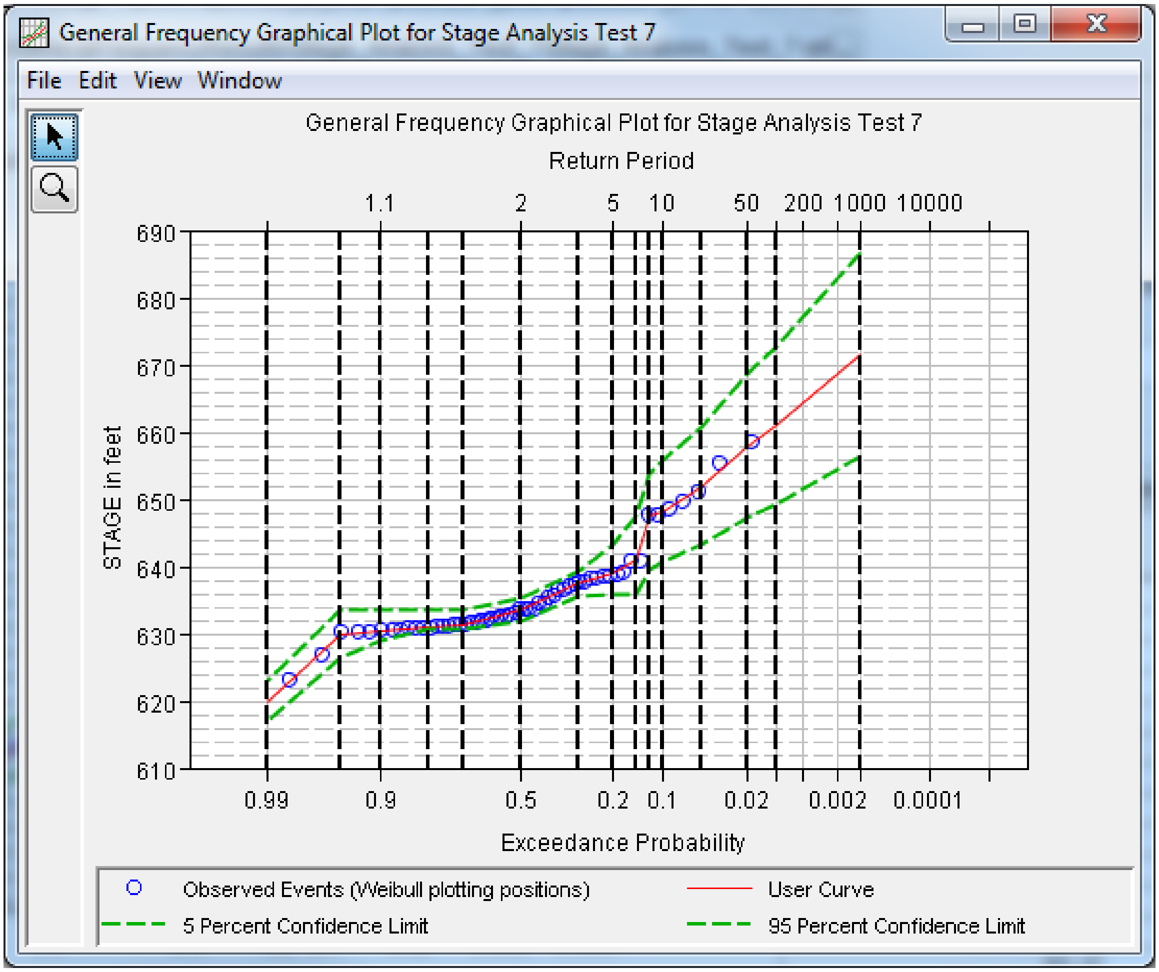
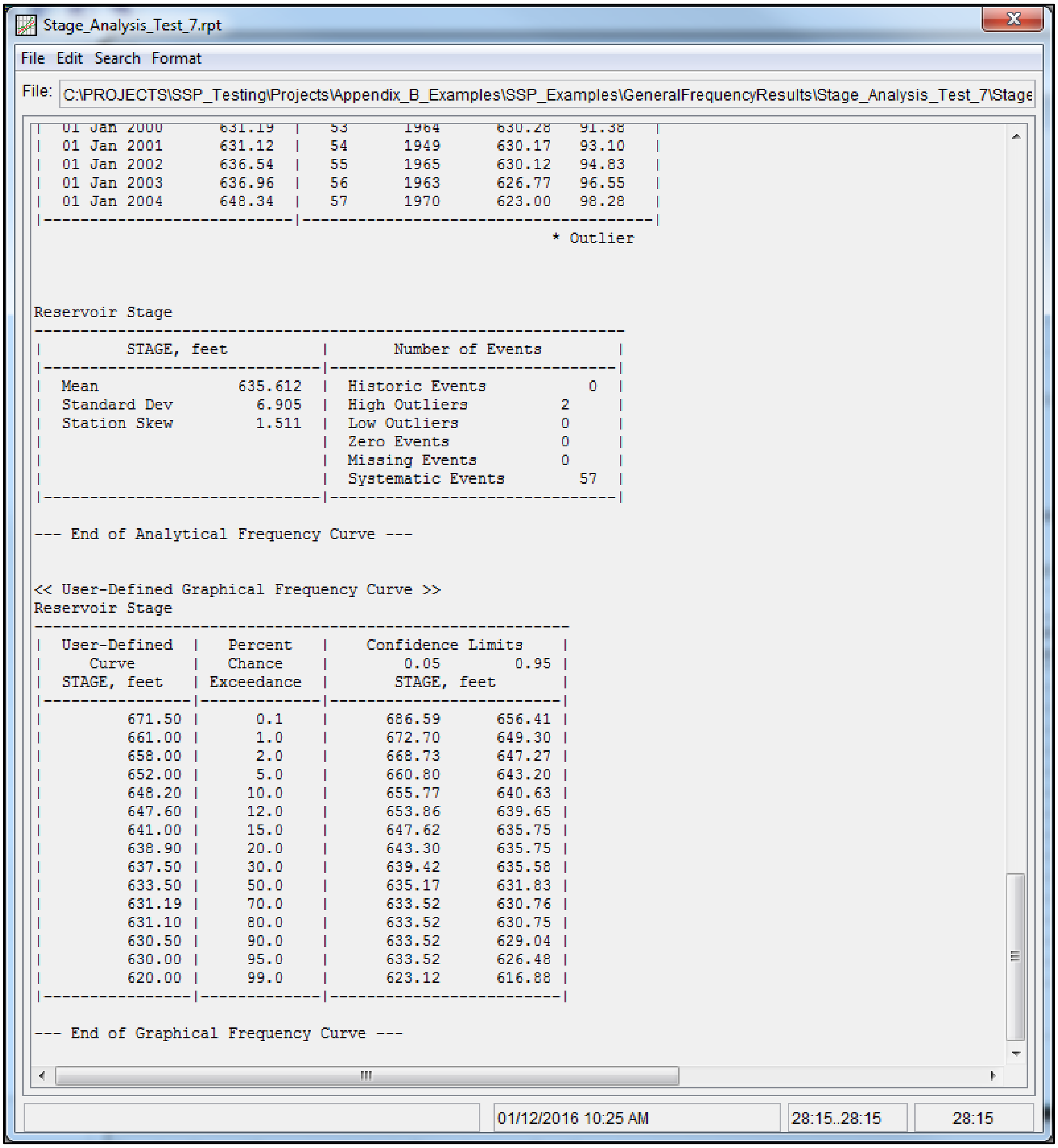


Figure B-49. Plot of the Frequency Curve Results for Stage Analysis Test 7.

Graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-50 is the report file for **Stage Analysis Test 7**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, the final computed frequency curve results, and the user-defined graphical frequency curve. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.



```
Stage_Analysis_Test_7.rpt
File  Edit  Search  Format
File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\GeneralFrequencyResults\Stage_Analysis_Test_7\Stage

|  01 Jan 2000      631.19  |  53      1964      630.28    91.38   |
|  01 Jan 2001      631.12  |  54      1949      630.17    93.10   |
|  01 Jan 2002      636.54  |  55      1965      630.12    94.83   |
|  01 Jan 2003      636.96  |  56      1963      626.77    96.55   |
|  01 Jan 2004      648.34  |  57      1970      623.00    98.28   |
|---------------------------|------------------------------------|
                                                     * Outlier


Reservoir Stage
----------------------------------------------------------------
|         STAGE, feet         |       Number of Events         |
|-----------------------------|--------------------------------|
|  Mean               635.612  |  Historic Events          0   |
|  Standard Dev         6.905  |  High Outliers         2      |
|  Station Skew         1.511  |  Low Outliers          0      |
|                              |  Zero Events           0      |
|                              |  Missing Events        0      |
|                              |  Systematic Events        57  |
|-----------------------------|--------------------------------|

--- End of Analytical Frequency Curve ---


<< User-Defined Graphical Frequency Curve >>
Reservoir Stage
----------------------------------------------------------
|  User-Defined  |   Percent   |    Confidence Limits    |
|     Curve      |   Chance    |      0.05        0.95   |
|  STAGE, feet   | Exceedance  |      STAGE, feet        |
|----------------|-------------|-------------------------|
|         671.50 |      0.1    |       686.59      656.41 |
|         661.00 |      1.0    |       672.70      649.30 |
|         658.00 |      2.0    |       668.73      647.27 |
|         652.00 |      5.0    |       660.80      643.20 |
|         648.20 |     10.0    |       655.77      640.63 |
|         647.60 |     12.0    |       653.86      639.65 |
|         641.00 |     15.0    |       647.62      635.75 |
|         638.90 |     20.0    |       643.30      635.75 |
|         637.50 |     30.0    |       639.42      635.58 |
|         633.50 |     50.0    |       635.17      631.83 |
|         631.19 |     70.0    |       633.52      630.76 |
|         631.10 |     80.0    |       633.52      630.75 |
|         630.50 |     90.0    |       633.52      629.04 |
|         630.00 |     95.0    |       633.52      626.48 |
|         620.00 |     99.0    |       623.12      616.88 |
|----------------|-------------|-------------------------|

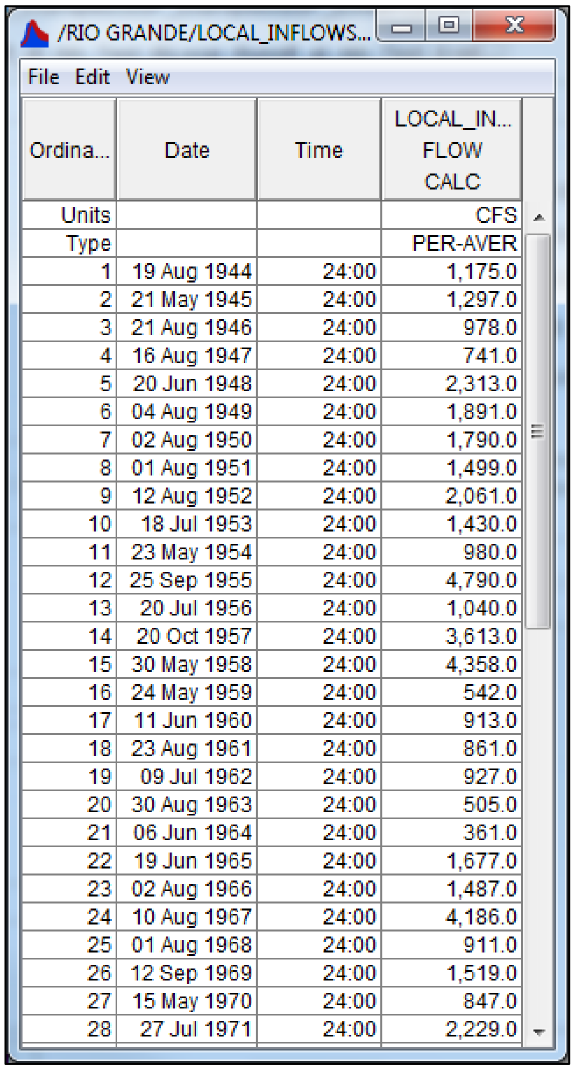
--- End of Graphical Frequency Curve ---

01/12/2016 10:25 AM     28:15..28:15     28:15
```

Figure B-50. Report File for Stage Analysis Test 7.

Example 8: Using User-Adjusted Statistics

This example demonstrates how to use the General Frequency analysis and enter user-adjusted statistics. The data for this example is from an analysis that computed local runoff for the Rio Grande at Albuquerque. The data includes unregulated daily average flows generated by rainfall-runoff from areas downstream of upstream reservoirs. The period of record used for this example is from 1944 to 2000. To view the data, right-click on the data record labeled "**Rio Grande at Alb Local Runoff**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-51.



/RIO GRANDE/LOCAL_INFLOWS...

File Edit View

Ordina...	Date	Time	LOCAL_IN... FLOW CALC
Units			CFS
Type			PER-AVER
1	19 Aug 1944	24:00	1,175.0
2	21 May 1945	24:00	1,297.0
3	21 Aug 1946	24:00	978.0
4	16 Aug 1947	24:00	741.0
5	20 Jun 1948	24:00	2,313.0
6	04 Aug 1949	24:00	1,891.0
7	02 Aug 1950	24:00	1,790.0
8	01 Aug 1951	24:00	1,499.0
9	12 Aug 1952	24:00	2,061.0
10	18 Jul 1953	24:00	1,430.0
11	23 May 1954	24:00	980.0
12	25 Sep 1955	24:00	4,790.0
13	20 Jul 1956	24:00	1,040.0
14	20 Oct 1957	24:00	3,613.0
15	30 May 1958	24:00	4,358.0
16	24 May 1959	24:00	542.0
17	11 Jun 1960	24:00	913.0
18	23 Aug 1961	24:00	861.0
19	09 Jul 1962	24:00	927.0
20	30 Aug 1963	24:00	505.0
21	06 Jun 1964	24:00	361.0
22	19 Jun 1965	24:00	1,677.0
23	02 Aug 1966	24:00	1,487.0
24	10 Aug 1967	24:00	4,186.0
25	01 Aug 1968	24:00	911.0
26	12 Sep 1969	24:00	1,519.0
27	15 May 1970	24:00	847.0
28	27 Jul 1971	24:00	2,229.0

Figure B-51. Tabulation of the Peak Flow Data for Example 8.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-52.

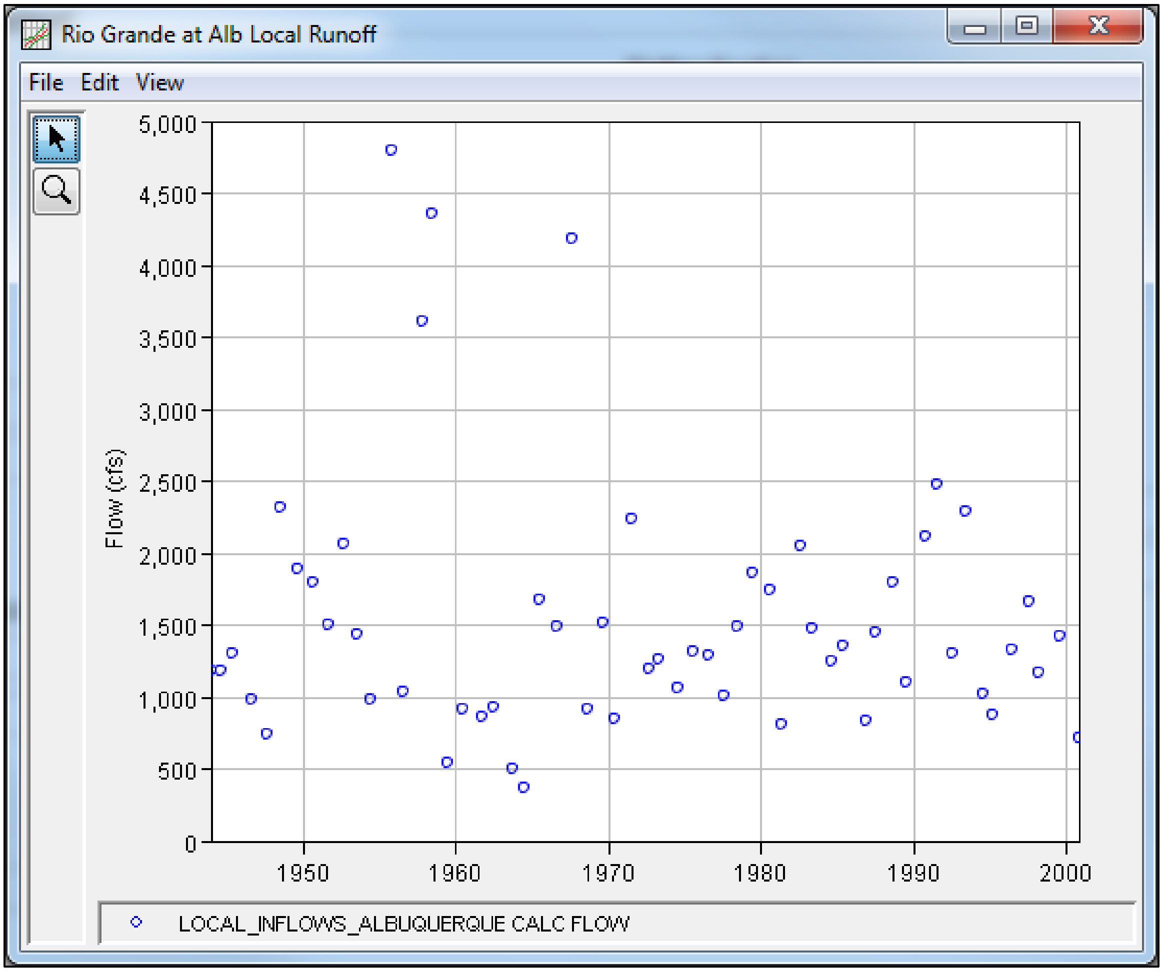


Figure B-52. Plot of Data for Example 8.

A General Frequency analysis has been developed for this example. To open the General Frequency analysis editor for this example, either double-click on the analysis labeled **Local Runoff at Alb Test 8** from the study explorer, or from the **Analysis** menu select open, then select **Local Runoff at Alb Test 8** from the list of available analyses. When test 8 is opened, the General Frequency analysis editor will appear as shown in Figure B-53.

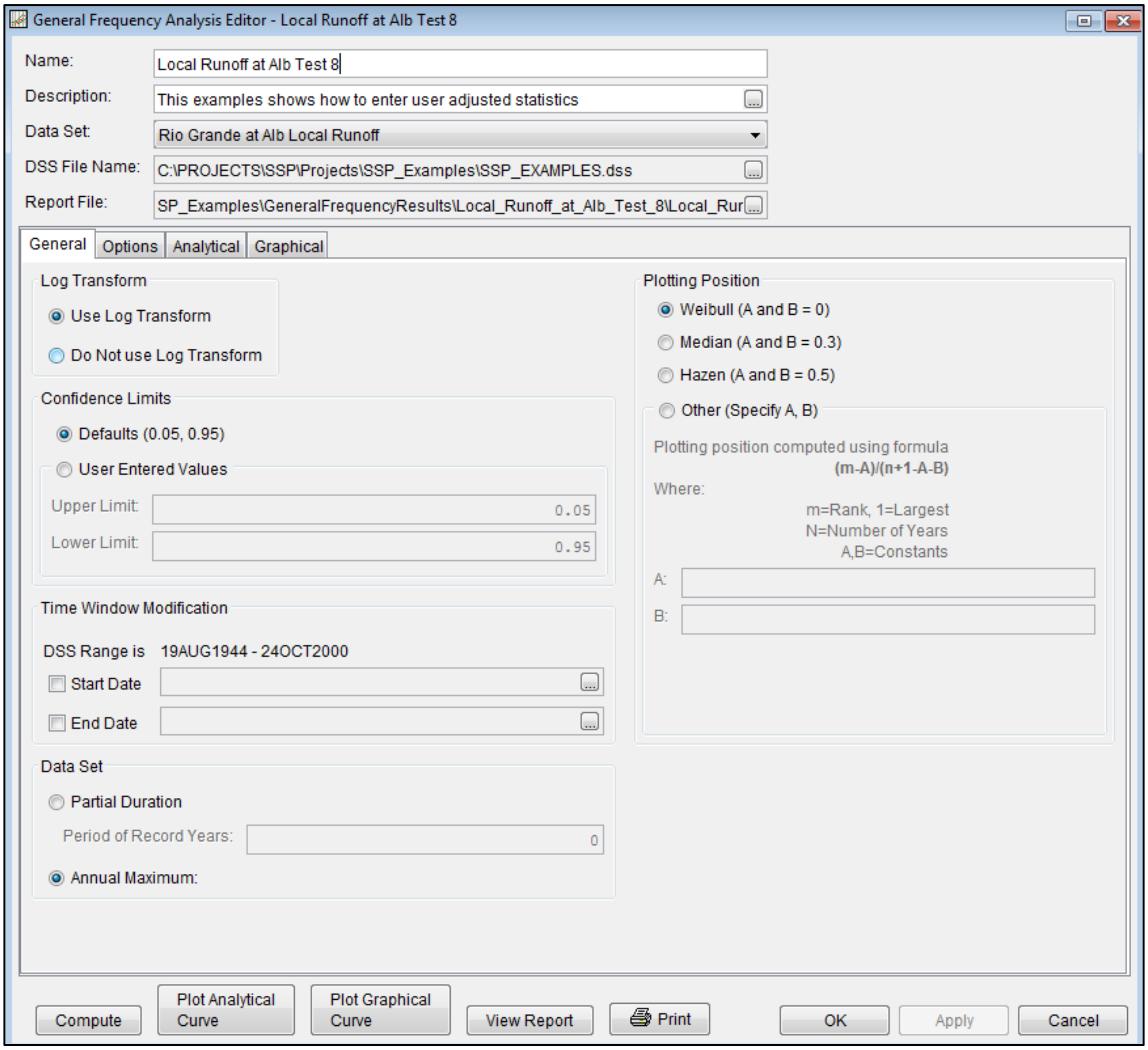


Figure B-53. General Frequency Analysis Editor for Local Runoff at Alb Test 8.

Shown in Figure B-53 are the general settings that were used to perform this frequency analysis. For this analysis, the **Use Log Transform** option was selected, the **Weibull** plotting position method was selected, the default **Confidence Limits** were selected, and no modification was made to the **Time Window**.

Shown in Figure B-54 is the General Frequency analysis editor with the **Options Tab** selected. Features on this tab include the **Low Outlier Threshold**, an option to use **Historic Data**, an option to override the default **Frequency Ordinates**, and **Output Labeling**. All defaults settings were selected for this example.

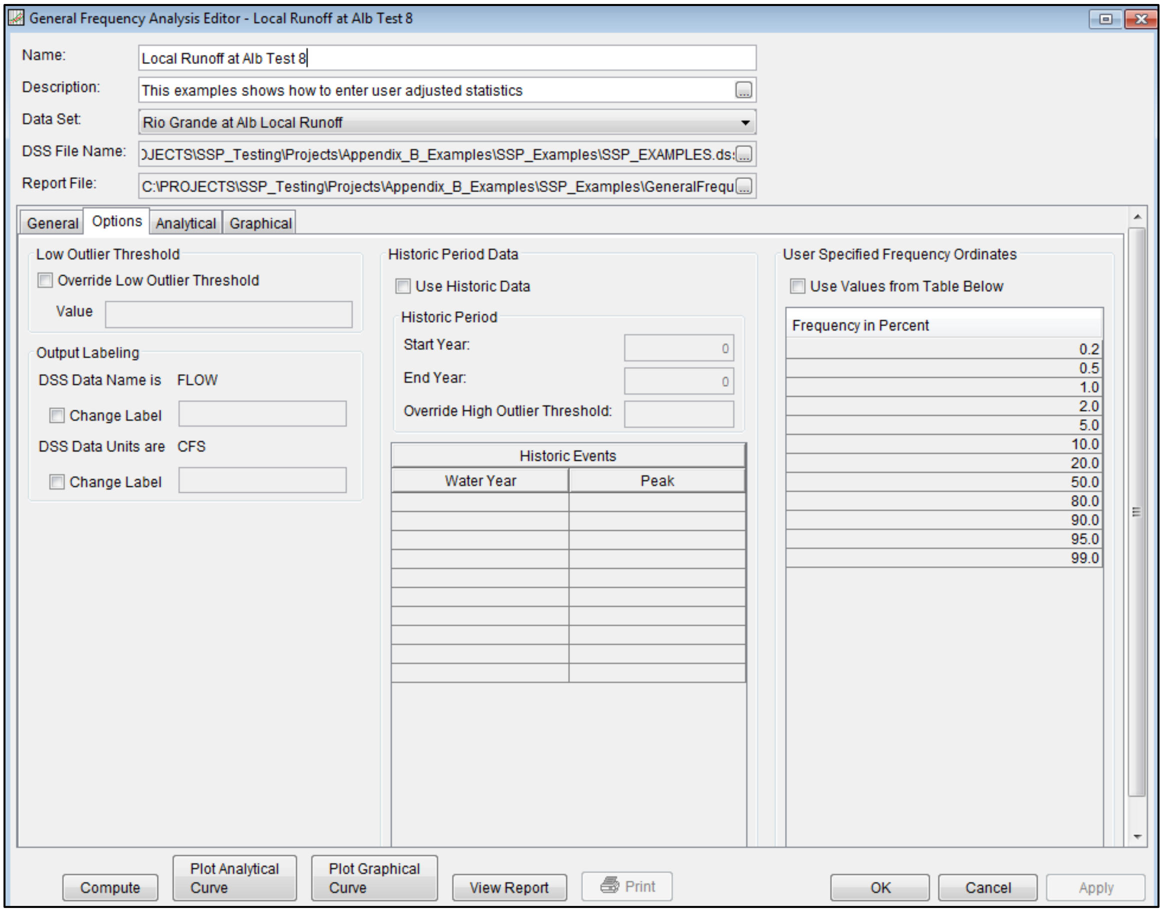


Figure B-54. General Frequency Analysis Editor with Options Tab Shown for Local Runoff at Alb Test 8.

Once all of the General and Optional settings are set or selected, the user can choose to perform an Analytical or Graphical analysis. In this example, an analytical analysis was performed. Shown in Figure B-55 is the **Settings** tab for the analytical analysis. As shown, the distribution selected for this example is LogPearsonIII. The **Skew** option was set to **Use Station Skew** and the **Do Not Compute Excepted Probability** option was selected.

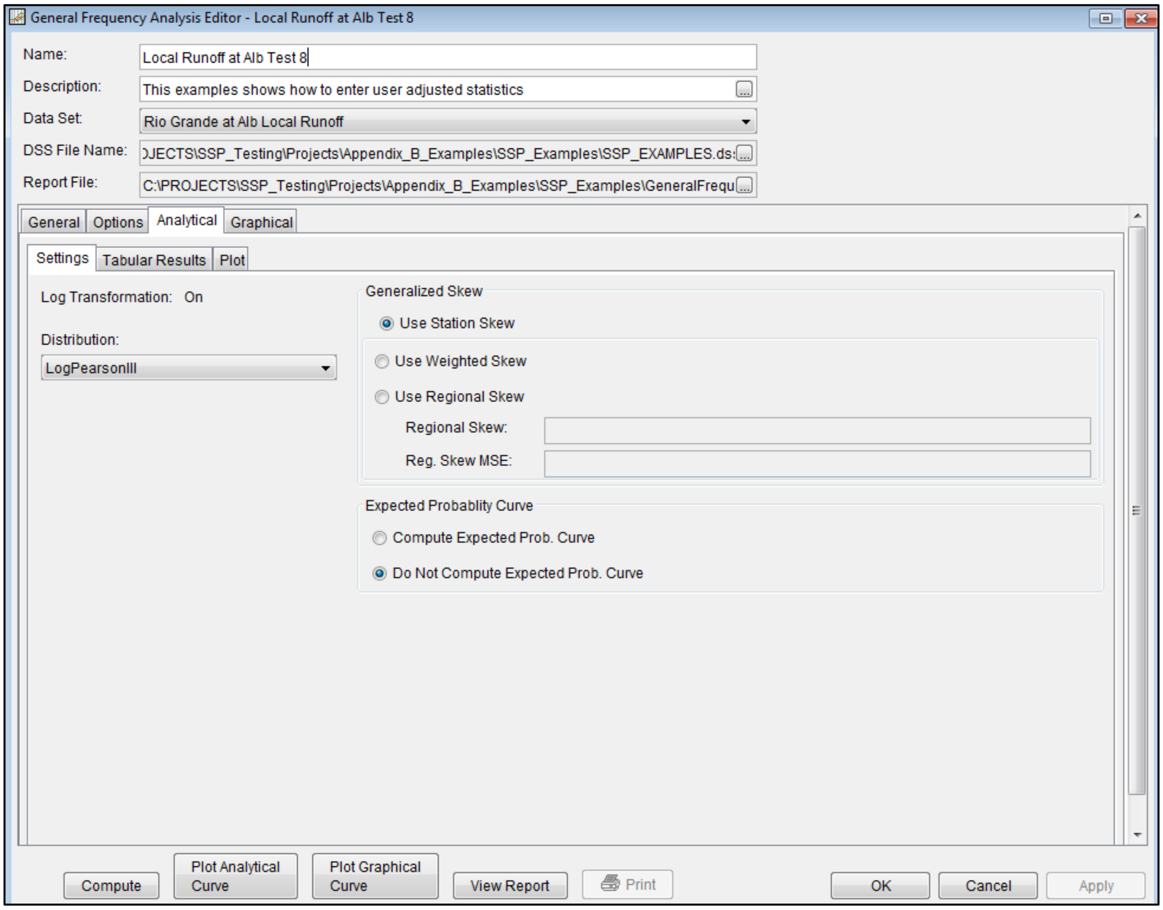


Figure B-55. General Frequency Analysis Editor with Settings Tab Shown for Local Runoff at Alb Test 8.

Press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Plot** tab within the analytical analysis. The analytical plot window should look Figure B-56.

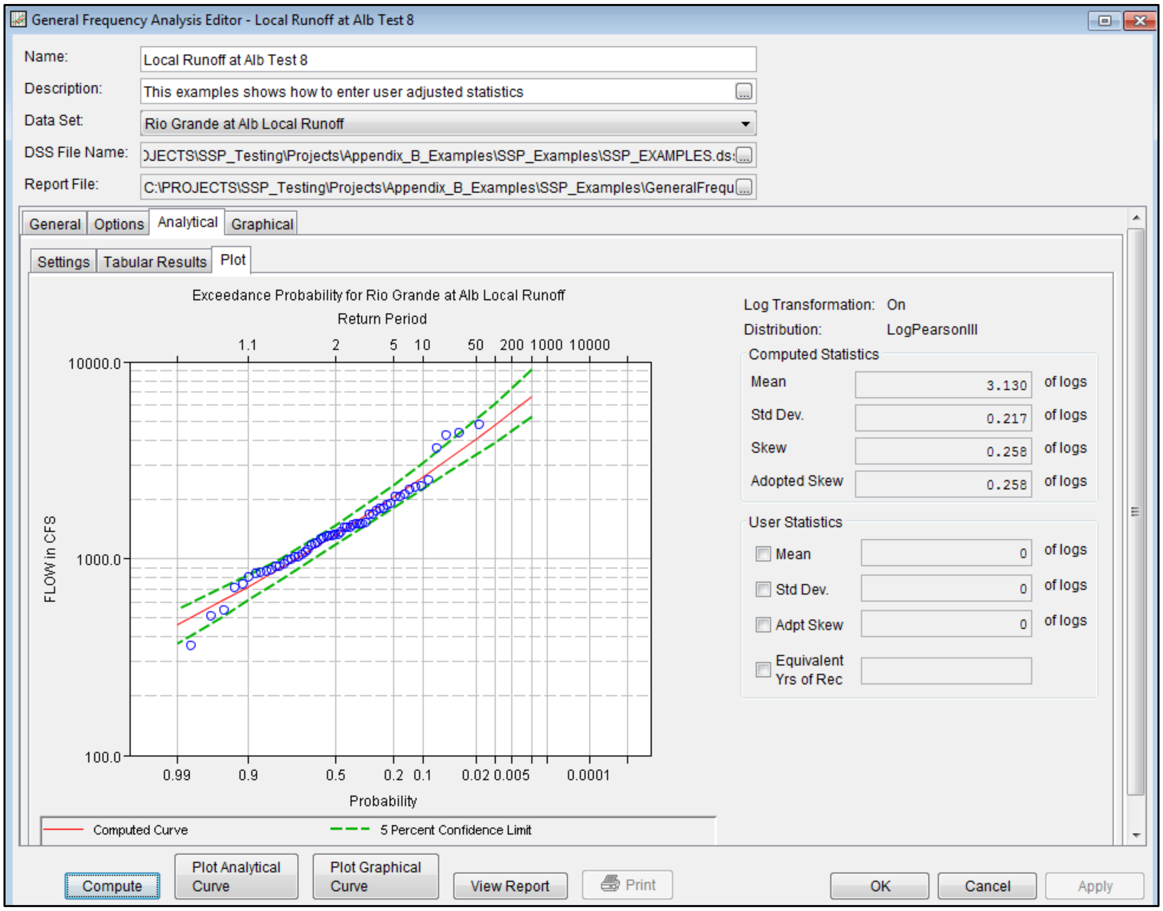


Figure B-56. The Plot Tab for Local Runoff at Alb Test 8.

As shown in Figure B-56, the **Plot** tab contains a graph of the systematic data, the computed frequency curve, and the confidence limits. The right side of the plot tab contains a table of **Computed Statistics** and **User Statistics**. The user has the option to enter a mean, standard deviation, adopted skew, and equivalent years of record in the User Statistics table. The **Compute** button must be pressed after User Statistics have been entered in order for the program to compute a frequency curve using the user statistics.

As mentioned at the beginning of this example, the annual peak flows were based on daily averaged flows. In order to compute an instantaneous peak flow frequency curve, a relationship between daily averaged flows and the corresponding instantaneous peak flows was developed. This was done by plotting daily averaged flow and the corresponding instantaneous peak flow for selected flood events. Using this relationship, a Mean of 3.371 was computed and entered in the User Statistics table and the analytical analysis was recomputed.

Figure B-57 shows that the frequency curve computed from the user-adjusted statistics is added to the graph. This figure also shows that the user does not have to enter values for all statistics in order for the program to compute a user-adjusted frequency curve. The program will use statistics computed from the systematic and historic data if the statistics are not defined in the User Statistics table. In this example, the program used the computed statistics for standard deviation, adopted skew, equivalent years of record and the user-defined mean of 3.371 when computing the user-adjusted frequency curve.

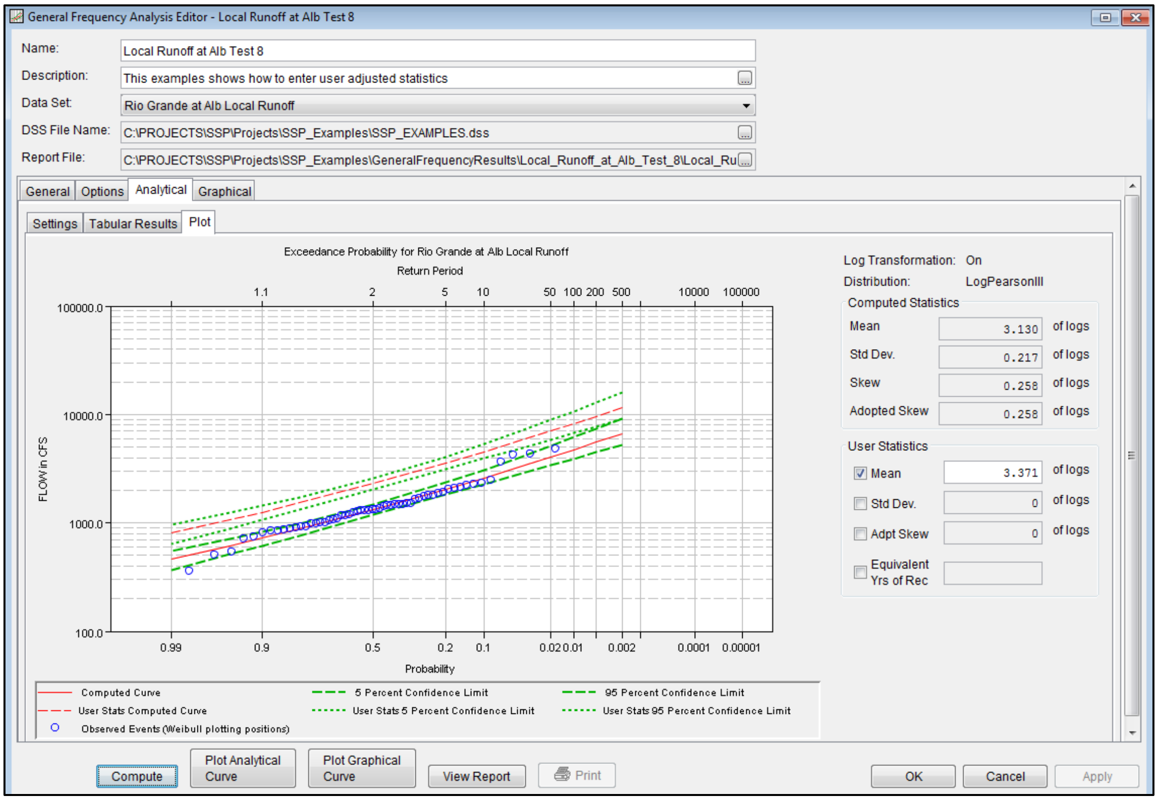


Figure B-57. Plot Tab with User Adjusted Statistics and Frequency Curves for Local Runoff at Alb Test 8.

Select the **Tabular Results** tab to see information for both the computed and user-adjusted frequency curves. As shown in Figure B-58, the Frequency Curve table contains the percent chance exceedance, computed curves (Log-Pearson III results), and the Confidence Limits (5% and 95% chance exceedance curves) for both the computed and user-adjusted statistics.

On the bottom left-hand side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom right-hand side of the results tab is a table of Number of Events showing the number of historic events used in the analysis, number of high outliers found, number of low outliers, number of zero or missing data years, number of systematic events in the gage record, and the historic record length (if historic data was entered).

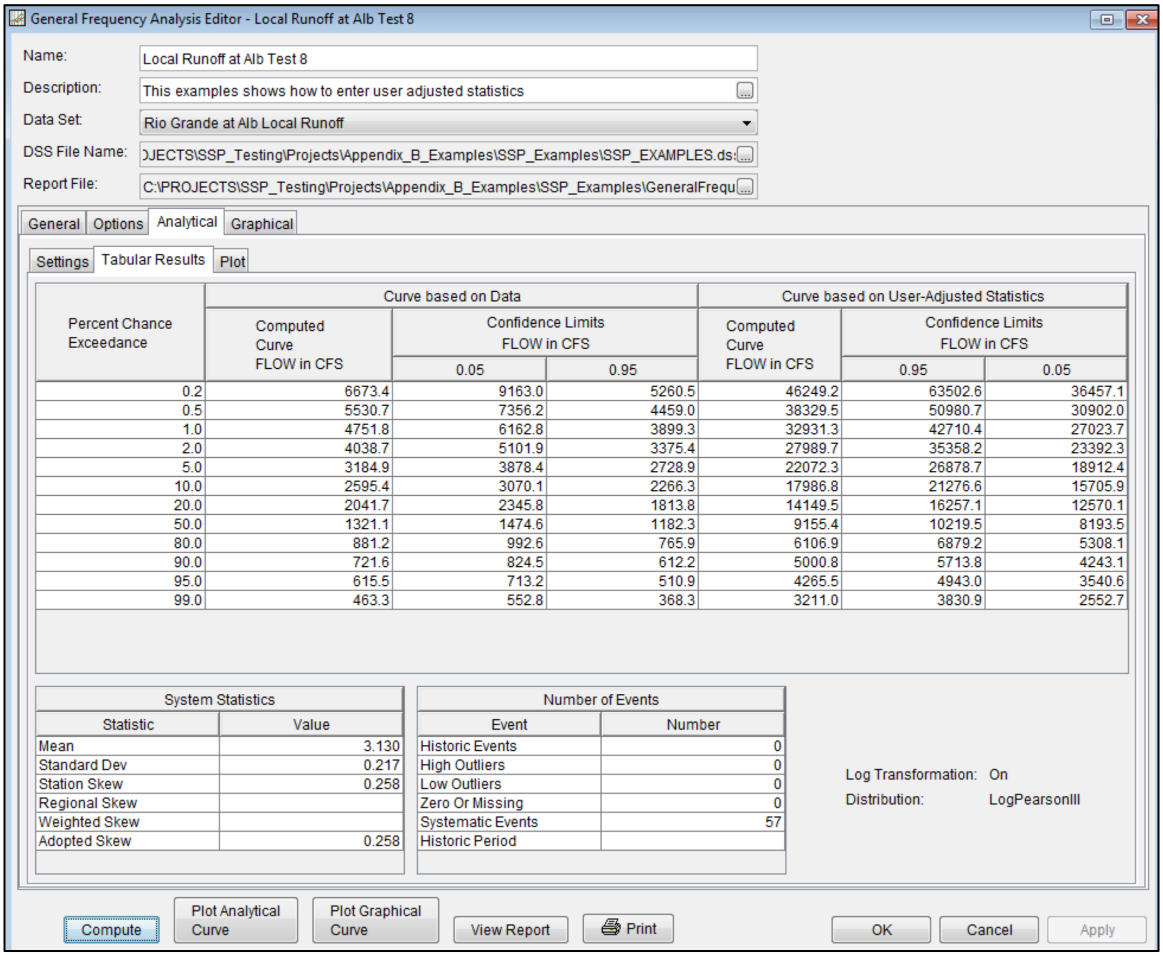


Figure B-58. General Frequency Editor with Results Tab Selected for Local Runoff at Alb Test 8.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Analytical Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-59.

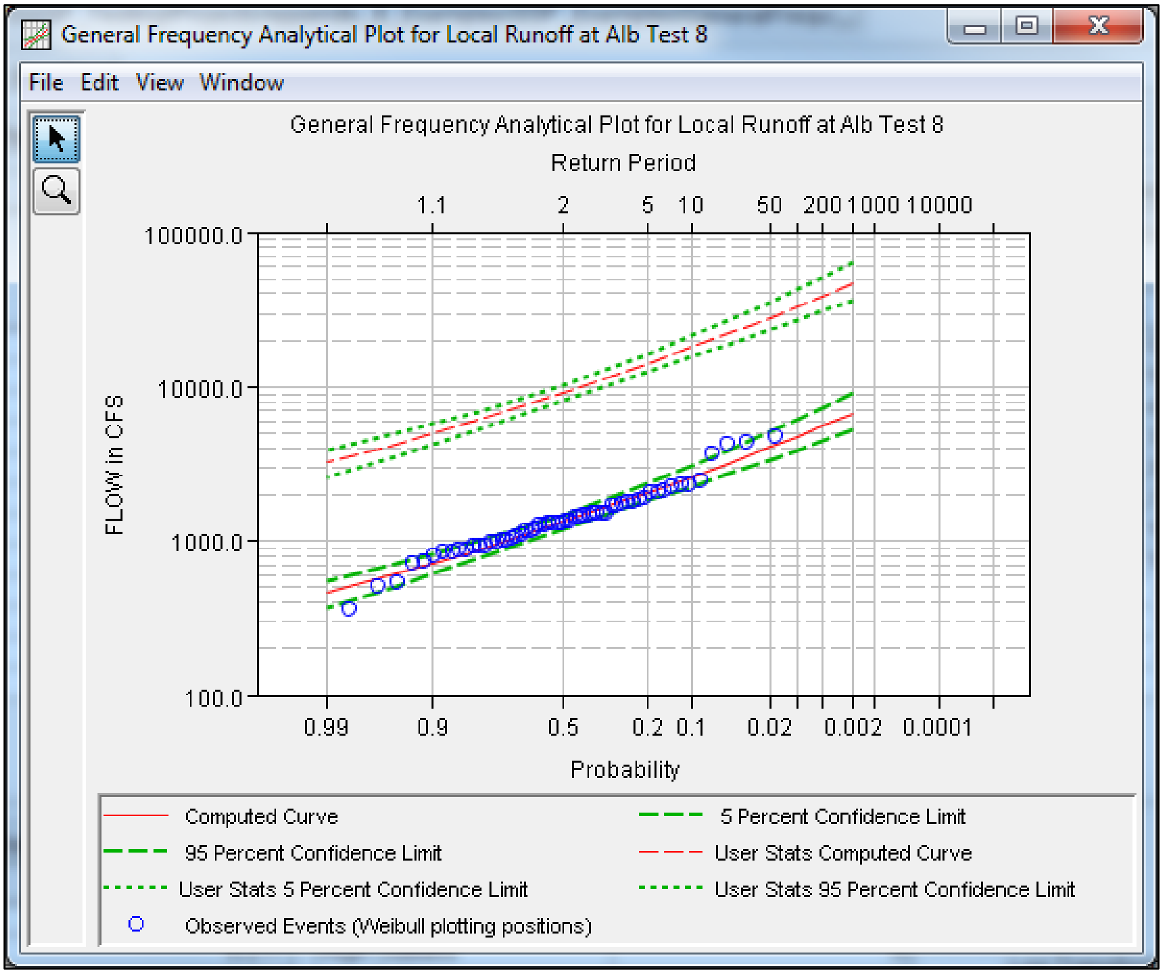
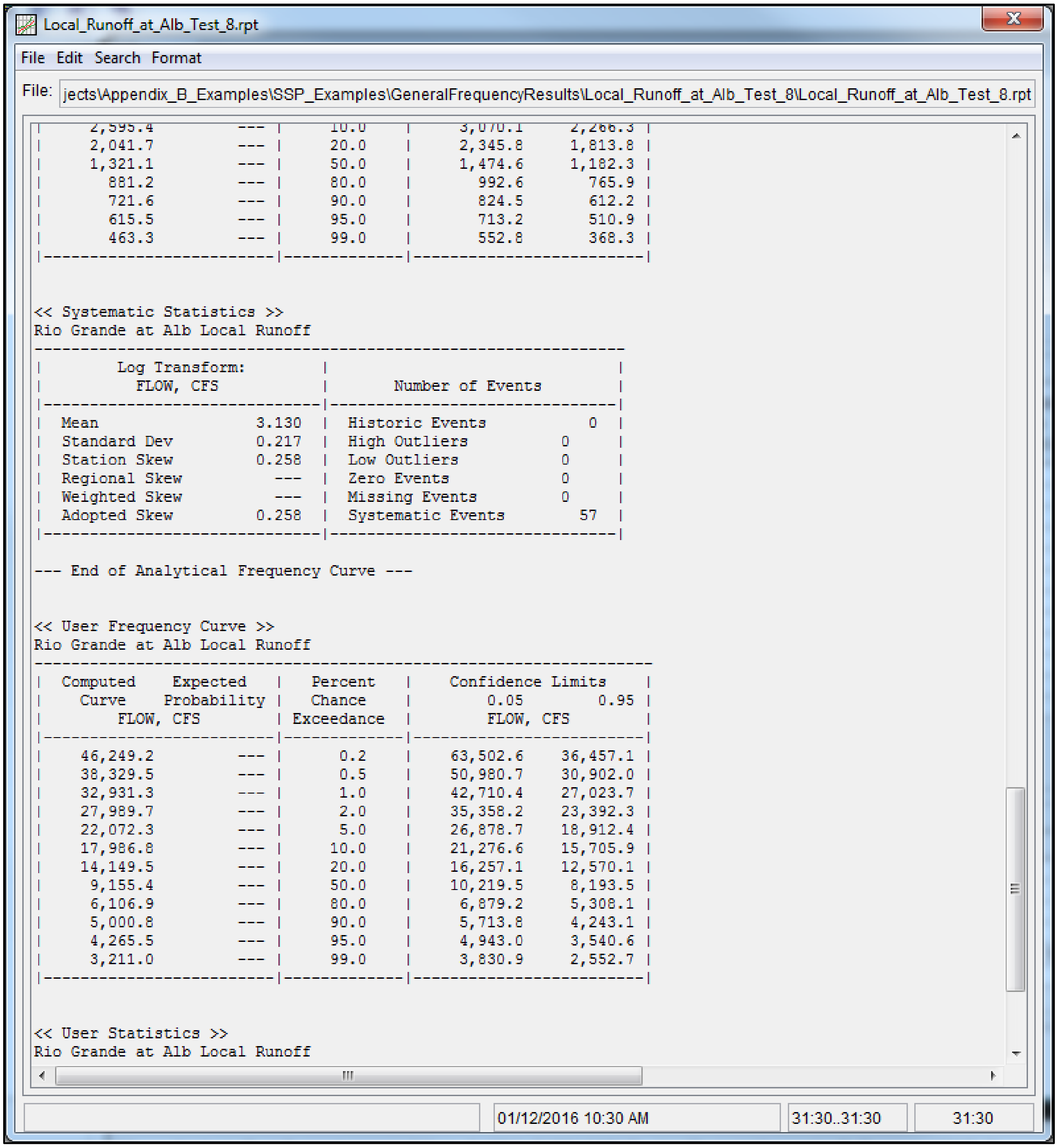


Figure B-59. Plot of the Frequency Curve Results for Local Runoff at Alb Test 8.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-60 is the report file for **Local Runoff at Alb Test 8**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.




```
|     2,595.4         --- |    10.0     |     3,070.1     2,266.3 |
|     2,041.7         --- |    20.0     |     2,345.8     1,813.8 |
|     1,321.1         --- |    50.0     |     1,474.6     1,182.3 |
|       881.2         --- |    80.0     |       992.6       765.9 |
|       721.6         --- |    90.0     |       824.5       612.2 |
|       615.5         --- |    95.0     |       713.2       510.9 |
|       463.3         --- |    99.0     |       552.8       368.3 |
|-------------------------|-------------|-------------------------|


<< Systematic Statistics >>
Rio Grande at Alb Local Runoff
---------------------------------------------------------------
|        Log Transform:         |                             |
|          FLOW, CFS             |      Number of Events       |
|-------------------------------|-----------------------------|
|  Mean                  3.130  |  Historic Events         0  |
|  Standard Dev          0.217  |  High Outliers        0     |
|  Station Skew          0.258  |  Low Outliers         0     |
|  Regional Skew           ---  |  Zero Events          0     |
|  Weighted Skew           ---  |  Missing Events       0     |
|  Adopted Skew          0.258  |  Systematic Events      57  |
|-------------------------------|-----------------------------|

--- End of Analytical Frequency Curve ---

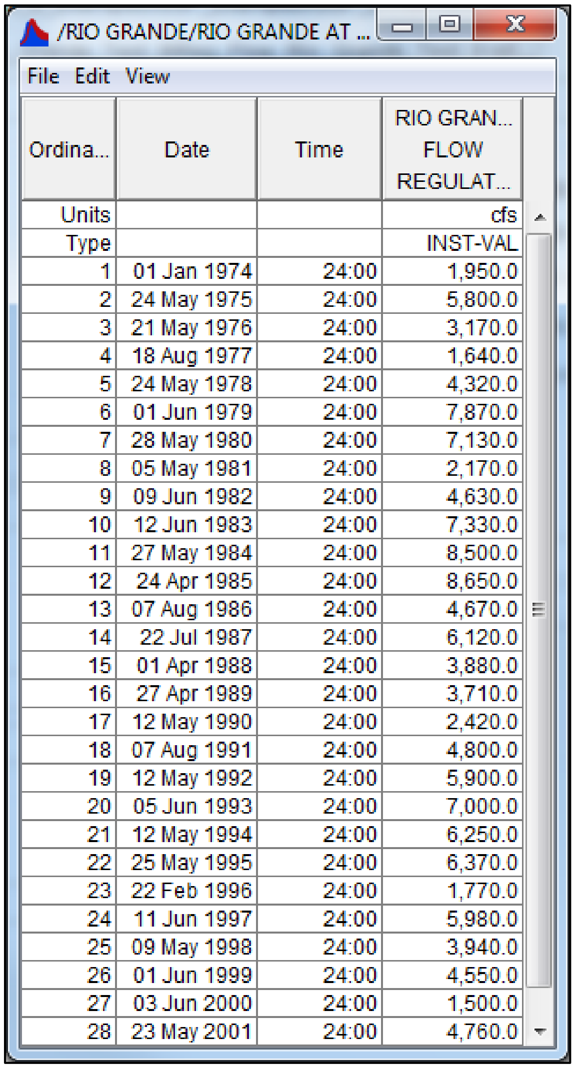

<< User Frequency Curve >>
Rio Grande at Alb Local Runoff
------------------------------------------------------------------
|  Computed    Expected  |   Percent    |    Confidence Limits    |
|    Curve    Probability |   Chance     |       0.05        0.95 |
|        FLOW, CFS        | Exceedance   |        FLOW, CFS        |
|-------------------------|-------------|-------------------------|
|    46,249.2         --- |     0.2     |    63,502.6    36,457.1 |
|    38,329.5         --- |     0.5     |    50,980.7    30,902.0 |
|    32,931.3         --- |     1.0     |    42,710.4    27,023.7 |
|    27,989.7         --- |     2.0     |    35,358.2    23,392.3 |
|    22,072.3         --- |     5.0     |    26,878.7    18,912.4 |
|    17,986.8         --- |    10.0     |    21,276.6    15,705.9 |
|    14,149.5         --- |    20.0     |    16,257.1    12,570.1 |
|     9,155.4         --- |    50.0     |    10,219.5     8,193.5 |
|     6,106.9         --- |    80.0     |     6,879.2     5,308.1 |
|     5,000.8         --- |    90.0     |     5,713.8     4,243.1 |
|     4,265.5         --- |    95.0     |     4,943.0     3,540.6 |
|     3,211.0         --- |    99.0     |     3,830.9     2,552.7 |
|-------------------------|-------------|-------------------------|


<< User Statistics >>
Rio Grande at Alb Local Runoff
```

Figure B-60. Report File for Local Runoff at Alb Test 8.

Example 9: General Frequency – Graphical Analysis

This example demonstrates how to create a Graphical Analysis within a General Frequency analysis. The data for this example is from an analysis that computed regulated flow for the Rio Grande at Albuquerque. The data includes regulated daily average flows from upstream reservoirs routed downstream to Albuquerque. The period of record used for this example is from 1974 to 2002. To view the data, right-click on the data record labeled "**Rio Grande at Alb Reg Flow**" in the study explorer and then select **Tabulate**. The data will appear as shown in Figure B-61.



Ordina...	Date	Time	RIO GRAN... FLOW REGULAT...
Units			cfs
Type			INST-VAL
1	01 Jan 1974	24:00	1,950.0
2	24 May 1975	24:00	5,800.0
3	21 May 1976	24:00	3,170.0
4	18 Aug 1977	24:00	1,640.0
5	24 May 1978	24:00	4,320.0
6	01 Jun 1979	24:00	7,870.0
7	28 May 1980	24:00	7,130.0
8	05 May 1981	24:00	2,170.0
9	09 Jun 1982	24:00	4,630.0
10	12 Jun 1983	24:00	7,330.0
11	27 May 1984	24:00	8,500.0
12	24 Apr 1985	24:00	8,650.0
13	07 Aug 1986	24:00	4,670.0
14	22 Jul 1987	24:00	6,120.0
15	01 Apr 1988	24:00	3,880.0
16	27 Apr 1989	24:00	3,710.0
17	12 May 1990	24:00	2,420.0
18	07 Aug 1991	24:00	4,800.0
19	12 May 1992	24:00	5,900.0
20	05 Jun 1993	24:00	7,000.0
21	12 May 1994	24:00	6,250.0
22	25 May 1995	24:00	6,370.0
23	22 Feb 1996	24:00	1,770.0
24	11 Jun 1997	24:00	5,980.0
25	09 May 1998	24:00	3,940.0
26	01 Jun 1999	24:00	4,550.0
27	03 Jun 2000	24:00	1,500.0
28	23 May 2001	24:00	4,760.0

Figure B-61. Tabulation of the Peak Flow Data for Example 9.

To plot the data for this example, right-click on the data record and then select **Plot**. A plot of the data will appear as shown in Figure B-62.

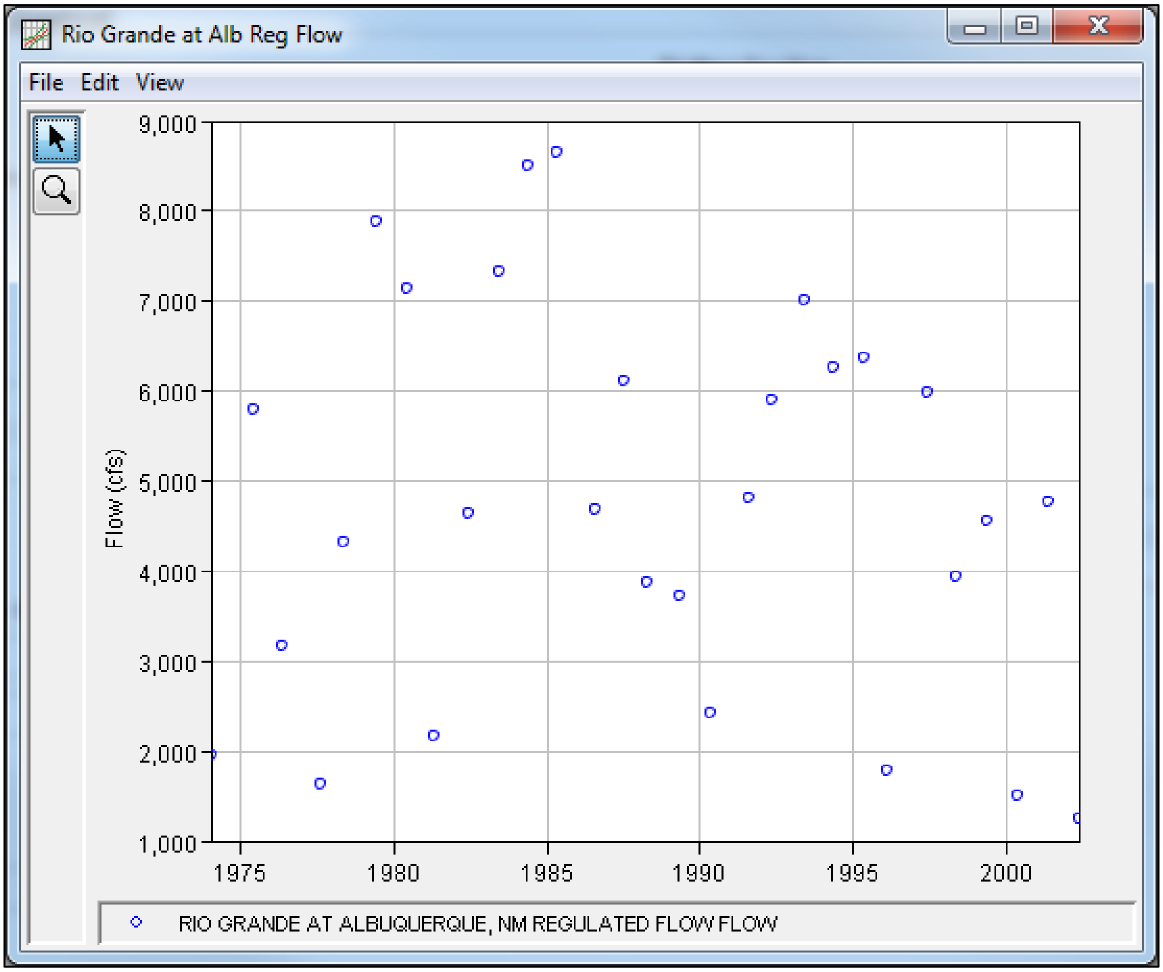


Figure B-62. Plot of Data for Example 9.

A General Frequency analysis has been developed for this example. To open the General Frequency analysis editor for this example, either double-click on the analysis labeled **Reg Flow Rio Grande Test 9** from the study explorer, or from the **Analysis** menu select open, then select **Reg Flow Rio Grande Test 9** from the list of available analyses. When Test 9 is opened, the General Frequency analysis editor will appear as shown in Figure B-63.

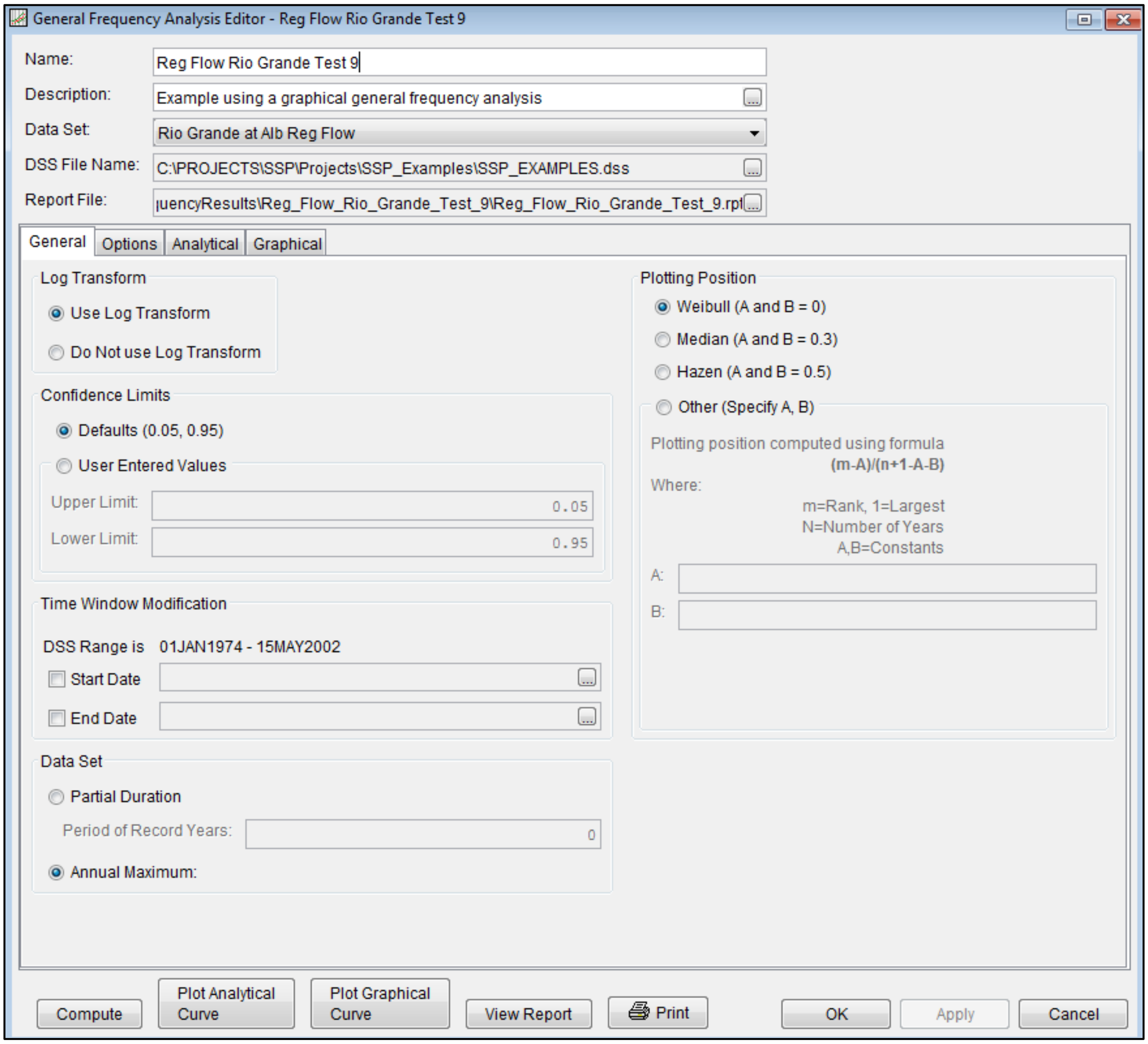


Figure B-63. General Frequency Analysis Editor for Reg Flow Rio Grande Test 9.

Shown in Figure B-63 are the general settings that were used to perform this frequency analysis. For this analysis, the **Use Log Transform** option was selected, the **Weibull** plotting position method was selected, the default **Confidence Limits** were selected, and no modification was made to the **Time Window**.

Shown in Figure B-64 is the General Frequency analysis editor with the **Options Tab** selected. Features on this tab include the **Low Outlier Threshold**, an option to use **Historic Data**, an option to override the default **Frequency Ordinates**, and **Output Labeling**. All defaults settings were selected for this example.

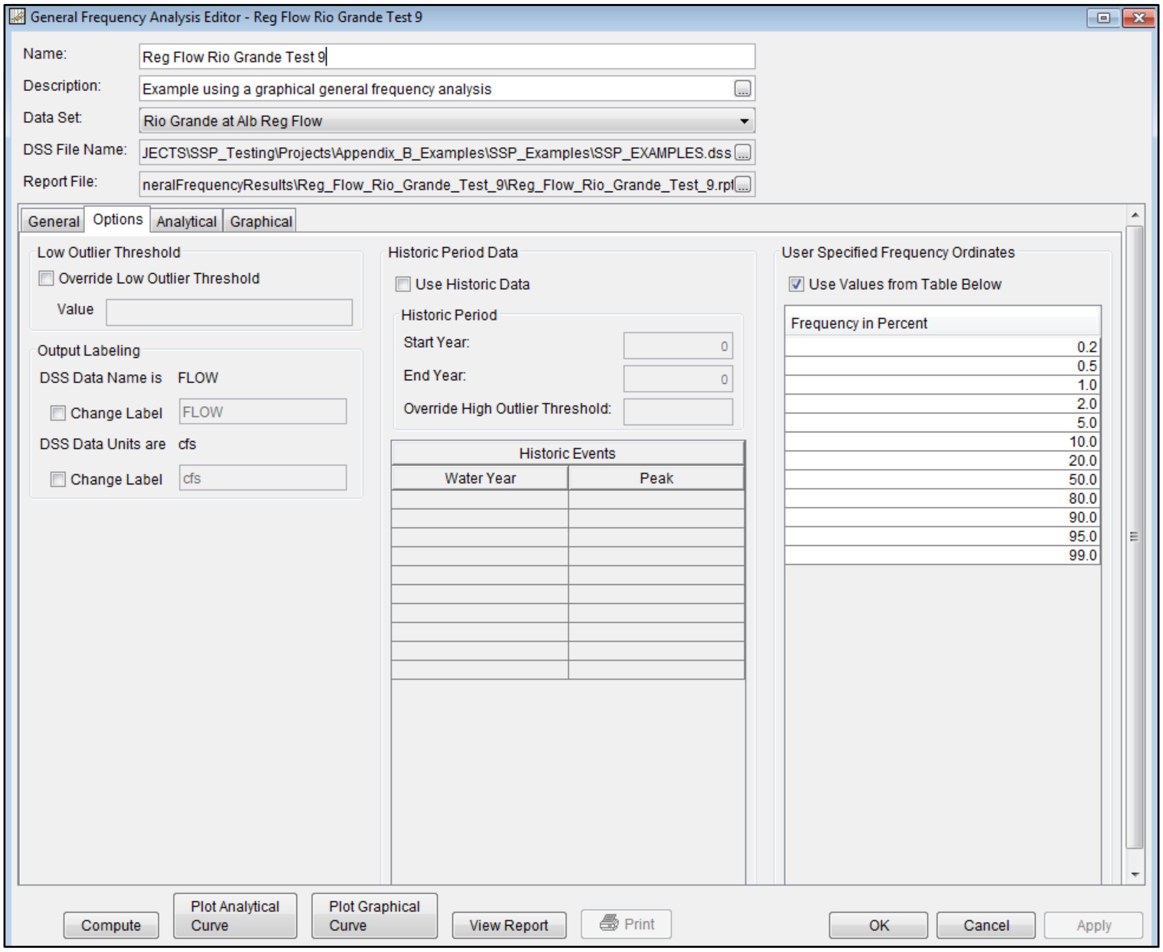


Figure B-64. General Frequency Analysis Editor with Options Tab Shown for Reg Flow Rio Grande Test 9.

Once all of the General and Optional settings are set or selected, the user can choose to perform an Analytical or Graphical analysis. In this example, a graphical analysis was performed. Shown in Figure B-65 is the **Graphical** analysis tab. As shown, a graph containing the systematic data and graphical curve is on the left side and a table containing the user-entered frequency curve is on the right side of the window. The frequency curve was entered manually into the **User-Defined Graphical Curve** table. When the **Compute** button is pressed, the program plots the graphical frequency curve along with the annual maximum flow values. For this example, a reservoir model was used to route synthetic hydrographs through the reservoir network upstream of Albuquerque using current operating criteria. This was done for the 0.2, 0.5, 1.0, 2.0, 10, 20, and 50 percent events. Output from the model was input into the Frequency Ordinates table. For the more frequent events (10 year and below), the graphical curve was fit to the data visually. This example shows how a reservoir network can influence the frequency curve. Notice how the frequency curve is flat for the 20 through the 1 percent chance events. The reservoir network is able to control flooding in this range. This example also shows that as flood events become larger, the reservoir network has less influence on controlling downstream flooding.

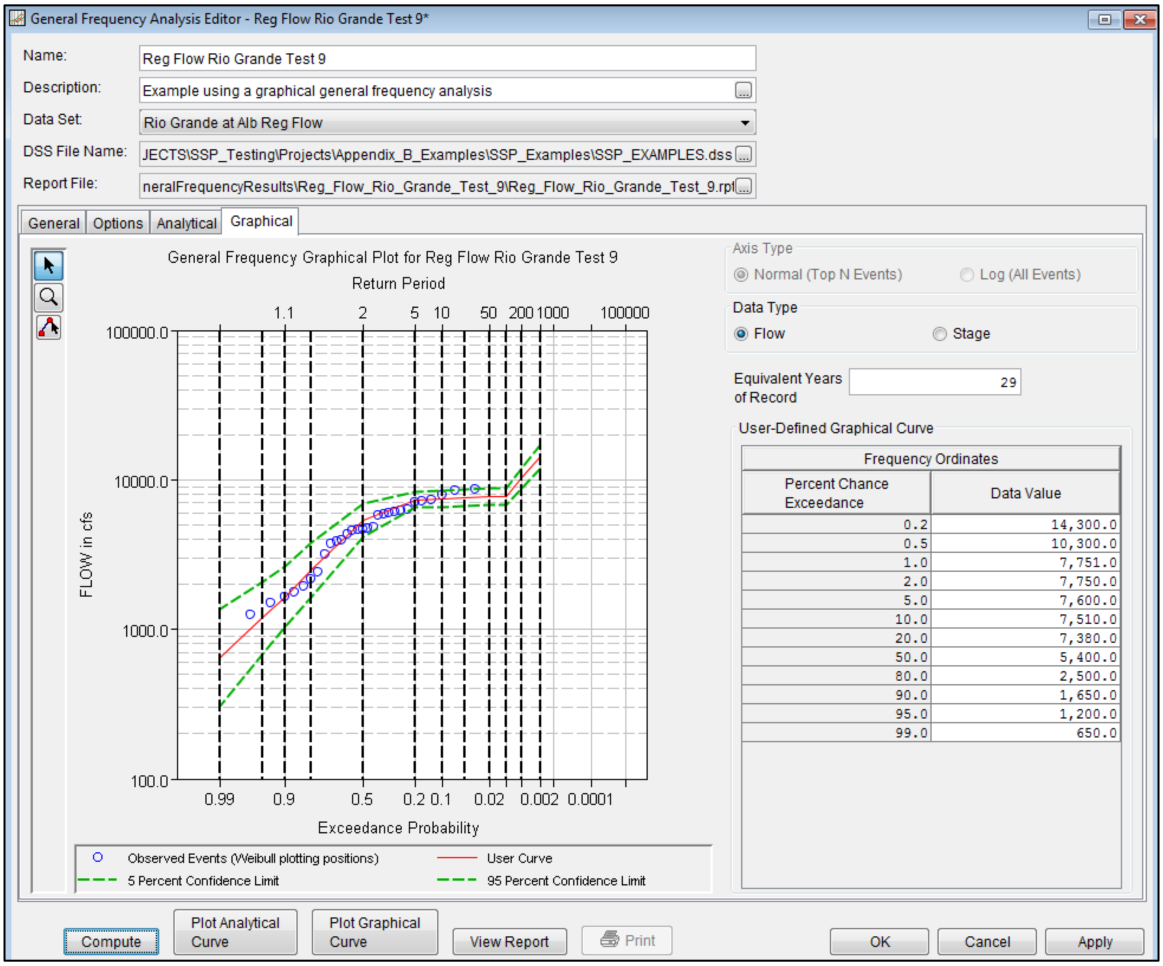


Figure B-65. Graphical Tab Shown for Reg Flow Rio Grande Test 9.

A graphical plot of the graphical frequency curve can be obtained by pressing the **Plot Graphical Curve** button at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-66.

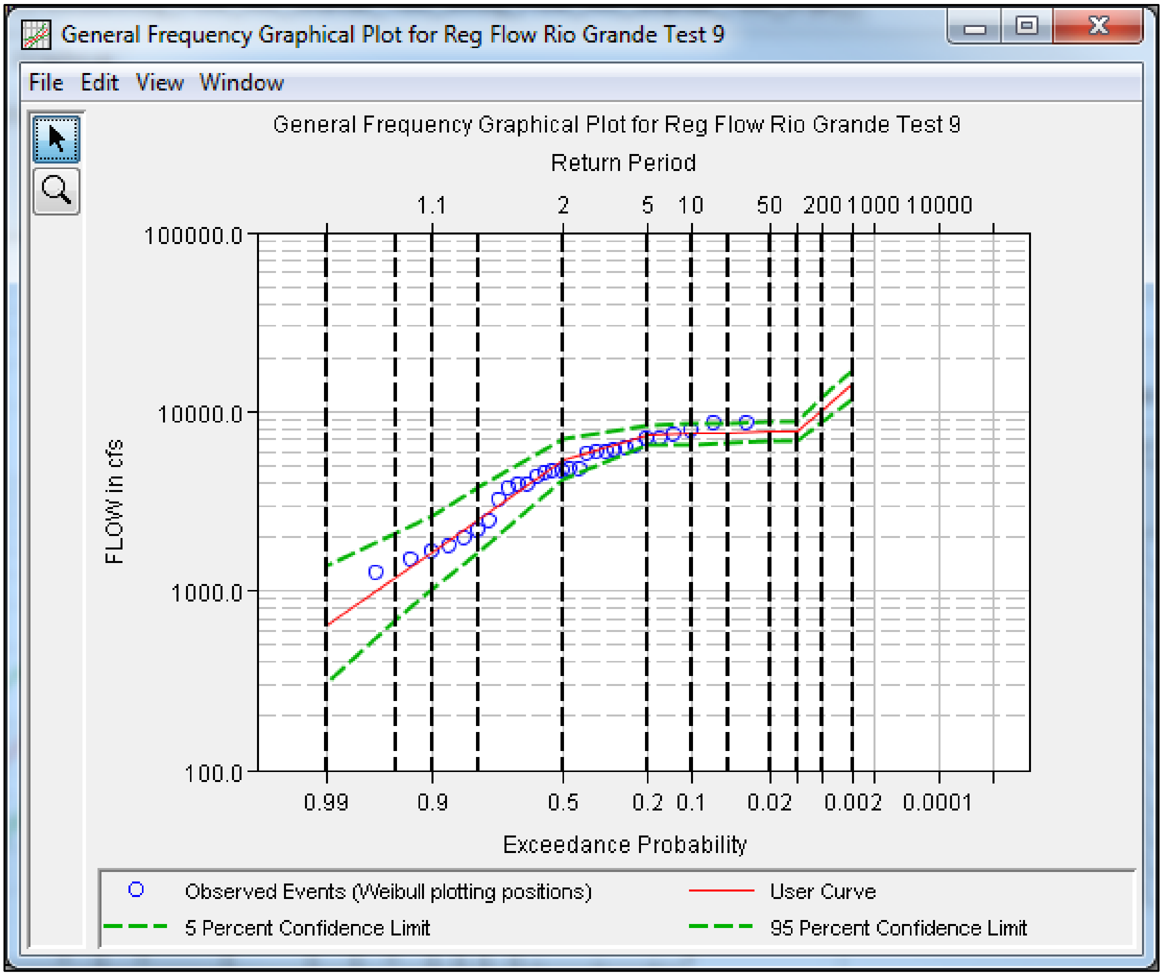
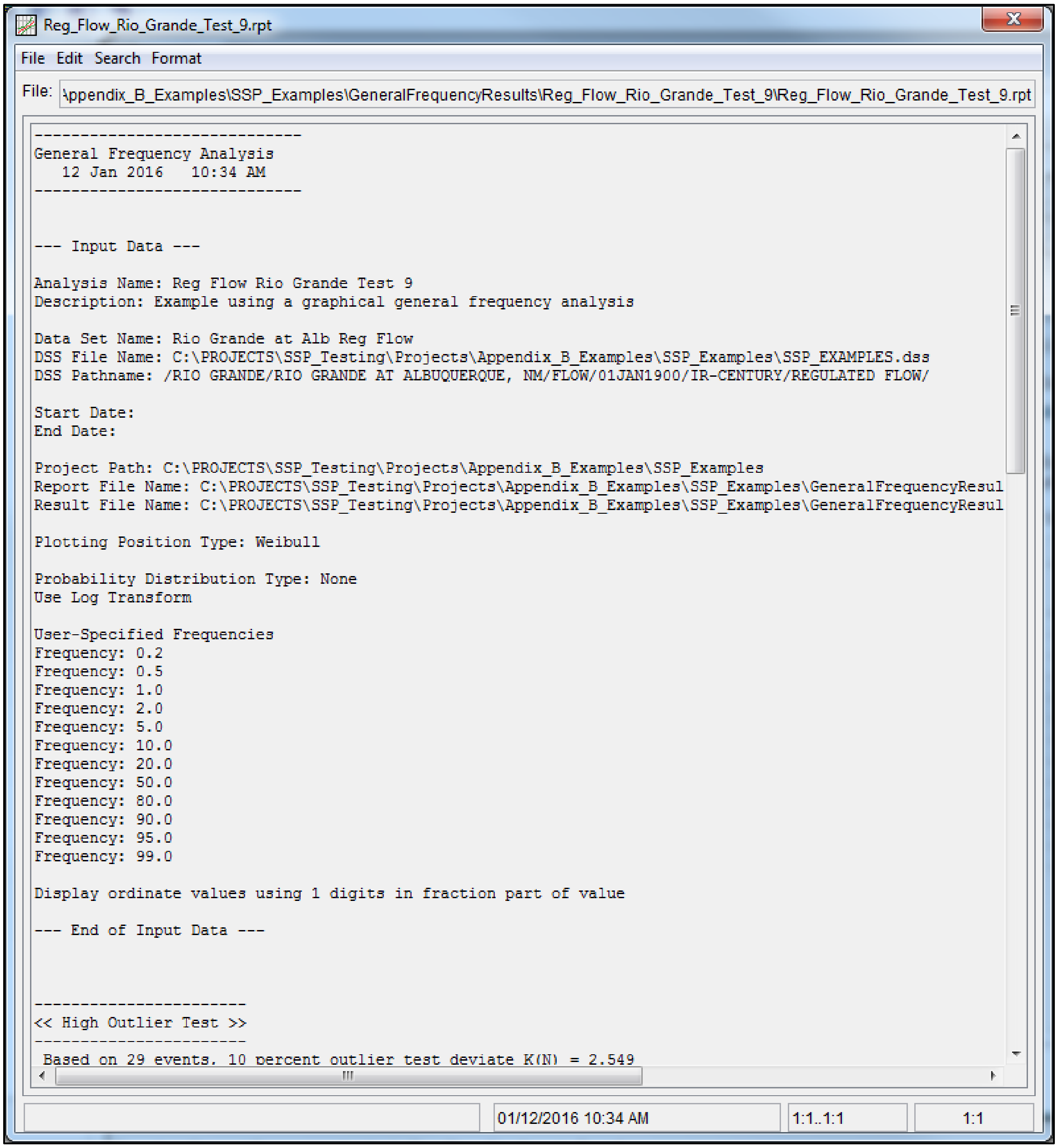


Figure B-66. Plot of the Frequency Curve Results for Reg Flow Rio Grande Test 9.

The graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-67 is the report file for **Reg Flow Rio Grande Test 9**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, and additional calculations needed. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.



Reg_Flow_Rio_Grande_Test_9.rpt

File Edit Search Format

File: \ppendix_B_Examples\SSP_Examples\GeneralFrequencyResults\Reg_Flow_Rio_Grande_Test_9\Reg_Flow_Rio_Grande_Test_9.rpt

```
----------------------------
General Frequency Analysis
   12 Jan 2016   10:34 AM
----------------------------


--- Input Data ---

Analysis Name: Reg Flow Rio Grande Test 9
Description: Example using a graphical general frequency analysis

Data Set Name: Rio Grande at Alb Reg Flow
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\SSP_EXAMPLES.dss
DSS Pathname: /RIO GRANDE/RIO GRANDE AT ALBUQUERQUE, NM/FLOW/01JAN1900/IR-CENTURY/REGULATED FLOW/

Start Date:
End Date:

Project Path: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples
Report File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\GeneralFrequencyResul
Result File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\GeneralFrequencyResul

Plotting Position Type: Weibull

Probability Distribution Type: None
Use Log Transform

User-Specified Frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 5.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---



-----------------------
<< High Outlier Test >>
-----------------------
 Based on 29 events, 10 percent outlier test deviate K(N) = 2.549
```

01/12/2016 10:34 AM | 1:1..1:1 | 1:1

Figure B-67. Report File for Reg Flow Rio Grande Test 9.

Example 10: Volume Frequency Analysis, Maximum Flows

This example demonstrates how to perform a Volume Frequency analysis for maximum flows. The data for this example was derived from an analysis where a time-series of daily average unregulated flows were computed for the Rio Grande at Albuquerque. The period of record for this example is from 1941 to 2002. To view the data, right-click on the data record labeled "**Rio Grande at Alb Unreg Daily**" in the study explorer and then select **Plot**. The data will appear as shown in Figure B-68.

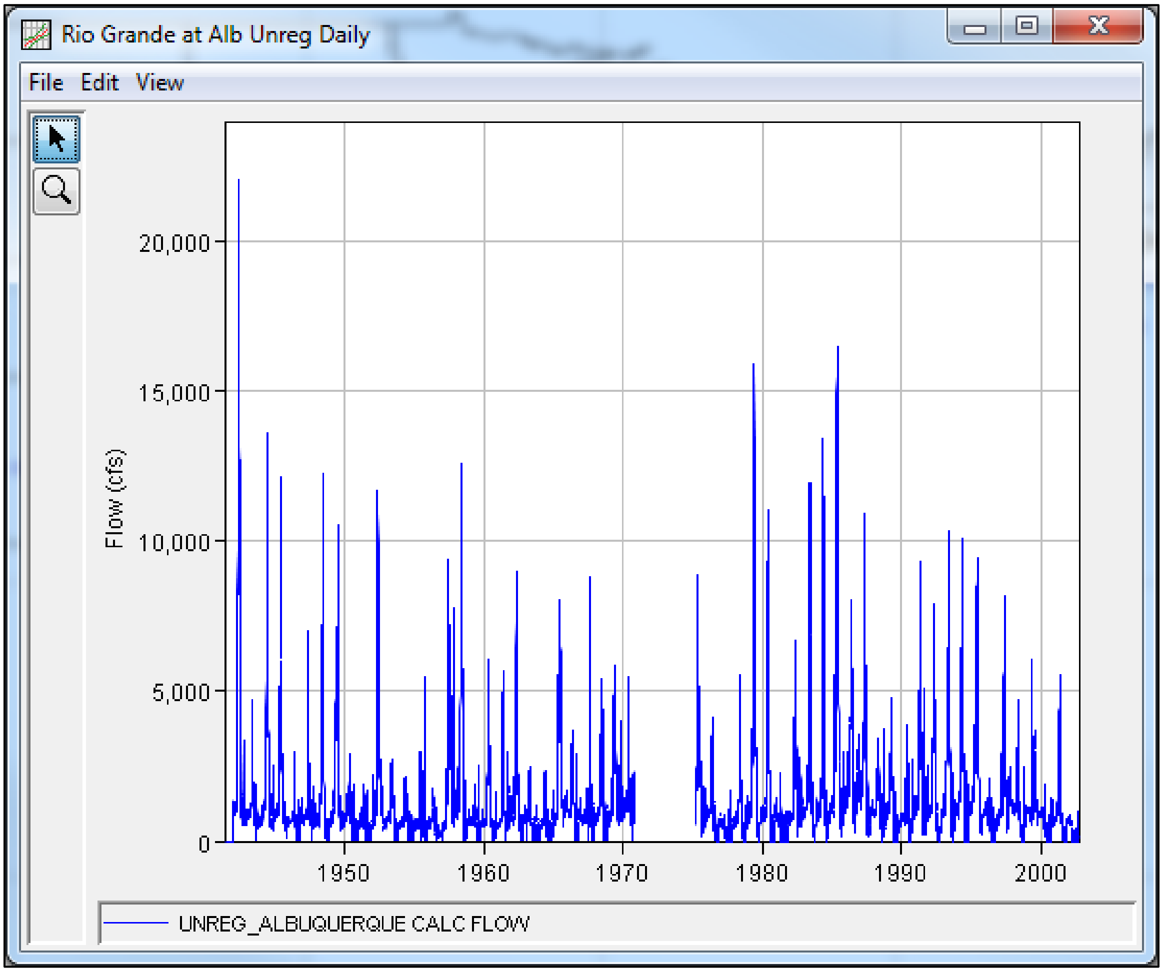


Figure B-68. Plot of Daily Average Flow for Example 10.

A Volume Frequency analysis has been developed for this example. To open the Volume Frequency Analysis editor for this example, either double-click on the analysis labeled **Unreg Flow Rio Grande Test 10** from the study explorer, or from the **Analysis** menu select open, then select **Unreg Flow Rio Grande Test 10** from the list of available analyses. When test 10 is opened, the Volume Frequency Analysis editor will appear as shown in Figure B-69.

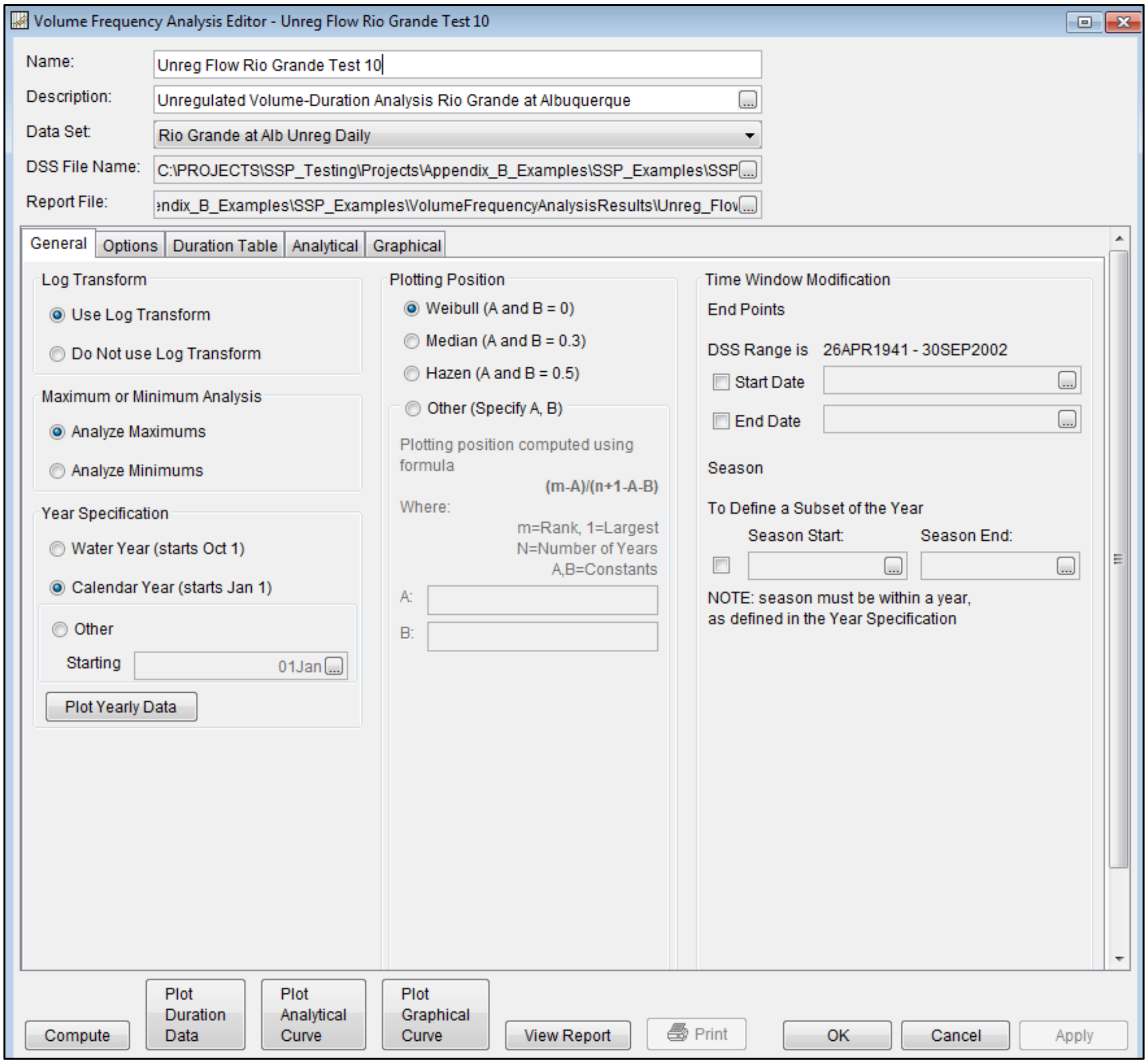


Figure B-69. Volume Frequency Analysis Editor for Unreg Flow Rio Grande Test 10.

Shown in Figure B-69 are the general settings that were used to perform this frequency analysis. For this analysis, the **Use Log Transform** option was selected, the **Weibull** plotting position method was selected, **Analyze Maximums** was selected, the **Calendar Year** option was selected, and no modification was made to the **Time Window**.

Shown in Figure B-70 is the Volume Frequency Analysis editor with the **Options Tab** selected. Features on this tab include an option to override the default **Flow Duration** values, an option to override the default

Frequency Ordinates, and **Output Labeling**. Both the flow-duration and frequency ordinate tables were modified.

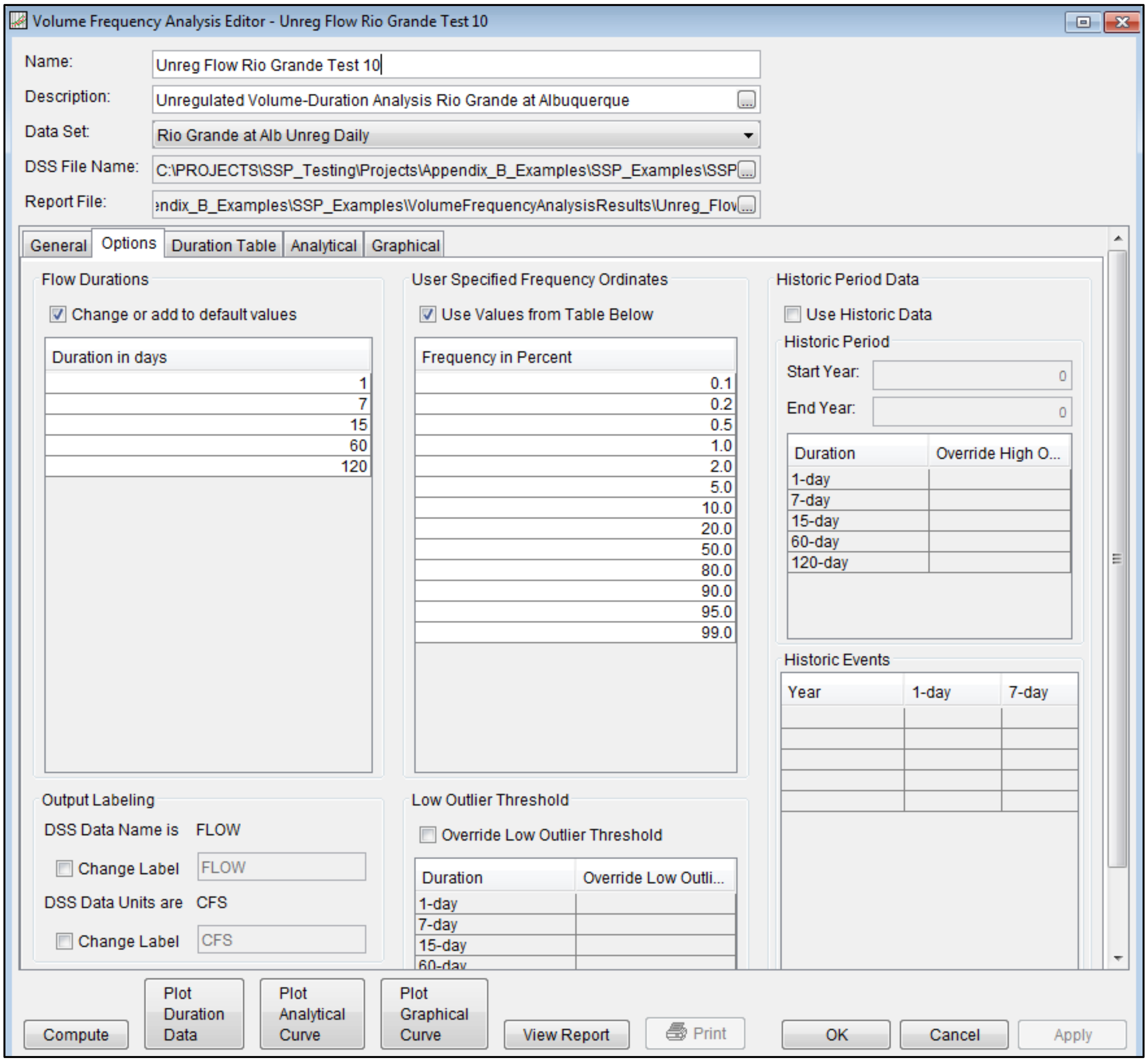
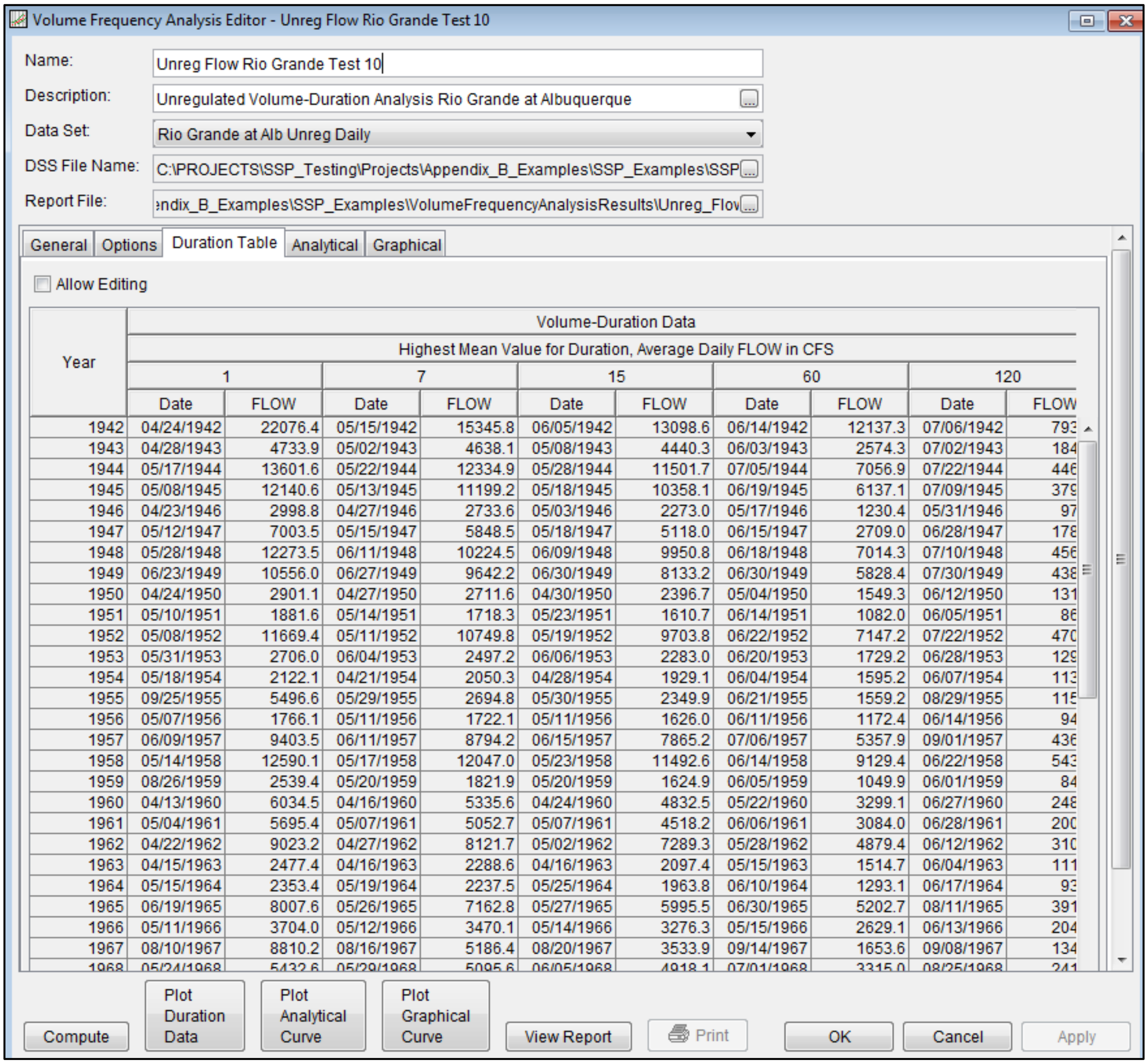


Figure B-70. Options Tab Shown for Unreg Flow Rio Grande Test 10.

Once all of the General and Optional settings are set or selected, the user can extract the volume-duration data from the time-series of daily flows. Select the **Duration Data** tab and press the **Extract Volume-Duration Data** button at the bottom of the table. The table should then fill with the flow-duration values, as shown in Figure B-71.



Year	Volume-Duration Data									
	Highest Mean Value for Duration, Average Daily FLOW in CFS									
	1		7		15		60		120	
	Date	FLOW	Date	FLOW	Date	FLOW	Date	FLOW	Date	FLOW
1942	04/24/1942	22076.4	05/15/1942	15345.8	06/05/1942	13098.6	06/14/1942	12137.3	07/06/1942	793
1943	04/28/1943	4733.9	05/02/1943	4638.1	05/08/1943	4440.3	06/03/1943	2574.3	07/02/1943	184
1944	05/17/1944	13601.6	05/22/1944	12334.9	05/28/1944	11501.7	07/05/1944	7056.9	07/22/1944	446
1945	05/08/1945	12140.6	05/13/1945	11199.2	05/18/1945	10358.1	06/19/1945	6137.1	07/09/1945	379
1946	04/23/1946	2998.8	04/27/1946	2733.6	05/03/1946	2273.0	05/17/1946	1230.4	05/31/1946	97
1947	05/12/1947	7003.5	05/15/1947	5848.5	05/18/1947	5118.0	06/15/1947	2709.0	06/28/1947	178
1948	05/28/1948	12273.5	06/11/1948	10224.5	06/09/1948	9950.8	06/18/1948	7014.3	07/10/1948	456
1949	06/23/1949	10556.0	06/27/1949	9642.2	06/30/1949	8133.2	06/30/1949	5828.4	07/30/1949	438
1950	04/24/1950	2901.1	04/27/1950	2711.6	04/30/1950	2396.7	05/04/1950	1549.3	06/12/1950	131
1951	05/10/1951	1881.6	05/14/1951	1718.3	05/23/1951	1610.7	06/14/1951	1082.0	06/05/1951	86
1952	05/08/1952	11669.4	05/11/1952	10749.8	05/19/1952	9703.8	06/22/1952	7147.2	07/22/1952	470
1953	05/31/1953	2706.0	06/04/1953	2497.2	06/06/1953	2283.0	06/20/1953	1729.2	06/28/1953	129
1954	05/18/1954	2122.1	04/21/1954	2050.3	04/28/1954	1929.1	06/04/1954	1595.2	06/07/1954	113
1955	09/25/1955	5496.6	05/29/1955	2694.8	05/30/1955	2349.9	06/21/1955	1559.2	08/29/1955	115
1956	05/07/1956	1766.1	05/11/1956	1722.1	05/11/1956	1626.0	06/11/1956	1172.4	06/14/1956	94
1957	06/09/1957	9403.5	06/11/1957	8794.2	06/15/1957	7865.2	07/06/1957	5357.9	09/01/1957	436
1958	05/14/1958	12590.1	05/17/1958	12047.0	05/23/1958	11492.6	06/14/1958	9129.4	06/22/1958	543
1959	08/26/1959	2539.4	05/20/1959	1821.9	05/20/1959	1624.9	06/05/1959	1049.9	06/01/1959	84
1960	04/13/1960	6034.5	04/16/1960	5335.6	04/24/1960	4832.5	05/22/1960	3299.1	06/27/1960	248
1961	05/04/1961	5695.4	05/07/1961	5052.7	05/07/1961	4518.2	06/06/1961	3084.0	06/28/1961	200
1962	04/22/1962	9023.2	04/27/1962	8121.7	05/02/1962	7289.3	05/28/1962	4879.4	06/12/1962	310
1963	04/15/1963	2477.4	04/16/1963	2288.6	04/16/1963	2097.4	05/15/1963	1514.7	06/04/1963	111
1964	05/15/1964	2353.4	05/19/1964	2237.5	05/25/1964	1963.8	06/10/1964	1293.1	06/17/1964	93
1965	06/19/1965	8007.6	05/26/1965	7162.8	05/27/1965	5995.5	06/30/1965	5202.7	08/11/1965	391
1966	05/11/1966	3704.0	05/12/1966	3470.1	05/14/1966	3276.3	05/15/1966	2629.1	06/13/1966	204
1967	08/10/1967	8810.2	08/16/1967	5186.4	08/20/1967	3533.9	09/14/1967	1653.6	09/08/1967	134
1968	05/24/1968	5432.6	05/29/1968	5095.6	06/05/1968	4918.1	07/01/1968	3315.0	08/25/1968	241

Figure B-71. Volume-Duration Data Table for Unreg Flow Rio Grande Test 10.

Once the data has been extracted, the user must choose to perform an Analytical or Graphical analysis. In this example, an analytical analysis was performed. Shown in Figure B-72 is the **Settings** tab for the analytical analysis. As shown, the distribution selected for this example is LogPearsonIII. The **Skew** option was set to **Use Station Skew** and the **Do Not Compute Excepted Probability** option was selected.

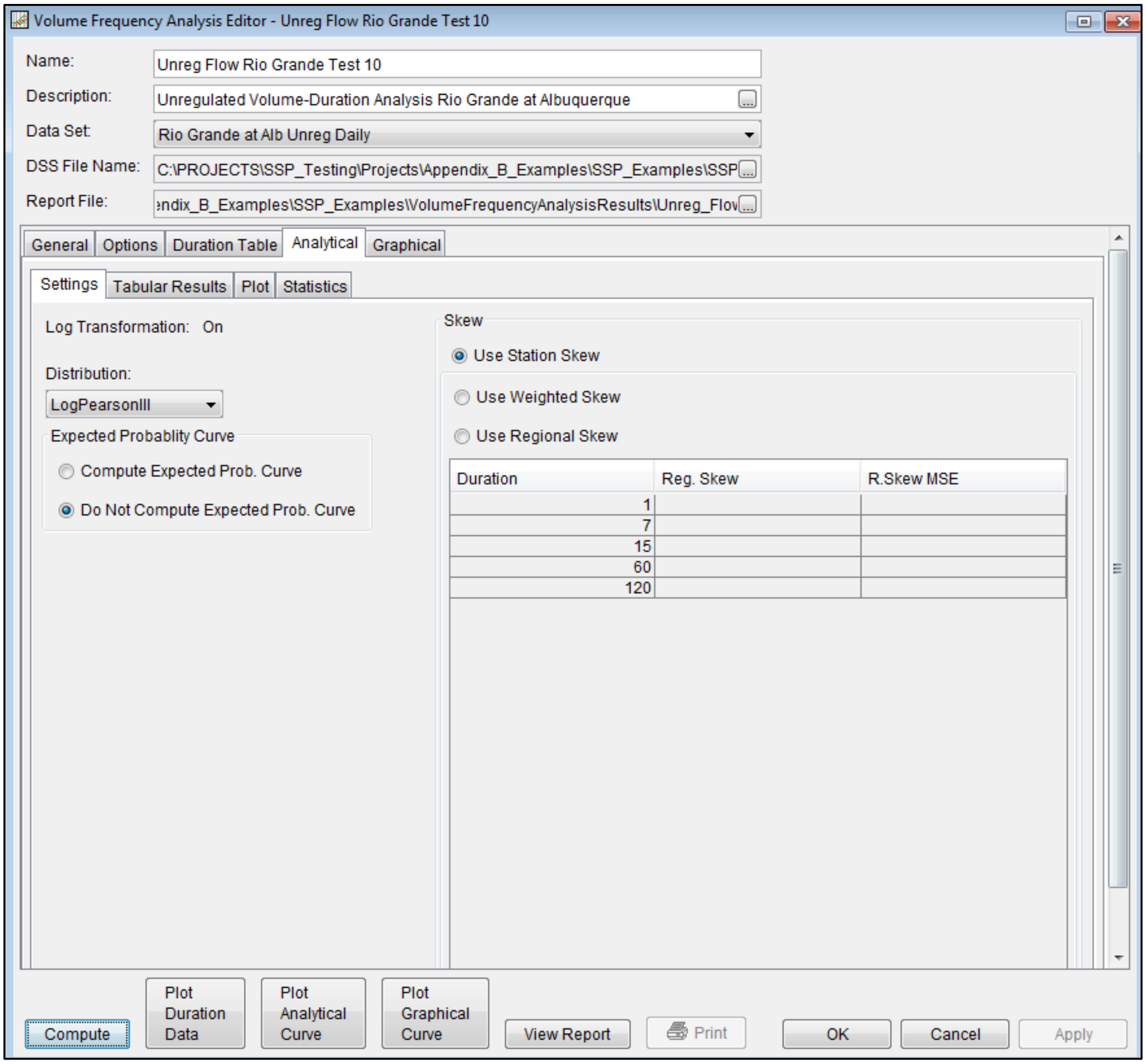
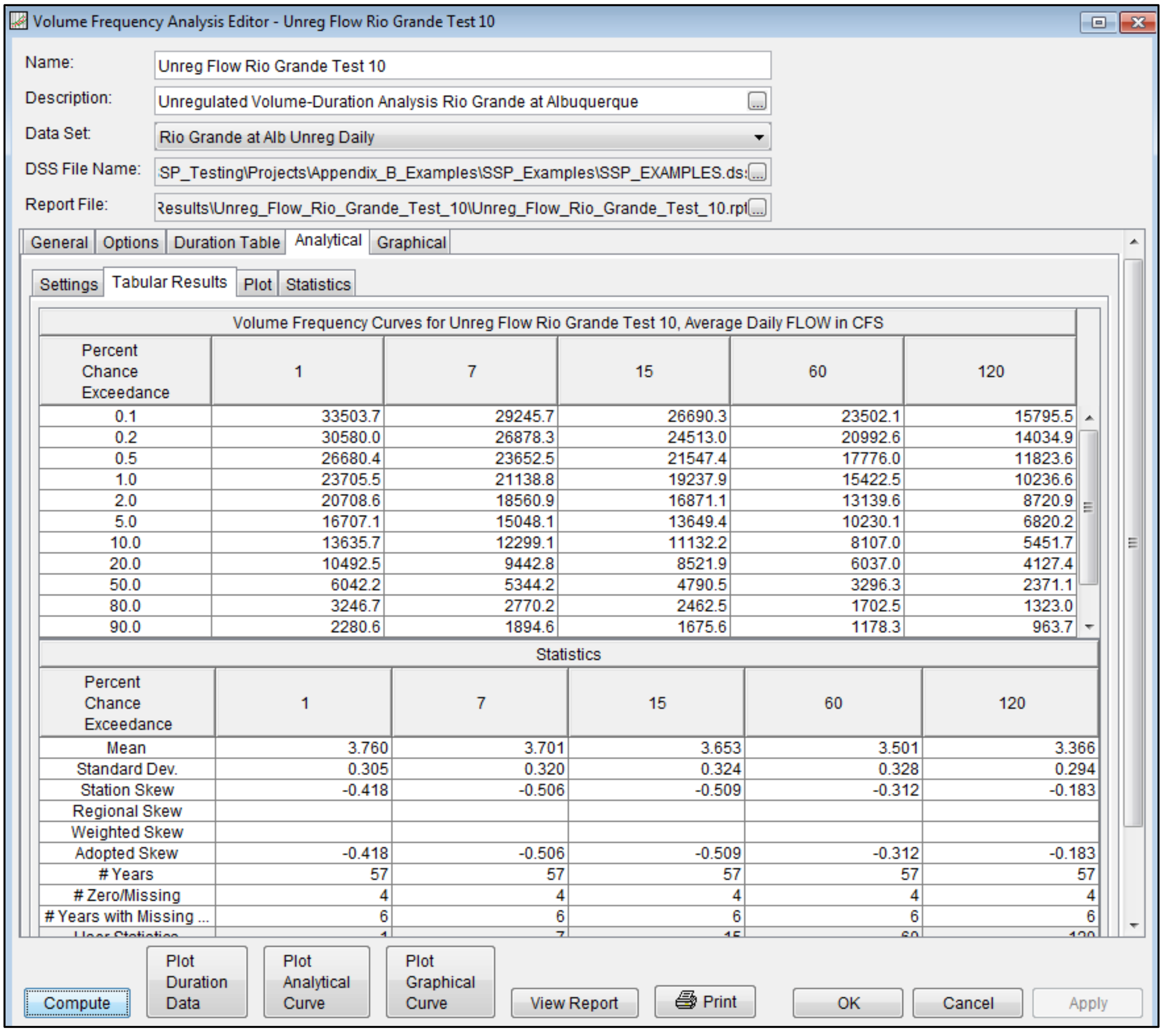


Figure B-72. Settings Tab Shown for Unreg Flow Rio Grande Test 10.

Press the **Compute** button to perform the analysis. A message window will open stating that a few of the annual maximums occurred during the beginning of the year. The message suggests that the user change the year/season specification to capture independent events. You want to minimize the possibility that the same flood event is used for consecutive years. Press the OK button to finish the compute. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab within the analytical analysis. The results table should look Figure B-73. The top portion of the results table contains the percent chance exceedance for all durations (the report contains confidence limits). The bottom portion of the results table contains the statistics for all duration.



Volume Frequency Curves for Unreg Flow Rio Grande Test 10, Average Daily FLOW in CFS

Percent Chance Exceedance	1	7	15	60	120
0.1	33503.7	29245.7	26690.3	23502.1	15795.5
0.2	30580.0	26878.3	24513.0	20992.6	14034.9
0.5	26680.4	23652.5	21547.4	17776.0	11823.6
1.0	23705.5	21138.8	19237.9	15422.5	10236.6
2.0	20708.6	18560.9	16871.1	13139.6	8720.9
5.0	16707.1	15048.1	13649.4	10230.1	6820.2
10.0	13635.7	12299.1	11132.2	8107.0	5451.7
20.0	10492.5	9442.8	8521.9	6037.0	4127.4
50.0	6042.2	5344.2	4790.5	3296.3	2371.1
80.0	3246.7	2770.2	2462.5	1702.5	1323.0
90.0	2280.6	1894.6	1675.6	1178.3	963.7

Statistics

Percent Chance Exceedance	1	7	15	60	120
Mean	3.760	3.701	3.653	3.501	3.366
Standard Dev.	0.305	0.320	0.324	0.328	0.294
Station Skew	-0.418	-0.506	-0.509	-0.312	-0.183
Regional Skew					
Weighted Skew					
Adopted Skew	-0.418	-0.506	-0.509	-0.312	-0.183
# Years	57	57	57	57	57
# Zero/Missing	4	4	4	4	4
# Years with Missing ...	6	6	6	6	6

Figure B-73. Tabular Results Tab for Unreg Flow Rio Grande Test 10.

Note: These tabular results use the default computed statistics.

As shown in Figure B-74, the **Plot** tab contains a graph of the systematic data and the computed frequency curves. Notice how some of the frequency curves look like they might cross if the lines were extended. The **Statistics** tab can be used to modify the computed statistics to ensure that the frequency curves are consistent.

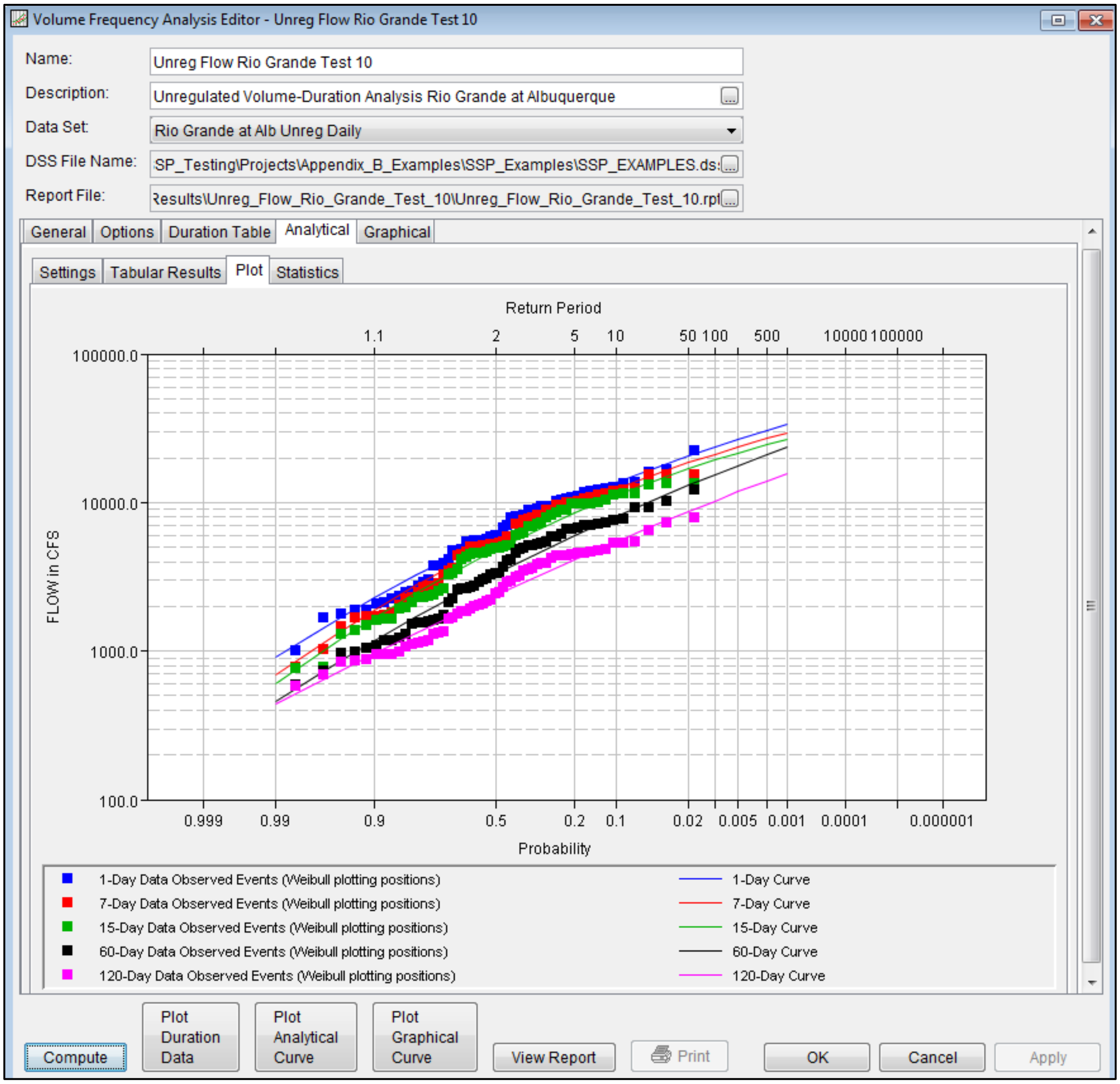


Figure B-74. Plot Tab for Unreg Flow Rio Grande Test 10.

For this example, the standard deviation and the adopted skew values were modified to make sure the volume frequency curves were consistent. As shown in Figure B-75, the check boxes next to mean, standard deviation, and adopted skew were checked and then user-adjusted statistics were entered into the table for all durations. The **Compute** button must be pressed after adjusted statistics have been entered in order for the program to recompute the frequency curves using the user-adjusted statistics. Figure B-76 shows the **Plot** tab after the user-adjusted statistics were entered on the **Statistics** tab. Results on the **Tabular Results** tab will also update when user-adjusted statistics are entered on the **Statistics** tab.

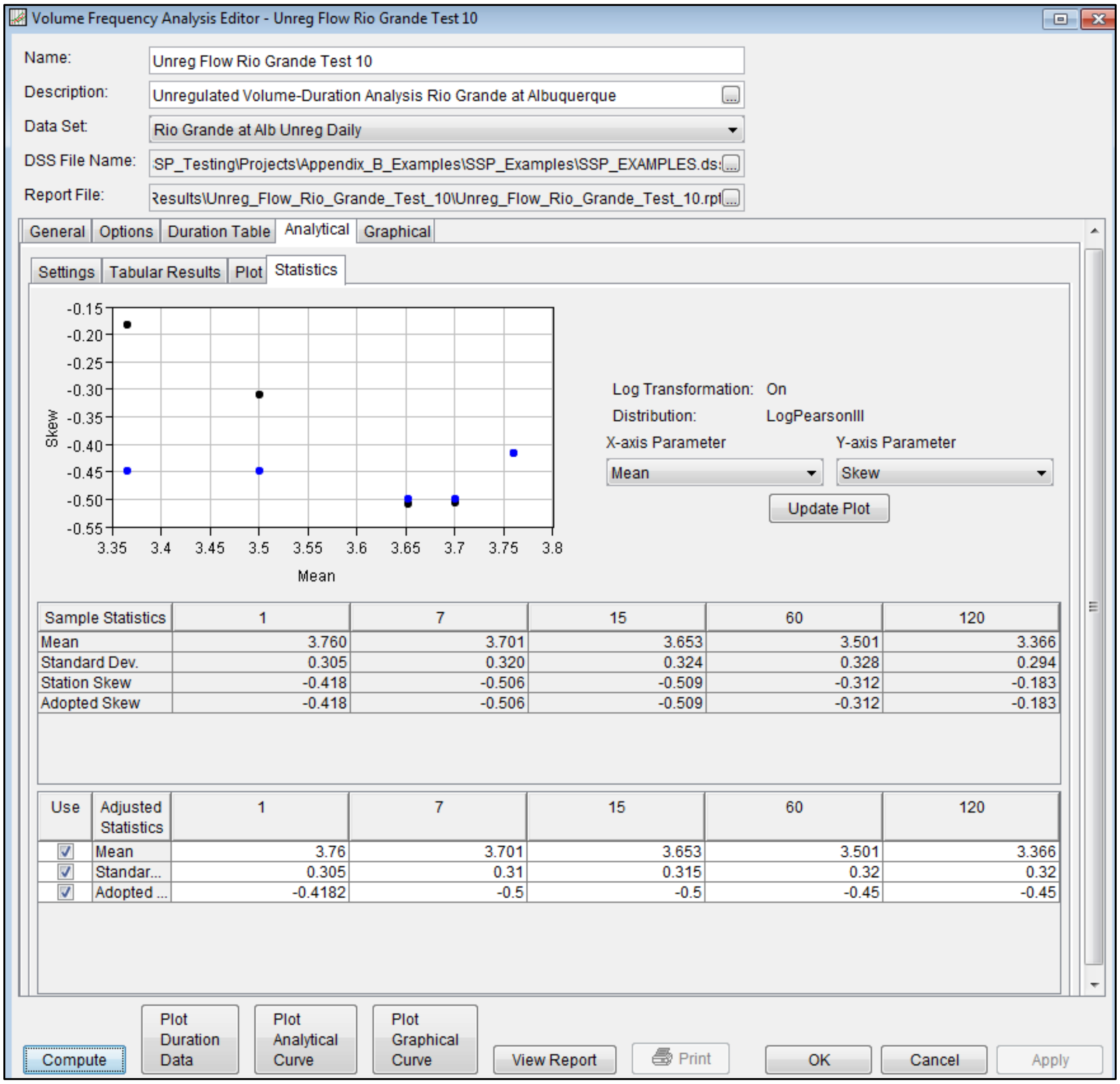


Figure B-75. Statistics Tab for Unreg Flow Rio Grande Test 10.

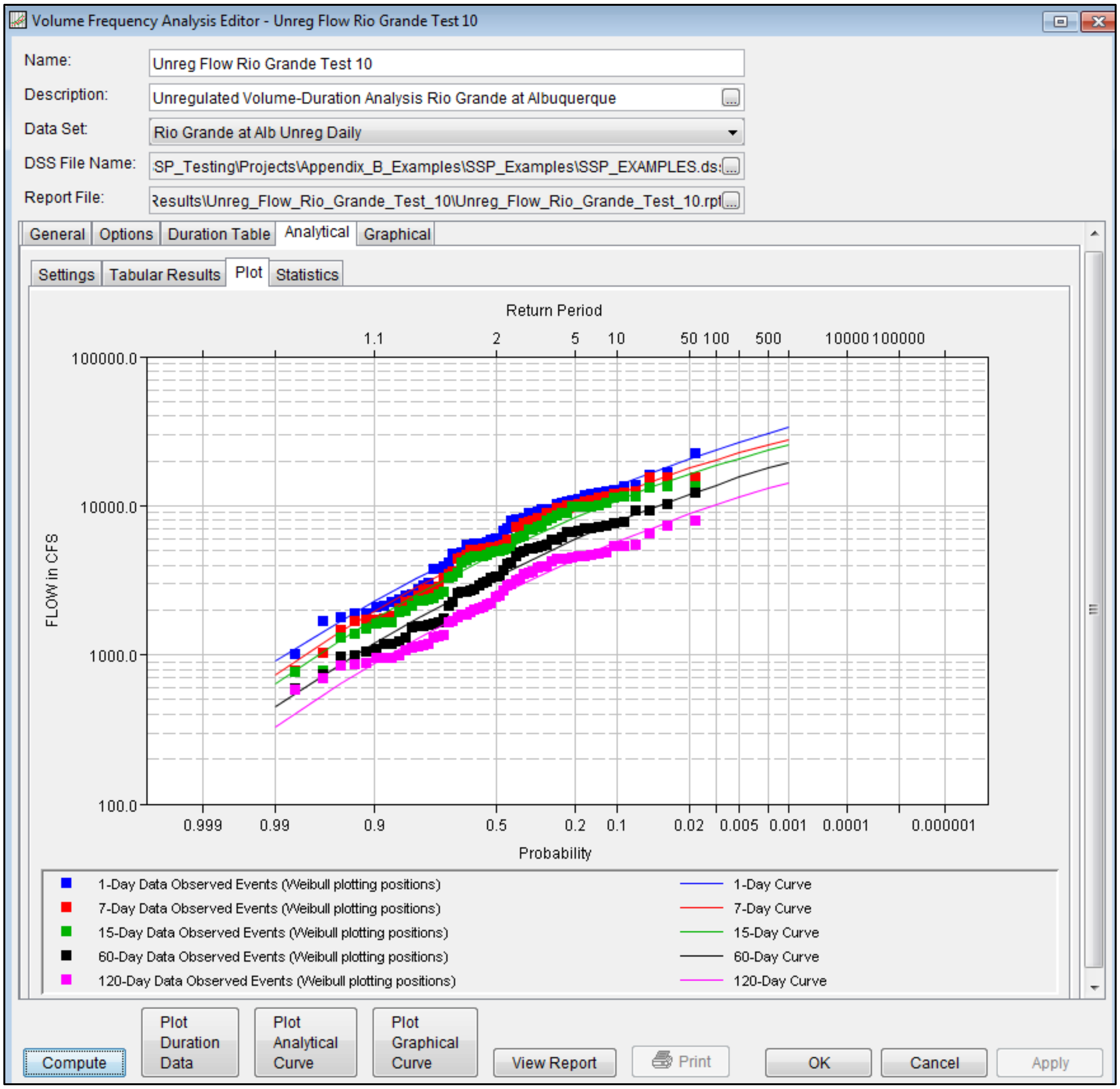


Figure B-76. Plot Tab for Unreg Flow Rio Grande Test 10 After the Statistics were Adjusted on the Statistics Tab.

In addition to the Tabular Results and Plot tabs, graphical plots can be opened by selecting the **Plot Duration Data** or **Plot Analytical Curve** buttons at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-77.

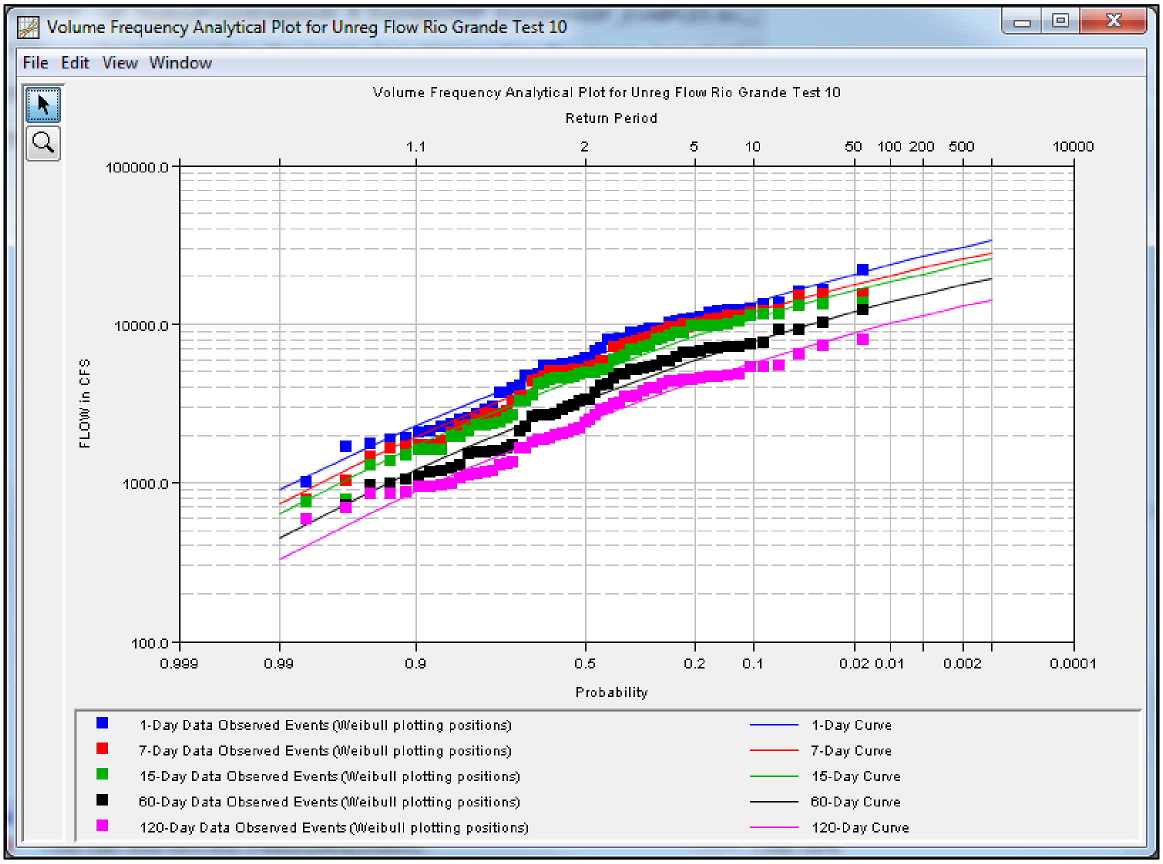
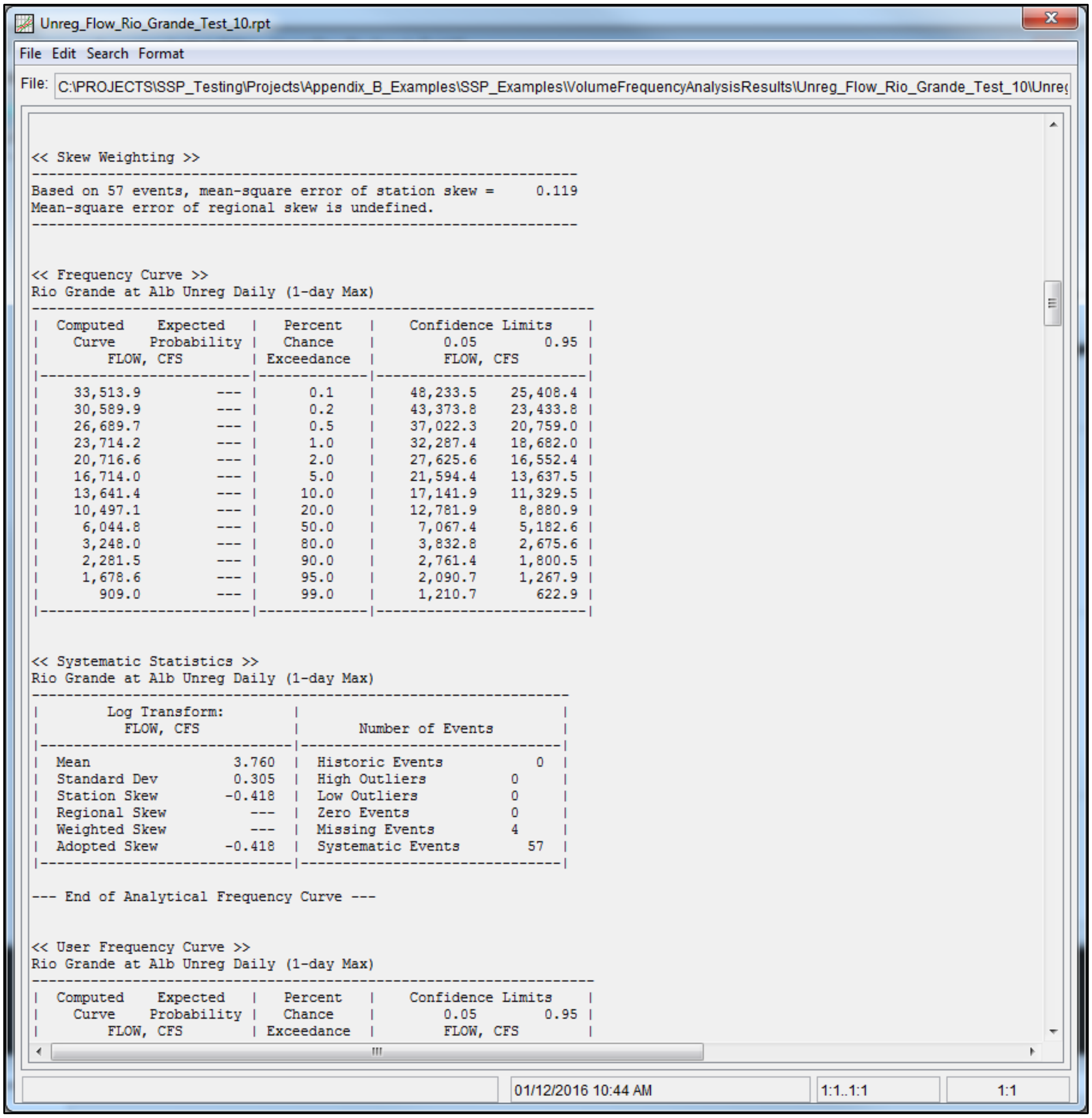


Figure B-77. Plot of the Frequency Curve Results for Unreg Flow Rio Grande Test 10.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-78 is the report file for **Unreg Flow Rio Grande Test 10**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.




```
<< Skew Weighting >>
---------------------------------------------------------------
Based on 57 events, mean-square error of station skew =     0.119
Mean-square error of regional skew is undefined.
---------------------------------------------------------------


<< Frequency Curve >>
Rio Grande at Alb Unreg Daily (1-day Max)
-----------------------------------------------------------------
|  Computed    Expected   |   Percent   |    Confidence Limits    |
|    Curve    Probability |   Chance    |      0.05        0.95  |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS        |
|-------------------------|-------------|-------------------------|
|    33,513.9         --- |     0.1     |   48,233.5    25,408.4 |
|    30,589.9         --- |     0.2     |   43,373.8    23,433.8 |
|    26,689.7         --- |     0.5     |   37,022.3    20,759.0 |
|    23,714.2         --- |     1.0     |   32,287.4    18,682.0 |
|    20,716.6         --- |     2.0     |   27,625.6    16,552.4 |
|    16,714.0         --- |     5.0     |   21,594.4    13,637.5 |
|    13,641.4         --- |    10.0     |   17,141.9    11,329.5 |
|    10,497.1         --- |    20.0     |   12,781.9     8,880.9 |
|     6,044.8         --- |    50.0     |    7,067.4     5,182.6 |
|     3,248.0         --- |    80.0     |    3,832.8     2,675.6 |
|     2,281.5         --- |    90.0     |    2,761.4     1,800.5 |
|     1,678.6         --- |    95.0     |    2,090.7     1,267.9 |
|       909.0         --- |    99.0     |    1,210.7       622.9 |
|-------------------------|-------------|-------------------------|


<< Systematic Statistics >>
Rio Grande at Alb Unreg Daily (1-day Max)
---------------------------------------------------------------
|        Log Transform:          |                              |
|          FLOW, CFS             |       Number of Events       |
|--------------------------------|------------------------------|
| Mean                    3.760  | Historic Events          0   |
| Standard Dev            0.305  | High Outliers        0       |
| Station Skew           -0.418  | Low Outliers         0       |
| Regional Skew             ---  | Zero Events          0       |
| Weighted Skew             ---  | Missing Events       4       |
| Adopted Skew           -0.418  | Systematic Events       57   |
|--------------------------------|------------------------------|

--- End of Analytical Frequency Curve ---


<< User Frequency Curve >>
Rio Grande at Alb Unreg Daily (1-day Max)
-----------------------------------------------------------------
|  Computed    Expected   |   Percent   |    Confidence Limits    |
|    Curve    Probability |   Chance    |      0.05        0.95  |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS        |
```

Figure B-78. Report File for Unreg Flow Rio Grande Test 10.

Example 11: Volume Frequency Analysis, Minimum Flows

This example demonstrates how to create a low flow Volume Frequency analysis. The data for this example was downloaded from the USGS. It is comprised of daily average flow for the Chattahoochee River at Cornelia, Georgia. Drought conditions were occurring in the region at the time of this analysis. Among other things, a low flow analysis can be used to determine the severity of a drought. The period of record for this example is from 1957 to 2007. To view the data, right-click on the data record labeled "**Chattahoochee River**" in the study explorer and then select **Plot**. The data will appear as shown in Figure B-79.

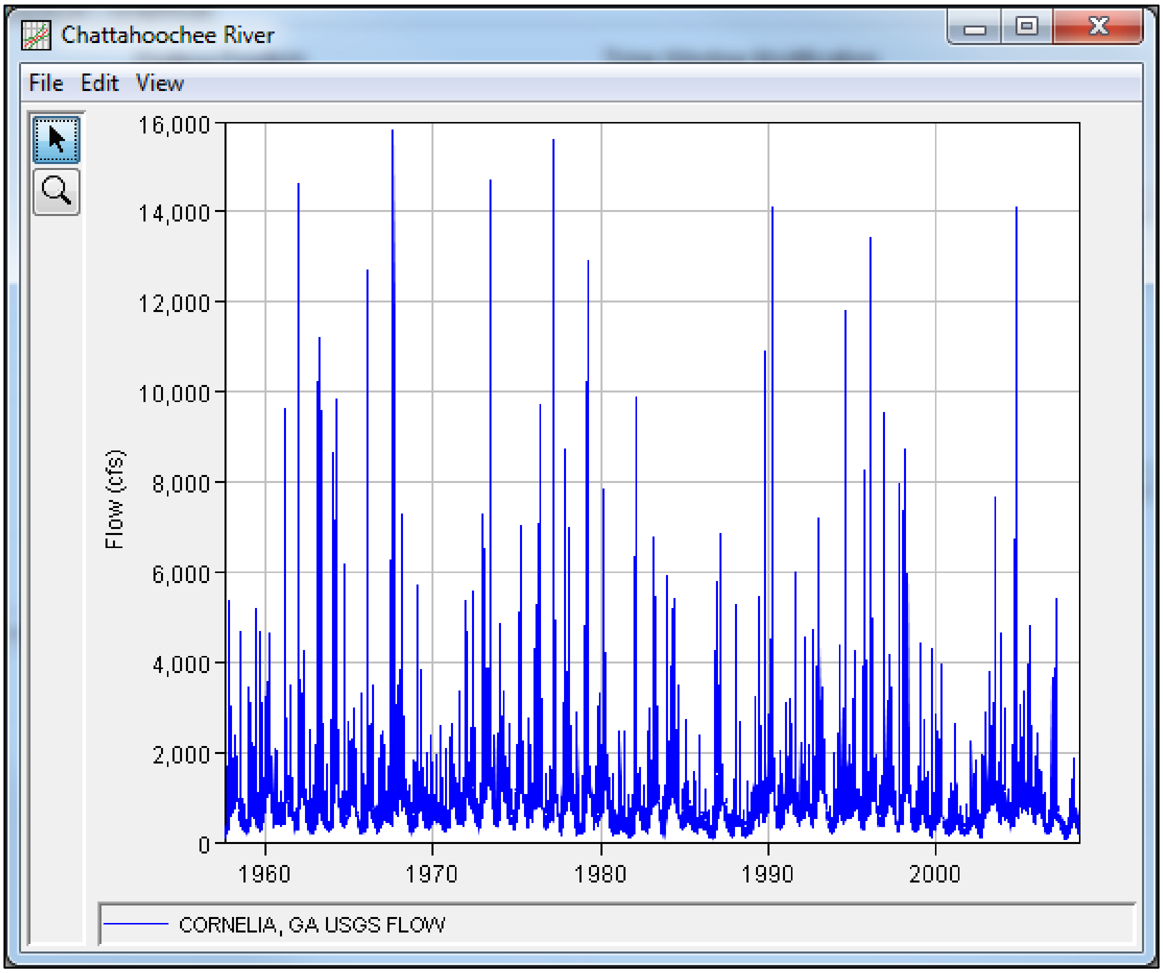


Figure B-79. Plot of Daily Average Flow for Example 11.

A Volume Frequency analysis has been developed for this example. To open the Volume Frequency Analysis editor for this example, either double-click on the analysis labeled **Low Flow Analysis Test 11** from the study explorer, or from the **Analysis** menu select open, then select **Low Flow Analysis Test 11** from the list of available analyses. When test 11 is opened, the Volume Frequency Analysis editor will appear as shown in Figure B-80.

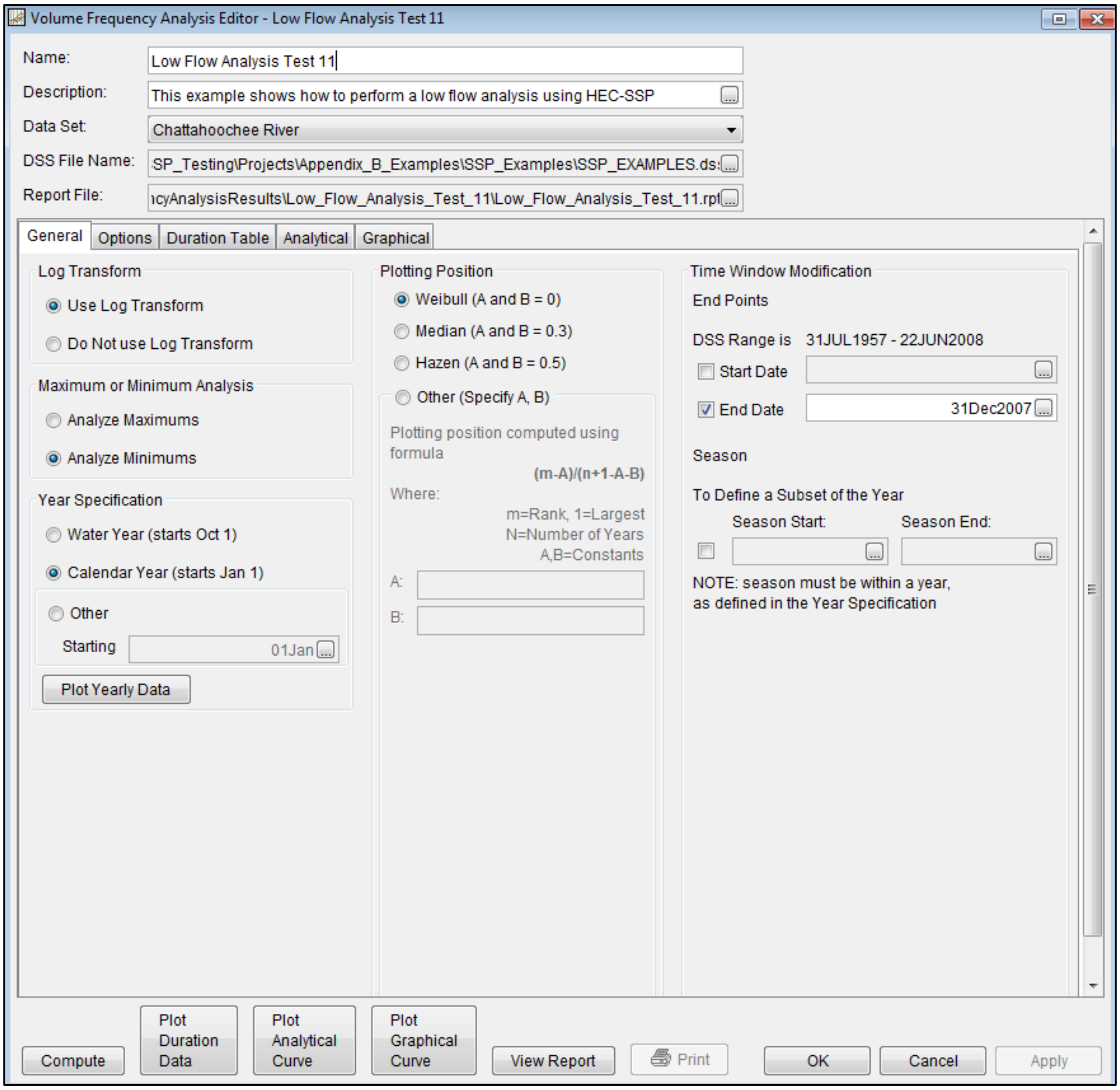


Figure B-80. Volume Frequency Analysis Editor for Low Flow Analysis Test 11.

Shown in Figure B-80 are the general settings that were used to perform this frequency analysis. For this analysis, the **Use Log Transform** option was selected, the **Weibull** plotting position method was selected, **Analyze Minimums** was selected, and the **Calendar Year** option was selected. The Calendar Year option was selected because low flows are possible in late September, early November. Starting the year on January 1 minimizes the possibility of using the same low flow event in multiple years. An end date of 31 December 2007 was entered in the **Time Window Modification**. This end date was specified because not all the data for the summer of 2008 was available at the time of the analysis.

Shown in Figure B-81 is the Volume Frequency Analysis editor with the **Options Tab** selected. Features on this tab include an option to override the default **Flow Duration** values, an option to override the default **Frequency Ordinates**, and **Output Labeling**.

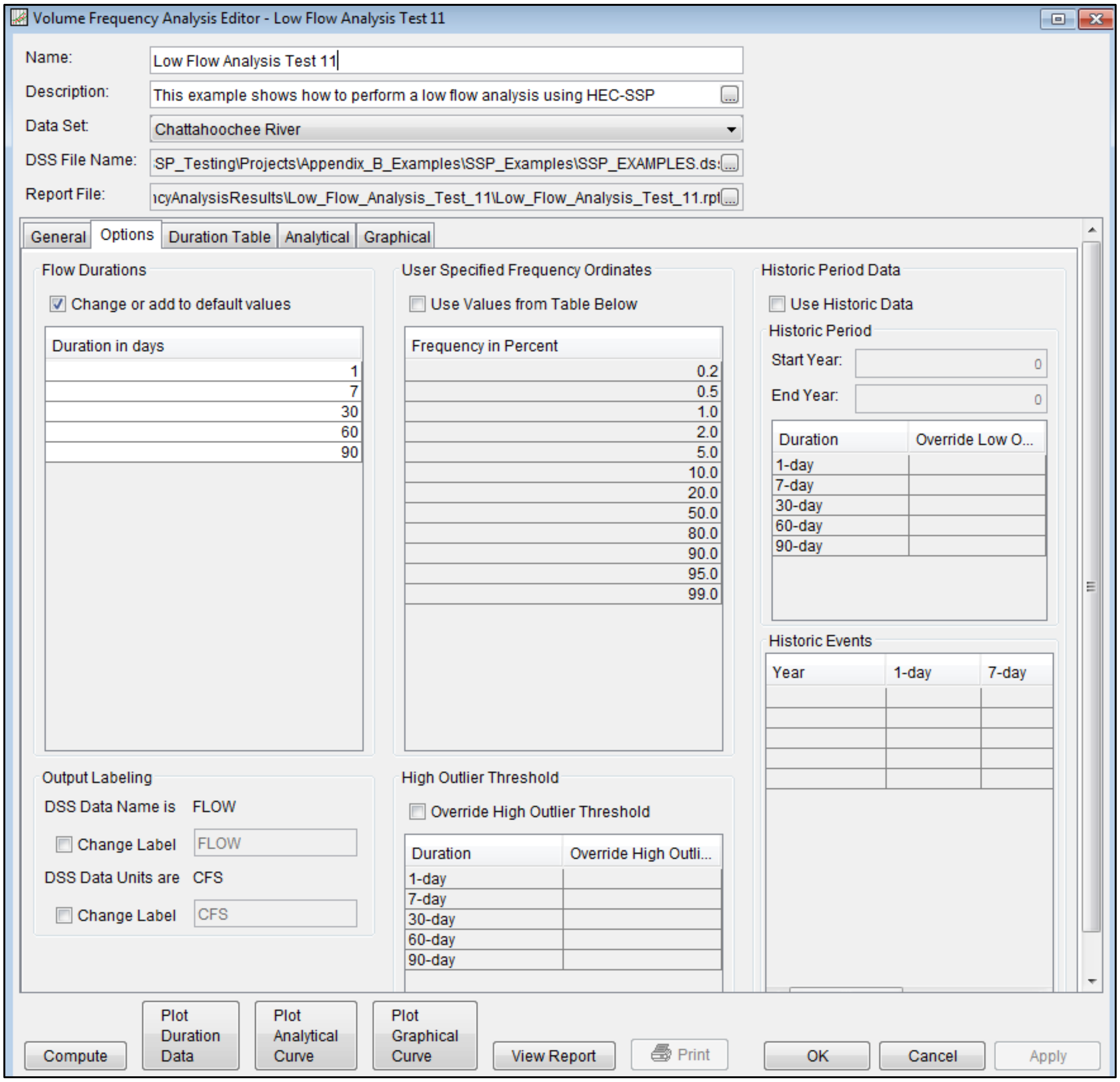


Figure B-81. Options Tab Shown for Low Flow Analysis Test 11.

Once all of the General and Optional settings are set or selected, the user can extract the volume-duration data. Select the **Duration Data** tab and press the **Extract Volume-Duration Data** button at the bottom of the table. The table should then fill with the flow-duration values, as shown in Figure B-82.

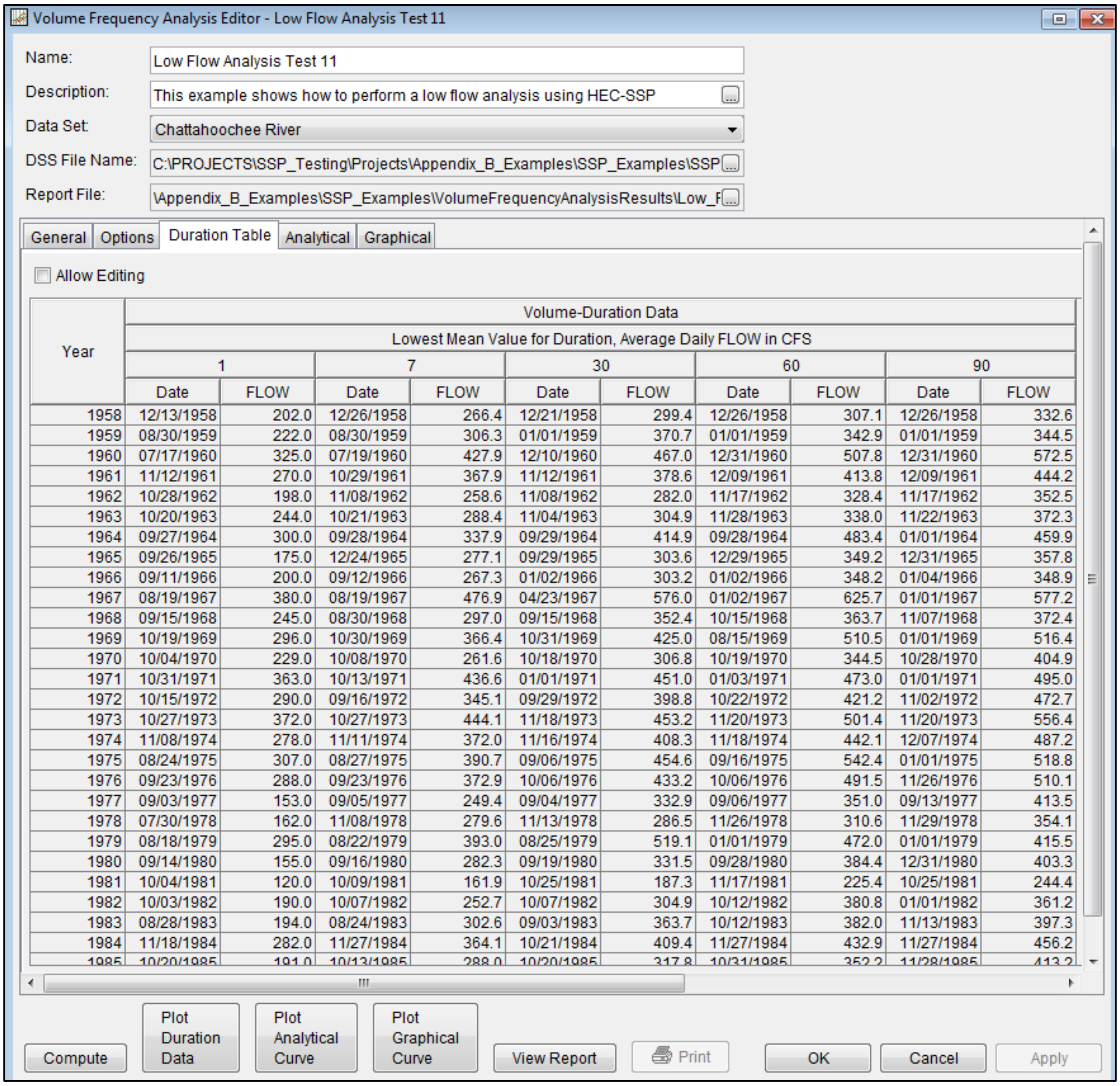


Figure B-82. Volume-Duration Data Table for Low Flow Analysis Test 11.

Once the data has been extracted, the user must choose to perform an Analytical or Graphical analysis. In this example, an analytical analysis was performed. Shown in Figure B-83 is the **Settings** tab for the analytical analysis. As shown, the distribution selected for this example is LogPearsonIII. The **Skew** option was set to **Use Station Skew** and the **Do Not Compute Excepted Probability** option was selected.

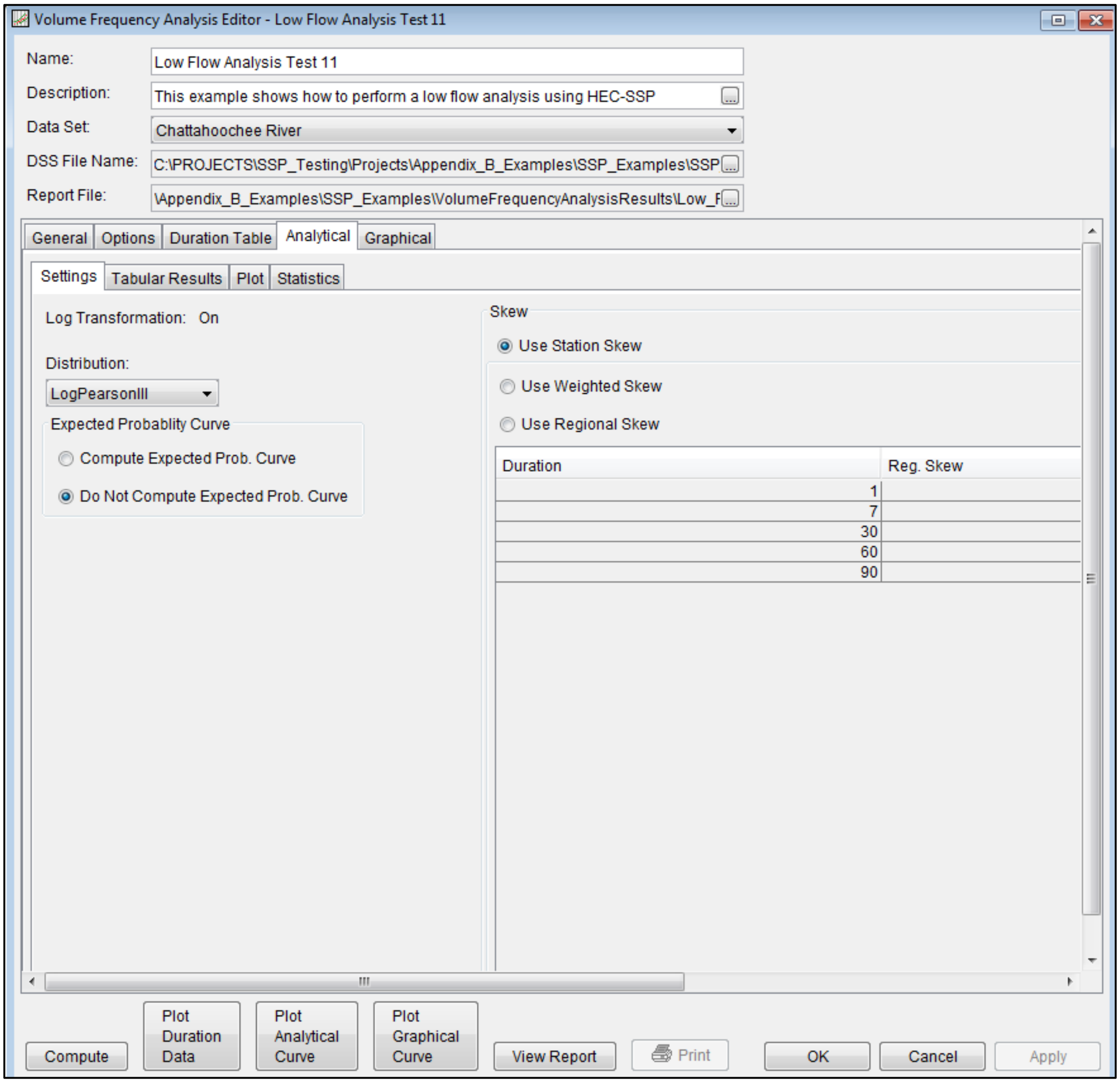
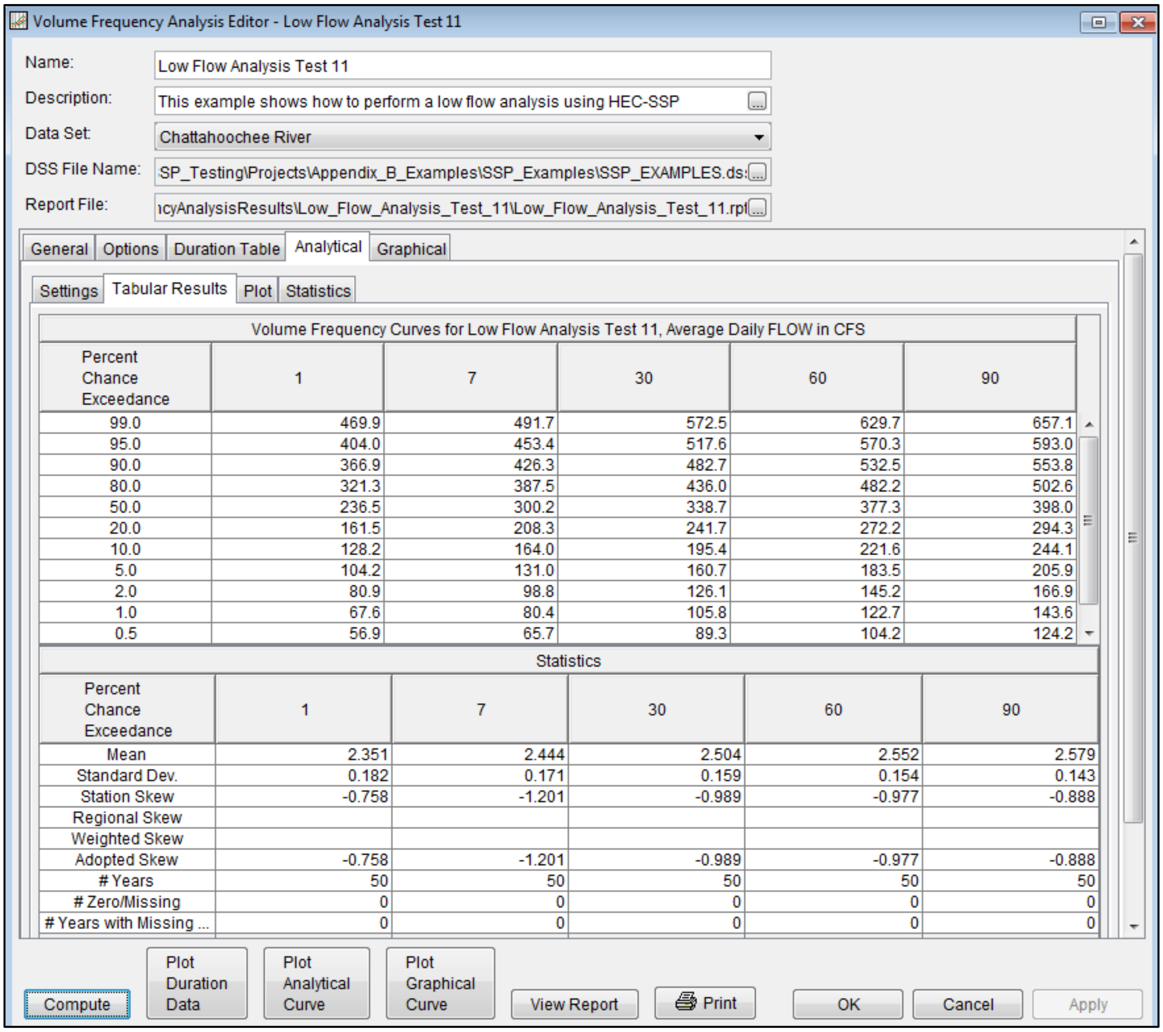


Figure B-83. Settings Tab Shown for Low Flow Analysis Test 11.

Press the **Compute** button to perform the analysis. A message window will open stating that a few of the annual maximums occurred during the beginning of the year. The message suggests that the user change the year/season specification to capture independent events. You want to minimize the possibility that the same flood event is used for consecutive years. Press the OK button to finish the computation. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Tabular Results** tab within the analytical analysis. The results table should look Figure B-84. The top portion of the results table contains the percent chance exceedance for all durations (the report contains confidence limits). The bottom portion of the results table contains the statistics for all durations.



Volume Frequency Curves for Low Flow Analysis Test 11, Average Daily FLOW in CFS					
Percent Chance Exceedance	1	7	30	60	90
99.0	469.9	491.7	572.5	629.7	657.1
95.0	404.0	453.4	517.6	570.3	593.0
90.0	366.9	426.3	482.7	532.5	553.8
80.0	321.3	387.5	436.0	482.2	502.6
50.0	236.5	300.2	338.7	377.3	398.0
20.0	161.5	208.3	241.7	272.2	294.3
10.0	128.2	164.0	195.4	221.6	244.1
5.0	104.2	131.0	160.7	183.5	205.9
2.0	80.9	98.8	126.1	145.2	166.9
1.0	67.6	80.4	105.8	122.7	143.6
0.5	56.9	65.7	89.3	104.2	124.2

Statistics					
Percent Chance Exceedance	1	7	30	60	90
Mean	2.351	2.444	2.504	2.552	2.579
Standard Dev.	0.182	0.171	0.159	0.154	0.143
Station Skew	-0.758	-1.201	-0.989	-0.977	-0.888
Regional Skew					
Weighted Skew					
Adopted Skew	-0.758	-1.201	-0.989	-0.977	-0.888
# Years	50	50	50	50	50
# Zero/Missing	0	0	0	0	0
# Years with Missing ...	0	0	0	0	0

Figure B-84. Tabular Results Tab for Low Flow Analysis Test 11.

Note: These tabular results use the default computed statistics.

As shown in Figure B-85, the **Plot** contains a graph of the systematic data and the computed frequency curves. Notice how some of the frequency curves look like they might cross if the lines were extended. The **Statistics** tab can be used to modify the computed statistics to ensure that the frequency curves are consistent.

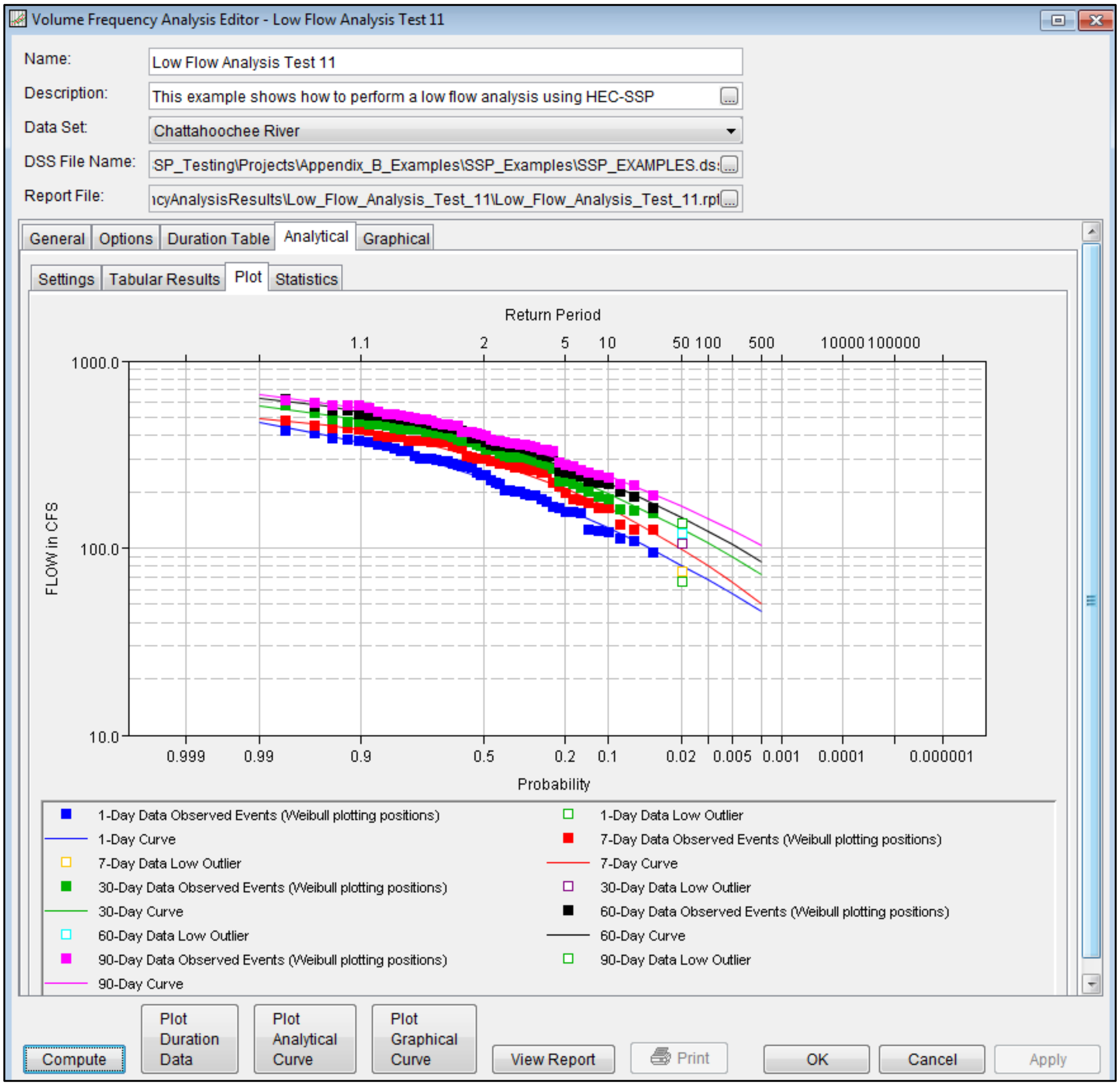


Figure B-85. Plot for Low Flow Analysis Test 11.

For this example, the standard deviation and the adopted skew were modified to make sure the volume frequency curves were consistent. As shown in Figure B-86, the check boxes next to mean, standard deviation, and adopted skew were checked and then user-adjusted statistics were entered into the table for all durations. The **Compute** button must be pressed after adjusted statistics have been entered in order for the program to recompute the frequency curves using the user-adjusted statistics. Figure B-87 shows the **Plot** tab after the user-adjusted statistics were entered on the **Statistics** tab. Results in the **Tabular Results** table will also update when user-adjusted statistics are entered on the **Statistics** tab.

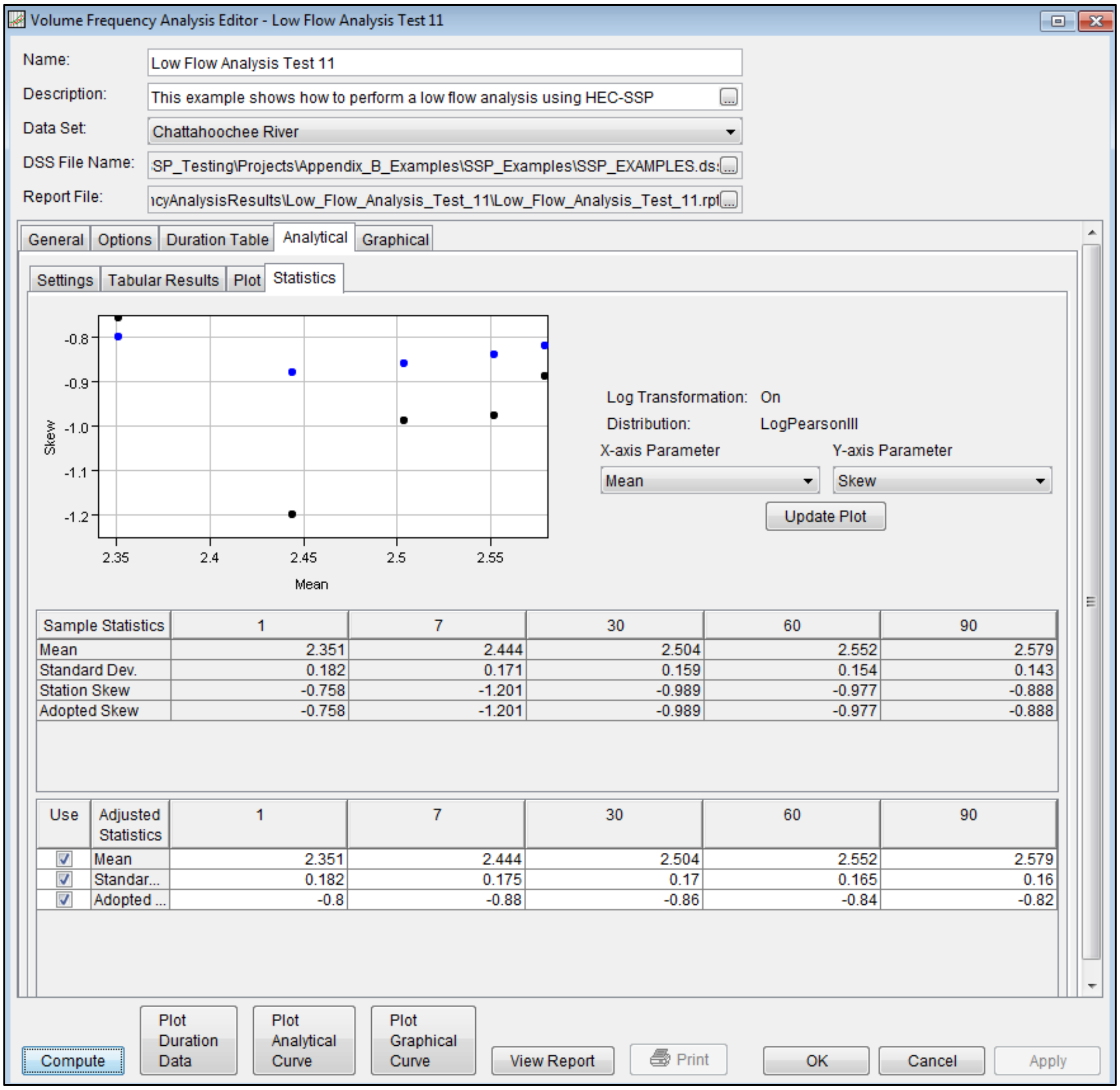


Figure B-86. Statistics Tab for Low Flow Analysis Test 11.

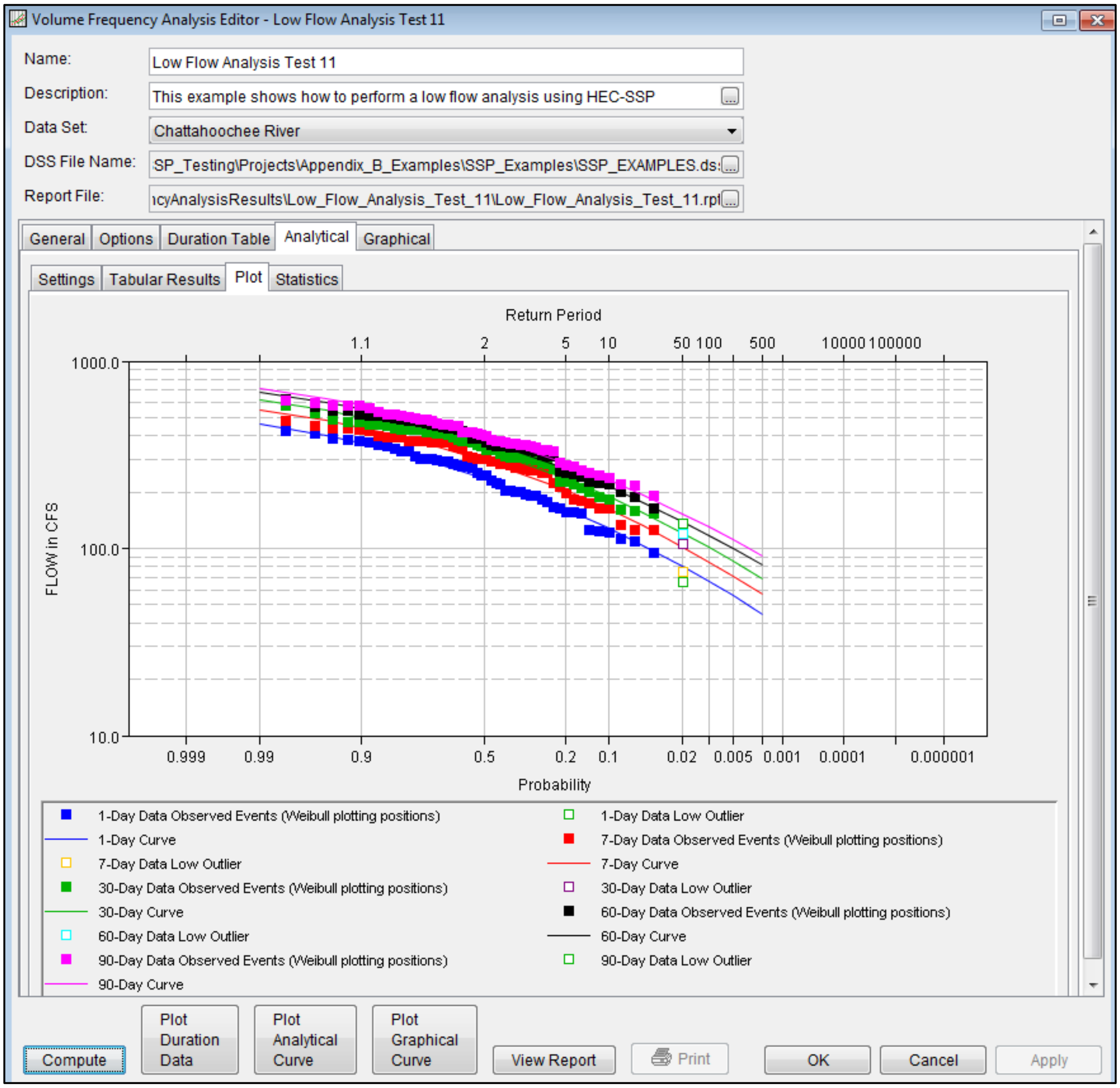


Figure B-87. Plot Tab for Low Flow Analysis Test 11.

In addition to the Tabular Results and Plot tabs, graphical plots can be opened by selecting the **Plot Duration Data** or **Plot Analytical Curve** buttons at the bottom of the analysis window. A plot of the results for this example is shown in Figure B-88.

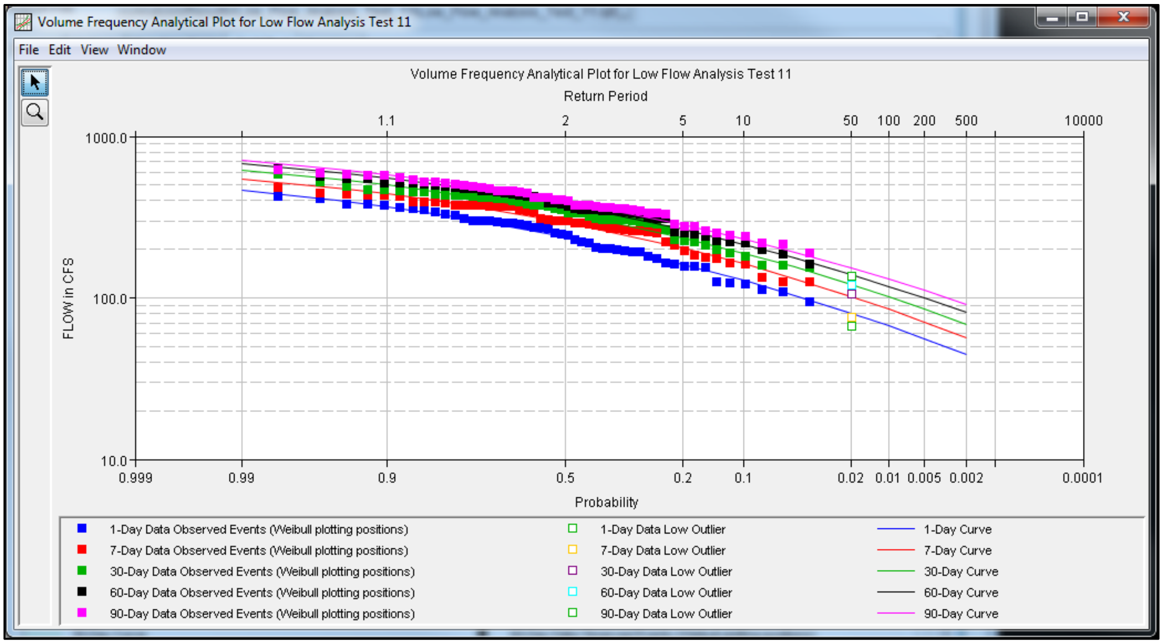


Figure B-88. Plot of the Frequency Curve Results for Low Flow Analysis Test 11.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-89 is the report file for **Low Flow Analysis Test 11**.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis.

```
Low_Flow_Analysis_Test_11.rpt
File  Edit  Search  Format
File: Testing\Projects\Appendix_B_Examples\SSP_Examples\VolumeFrequencyAnalysisResults\Low_Flow_Analysis_Test_11\Low_Flow_Analysis_Test_11.rpt


<< Skew Weighting >>
-----------------------------------------------------------------
Based on 50 events, mean-square error of station skew =     0.163
Mean-square error of regional skew is undefined.
-----------------------------------------------------------------


<< Frequency Curve >>
Chattahoochee River (1-day Min)
-------------------------------------------------------------------
|  Computed    Expected  |   Percent   |    Confidence Limits    |
|    Curve    Probability | Chance Non- |     0.05         0.95   |
|       FLOW, CFS        | Exceedance  |        FLOW, CFS        |
|------------------------|-------------|-------------------------|
|        470.4        --- |    99.0     |     564.1        409.1  |
|        404.3        --- |    95.0     |     473.5        357.0  |
|        367.1        --- |    90.0     |     424.0        326.9  |
|        321.4        --- |    80.0     |     364.9        289.0  |
|        236.4        --- |    50.0     |     261.5        214.4  |
|        161.4        --- |    20.0     |     179.2        142.7  |
|        128.1        --- |    10.0     |     144.7        109.8  |
|        104.0        --- |     5.0     |     120.0         86.3  |
|         80.7        --- |     2.0     |      95.9         64.2  |
|         67.4        --- |     1.0     |      81.8         51.9  |
|         56.7        --- |     0.5     |      70.4         42.3  |
|         45.5        --- |     0.2     |      58.1         32.5  |
|------------------------|-------------|-------------------------|


<< Systematic Statistics >>
Chattahoochee River (1-day Min)
----------------------------------------------------------------
|        Log Transform:        |                               |
|          FLOW, CFS           |       Number of Events        |
|------------------------------|-------------------------------|
|  Mean                 2.351  |  Historic Events          0   |
|  Standard Dev         0.182  |  High Outliers         0      |
|  Station Skew        -0.758  |  Low Outliers          1      |
|  Regional Skew          ---  |  Zero Events           0      |
|  Weighted Skew          ---  |  Missing Events        0      |
|  Adopted Skew        -0.758  |  Systematic Events       50   |
|------------------------------|-------------------------------|

--- End of Analytical Frequency Curve ---


<< User Frequency Curve >>
Chattahoochee River (1-day Min)
-------------------------------------------------------------------
|  Computed    Expected  |   Percent   |    Confidence Limits    |
|    Curve    Probability | Chance Non- |     0.05         0.95   |
|       FLOW, CFS        | Exceedance  |        FLOW, CFS        |

01/12/2016 10:54 AM    30:22..30:22    30:22
```

Figure B-89. Report File for Low Flow Analysis Test 11.

Example 12: Duration Analysis, BIN (STATS) Method

This example demonstrates how to use the Duration analysis. The data for this example is daily average flow from the Fishkill Creek (Beacon NY) USGS stream gage. The period of record used for this example is from 01 Oct, 1944 to 30 Sep, 1968. To view the data, right-click on the data record labeled "**Fishkill Creek-Daily Flow**" in the study explorer and then select **Plot**. The data will appear as shown in Figure B-90.

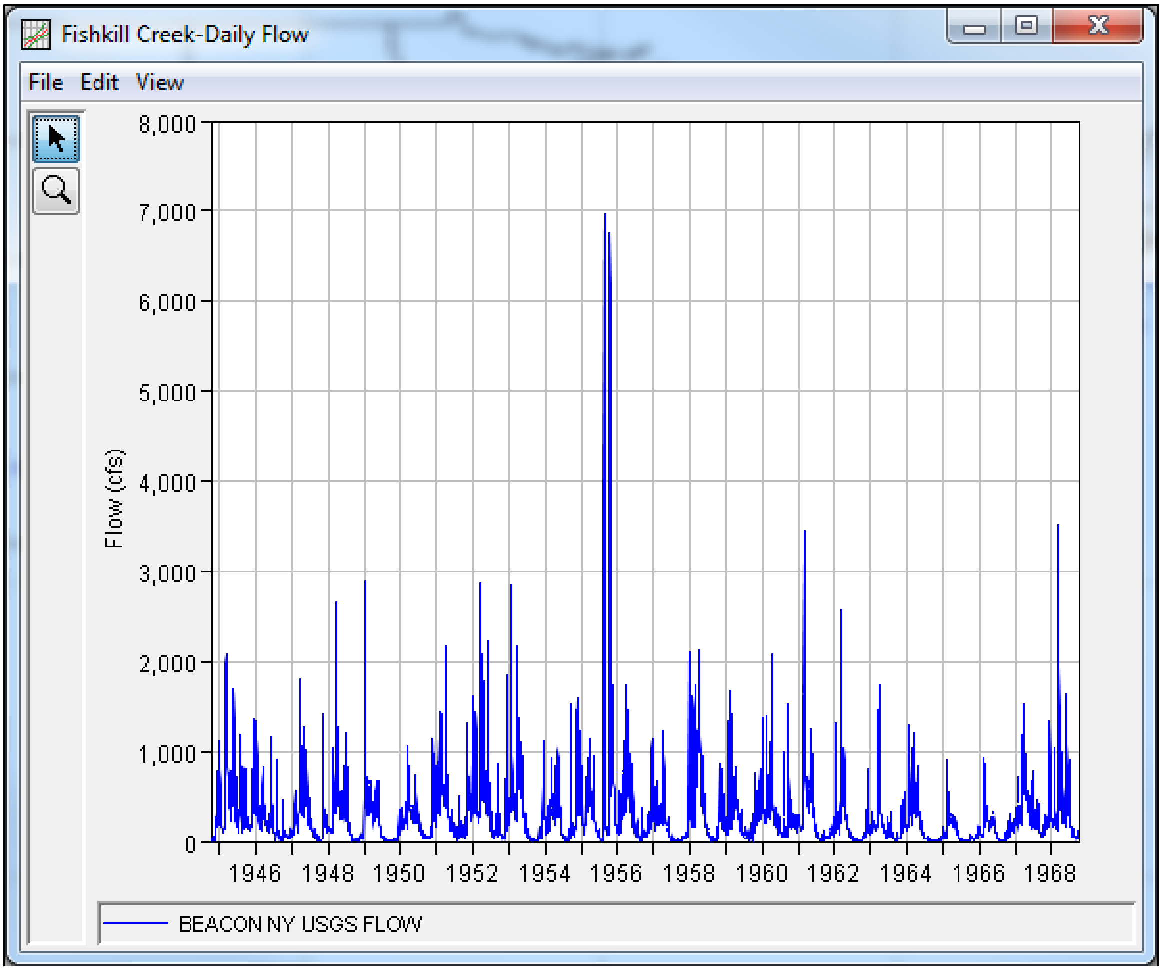


Figure B-90. Plot of the Daily Average Flow for Example 12.

A Duration analysis has been developed for this example. To open the analysis editor for this example, either double-click on the analysis labeled **Fishkill Creek Test 12** from the study explorer, or from the **Analysis** menu select open, then select **Fishkill Creek Test 12** from the list of available analyses. When Test 12 is opened, the duration analysis editor will appear as shown in Figure B-91.

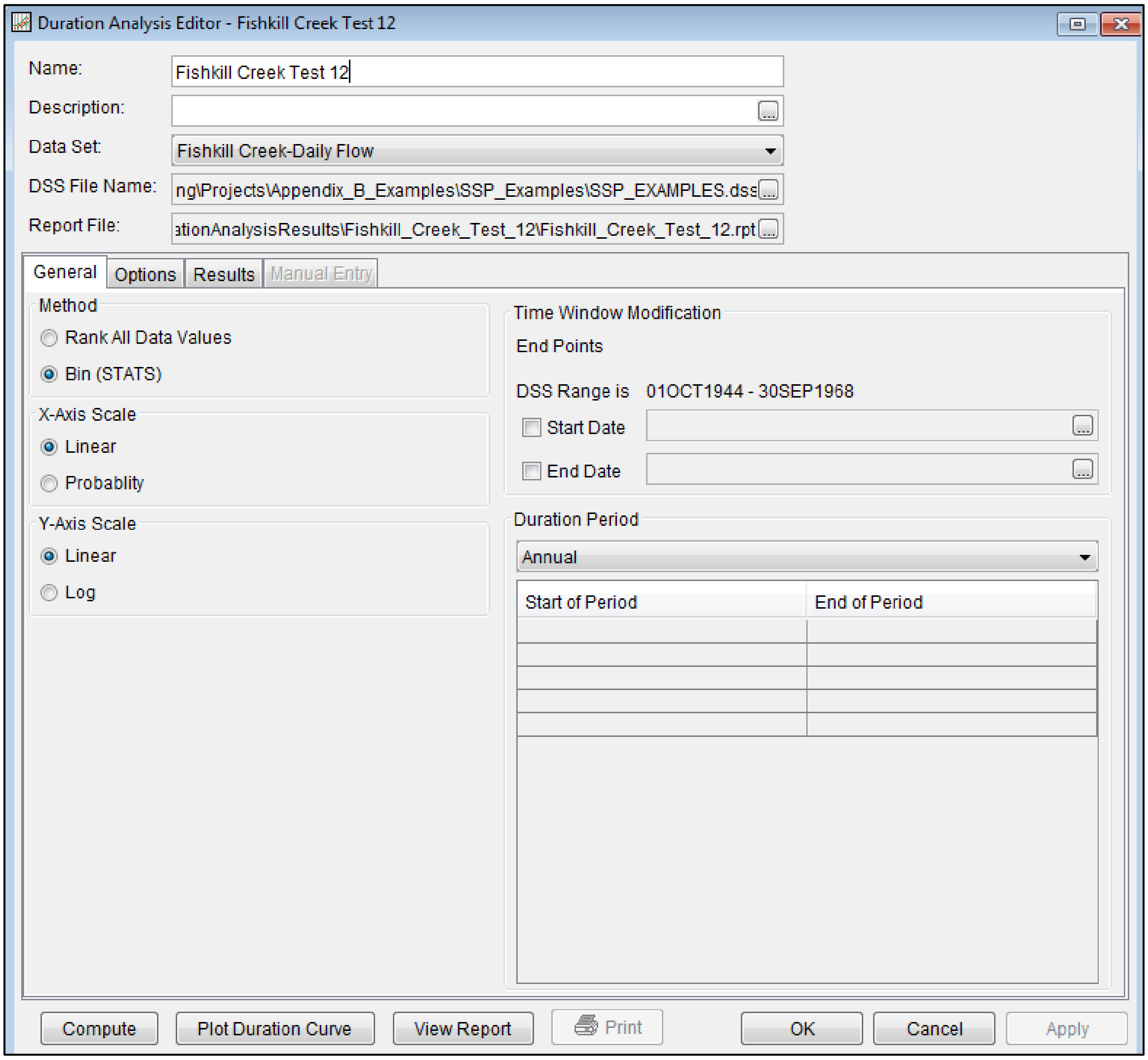


Figure B-91. Duration Analysis Editor for Fishkill Creek Test 12.

Shown in Figure B-91 are the general settings that were used to perform this duration analysis. For this analysis, the **Bin (STATS)** method was selected, the x-axis scale was set to **Linear**, the y-axis scale was set to **Linear**, and the **Annual** duration period was selected.

The **Options Tab** is shown in Figure B-92. Features on this tab include **Output Labeling**, the **Percent of Time Exceeded** ordinates, and **Bin Limits**. The Bin Limits panel is active in this example because the Bin (STATS) method was selected on the General tab. The User-Defined bin limits method was selected and the bin limits were entered manually.

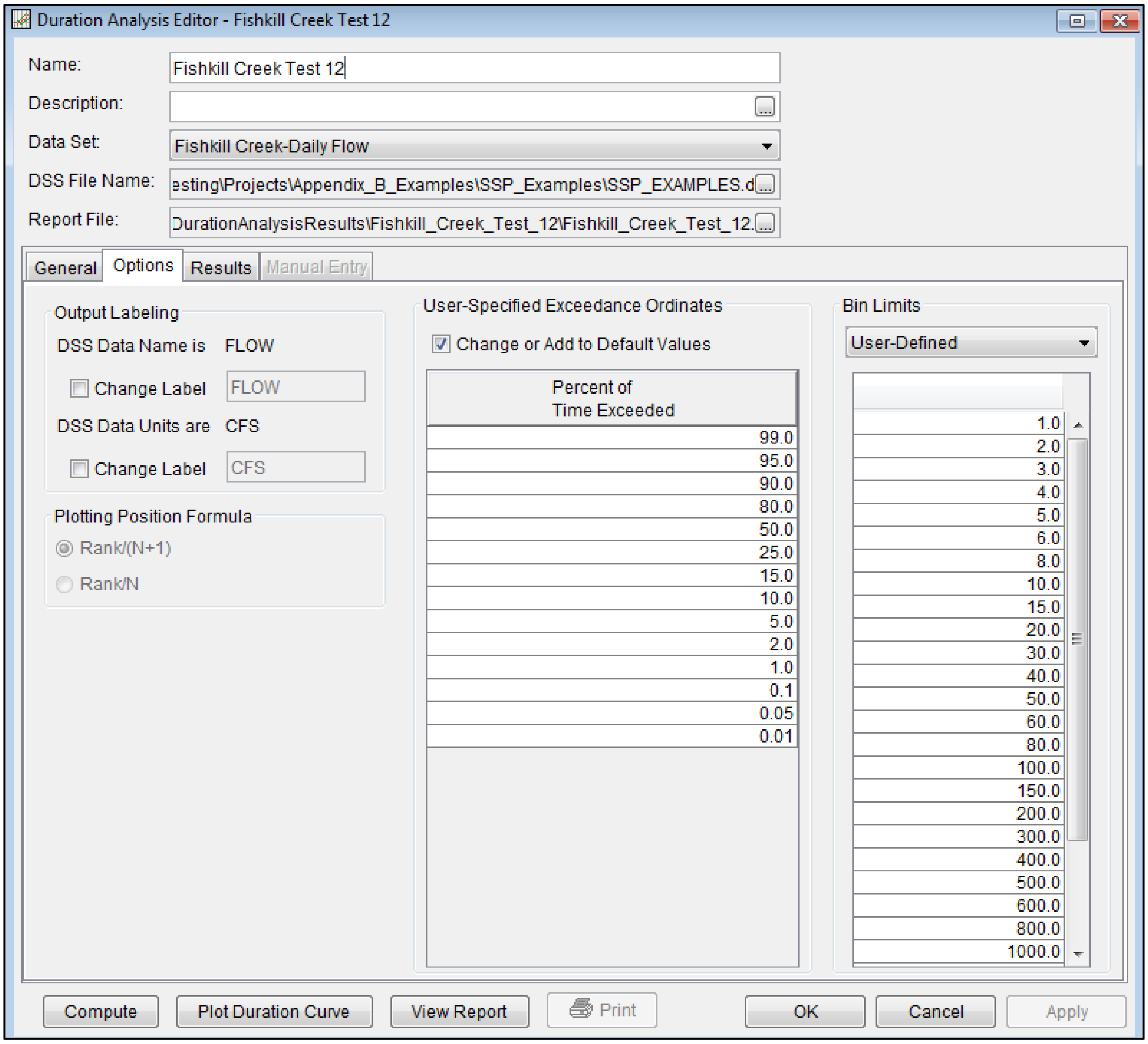
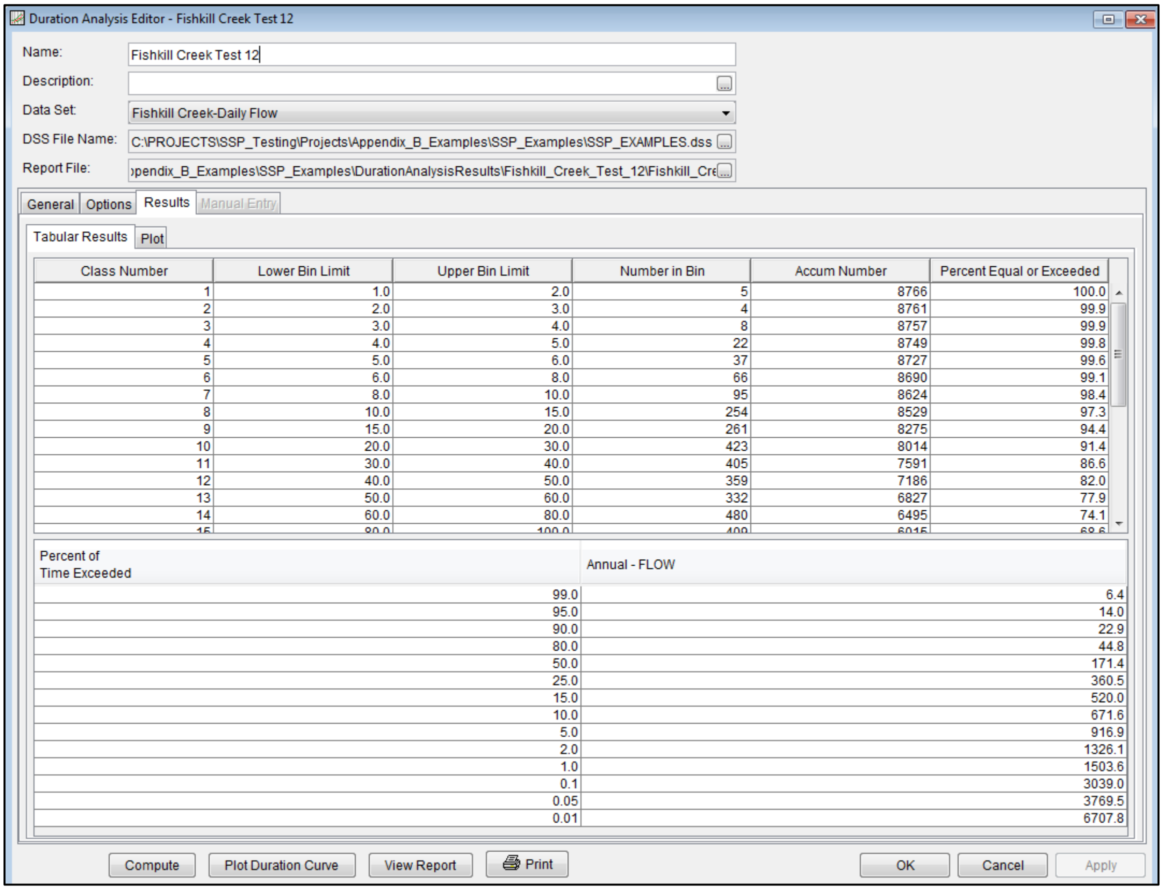


Figure B-92. Duration Analysis Editor with Options Tab Shown for Fishkill Creek Test 12.

Once all of the General and Optional settings are set or selected, the user can choose to compute the analysis by pressing the **Compute** button. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab, shown in Figure B-93.



Class Number	Lower Bin Limit	Upper Bin Limit	Number in Bin	Accum Number	Percent Equal or Exceeded
1	1.0	2.0	5	8766	100.0
2	2.0	3.0	4	8761	99.9
3	3.0	4.0	8	8757	99.9
4	4.0	5.0	22	8749	99.8
5	5.0	6.0	37	8727	99.6
6	6.0	8.0	66	8690	99.1
7	8.0	10.0	95	8624	98.4
8	10.0	15.0	254	8529	97.3
9	15.0	20.0	261	8275	94.4
10	20.0	30.0	423	8014	91.4
11	30.0	40.0	405	7591	86.6
12	40.0	50.0	359	7186	82.0
13	50.0	60.0	332	6827	77.9
14	60.0	80.0	480	6495	74.1

Percent of Time Exceeded	Annual - FLOW
99.0	6.4
95.0	14.0
90.0	22.9
80.0	44.8
50.0	171.4
25.0	360.5
15.0	520.0
10.0	671.6
5.0	916.9
2.0	1326.1
1.0	1503.6
0.1	3039.0
0.05	3769.5
0.01	6707.8

Figure B-93. The Results Tab for Fishkill Creek Test 12.

As shown in Figure B-93, the **Result** tab contains both tabular and graphical results. The **Tabular Results** tab contains a table with information about the bins, like the lower bin limit, the number of values in the bin, the accumulated number of values greater than or equal to the lower bin limit, and the percent of time equaled or exceeded for each bin. Tabular results also include a table of the duration curve interpolated to the percent of time exceeded ordinates defined on the Options tab. The **Plot** tab contains a graph of the duration curve, shown in Figure B-94. The plot includes the computed duration curve and the duration curve interpolated to the user-defined percent of time exceeded ordinates. The duration curve plot can also be opened by pressing the **Plot Duration Curve** button at the bottom of the analysis window.

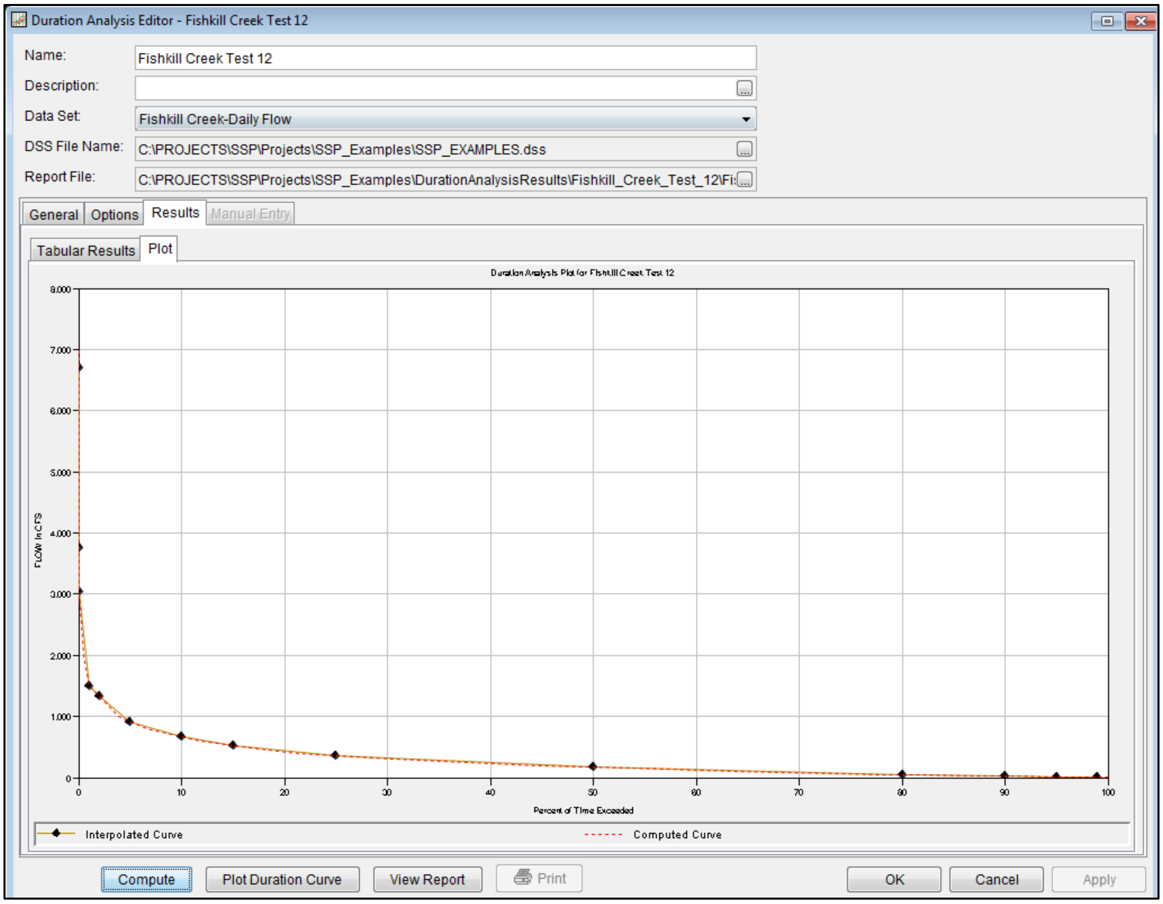


Figure B-94. Plot Tab for Fishkill Creek Test 12.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the input data and results for the analysis. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-95 is the report file for **Fishkill Creek Test 12**.

Fishkill_Creek_Test_12.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\DurationAnalysisResults\Fishkill_Creek_Test_12\Fish

Annual Duration Analysis

Time Period: 01Jan - 31Dec

Number Valid Values: 8766
Number Missing Values: 0

Minimum Value: 1.1
Maximum Value: 6,970.0

Bin Number	Lower Bin Limit	Number in Bin	Accum Number	Percent Equal or Exceeded
1	1.0	5	8766	100.000
2	2.0	4	8761	99.943
3	3.0	8	8757	99.897
4	4.0	22	8749	99.806
5	5.0	37	8727	99.555
6	6.0	66	8690	99.133
7	8.0	95	8624	98.380
8	10.0	254	8529	97.296
9	15.0	261	8275	94.399
10	20.0	423	8014	91.421
11	30.0	405	7591	86.596
12	40.0	359	7186	81.976
13	50.0	332	6827	77.880
14	60.0	480	6495	74.093
15	80.0	409	6015	68.617
16	100.0	888	5606	63.952
17	150.0	783	4718	53.822
18	200.0	1246	3935	44.889
19	300.0	822	2689	30.675
20	400.0	484	1867	21.298
21	500.0	340	1383	15.777
22	600.0	465	1043	11.898
23	800.0	239	578	6.594
24	1,000.0	251	339	3.867
25	1,500.0	47	88	1.004
26	2,000.0	32	41	0.468
27	3,000.0	6	9	0.103
28	4,000.0	0	3	0.034
29	6,000.0	3	3	0.034
30	7,000.0	0	0	0.000

01/12/2016 11:05 AM 1:1..1:1 1:1

Figure B-95. Report File for Fishkill Creek Test 12.

Example 13: Duration Analysis, Rank All Data Method

This example demonstrates how to use the Duration analysis. The data for this example is daily average flow and the period of record is from 01 Apr, 1899 to 28 Jan, 2010. To view the data, right-click on the data record labeled "**Wondering River-Franklin**" in the study explorer and then select **Plot**. The data will appear as shown in Figure B-96.

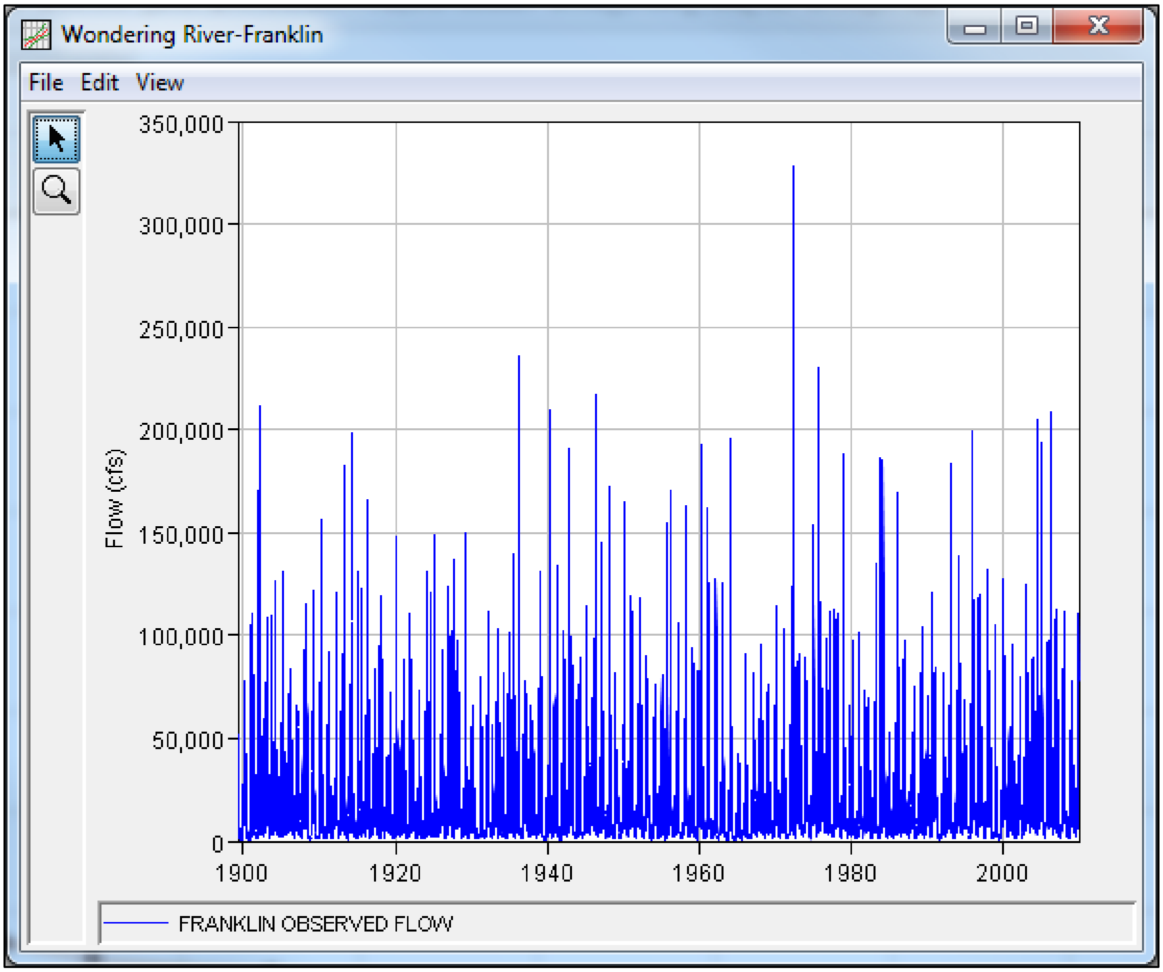


Figure B-96. Plot of the Daily Average Flow for Example 13.

A Duration analysis has been developed for this example. To open the analysis editor for this example, either double-click on the analysis labeled **Duration Curve Test 13** from the study explorer, or from the **Analysis** menu select open, then select **Duration Curve Test 13** from the list of available analyses. When **Duration Curve Test 13** is opened, the duration analysis editor will appear as shown in Figure B-97.

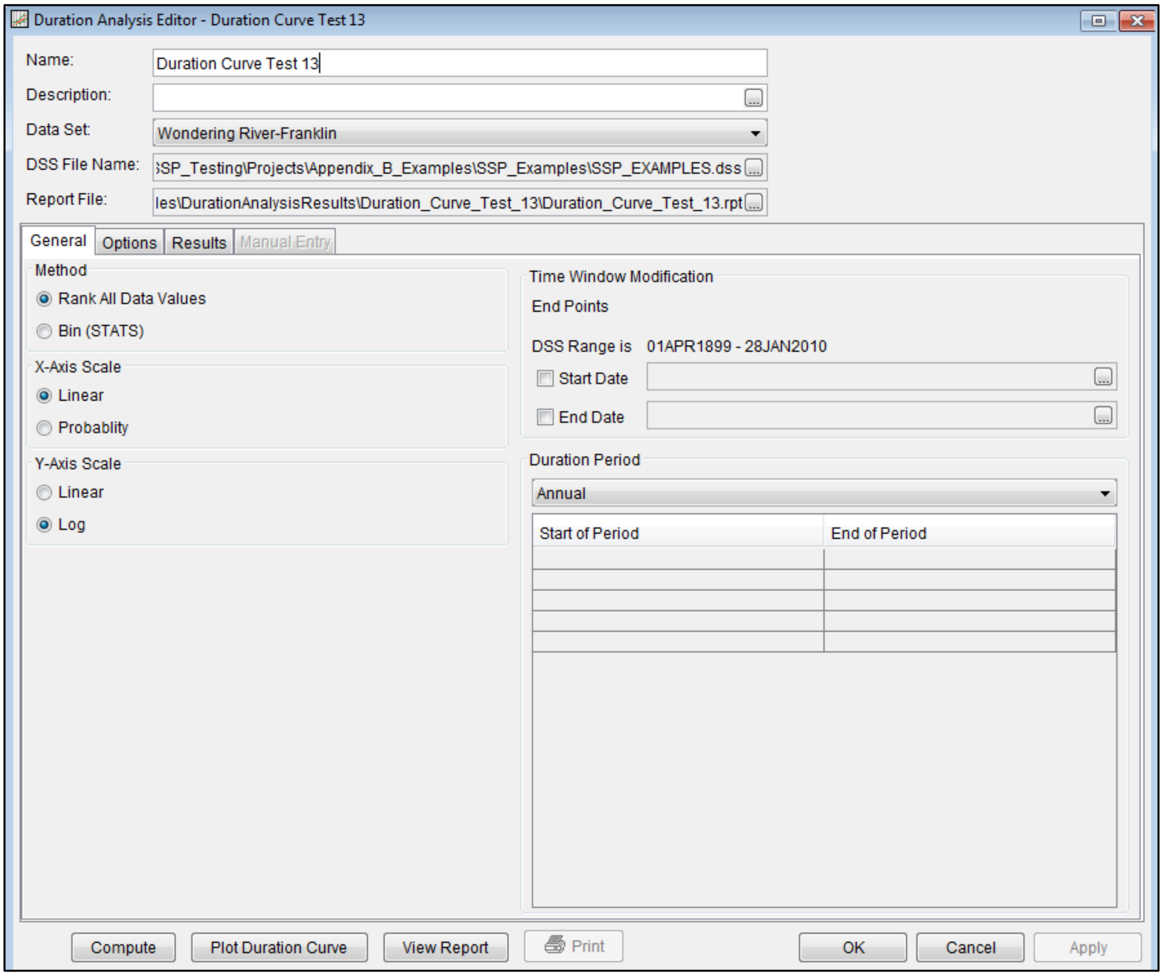


Figure B-97. Duration Analysis Editor for Duration Curve Test 13.

Shown in Figure B-97 are the general settings that were used to perform this duration analysis. For this analysis, the **Rank All DataValues** method was selected, x-axis scale was set to **Linear**, the y-axis scale was set to **Log**, and the **Annual** duration period was selected.

The **Options Tab** is shown in Figure B-98. Features on this tab include **Output Labeling**, the **Percent of Time Exceeded** ordinates, and **Bin Limits**. The Bin Limits panel is not active in this example because the Bin (STATS) method was not selected on the General tab.

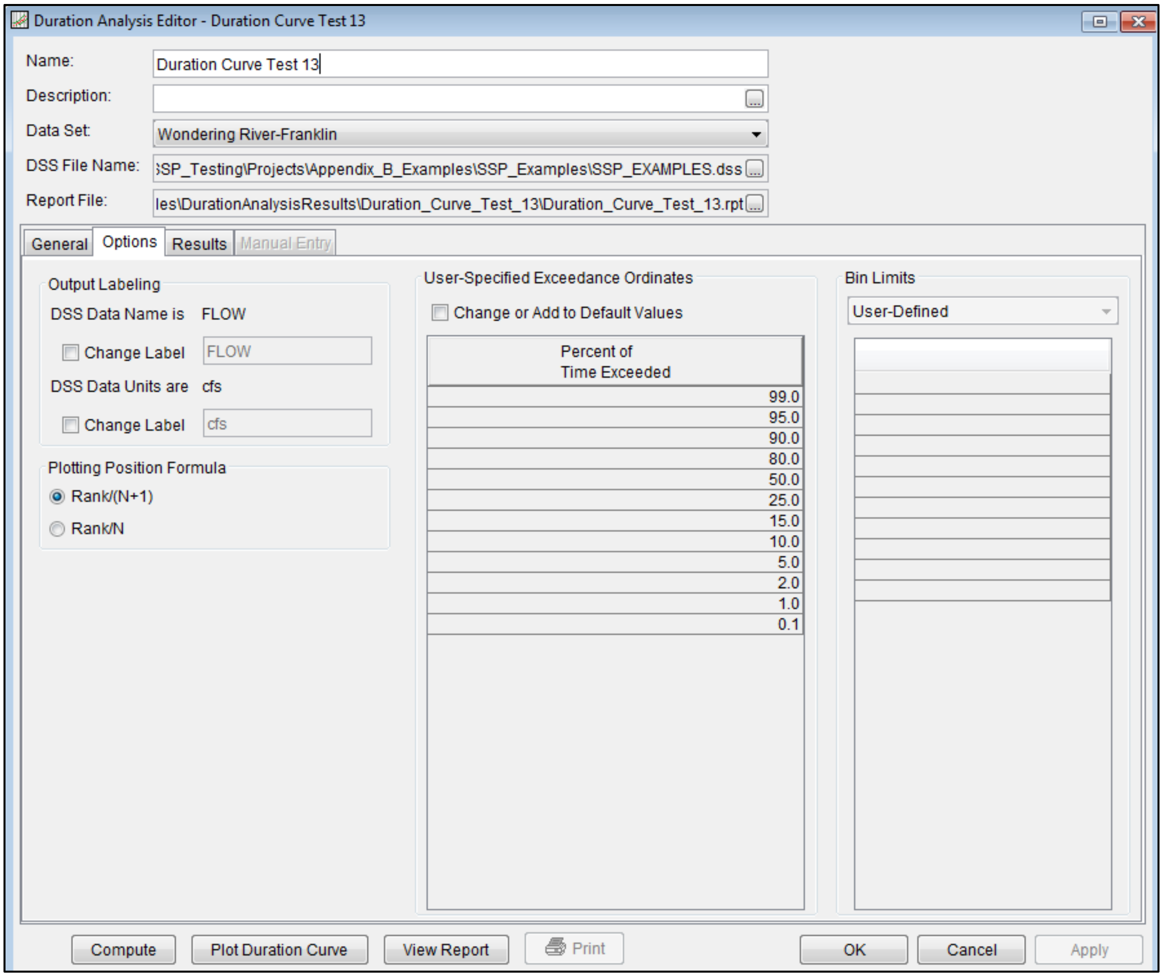


Figure B-98. Duration Analysis Editor with Options Tab Shown for Duration Curve Test 13.

Once all of the General and Optional settings are set or selected, the user can choose to compute the analysis by pressing the **Compute** button. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab, shown in Figure B-99.

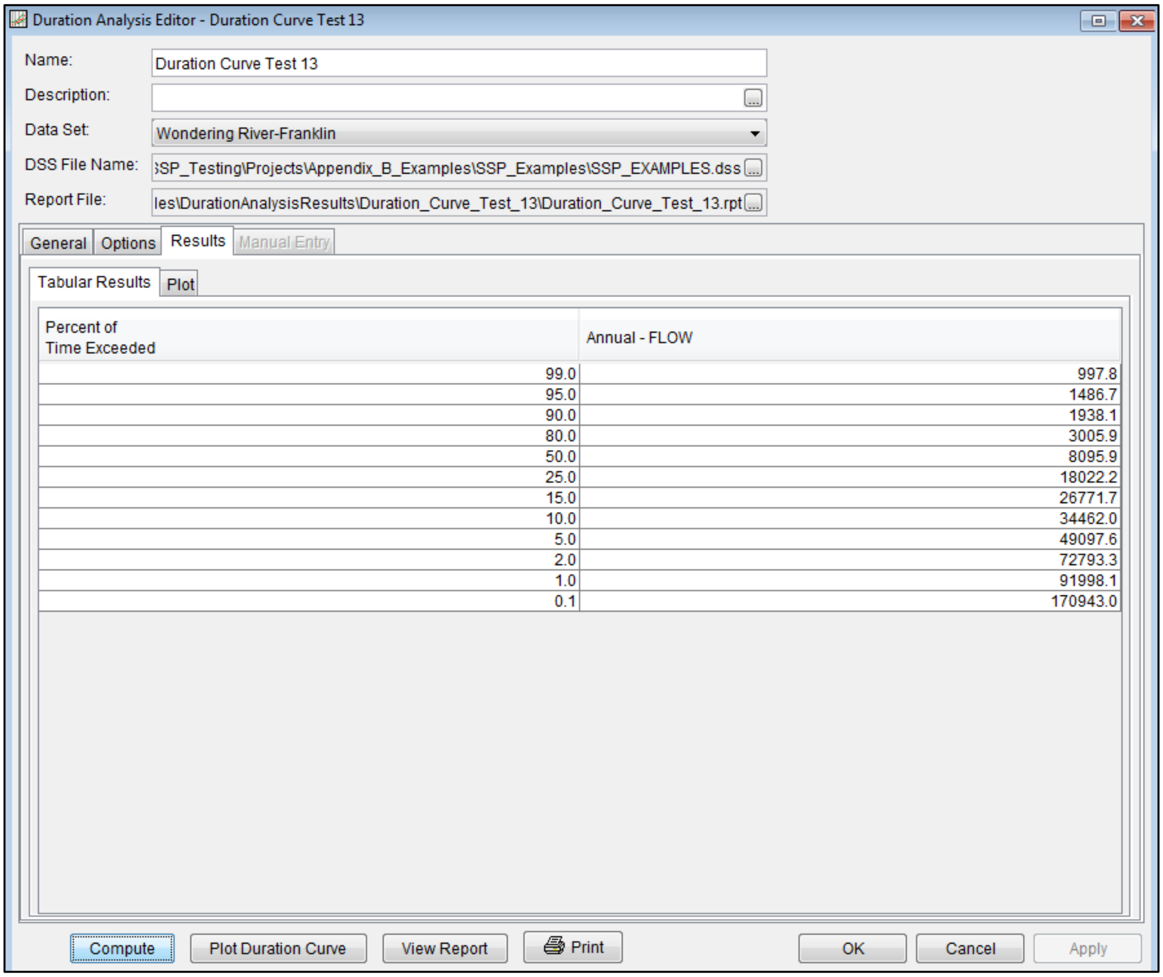


Figure B-99. The Results Tab for Duration Curve Test 13.

As shown in Figure B-99, the **Result** tab contains both tabular and graphical results. The **Tabular Results** tab contains a table of the duration curve interpolated to the percent of time exceeded ordinates defined on the Options tab. The **Plot** tab contains a graph of the duration curve. The plot includes the computed duration curve and the duration curve interpolated to the user-defined percent of time exceeded ordinates. The duration curve plot can also be opened by pressing the **Plot Duration Curve** button at the bottom of the analysis window, shown in Figure B-100.

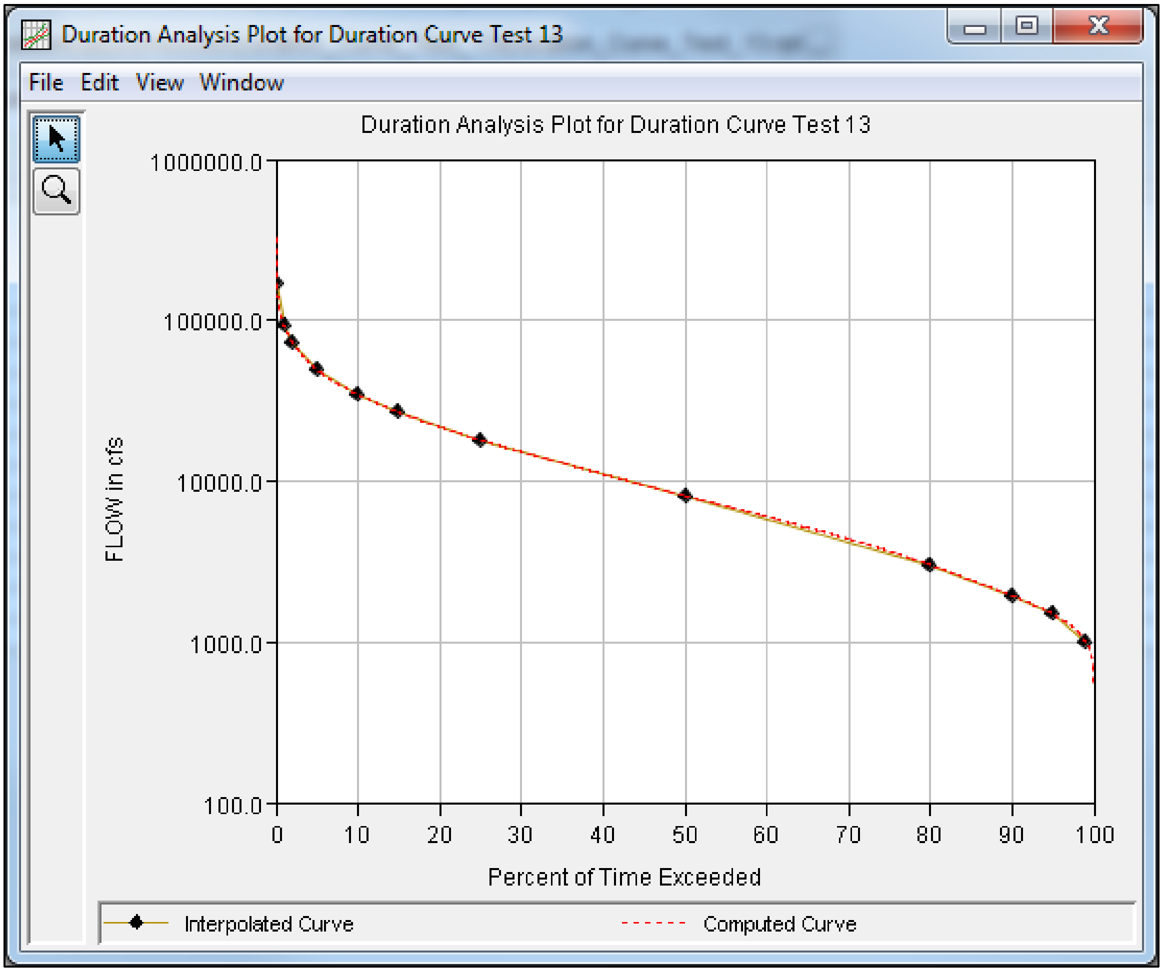
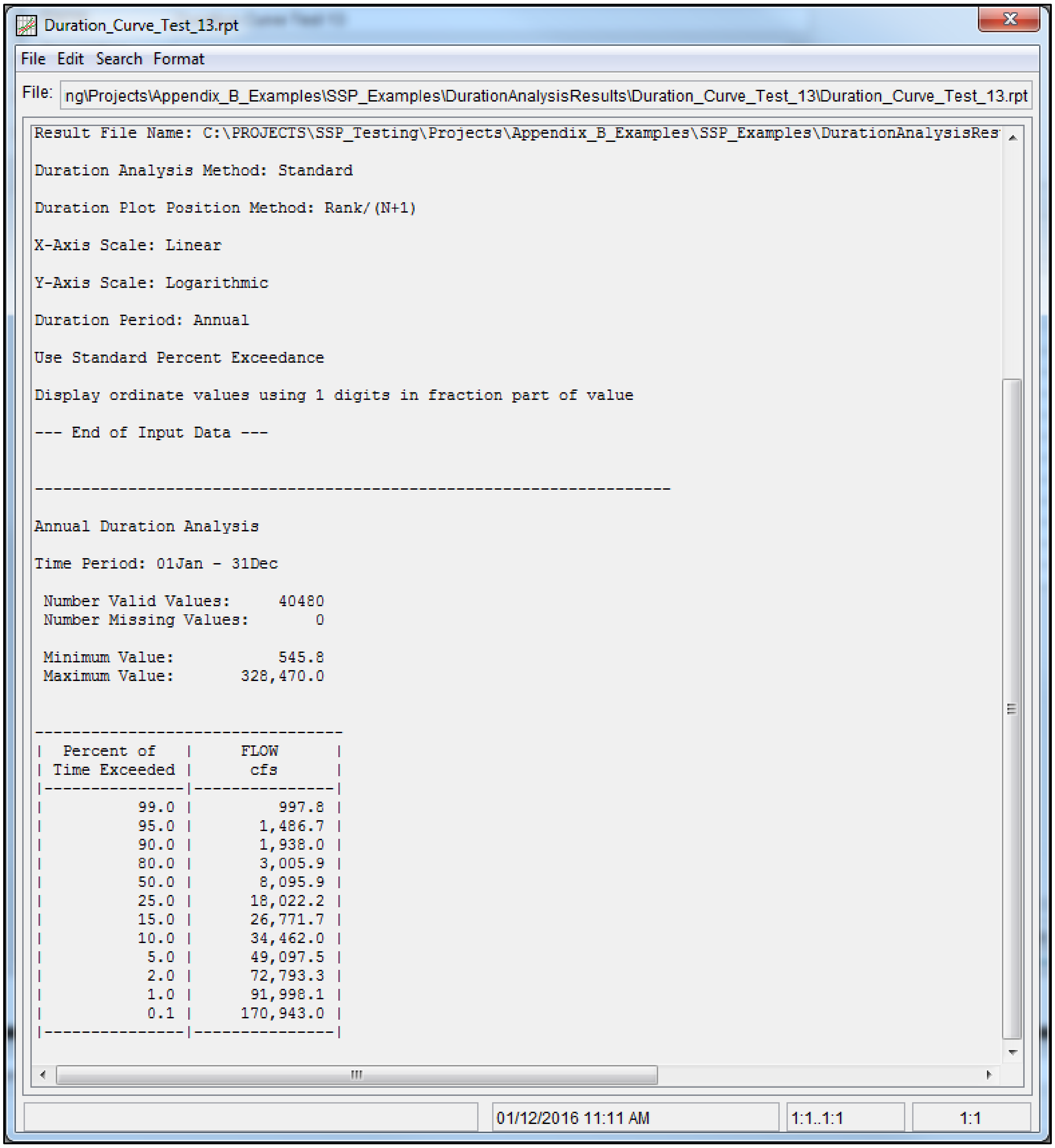


Figure B-100. Plot Tab for Duration Curve Test 13.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot and then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows the input data and results for the analysis. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-101 is the report file for **Duration Curve Test 13**.


Duration_Curve_Test_13.rpt

File Edit Search Format

File: ng\Projects\Appendix_B_Examples\SSP_Examples\DurationAnalysisResults\Duration_Curve_Test_13\Duration_Curve_Test_13.rpt

```
Result File Name: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\DurationAnalysisRes

Duration Analysis Method: Standard

Duration Plot Position Method: Rank/(N+1)

X-Axis Scale: Linear

Y-Axis Scale: Logarithmic

Duration Period: Annual

Use Standard Percent Exceedance

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--------------------------------------------------------------------

Annual Duration Analysis

Time Period: 01Jan - 31Dec

 Number Valid Values:     40480
 Number Missing Values:       0

 Minimum Value:           545.8
 Maximum Value:       328,470.0


---------------------------------
|  Percent of   |      FLOW      |
| Time Exceeded |       cfs      |
|---------------|----------------|
|          99.0 |          997.8 |
|          95.0 |        1,486.7 |
|          90.0 |        1,938.0 |
|          80.0 |        3,005.9 |
|          50.0 |        8,095.9 |
|          25.0 |       18,022.2 |
|          15.0 |       26,771.7 |
|          10.0 |       34,462.0 |
|           5.0 |       49,097.5 |
|           2.0 |       72,793.3 |
|           1.0 |       91,998.1 |
|           0.1 |      170,943.0 |
|---------------|----------------|
```

01/12/2016 11:11 AM | 1:1..1:1 | 1:1

Figure B-101. Report File for Duration Curve Test 13.

Example 14: Duration Analysis, Manual Entry

This example demonstrates how to use the Duration analysis and enter the duration curve manually. To open the analysis editor for this example, either double-click on the analysis labeled **Manual Duration Curve Test 14** from the study explorer, or from the **Analysis** menu select open, then select **Manual Duration Curve Test 14** from the list of available analyses. As shown in Figure B-102, the "None" data set was selected for this analysis. The **Manual Entry** tab becomes active when the "None" data set is selected (the **Result** tab will become inactive).

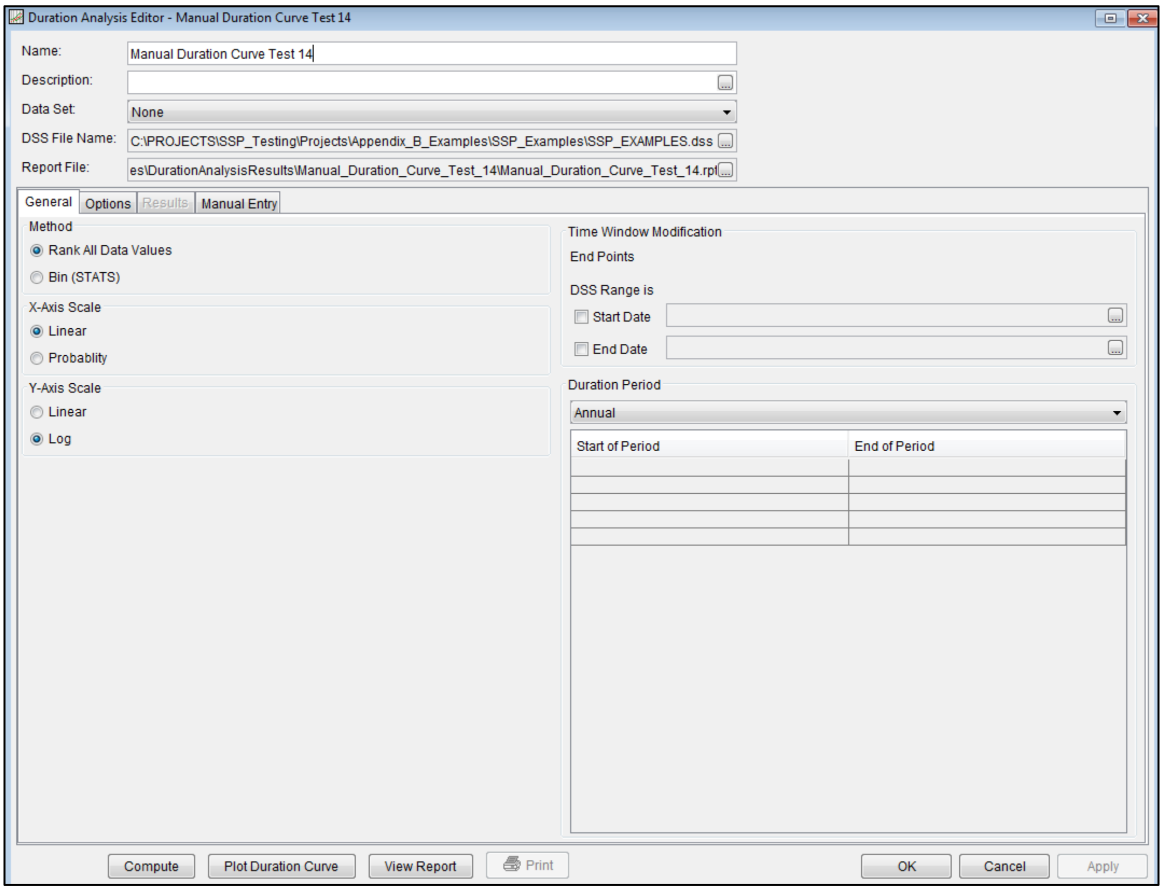


Figure B-102. Duration Analysis Editor for Manual Duration Curve Test 14.

The y-axis scale was set to **Log** while all other default options were selected on the General and Options tabs. Figure B-103 shows the **Manual Entry** tab for **Manual Duration Curve Test 14**. A variable name of "FLOW" and units of "cfs" were entered as well as the duration curve. The program will plot the duration curve when the **Compute** button is pressed.

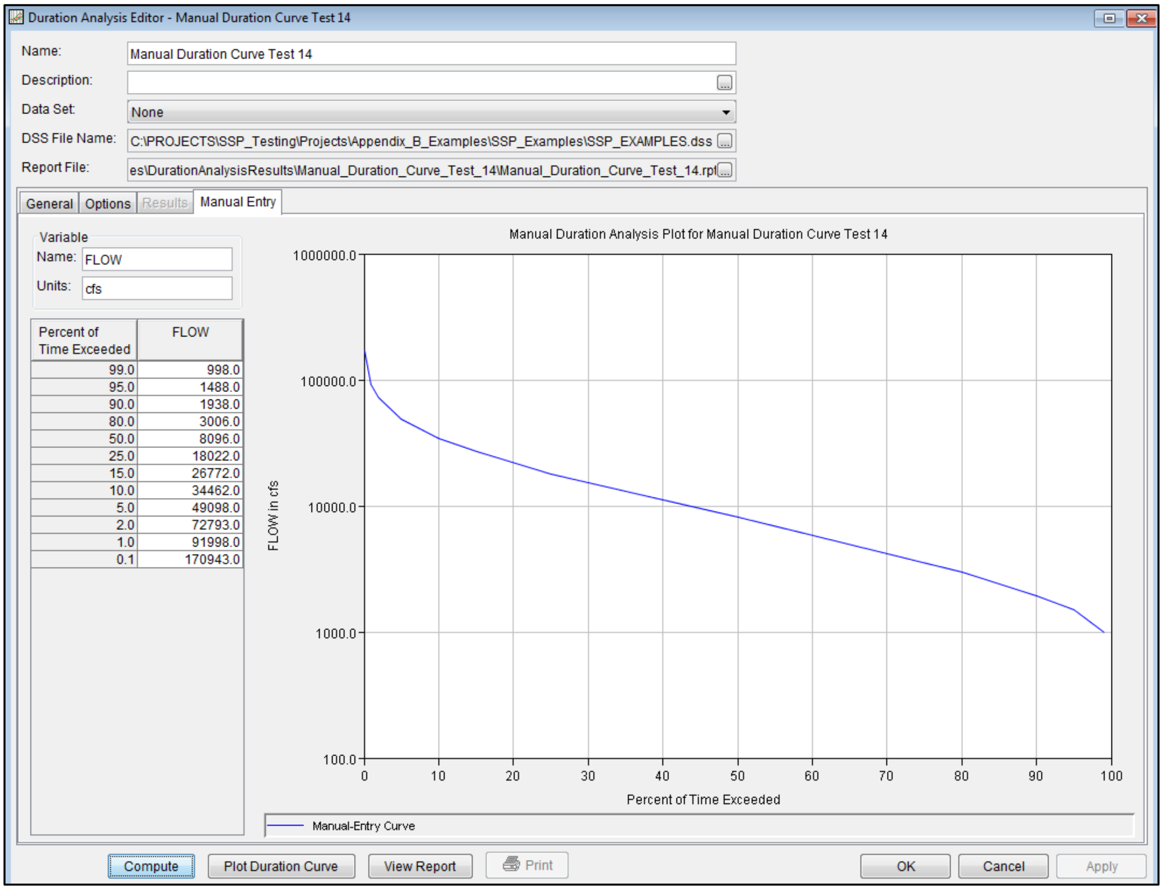


Figure B-103. Duration Analysis Editor with Options Tab Shown for Manual Duration Curve Test 14.

The duration curve plot can also be opened by pressing the **Plot Duration Curve** button at the bottom of the analysis window, shown in Figure B-104.

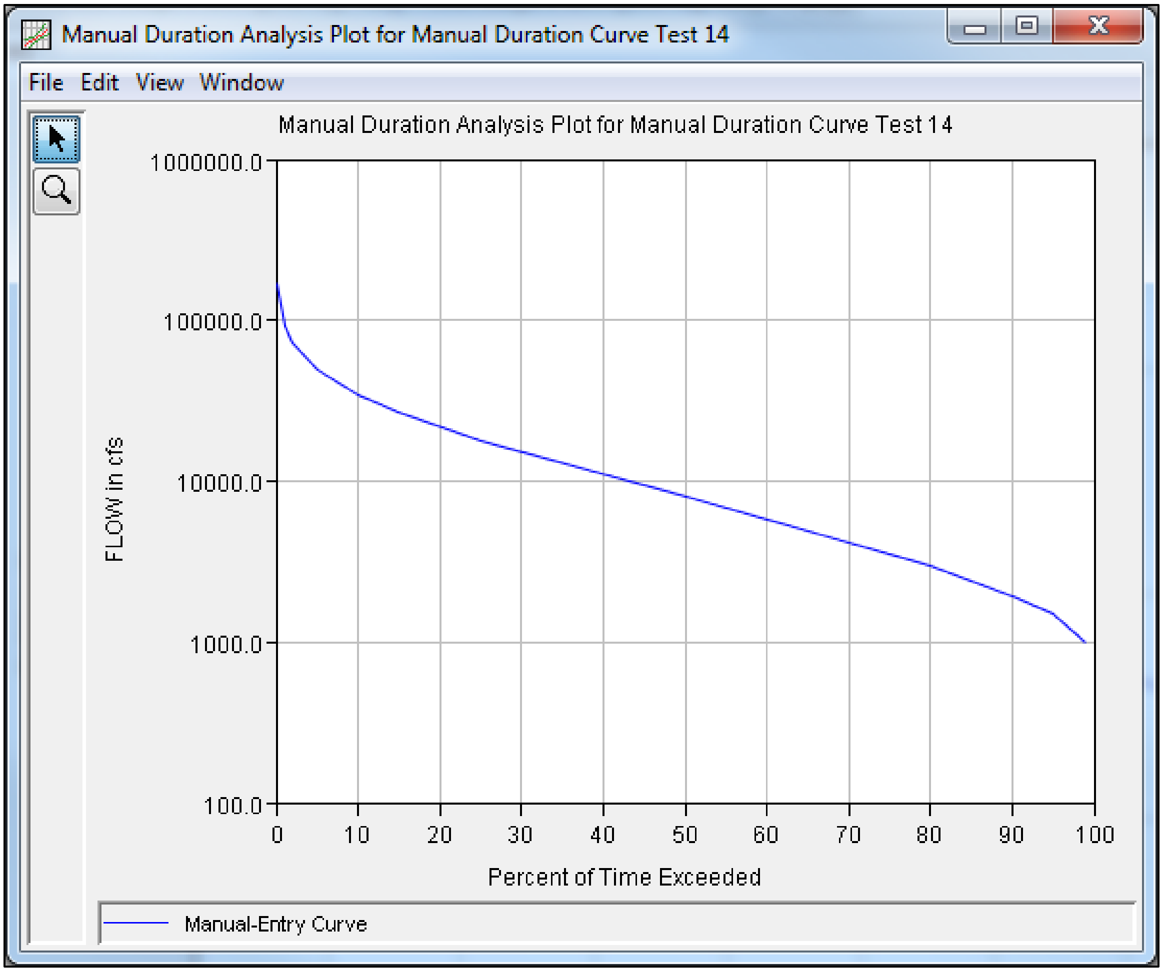


Figure B-104. Plot Tab for Manual Duration Curve Test 14.

Example 15: Coincident Frequency Analysis, A and B can be Assumed Independent

This example demonstrates how to create a coincident frequency analysis. Figure B-105 illustrates the scenario for **Coincident Freq Test 15**. The goal of this example is to develop a stage-frequency curve at a point along the tributary (variable C) given flows on the tributary (variable A) and flows in the mainstem (variable B). Large flows on the mainstem do cause backwater along the tributary and thus affect the stage at the point of interest. The data for this example comes from an existing flow frequency curve for Variable A and an existing flow duration curve for Variable B. An HEC-RAS model was used to simulate the response of Variable C (stage at the point of interest) for multiple combinations of flow on the tributary and flow in the mainstem.

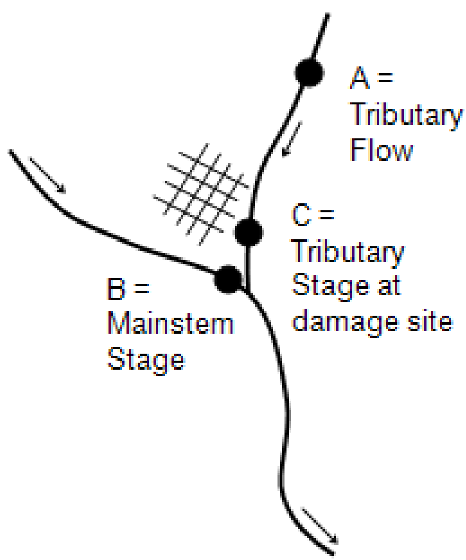


Figure B-105. Scenario for **Coincident Freq Test 15**.

A Coincident Frequency analysis has been developed for this example. To open the Coincident Frequency Analysis editor for this example, either double-click on the analysis labeled **Coincident Freq Test 15** from the study explorer, or from the **Analysis** menu select open, then select **Coincident Freq Test 15** from the list of available analyses. When **Coincident Freq Test 15** is opened, the Coincident Frequency Analysis editor will appear as shown in Figure B-106.

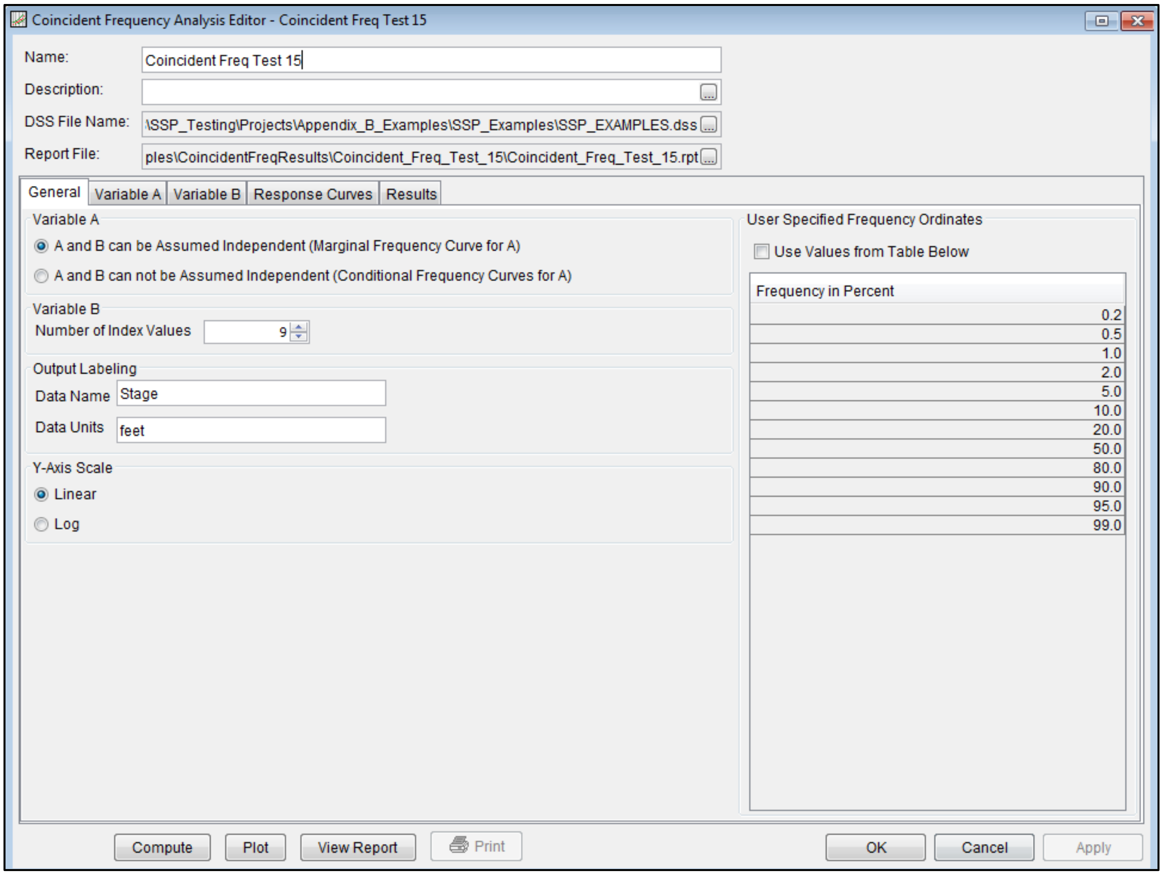


Figure B-106. General Tab Shown for Coincident Freq Test 15.

Shown in Figure B-106 are the general settings for this coincident frequency analysis. For this analysis, the **A and B can be Assumed Independent (Marginal Frequency Curve for A)** option was selected. This would be determined by performing a correlation analysis between variables A and B; little correlation would indicate that variables A and B could be assumed independent. The number of variable B index values was set to 9, the **Data Name** was set to “Stage” and the **Data Units** to “feet”, and the y-axis scale was set to **Linear**.

Shown in Figure B-107 is the Coincident Frequency Analysis editor with the **Variable A Tab** selected. The **Manual Entry** option was selected and a **Data Name** of “Flow” and **Data Units** of “cfs” were entered. The frequency curve values were manually entered into the **Variable A Frequency Curve** table.

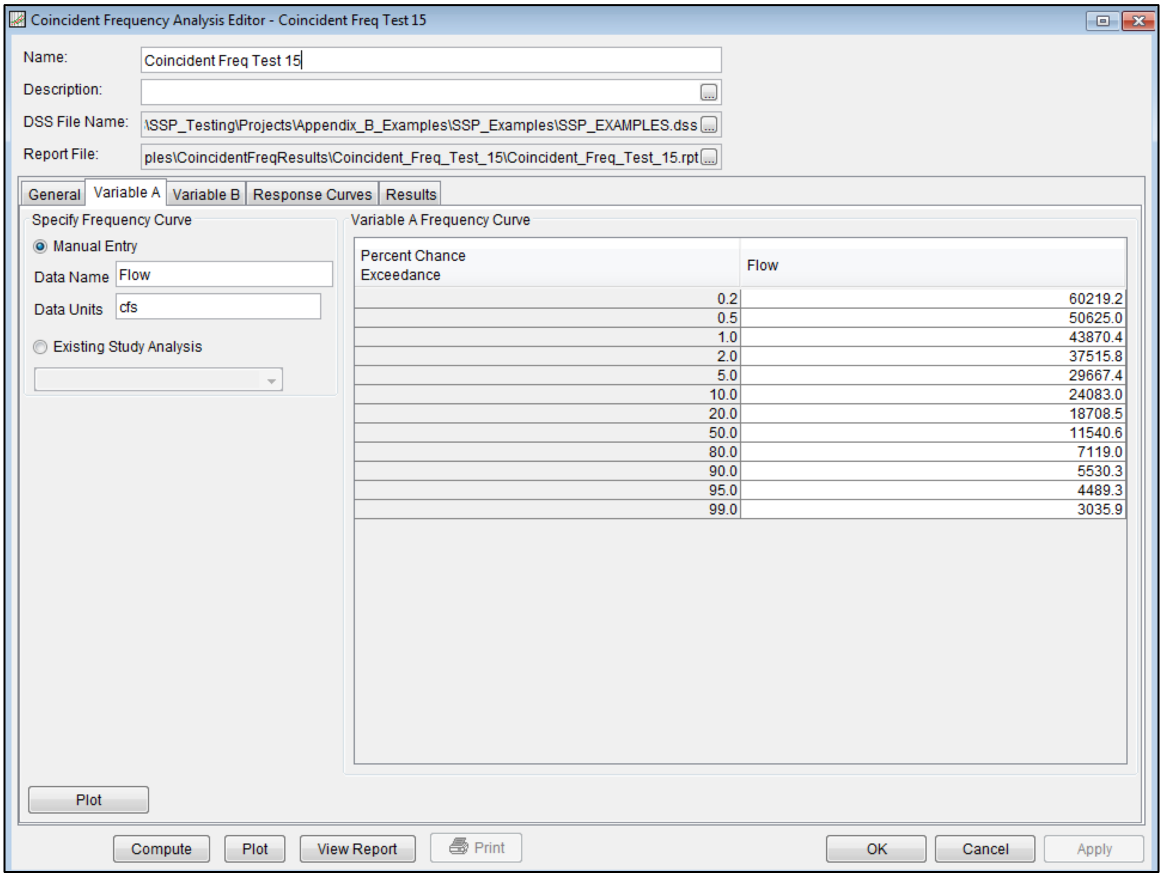


Figure B-107. Variable A Tab for Coincident Freq Test 15.

Shown in Figure B-108 is the Coincident Frequency Analysis editor with the **Variable B** tab selected. The Duration Curve from Test 13 was selected in the drop-down list. Once selected, the duration curve table automatically fills with the computed ordinates from the duration curve. In the **Develop Probabilities from Duration Curve** panel, the **Define Automatically** option was selected. This option uses a predefined probability pattern to discretize the duration curve into index points. The **Generate Table** button was pressed in order activate the predefined probability pattern. In this example, the first index value is 3005.92 (cfs). This value is taken at the midpoint between percent of time exceeded values at 100 and 60 percent (from Duration Curve Test 13). This index value is assigned a probability of 40 percent; this flow value could be expected 40 percent of the time. The second index value is 8095.9. This value is taken at the midpoint between percent of time exceeded values at 60 and 40 percent and is assigned a probability of 20 percent.

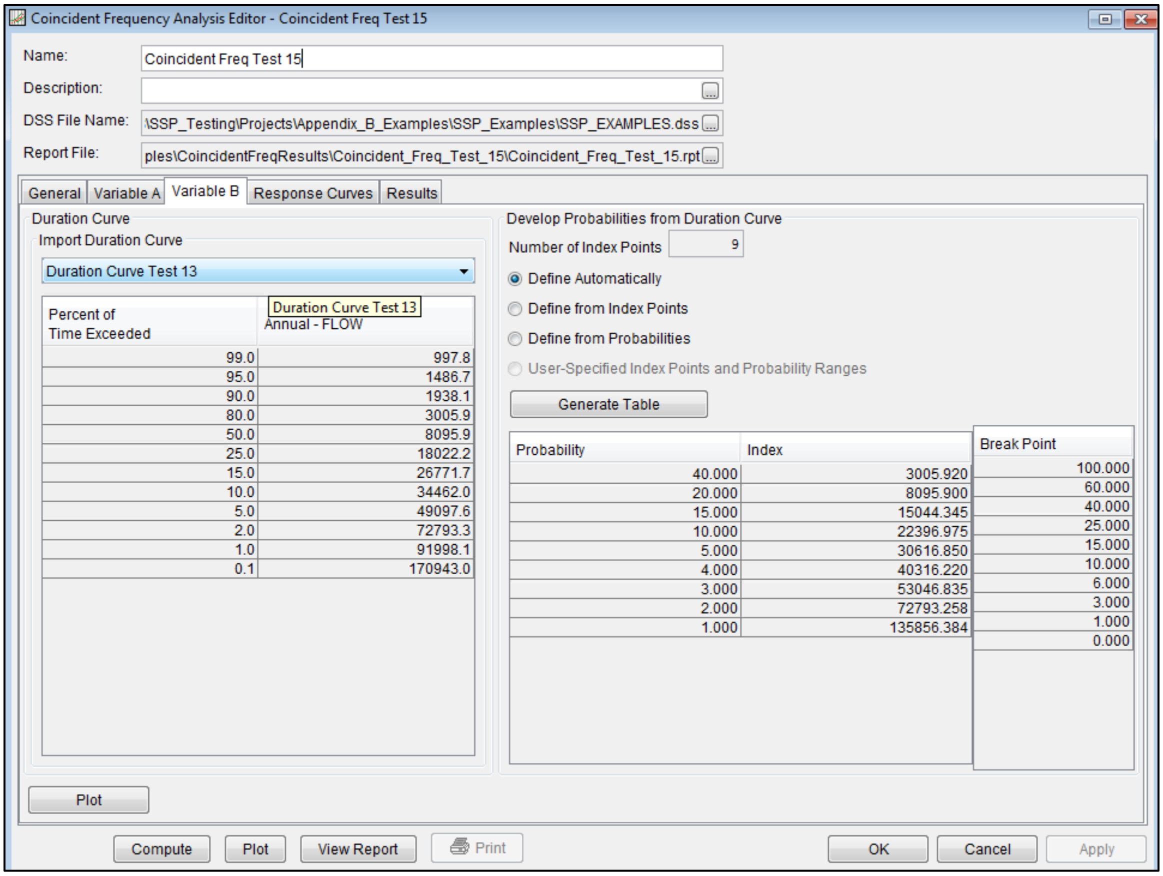
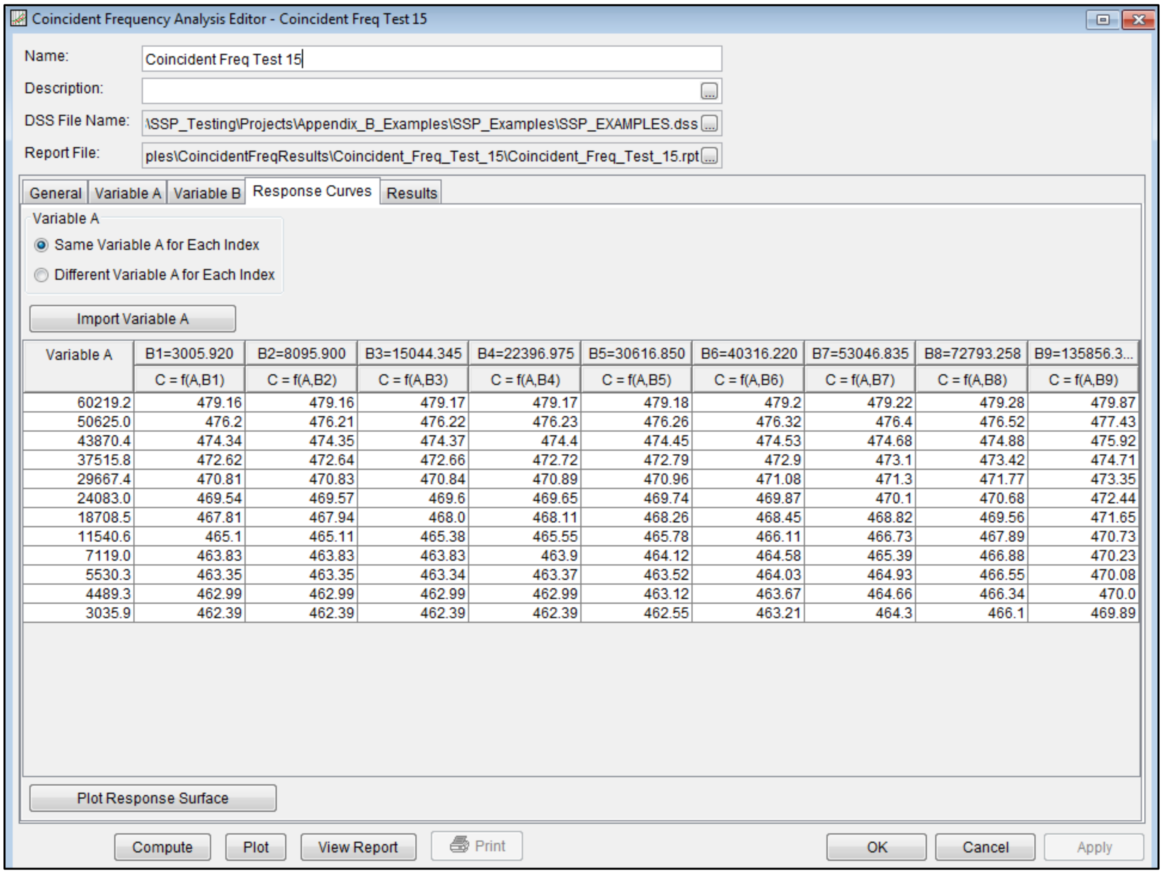


Figure B-108. Variable B Tab for Coincident Freq Test 15.

Once the Variable A and Variable B tabs have been completed, the user can populate the response curves table. Figure B-109 shows the Response Curves tab for **Coincident Freq Test 15**. The **Same Variable A for Each Index** option was selected and the **Import Variable A** button was pressed to automatically copy values from the Variable A tab and fill in the **Variable A** column. The remaining columns in the table were populated with results from a hydraulics model. For example, the first value in the second column is 479.16. This value is the stage at the point of interest given a flow of 60219.18 (cfs) on the tributary (variable A) and a flow of 3005.92 (cfs) on the mainstem (variable B). A total of 108 simulations were required from the hydraulics model to fill in the response curves table. Figure B-110 shows a plot of the response surface. The plot shows variable A (x-axis) and variable C (y-axis). For this example, the response surface shows that flows greater than 53000 (7th index point) on the mainstem affect the stage at the point of interest on the tributary. When the flow in the mainstem is below 53000 (cfs), only the flow on the tributary affects the stage at the point of interest.



Variable A	B1=3005.920	B2=8095.900	B3=15044.345	B4=22396.975	B5=30616.850	B6=40316.220	B7=53046.835	B8=72793.258	B9=135856.3...
	C = f(A,B1)	C = f(A,B2)	C = f(A,B3)	C = f(A,B4)	C = f(A,B5)	C = f(A,B6)	C = f(A,B7)	C = f(A,B8)	C = f(A,B9)
60219.2	479.16	479.16	479.17	479.17	479.18	479.2	479.22	479.28	479.87
50625.0	476.2	476.21	476.22	476.23	476.26	476.32	476.4	476.52	477.43
43870.4	474.34	474.35	474.37	474.4	474.45	474.53	474.68	474.88	475.92
37515.8	472.62	472.64	472.66	472.72	472.79	472.9	473.1	473.42	474.71
29667.4	470.81	470.83	470.84	470.89	470.96	471.08	471.3	471.77	473.35
24083.0	469.54	469.57	469.6	469.65	469.74	469.87	470.1	470.68	472.44
18708.5	467.81	467.94	468.0	468.11	468.26	468.45	468.82	469.56	471.65
11540.6	465.1	465.11	465.38	465.55	465.78	466.11	466.73	467.89	470.73
7119.0	463.83	463.83	463.83	463.9	464.12	464.58	465.39	466.88	470.23
5530.3	463.35	463.35	463.34	463.37	463.52	464.03	464.93	466.55	470.08
4489.3	462.99	462.99	462.99	462.99	463.12	463.67	464.66	466.34	470.0
3035.9	462.39	462.39	462.39	462.39	462.55	463.21	464.3	466.1	469.89

Figure B-109. Response Curves Tab for Coincident Freq Test 15.

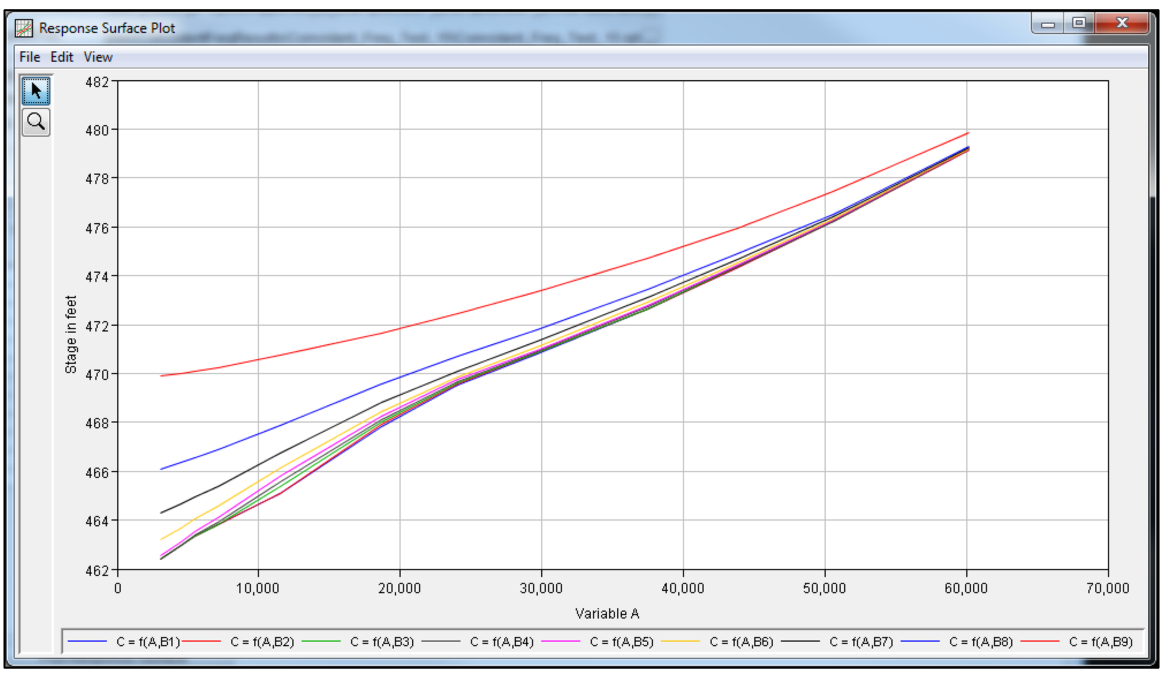


Figure B-110. Response Curves Plot for Coincident Freq Test 15.

Press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab. The results tab should look Figure B-111. The left portion of the results tab contains the computed variable C frequency curve and the right portion of the results tab contains a plot of the computed variable C frequency curve.

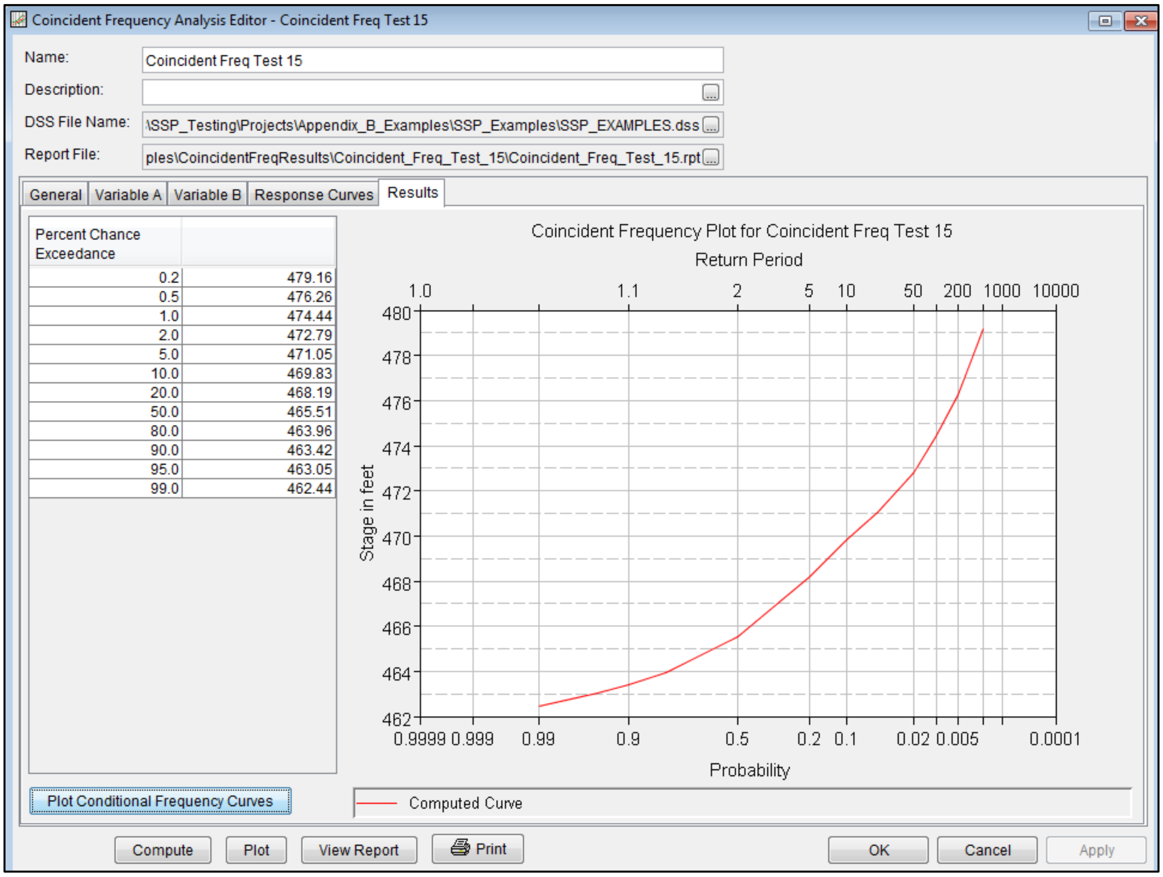
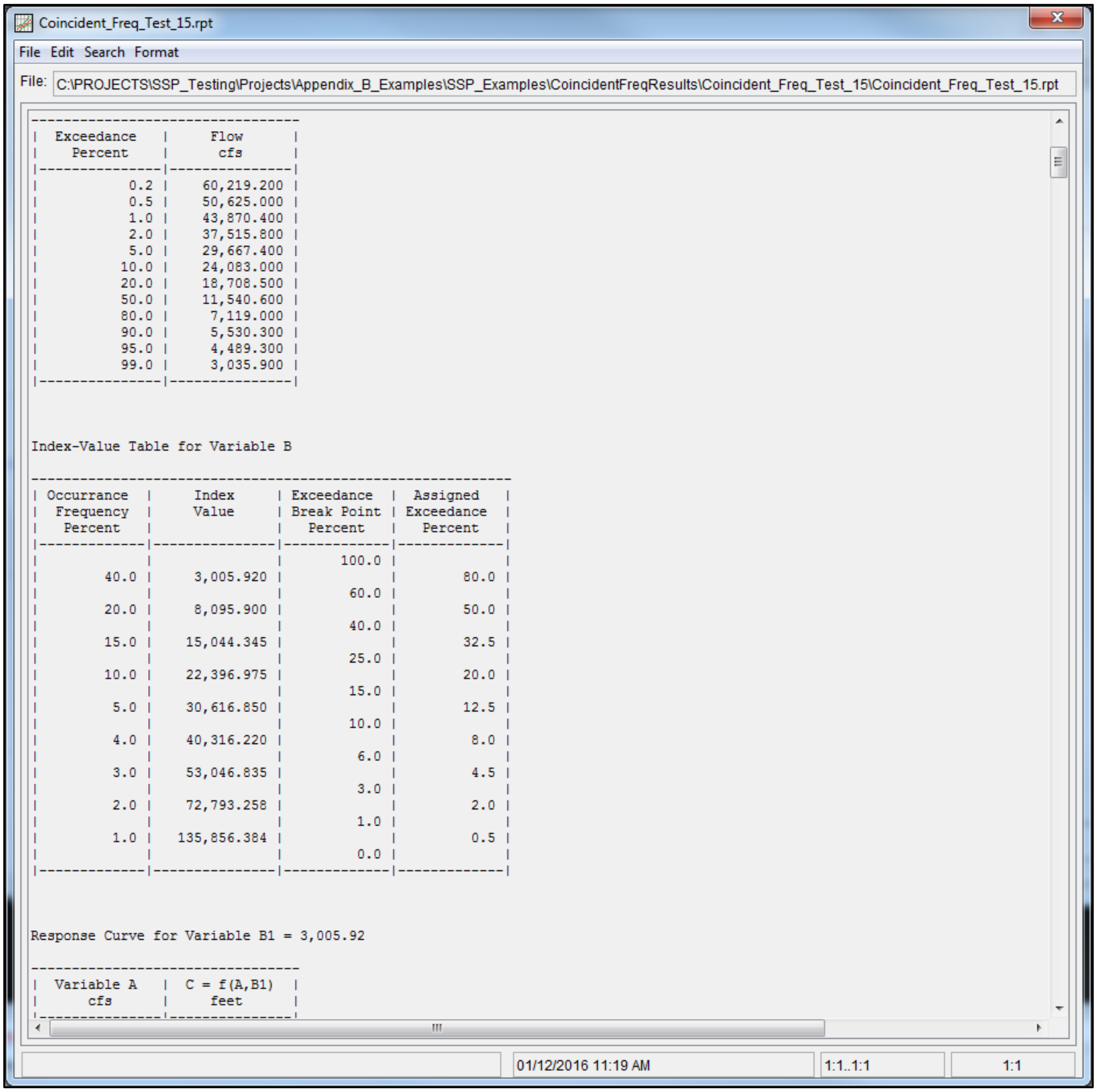


Figure B-111. Results Tab for Coincident Freq Test 15.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot by pressing the **Plot** button from the bottom of the analysis. Then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows input data and results. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-112 is the report file for **Coincident Freq Test 15**.



Exceedance Percent	Flow cfs
0.2	60,219.200
0.5	50,625.000
1.0	43,870.400
2.0	37,515.800
5.0	29,667.400
10.0	24,083.000
20.0	18,708.500
50.0	11,540.600
80.0	7,119.000
90.0	5,530.300
95.0	4,489.300
99.0	3,035.900

Index-Value Table for Variable B

Occurrance Frequency Percent	Index Value	Exceedance Break Point Percent	Assigned Exceedance Percent
		100.0	
40.0	3,005.920		80.0
		60.0	
20.0	8,095.900		50.0
		40.0	
15.0	15,044.345		32.5
		25.0	
10.0	22,396.975		20.0
		15.0	
5.0	30,616.850		12.5
		10.0	
4.0	40,316.220		8.0
		6.0	
3.0	53,046.835		4.5
		3.0	
2.0	72,793.258		2.0
		1.0	
1.0	135,856.384		0.5
		0.0	

Response Curve for Variable B1 = 3,005.92

Variable A cfs	C = f(A,B1) feet

Figure B-112. Report File for Coincident Freq Test 15.

Example 16: Coincident Frequency Analysis, A and B can not be Assumed Independent

This example demonstrates how to create a coincident frequency analysis when variables A and B are not independent. Figure B-113 illustrates the scenario for **Coincident Freq Test 16**. The goal of this example is to develop a stage-frequency curve at a point along the tributary (variable C) given flows on the tributary (variable A) and flows in the mainstem (variable B). Large flows on the mainstem do cause backwater along the tributary and thus affect the stage at the point of interest. The data for this example comes from existing conditional flow frequency curves for Variable A and an existing flow duration curve for variable B. An HEC-RAS model was used to simulate the response of variable C (stage at the point of interest) for multiple combinations of flow on the tributary and flow in the mainstem.

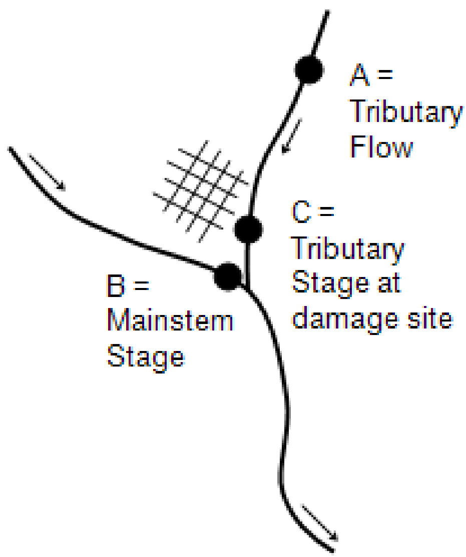


Figure B-113. Scenario for **Coincident Freq Test 16**.

A Coincident Frequency analysis has been developed for this example. To open the Coincident Frequency analysis editor for **Coincident Freq Test 16**, either double-click on the analysis labeled **Coincident Freq Test 16** from the study explorer, or from the **Analysis** menu select open, then select **Coincident Freq Test 16** from the list of available analyses. When **Coincident Freq Test 16** is opened, the Coincident Frequency analysis editor will appear as shown in Figure B-114.

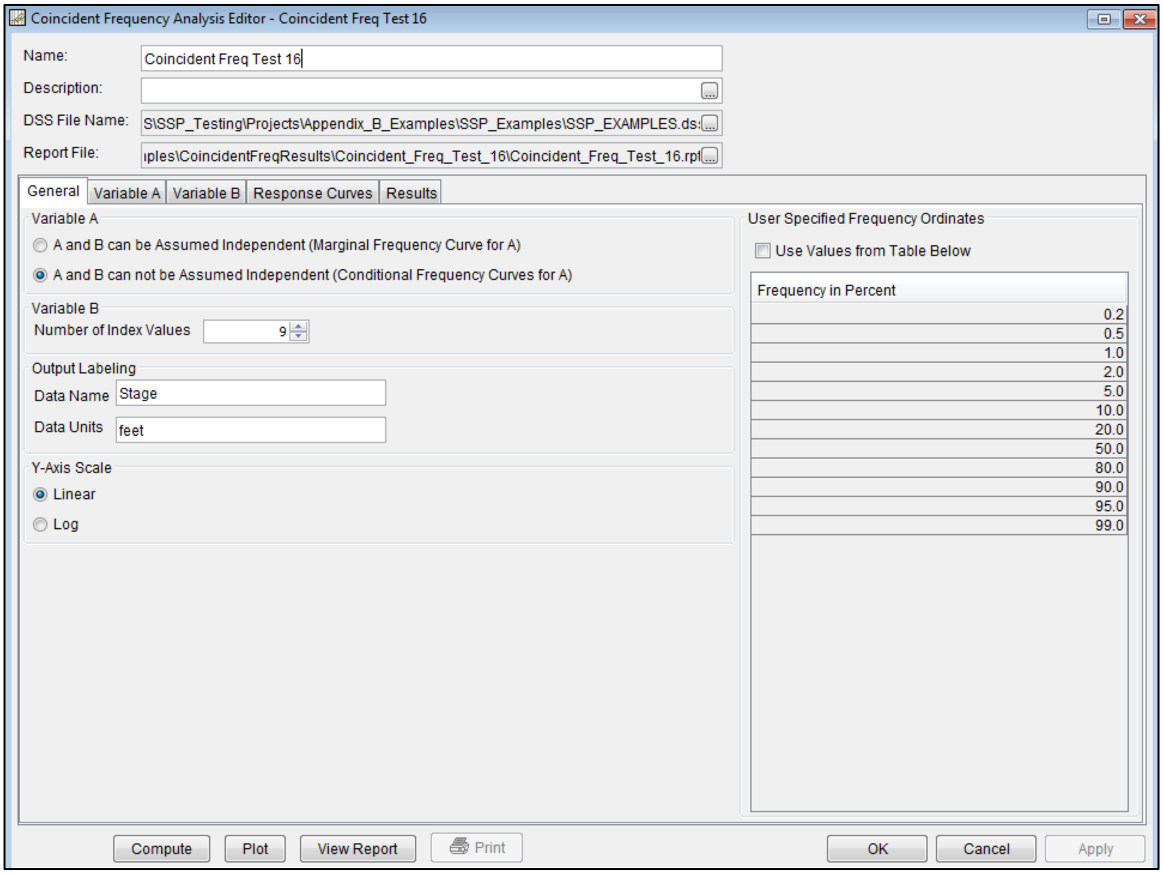
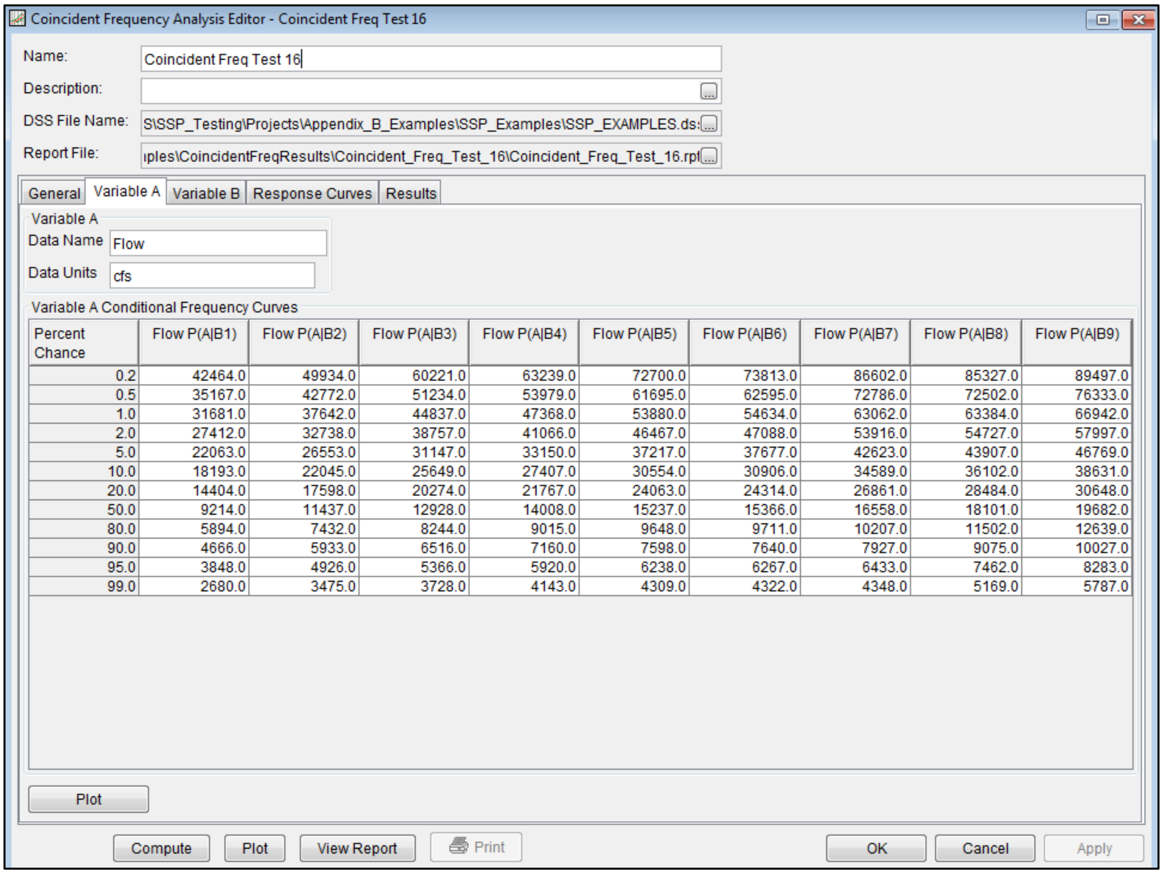


Figure B-114. General Tab Shown for Coincident Freq Test 16.

Shown in Figure B-114 are the general settings for this coincident frequency analysis. For this analysis, the **A and B can not be Assumed Independent (Conditional Frequency Curve for A)** option was selected. This would be determined by performing a correlation analysis between variables A and B; a correlation coefficient in the range of 0.3 – 0.7 would indicate that variables A and B could not be assumed independent. The number of variable B index values was set to 9, the **Data Name** was set to "Stage" and the **Data Units** to "feet", and the Y-Axis scale was set to **Linear**.

Shown in Figure B-115 is the Coincident Frequency Analysis editor with the **Variable A Tab** selected. A **Data Name** of "Flow" and **Data Units** of "cfs" were entered. A separate frequency curve for variable A was developed for each index value defined on the Variable B tab. For example, the frequency curve in the "Flow P(A|B1)" column is the variable A frequency curve for the 1st variable B index value. The variable B tab shows the 1st index value, 3005.92, is assigned a proportion of time of 40 percent. Therefore, the 1st variable A frequency curve was developed using annual peak flows on the tributary when flows in the mainstem were in the range of the 1st variable B index value. For this example, a multivariate lognormal random number generator was used to develop a large enough data set so that variable A frequency curves could be computed for each variable B index value. The random numbers were generated using statistics from the annual peak flows occurring on the tributary, statistics from the coincident (same day) flows occurring on the main stem, and the covariance between the two datasets.



Percent Chance	Flow P(A|B1)	Flow P(A|B2)	Flow P(A|B3)	Flow P(A|B4)	Flow P(A|B5)	Flow P(A|B6)	Flow P(A|B7)	Flow P(A|B8)	Flow P(A|B9)
0.2	42464.0	49934.0	60221.0	63239.0	72700.0	73813.0	86602.0	85327.0	89497.0
0.5	35167.0	42772.0	51234.0	53979.0	61695.0	62595.0	72786.0	72502.0	76333.0
1.0	31681.0	37642.0	44837.0	47368.0	53880.0	54634.0	63062.0	63384.0	66942.0
2.0	27412.0	32738.0	38757.0	41066.0	46467.0	47088.0	53916.0	54727.0	57997.0
5.0	22063.0	26553.0	31147.0	33150.0	37217.0	37677.0	42623.0	43907.0	46769.0
10.0	18193.0	22045.0	25649.0	27407.0	30554.0	30906.0	34589.0	36102.0	38631.0
20.0	14404.0	17598.0	20274.0	21767.0	24063.0	24314.0	26861.0	28484.0	30648.0
50.0	9214.0	11437.0	12928.0	14008.0	15237.0	15366.0	16558.0	18101.0	19682.0
80.0	5894.0	7432.0	8244.0	9015.0	9648.0	9711.0	10207.0	11502.0	12639.0
90.0	4666.0	5933.0	6516.0	7160.0	7598.0	7640.0	7927.0	9075.0	10027.0
95.0	3848.0	4926.0	5366.0	5920.0	6238.0	6267.0	6433.0	7462.0	8283.0
99.0	2680.0	3475.0	3728.0	4143.0	4309.0	4322.0	4348.0	5169.0	5787.0

Figure B-115. Variable A Tab for Coincident Freq Test 16.

Shown in Figure B-116 is the Coincident Frequency analysis editor with the **Variable B Tab** selected. No duration curve was selected for this example. In the **Develop Probabilities from Duration Curve** panel, the **User-Specified Index Points and Probability Ranges** option was selected. The probabilities and index values were defined manually and the Generate Table button was pressed in order to compute the Break Points.

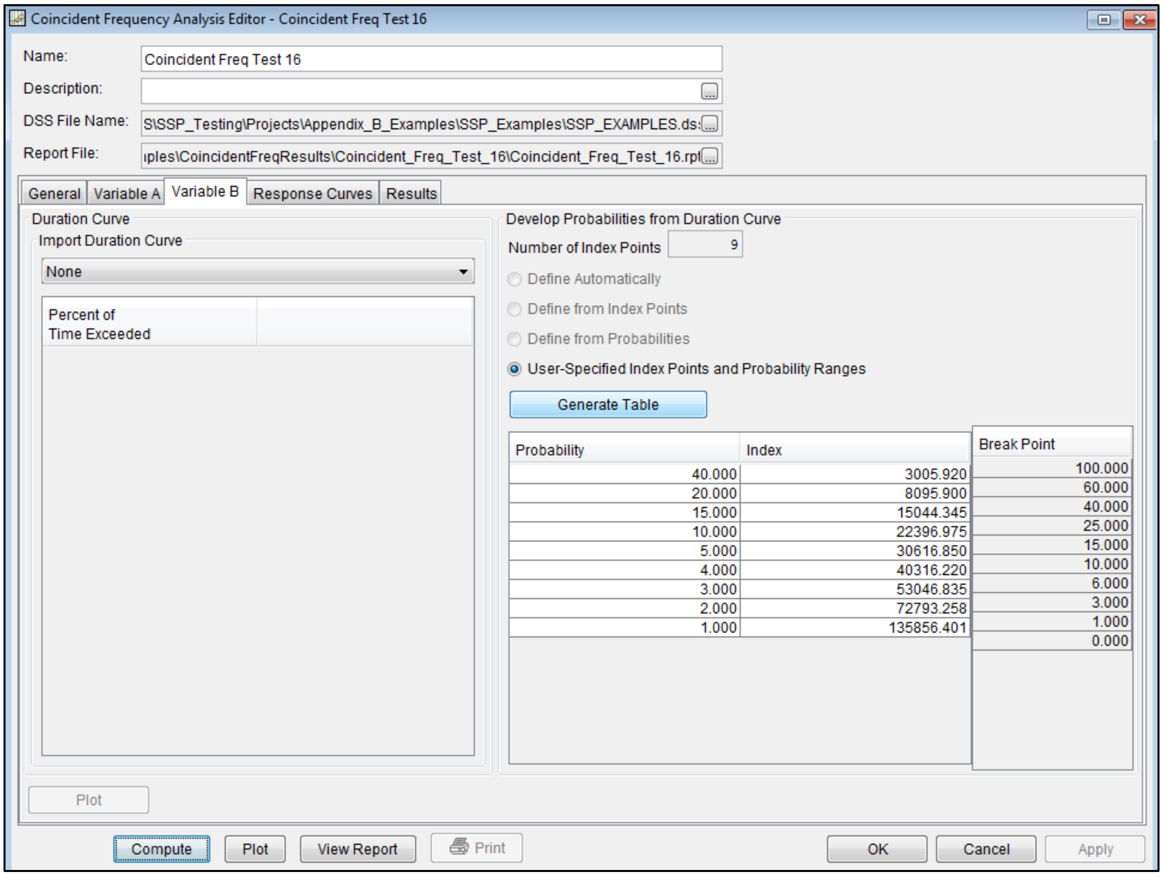


Figure B-116. Variable B Tab for Coincident Freq Test 16.

Once the Variable A and Variable B tabs have been completed, the user can populate the response curves table. Figure B-117 shows the Response Curves tab for **Coincident Freq Test 16**. The **Different Variable A for Each Index** option was selected. When selected, a separate Variable A column is added for each variable B index value. For example, the first Variable A column is linked to the C = f(A,B1) column. The second variable A column is lined to the C = f(A,B2), and so on. The **Import Variable A** button was pressed to automatically copy values from the Variable A tab to fill in appropriate **Variable A** column. The remaining columns in the table were populated with results from the hydraulics model. For example, the first value in the second column is 473.95. This value is the stage at the point of interest given a flow of 42464 (cfs) on the tributary (variable A) and a flow of 3005.92 (cfs) on the mainstem (variable B). A total of 108 simulations were required from the hydraulics model to fill in the response curves table.

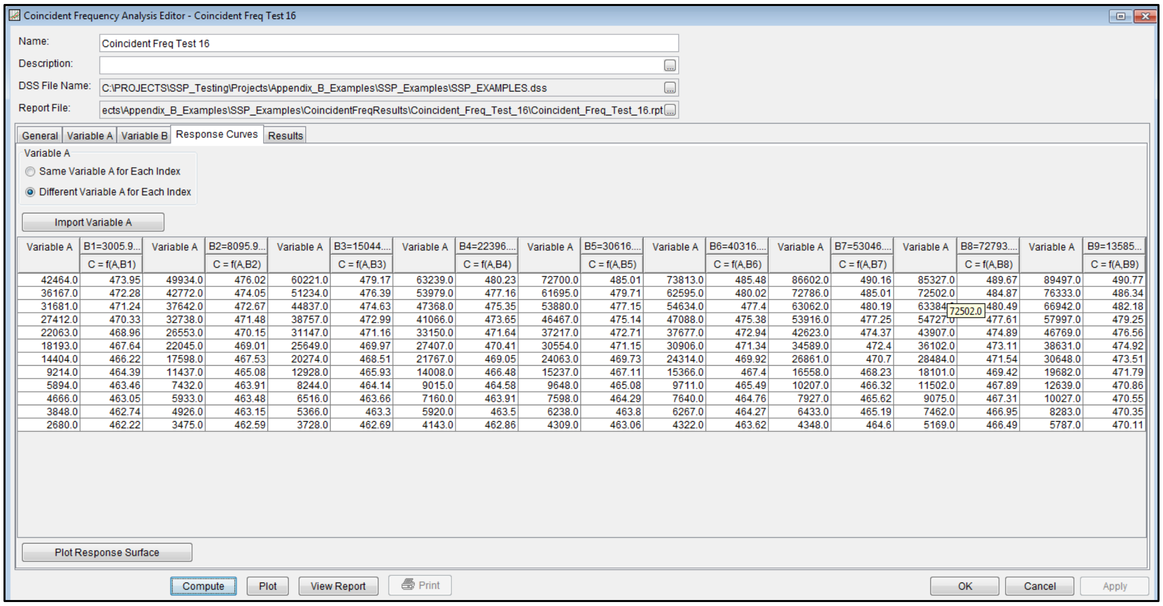


Figure B-117. Response Curves Tab for Coincident Freq Test 16.

Press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab. The **Results** tab should look Figure B-118. The left portion of the results tab contains the computed variable C frequency curve and the right portion of the results tab contains a plot of the computed variable C frequency curve.

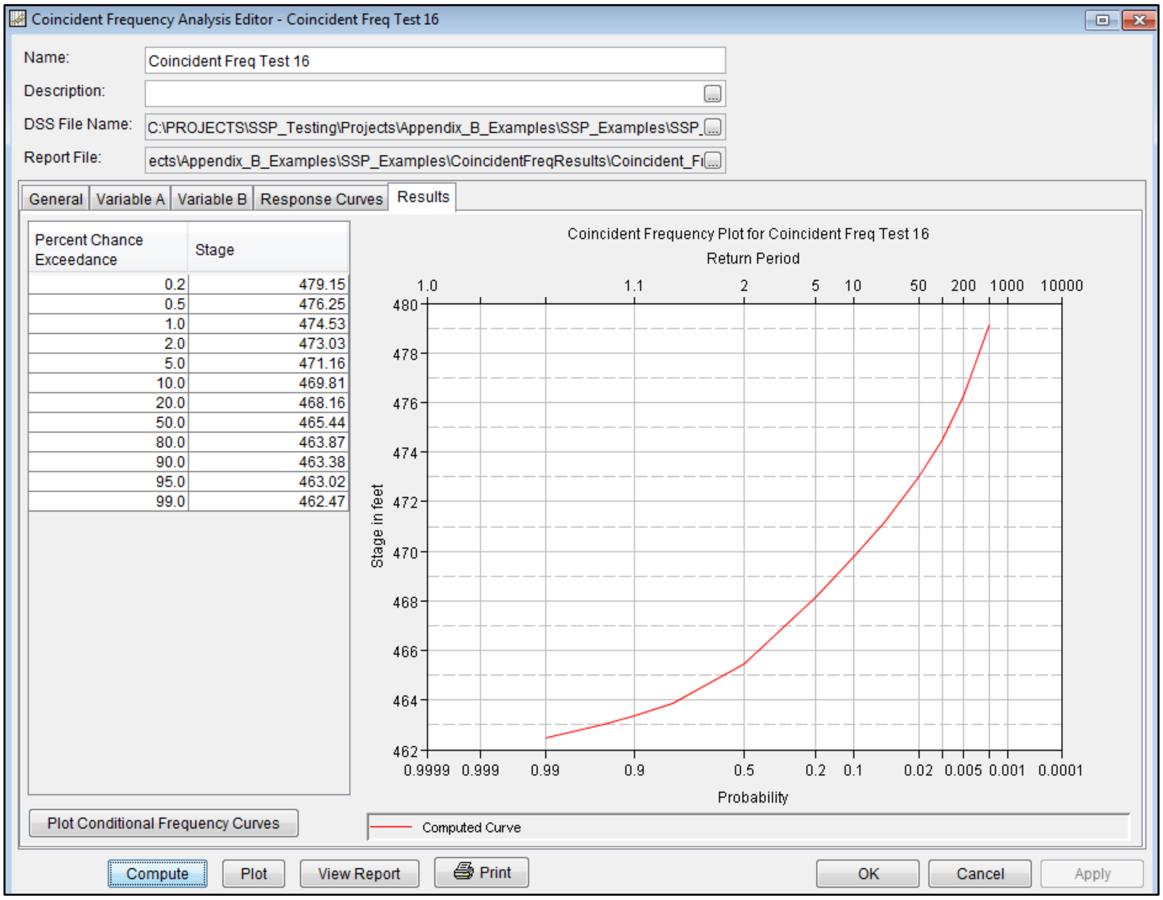
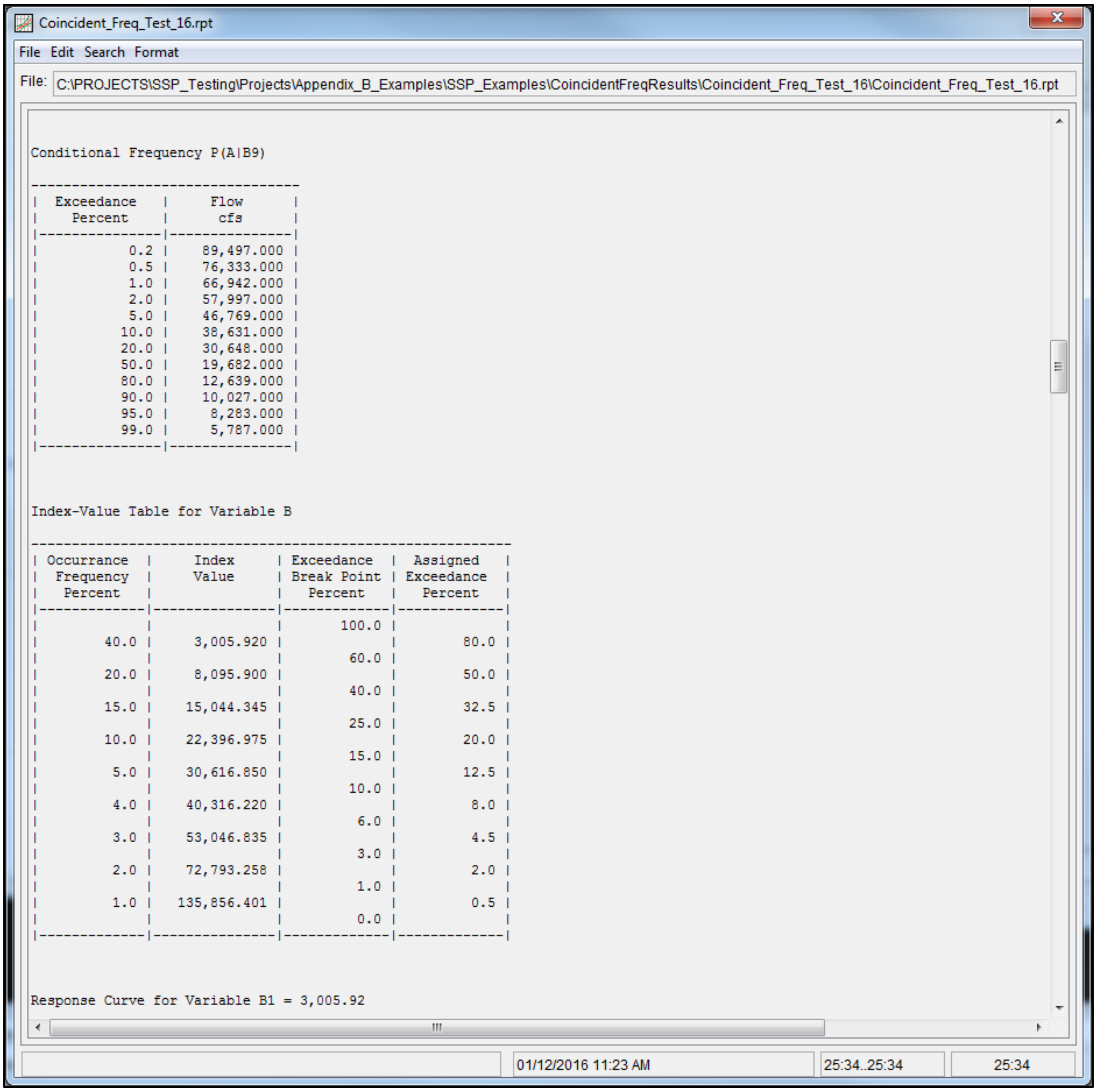


Figure B-118. Results Tab for Coincident Freq Test 16.

The tabular and graphical results can be sent to the printer or the windows clipboard for transfer into another piece of software. To print the tabular results, select **Print** from the bottom of the analysis window. To send the tabular results to the windows clipboard, highlight the data you want to send to the clipboard and then press the Control-C key sequence. To print the graphical results, first bring up the graphical plot by pressing the **Plot** button from the bottom of the analysis. Then select **Print** from the **File** menu. To send the graphic to the windows clipboard, select **Copy to Clipboard** from the **File** menu.

In addition to the tabular and graphical results, there is a report file that shows input data and results. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-119 is the report file for **Coincident Freq Test 16**.



Coincident_Freq_Test_16.rpt

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File: C:\PROJECTS\SSP_Testing\Projects\Appendix_B_Examples\SSP_Examples\CoincidentFreqResults\Coincident_Freq_Test_16\Coincident_Freq_Test_16.rpt

Conditional Frequency P(A|B9)

Exceedance Percent	Flow cfs
0.2	89,497.000
0.5	76,333.000
1.0	66,942.000
2.0	57,997.000
5.0	46,769.000
10.0	38,631.000
20.0	30,648.000
50.0	19,682.000
80.0	12,639.000
90.0	10,027.000
95.0	8,283.000
99.0	5,787.000

Index-Value Table for Variable B

Occurrance Frequency Percent	Index Value	Exceedance Break Point Percent	Assigned Exceedance Percent
		100.0	
40.0	3,005.920		80.0
		60.0	
20.0	8,095.900		50.0
		40.0	
15.0	15,044.345		32.5
		25.0	
10.0	22,396.975		20.0
		15.0	
5.0	30,616.850		12.5
		10.0	
4.0	40,316.220		8.0
		6.0	
3.0	53,046.835		4.5
		3.0	
2.0	72,793.258		2.0
		1.0	
1.0	135,856.401		0.5
		0.0	

Response Curve for Variable B1 = 3,005.92

01/12/2016 11:23 AM 25:34..25:34 25:34

Figure B-119. Report File for Coincident Freq Test 16.

Example 17: Balanced Hydrograph Analysis, Using an Historical Event Hydrograph

This example demonstrates how to create a **Balanced Hydrograph** analysis using an historical event hydrograph shape. In this example, information from previously-computed Bulletin 17 and Volume Frequency analyses will be used along with an historical event to create numerous balanced hydrographs which are "balanced" across multiple durations.

A Balanced Hydrograph analysis has been developed for this example. To open the Balanced Hydrograph analysis editor for this example, either double-click on the analysis labeled **Balanced Hydrograph Test 17** from the study explorer, or from the **Analysis** menu select open, then select **Balanced Hydrograph Test 17** from the list of available analyses. When test 17 is opened, the Balanced Hydrograph Analysis editor will appear as shown in Figure B-120.

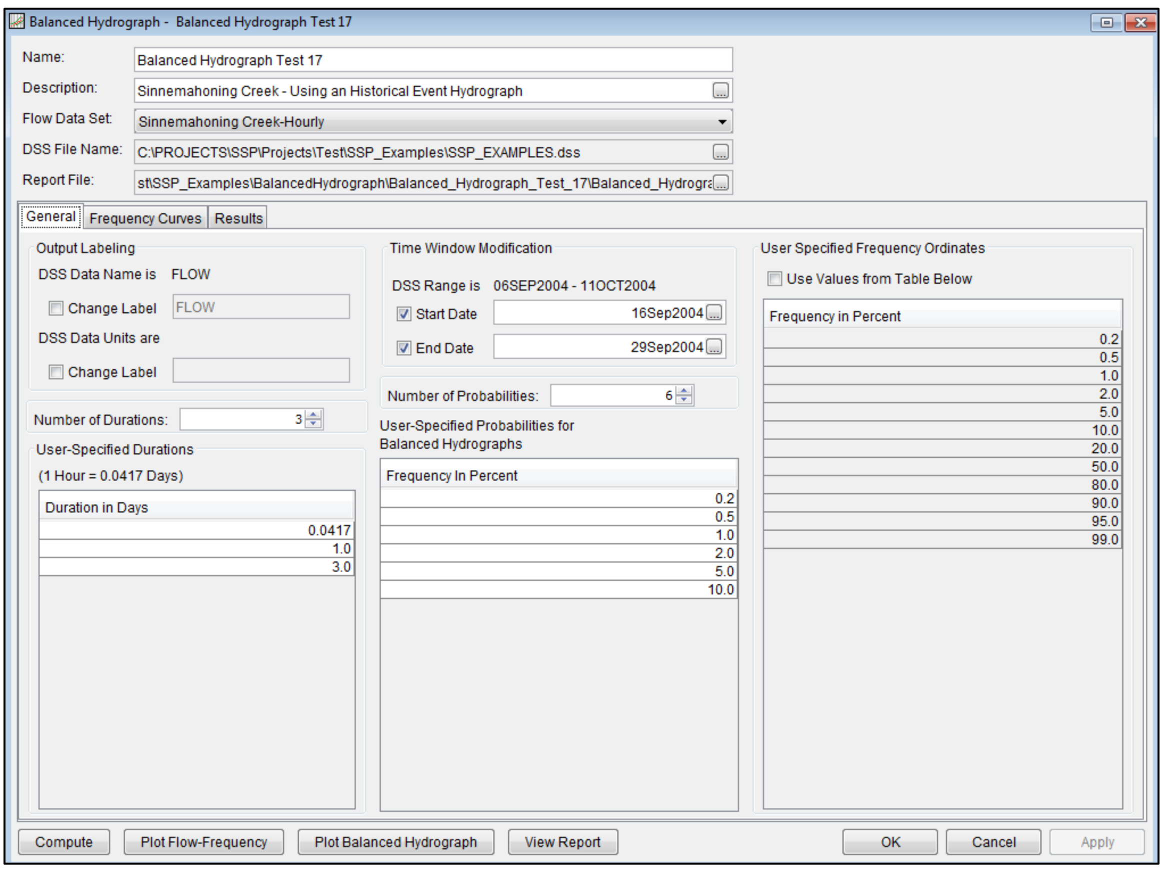


Figure B-120. General Tab Shown for Balanced Hydrograph Test 17.

Shown in Figure B-120 are the general settings for this curve combination analysis. The Number of Durations was set to three: 0.0417-days (1-

hour), 1-day, and 3-days. These three durations are those which will be used to "balance" throughout the analysis. The DSS Range was set to 16Sep2004 through 29Sep2004, which corresponded to the passage of the remnants of Tropical Storm Ivan, as shown in Figure B-121.

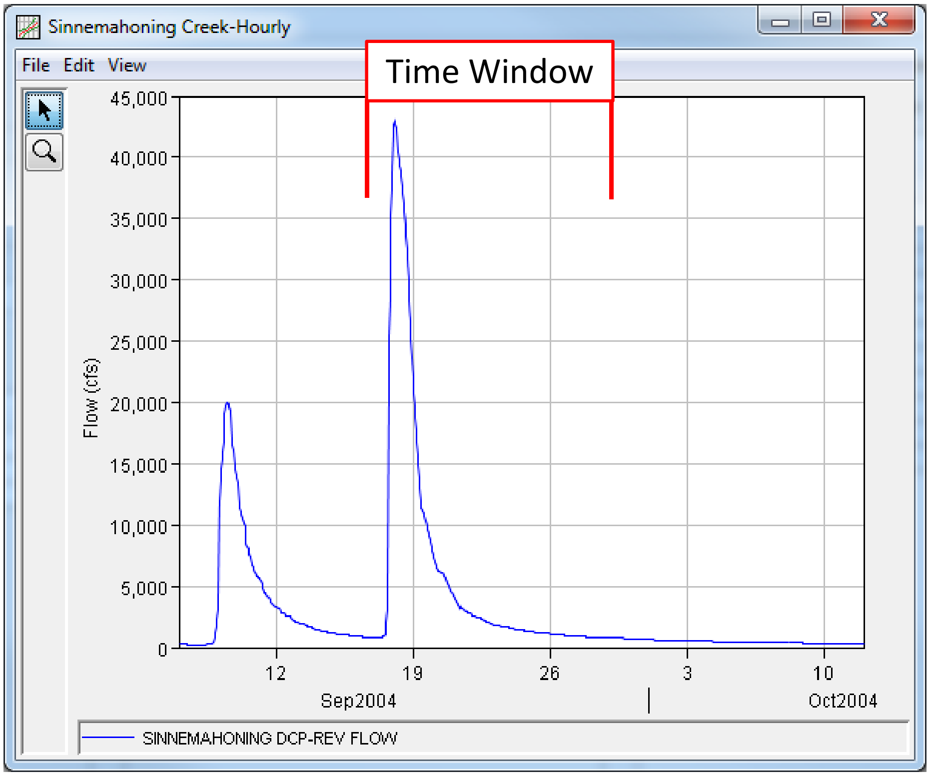


Figure B-121. DSS Time Window Used within Balanced Hydrograph Test 17.

The number of probabilities was set to six: 0.2, 0.5, 1, 2, 5, and 10 percent frequencies. Using six probabilities will result in the creation of six balanced hydrographs. The frequency ordinates were left as the default values.

Shown in Figure B-122 is the Balanced Hydrograph analysis editor with the **Frequency Curves** tab selected. Frequency Curve Duration 1 was manually defined using results from the Bulletin 17 analysis named "Sinnemahoning_B17C". Frequency Curve Duration 1 corresponds to a duration of 0.0417-days or 1-hour. It is assumed that the Log Pearson Type III distribution that was fit within the "Sinnemahoning_B17C" Bulletin 17 analysis is indicative of a 0.0417-day duration. Log Pearson Type III parameters were entered for both Frequency Curve Duration 2 and Frequency Curve Duration 3 using results from the Volume Frequency analysis named "Sinnemahoning_VolumeFrequency". Frequency Curve Duration 2 uses the 1-day results while Frequency Curve

Duration 3 uses the 3-day statistics from the Volume Frequency analysis. Figure B-123 shows the plotted frequency curves for this analysis.

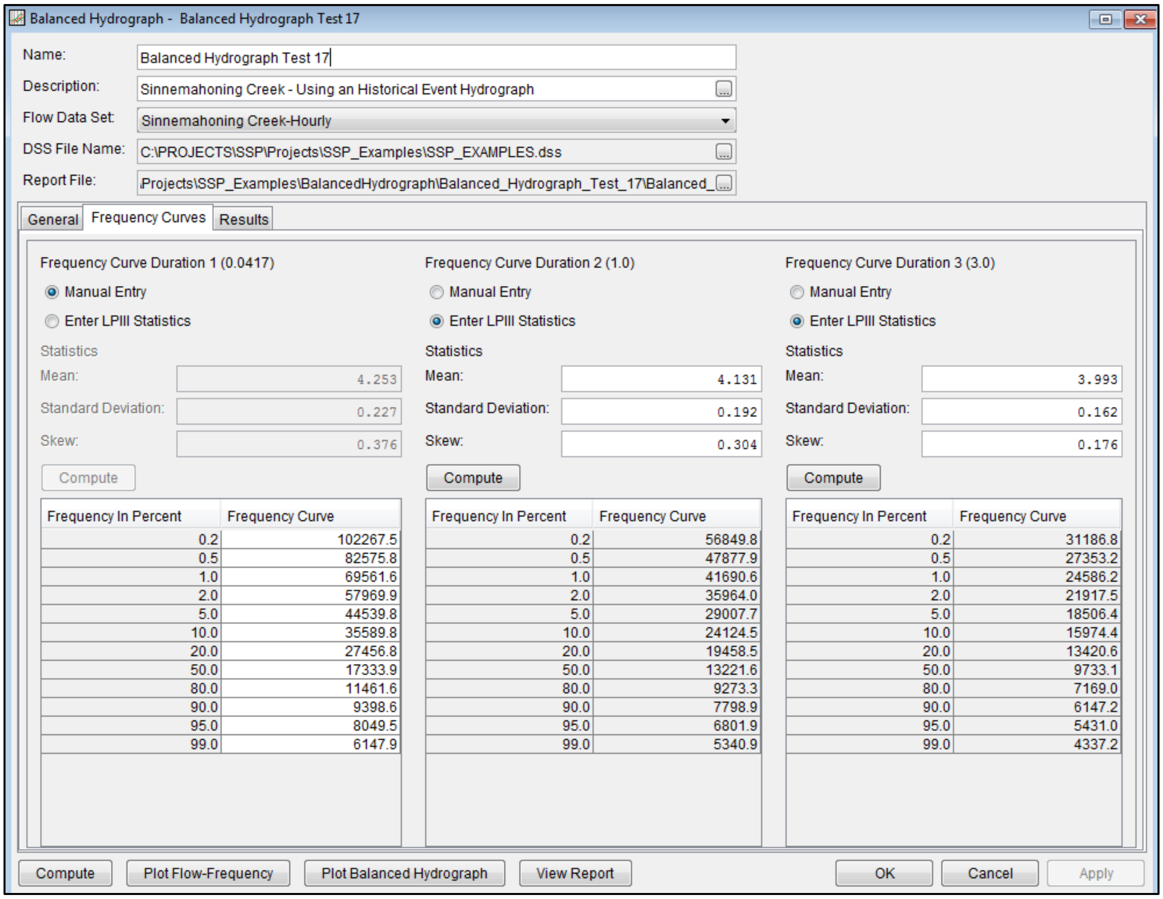


Figure B-122. Frequency Curves Tab for Balanced Hydrograph Test 17.

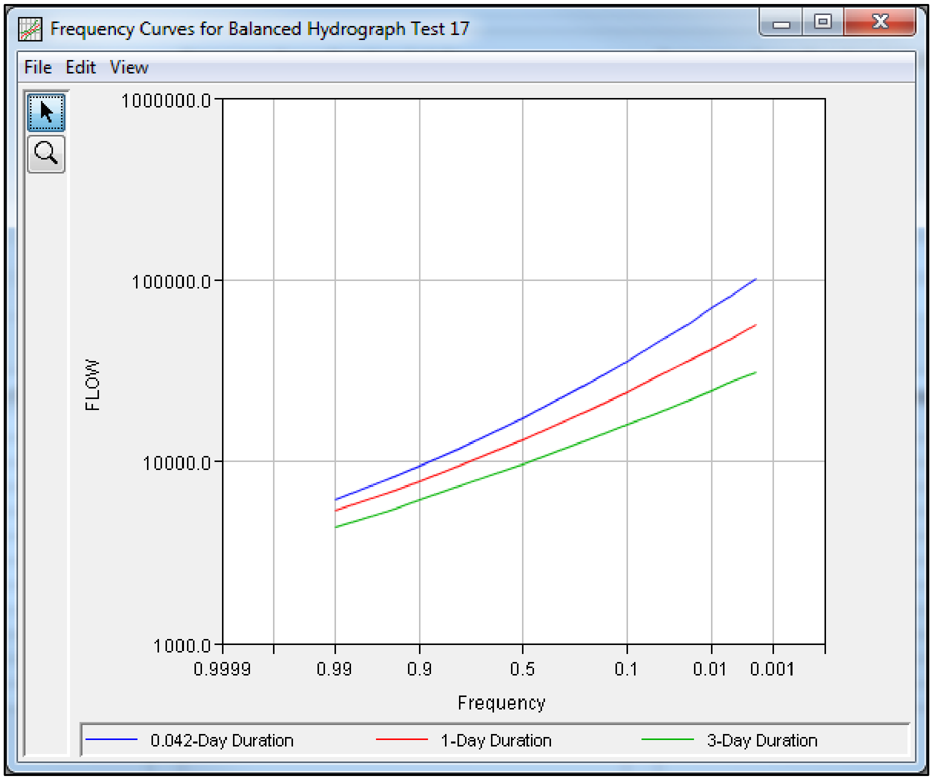


Figure B-123. Plotted Frequency Curves for Balanced Hydrograph Test 17.

Press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab. The results tab should look Figure B-124. The left portion of the Results tab window displays the computed balanced hydrographs in a table using the six frequencies that were previously defined on the General tab. The right portion of the Results tab displays all six balanced hydrographs in a plot. To view the balanced hydrographs in a separate window, either click **Plot Balanced Hydrograph** or double click on the plot within the Results tab.

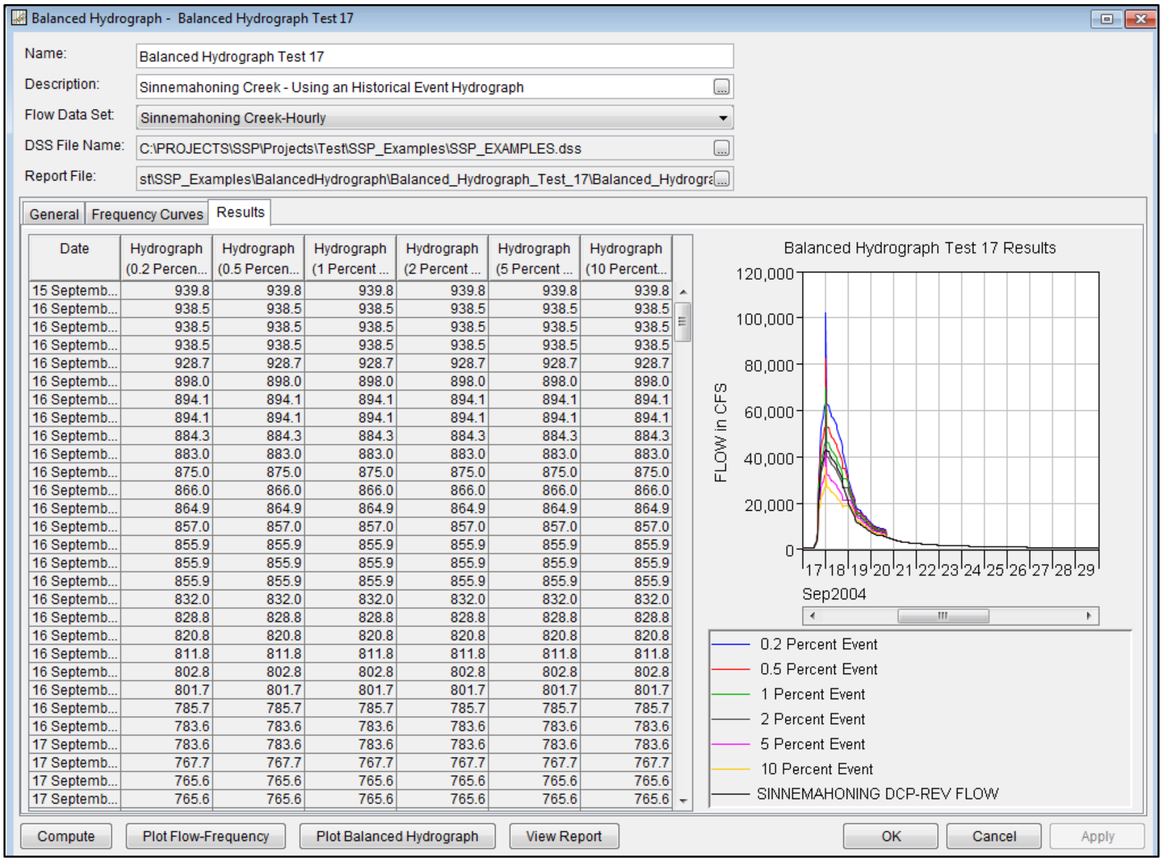
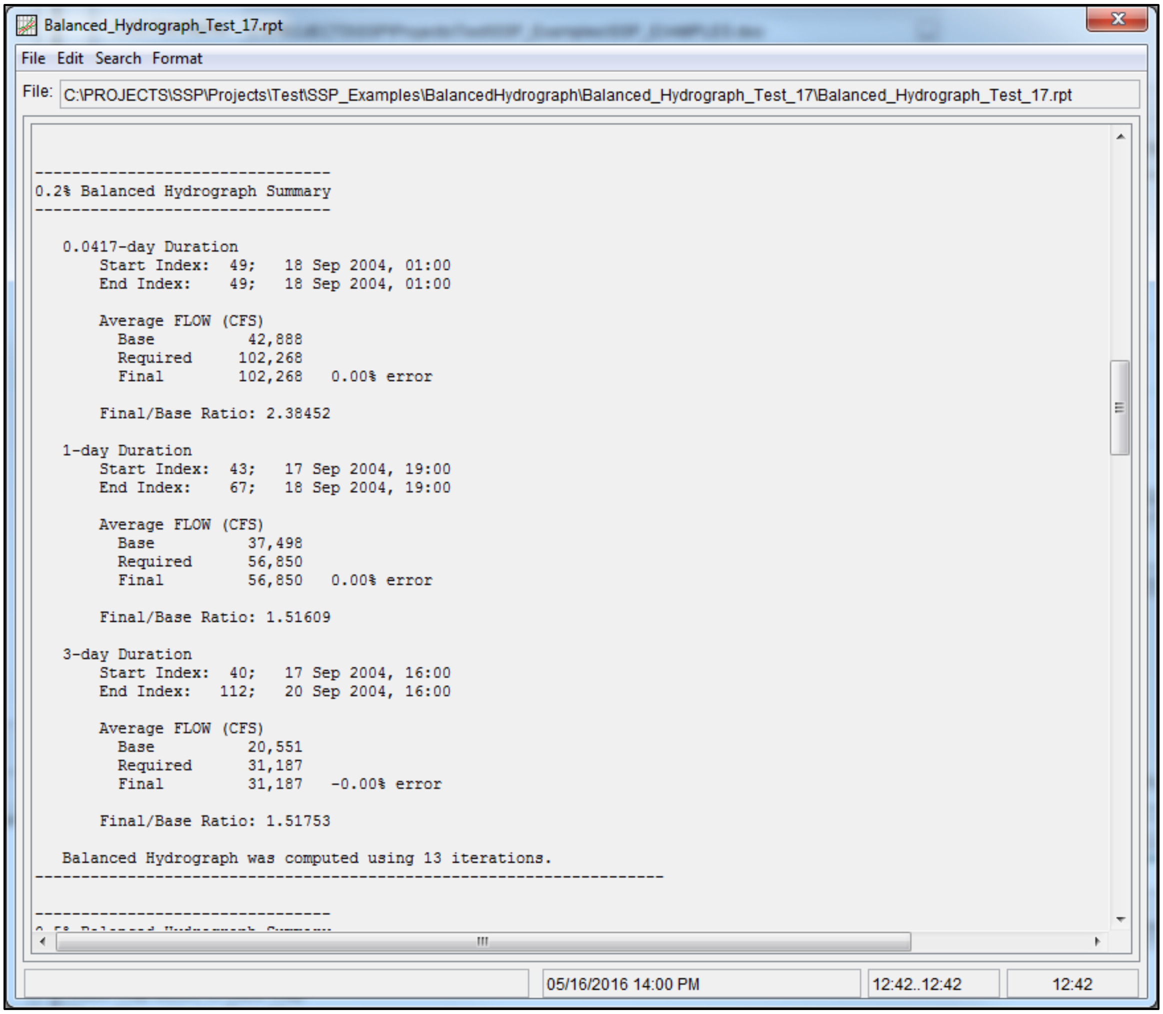


Figure B-124. Results Tab for Balanced Hydrograph Test 17.

In addition to the tabular and graphical results, there is a report file that shows input data and results. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-125 is the report file for **Balanced Hydrograph Test 17**.



Balanced_Hydrograph_Test_17.rpt

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```
--------------------------------
0.2% Balanced Hydrograph Summary
--------------------------------

   0.0417-day Duration
       Start Index:  49;   18 Sep 2004, 01:00
       End Index:    49;   18 Sep 2004, 01:00

       Average FLOW (CFS)
         Base           42,888
         Required      102,268
         Final         102,268   0.00% error

       Final/Base Ratio: 2.38452

   1-day Duration
       Start Index:  43;   17 Sep 2004, 19:00
       End Index:    67;   18 Sep 2004, 19:00

       Average FLOW (CFS)
         Base           37,498
         Required       56,850
         Final          56,850   0.00% error

       Final/Base Ratio: 1.51609

   3-day Duration
       Start Index:  40;   17 Sep 2004, 16:00
       End Index:   112;   20 Sep 2004, 16:00

       Average FLOW (CFS)
         Base           20,551
         Required       31,187
         Final          31,187   -0.00% error

       Final/Base Ratio: 1.51753

   Balanced Hydrograph was computed using 13 iterations.
--------------------------------------------------------------------
```

05/16/2016 14:00 PM | 12:42..12:42 | 12:42

Figure B-125. Report File for Balanced Hydrograph Test 17.

Example 18: Balanced Hydrograph Analysis, Using a Triangular-shaped Hydrograph

This example demonstrates how to create a **Balanced Hydrograph** analysis using a hypothetical triangular hydrograph shape. In this example, information from previously-computed Bulletin 17 and Volume Frequency analyses will be used along with an historical event to create numerous balanced hydrographs which are "balanced" across multiple durations.

A Balanced Hydrograph analysis has been developed for this example. To open the Balanced Hydrograph analysis editor for **Balanced Hydrograph Test 18**, either double-click on the analysis labeled **Balanced Hydrograph Test 18** from the study explorer, or from the **Analysis** menu select open, then select **Balanced Hydrograph Test 18** from the list of available analyses. When test 18 is opened, the Balanced Hydrograph Analysis editor will appear as shown in Figure B-126.

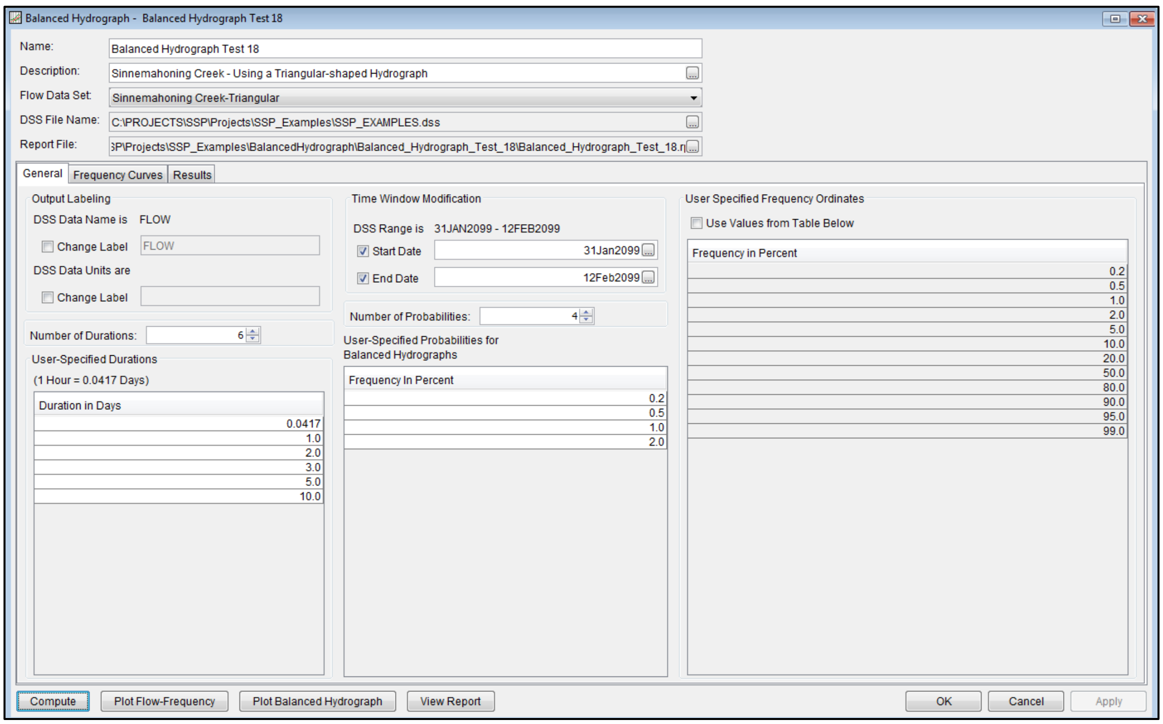


Figure B-126. General Tab Shown for Balanced Hydrograph Test 18.

Shown in Figure B-126 are the general settings for this curve combination analysis. The Number of Durations was set to six: 0.0417-days (1-hour), 1-day, 2-days, 3-days, 5-days, and 10-days. These six durations are those which will be used to "balance" throughout the analysis. The DSS Range was set to 31Jan2099 through 12Feb2099, which is used to signify the hypothetical nature of the triangular hydrograph shape. This triangular hydrograph was created using HEC-DSSVue and initially starts at 100 cfs and increases to a peak of 101 cfs and then decreases to 100 cfs over the course of 10 days, as shown in Figure B-127.

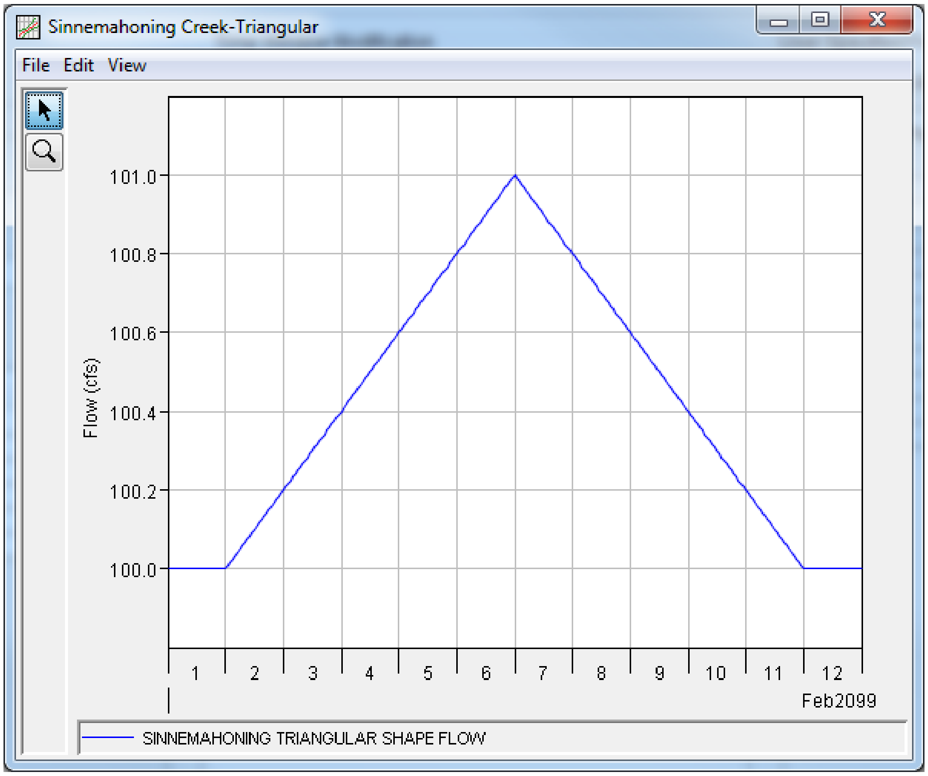


Figure B-127. Hypothetical Triangular Hydrograph Used within Balanced Hydrograph Test 18.

The number of probabilities was set to four: 0.2, 0.5, 1, and 2 percent frequencies. Using four probabilities will result in the creation of four balanced hydrographs. The frequency ordinates were left as the default values.

Shown in Figure B-128 is the Balanced Hydrograph analysis editor with the **Frequency Curves** tab selected. Frequency Curve Duration 1 was manually defined using results from the Bulletin 17 analysis named “Sinnemahoning_B17C”. Frequency Curve Duration 1 corresponds to a duration of 0.0417-days or 1-hour. It is assumed that the Log Pearson Type III distribution that was fit within the “Sinnemahoning_B17C” Bulletin 17 analysis is indicative of a 0.0417-day duration. Log Pearson Type III parameters were entered for Frequency Curve Duration 2, Frequency Curve Duration 3, Frequency Curve Duration 4, Frequency Curve Duration 5, and Frequency Curve Duration 6 using results from the Volume Frequency analysis named “Sinnemahoning_VolumeFrequency”.

Frequency Curve Duration 2 uses the 1-day results, Frequency Curve Duration 3 uses the 2-day results, Frequency Curve Duration 4 uses the 3-day results, Frequency Curve Duration 5 uses the 5-day results, and Frequency Curve Duration 6 uses the 10-day results from the Volume Frequency analysis. Figure B-129 shows the plotted frequency curves for this analysis.

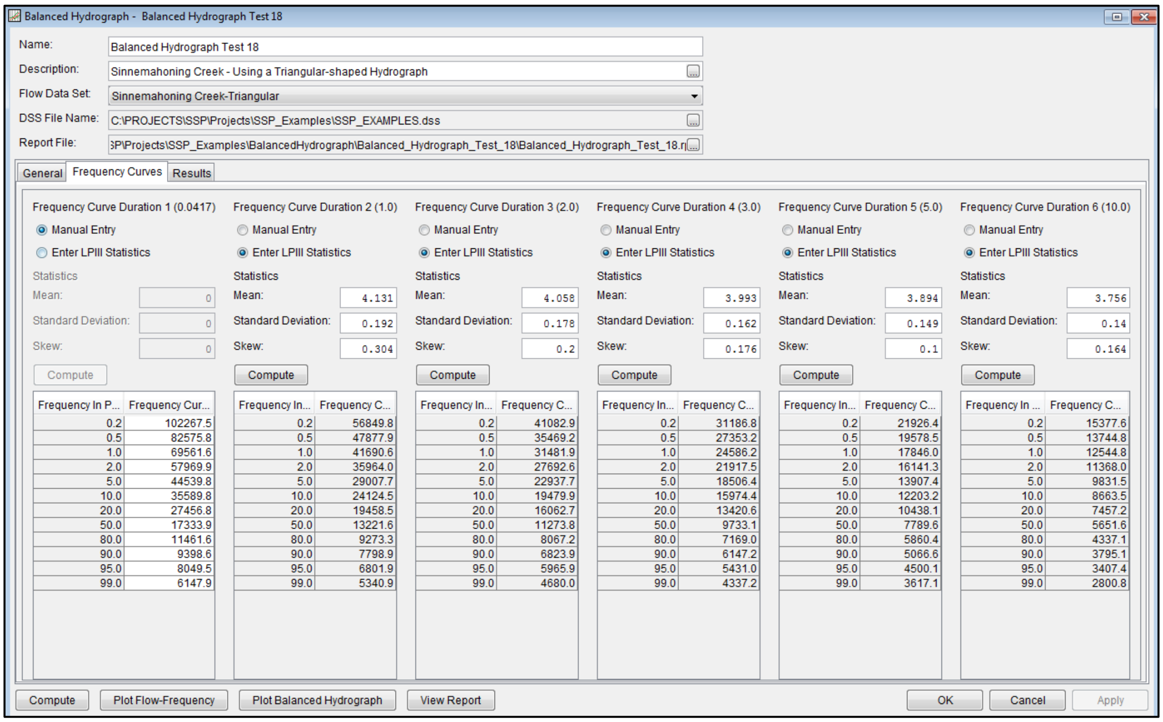


Figure B-128. Frequency Curves Tab for Balanced Hydrograph Test 18.

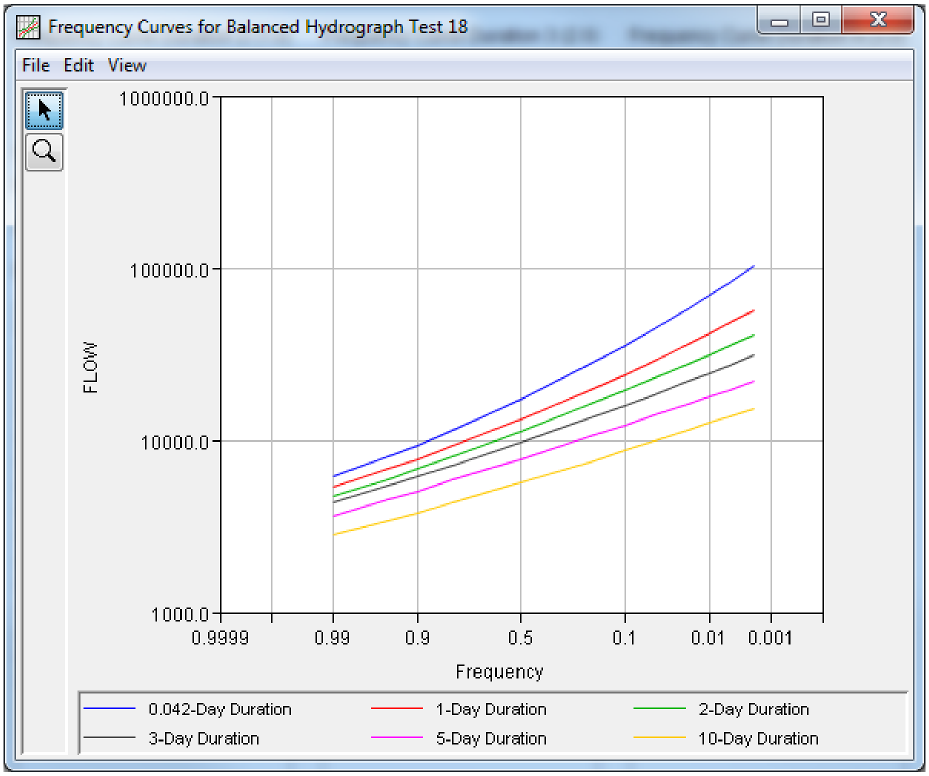


Figure B-129. Plotted Frequency Curves for Balanced Hydrograph Test 18.

Press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stating **Compute Complete.** Close this window and then select the **Results** tab. The results tab should look Figure B-130. The left portion of the Results tab window displays the computed balanced hydrographs in a table using the four frequencies that were previously defined on the General tab. The right portion of the Results tab displays all four balanced hydrographs in a plot. To view the balanced hydrographs in a separate window, either click **Plot Balanced Hydrograph** or double click on the plot within the Results tab.

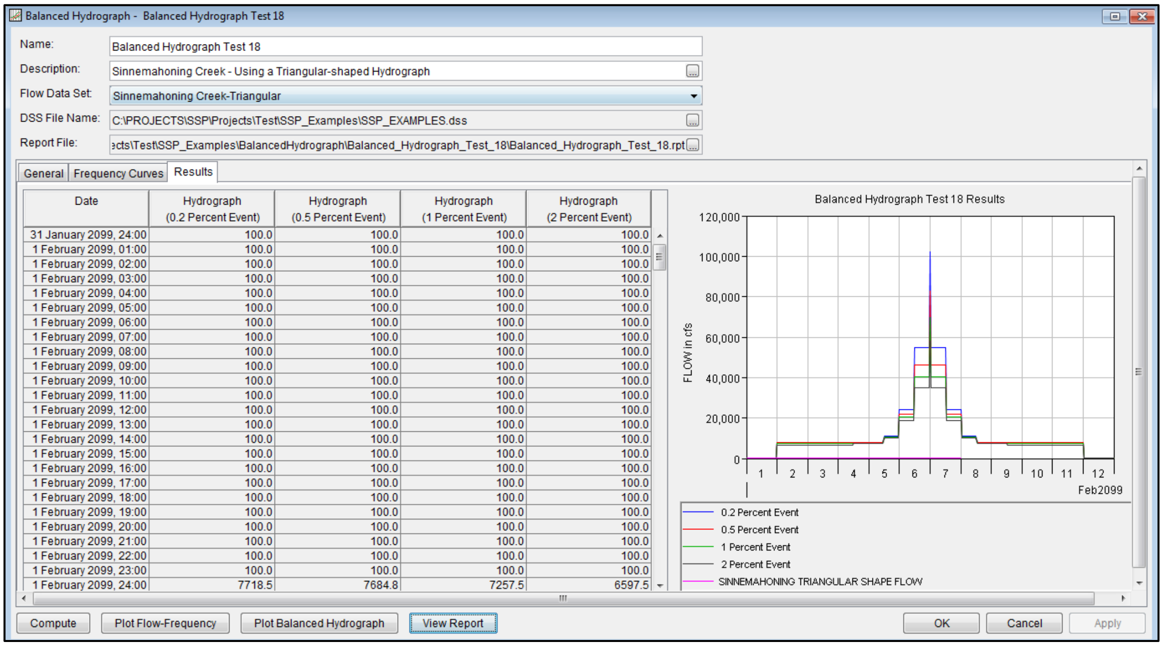


Figure B-130. Results Tab for Balanced Hydrograph Test 18.

In addition to the tabular and graphical results, there is a report file that shows input data and results. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected a text viewer will open the report file and display it on the screen. Shown in Figure B-131 is the report file for **Balanced Hydrograph Test 18**.

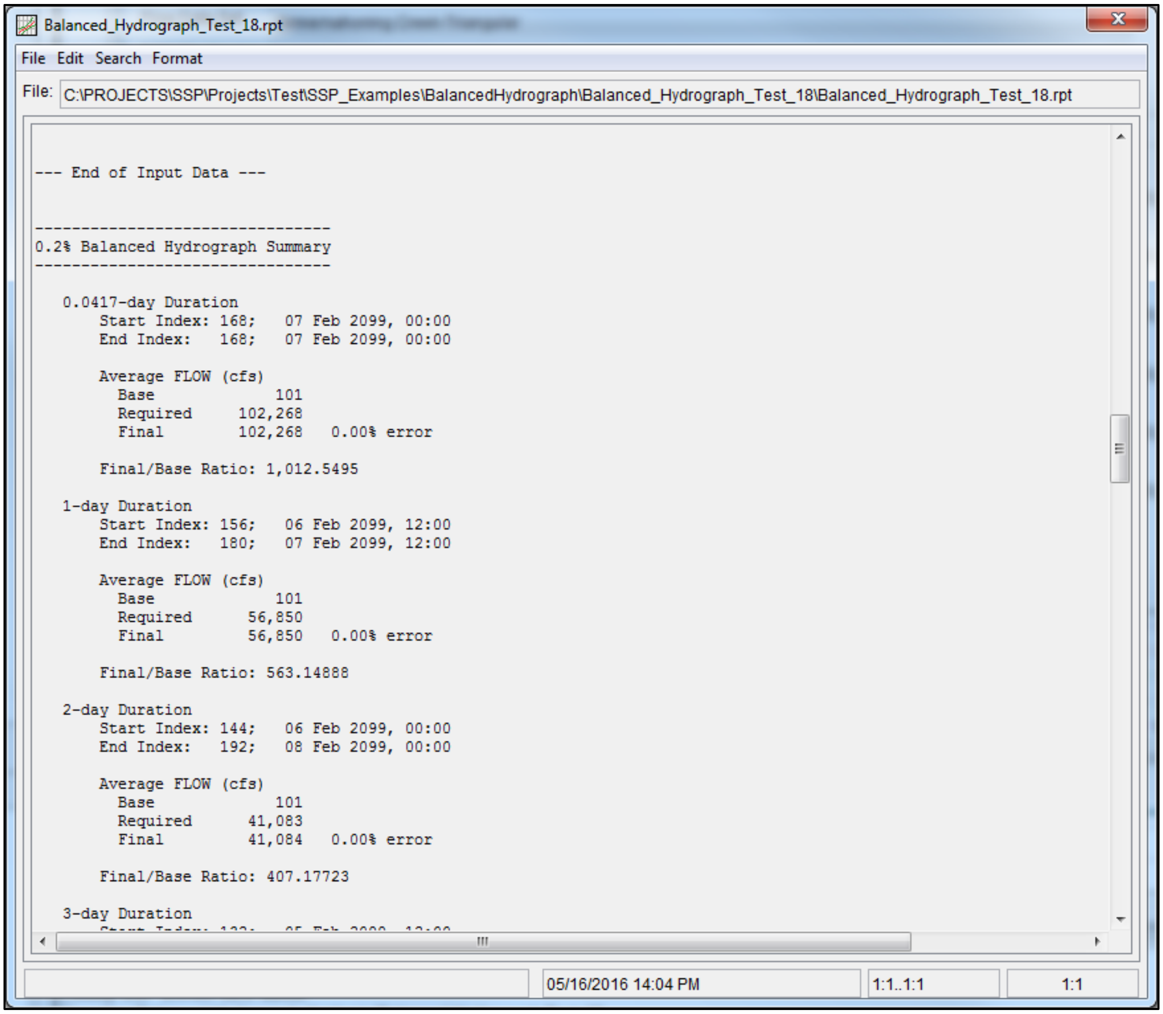


Figure B-131. Report File for Balanced Hydrograph Test 18.

A P P E N D I X C

Bulletin 17C / Expected Moments Algorithm Examples

This Appendix provides six examples using the Expected Moments Algorithm (EMA) to fit the Log Pearson Type III distribution to annual maximum flow data sets. The multiple inputs and outputs are provided to illustrate the use of selected options and to assist in verifying the correct execution of the program.

These examples use the same data sets that are provided with the Bulletin 17C document (England, et al., 2015) which emphases the use of the USGS PeakFQ Software (Veilleux, Cohn, Flynn, Mason, & Hummel, 2013). As shown in the example data sets, the HEC-SSP software produces the same results as PeakFQ for these six data sets. In fact, the current EMA implementation within HEC-SSP makes use of the same computational code inherent within PeakFQ.

All of these test examples are provided with the software as a single HEC-SSP study labeled "Bulletin 17C Examples". You can install this study on your computer by selecting the **Help→Install Example Data** menu option. After opening this study for the first time on your computer, you must compute each example before viewing tabular and graphical results.

A brief description of each example is provided. In most cases the computed at-site station skew is used in lieu of a weighted skew to more clearly illustrate the effects of EMA and the other procedures outlined within Bulletin 17C.

The example problems shown in this section are entitled:

1. Systematic Record – Moose River at Victory, VT
2. Analysis with Low Outliers – Orestimba Creek near Newman, CA
3. Broken Record – Back Creek near Jones Springs, WV
4. Historical and Data – Arkansas River at Pueblo, CO
5. Crest Stage Gage Censored Data – Bear Creek at Ottumwa, IA
6. Historic Data and Low Outliers – Santa Cruz River at Lochiel, AZ

When the "Bulletin 17C Examples" study file is open, the screen will appear as shown in Figure C-1. The following sections document each of the example data sets.

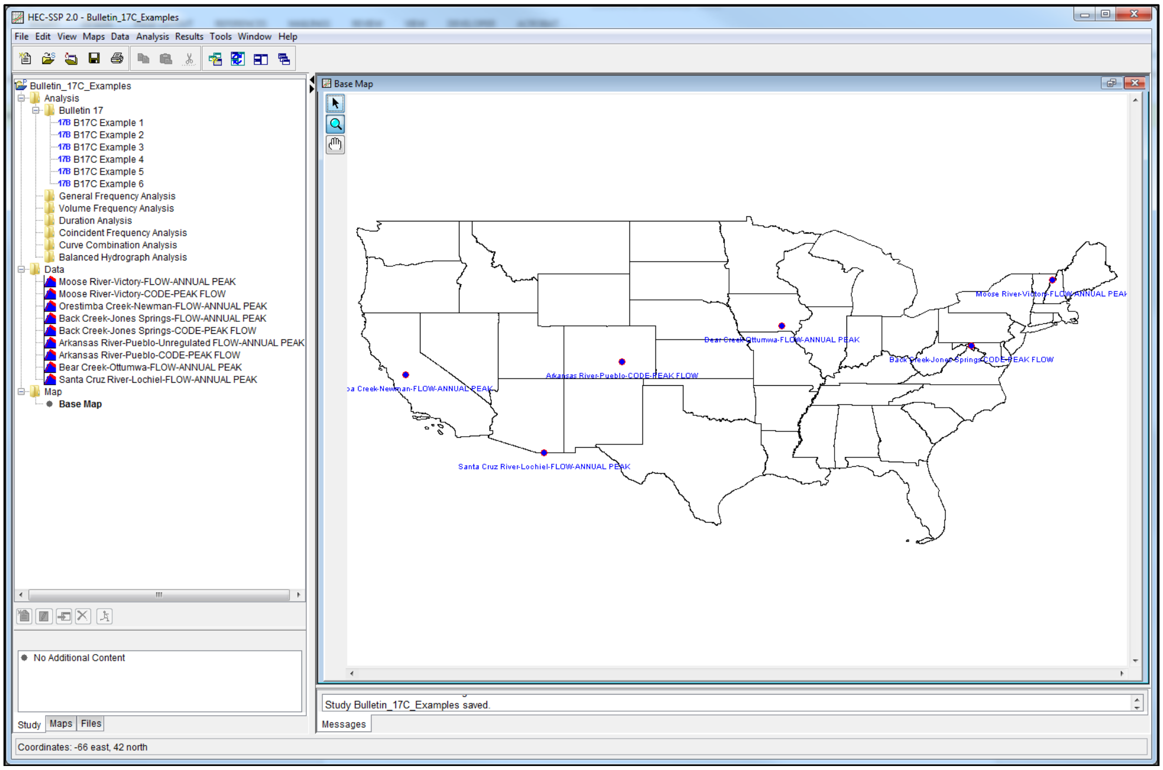


Figure C-1. Bulletin 17C Examples Study.

Example 1: Systematic Record – Moose River at Victory, VT

Example 1 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of systematic flood peaks. For this example, USGS gage 01134500 Moose River at Victory, Vermont is used. The Moose River is located in the northeastern part of the state and flows mostly from north to south through very hilly terrain. The Moose River basin is approximately 75 square miles of nearly all forest (England, et al., 2015). Historically, it was an important logging area and some logging still continues today. Attempts at farming in the basin have generally failed due to the presence of shallow rocky soil. There are a small number of villages in the basin, but overall it is sparsely populated with only a few miles of paved roadway. There is also a large bog approximately a third of a mile upstream from the gage. The bog is part of the 5,000 acre Victory Basin Wildlife management area. While there is no streamflow regulation in the basin, the bog attenuates peaks in the basin. The Moose River at Victory, VT stream gage has an annual peak record consisting of 68 peaks beginning in 1947 and ending in 2014, as shown in Figure C-2. The annual peak flow record is tabulated within Table C-.

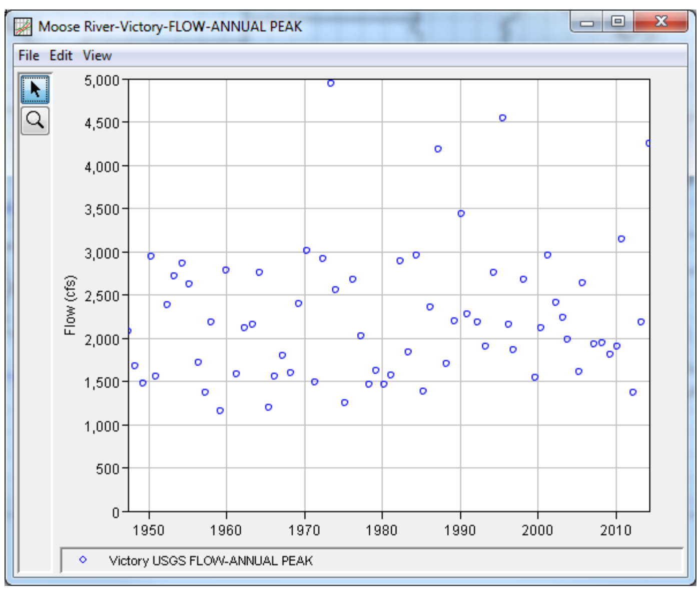


Figure C-2. Moose River at Victory, VT Annual Peak Flow Record.

Table C-1. Moose River at Victory, VT Annual Peak Flow Record.

Date	Flow (cfs)	Date	Flow (cfs)
13 Apr 1947	2080	21 Feb 1981	1570
28 Mar 1948	1670	18 Apr 1982	2890
28 Mar 1949	1480	04 May 1983	1840
21 Apr 1950	2940	31 May 1984	2950
05 Dec 1950	1560	17 Apr 1985	1380
02 Jun 1952	2380	31 Mar 1986	2350
27 Mar 1953	2720	31 Mar 1987	4180
23 Apr 1954	2860	06 Apr 1988	1700
15 Apr 1955	2620	06 Apr 1989	2200
30 Apr 1956	1710	18 Mar 1990	3430
22 Apr 1957	1370	24 Dec 1990	2270
21 Dec 1957	2180	23 Apr 1992	2180
04 Apr 1959	1160	17 Apr 1993	1900
29 Nov 1959	2780	17 Apr 1994	2760
24 Apr 1961	1580	06 Aug 1995	4536
08 Apr 1962	2110	24 Apr 1996	2160
22 Apr 1963	2160	02 Dec 1996	1860
15 Apr 1964	2750	31 Mar 1998	2680
14 Jun 1965	1190	18 Sep 1999	1540
26 Mar 1966	1560	11 May 2000	2110
03 Apr 1967	1800	25 Apr 2001	2950
24 Mar 1968	1600	14 Apr 2002	2410
29 Apr 1969	2400	30 Mar 2003	2230
25 Apr 1970	3010	28 Oct 2003	1980
04 May 1971	1490	04 Apr 2005	1610
05 May 1972	2920	17 Oct 2005	2640
01 Jul 1973	4940	24 Apr 2007	1930
22 Dec 1973	2550	20 Apr 2008	1940
20 Apr 1975	1250	04 Apr 2009	1810
02 Apr 1976	2670	24 Mar 2010	1900
31 Mar 1977	2020	01 Oct 2010	3140
10 May 1978	1460	20 Mar 2012	1370
26 Mar 1979	1620	20 Apr 2013	2180
10 Apr 1980	1460	16 Apr 2014	4250

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 1**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 1**" from the list of available analyses. When "B17C Example 1" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-3.

Shown in Figure C-3 are the general settings that were used to perform this Bulletin 17 Analysis. As shown, the **Skew** option was set to use the **Weighted Skew**. To use the weighted skew option, the user must enter a value for the Regional Skew and the Regional Skew Mean Square Error

(MSE). In this example, a regional skew of 0.44 was used along with a Regional Skew MSE of 0.078.

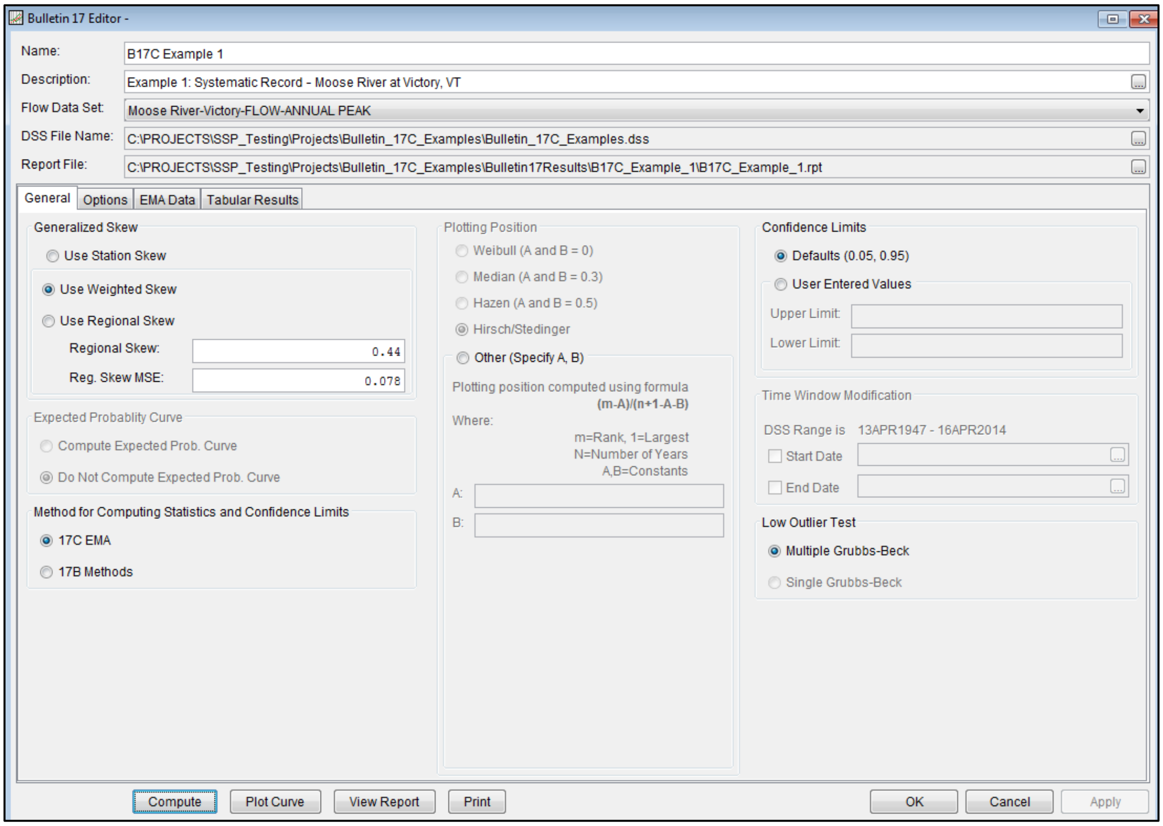


Figure C-3. Bulletin 17 Analysis General Tab for “B17C Example 1”.

No changes to the **Options** tab are necessary.

The **EMA Data** tab for this example is shown in Figure C-4. Since this example uses an annual maximum series consisting entirely of systematic data with a complete record, a single zero – inf perception threshold is adequate. No modifications to the default flow ranges and data types are necessary.

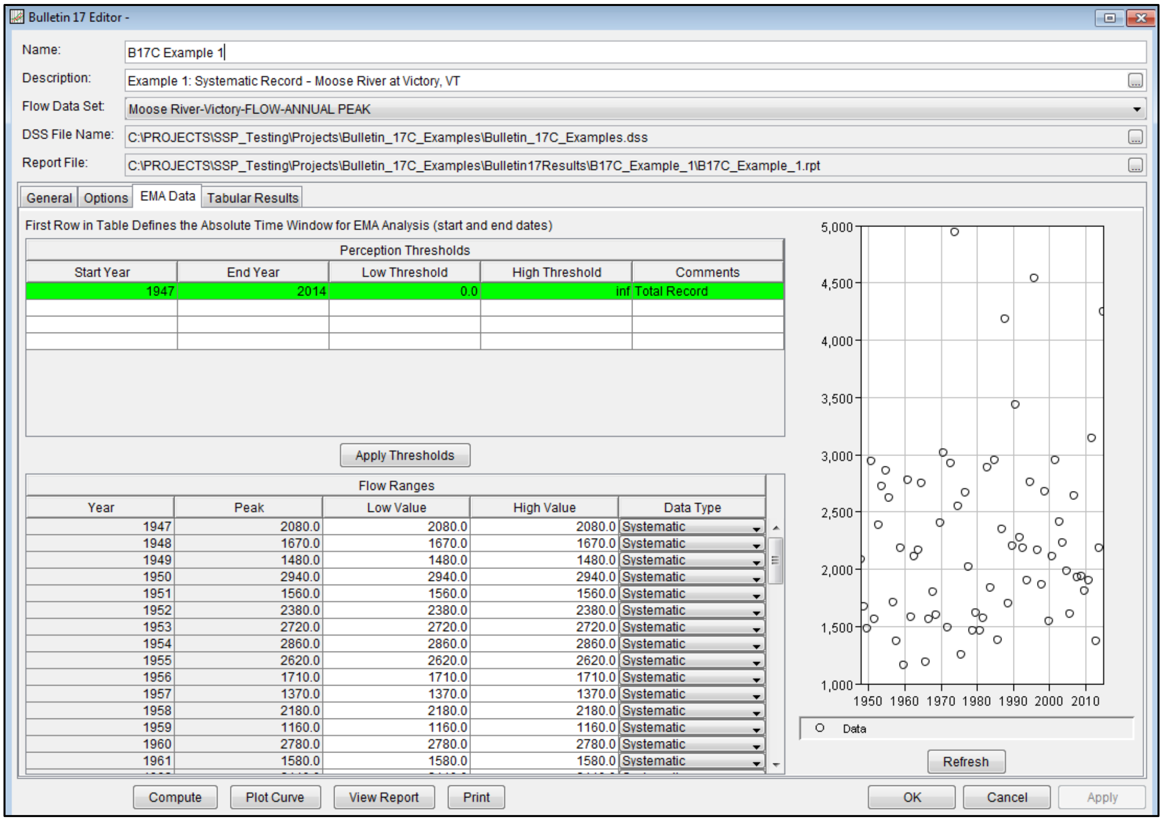


Figure C-4. Bulletin 17 Analysis EMA Data Tab for "B17C Example 1".

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-5.

As shown in Figure C-5, the Frequency Curve table contains the following results:

- Percent Chance Exceedance
- Computed Curve (Log Pearson Type III results)
- Confidence Limits (5% and 95% chance exceedance)

On the bottom, left side of the results tab is a table of Statistics for the observed station data (mean, standard deviation, and station skew) and regional adjustment (regional skew, weighted skew, and adopted skew). Also on the bottom, right side of the results tab is a Number of Events table showing the number of historic events used in the analysis, number of high outliers found, number of low outliers and zero flows found, number of missing flows, number of systematic events, and the historic period in years. In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA and Bulletin 17C procedures to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger plotting positions are shown in Figure C-6.

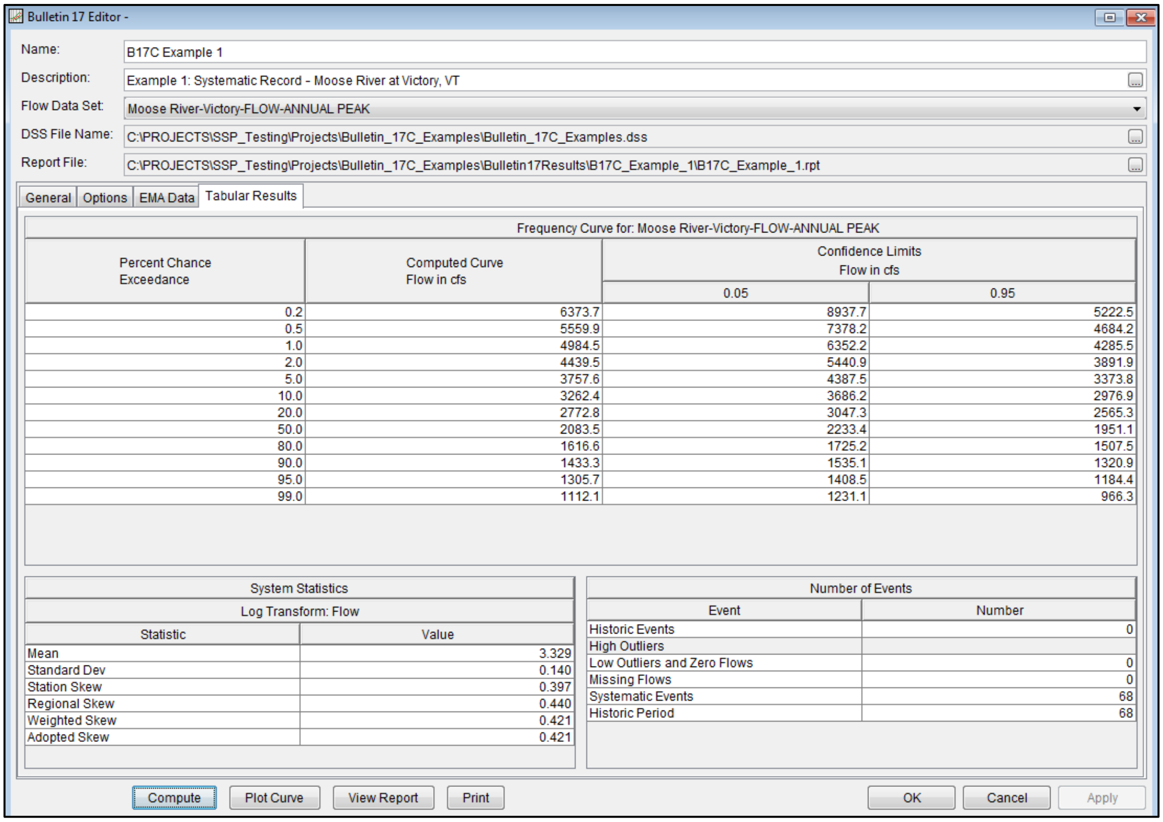


Figure C-5. Bulletin 17 Analysis Tabular Results Tab for “B17C Example 1”.

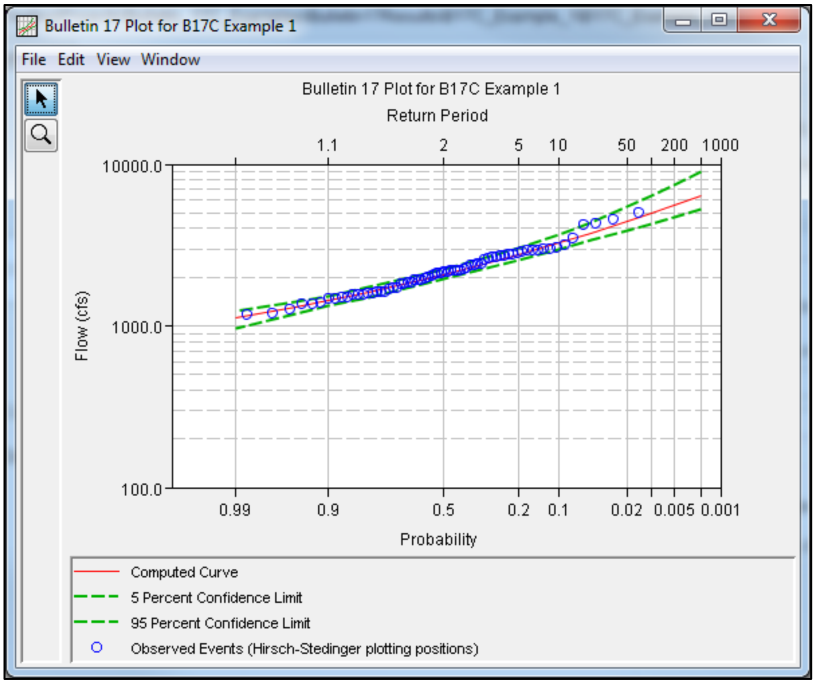
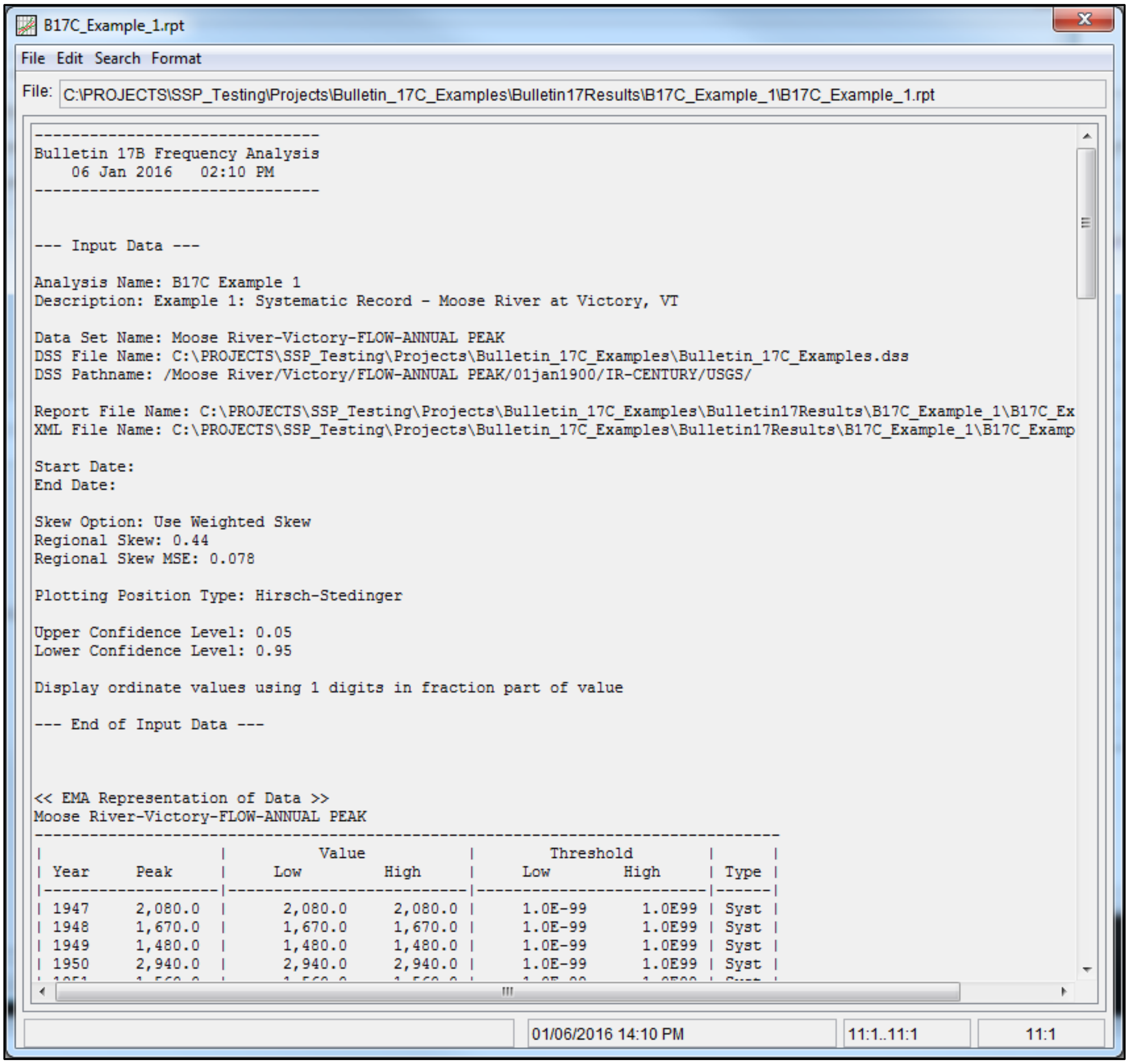


Figure C-6. Plotted Frequency Curves for "B17C Example 1".

Because the annual peak flow record contains only systematic peaks with no historic information, no censored peaks, and no low outliers identified using the Multiple Grubbs-Beck Test, the fitted peak flow frequency curve using EMA and Bulletin 17C procedures is the same as that obtained using Bulletin 17B procedures. However, due to the appropriate use of diverse information within the Bulletin 17C procedures, the 5% and 95% confidence limits are different when compared against results obtained using Bulletin 17B procedures.

In addition to the tabular and graphical results, there is a report file that shows the order in which the calculations were performed. To review the report file, press the **View Report** button at the bottom of the analysis window. When this button is selected, a text viewer will open the file and display it on the screen. Shown in Figure C-7 is the report file.

The report file contains a listing of the input data, preliminary results, outlier and historical data tests, additional calculations needed, and the final frequency curve results. Different types and amounts of information will show up in the report file depending on the data and the options that have been selected for the analysis. The user should review the report file to understand how the Bulletin 17C procedures were applied.



B17C_Example_1.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_1\B17C_Example_1.rpt

```
------------------------------
Bulletin 17B Frequency Analysis
    06 Jan 2016   02:10 PM
------------------------------


--- Input Data ---

Analysis Name: B17C Example 1
Description: Example 1: Systematic Record - Moose River at Victory, VT

Data Set Name: Moose River-Victory-FLOW-ANNUAL PEAK
DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin_17C_Examples.dss
DSS Pathname: /Moose River/Victory/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_1\B17C_Ex
XML File Name: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_1\B17C_Examp

Start Date:
End Date:

Skew Option: Use Weighted Skew
Regional Skew: 0.44
Regional Skew MSE: 0.078

Plotting Position Type: Hirsch-Stedinger

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---



<< EMA Representation of Data >>
Moose River-Victory-FLOW-ANNUAL PEAK
--------------------------------------------------------------------------------
|                   |          Value           |        Threshold         |      |
| Year     Peak     |     Low          High    |    Low          High     | Type |
|-------------------|--------------------------|--------------------------|------|
| 1947     2,080.0  |     2,080.0      2,080.0 |    1.0E-99       1.0E99  | Syst |
| 1948     1,670.0  |     1,670.0      1,670.0 |    1.0E-99       1.0E99  | Syst |
| 1949     1,480.0  |     1,480.0      1,480.0 |    1.0E-99       1.0E99  | Syst |
| 1950     2,940.0  |     2,940.0      2,940.0 |    1.0E-99       1.0E99  | Syst |
```

01/06/2016 14:10 PM 11:1..11:1 11:1

Figure C-7. Report File for “B17C Example 1”.

Example 2: Analysis with Low Outliers – Orestimba Creek near Newman, CA

Example 2 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of systematic flood peaks when low outliers (a.k.a. Potentially Influential Low Flows, PILFs) are present.

For this example, USGS gage 11274500 Orestimba Creek near Newman, CA is used. Orestimba Creek is a tributary to the San Joaquin River, whose 134 sq. mi. drainage area lies on the eastern slope of the Diablo Range section of the Coast Range Mountains of California. The drainage basin has an average basin elevation of approximately 1,550 feet with peak flows usually occurring in late winter. Orestimba Creek is one of the few tributaries in the area to maintain a definite stream channel from the foothills to the San Joaquin River (England, et al., 2015)

The Orestimba Creek near Newman, CA stream gage has an annual peak record consisting of 82 peaks beginning in 1932 and ending in water year 2013. Of the 82 annual peaks, there are 12 years for which the annual peak is 0 cfs. The annual maximum series is plotted in Figure C-8 and tabulated in Table C-.

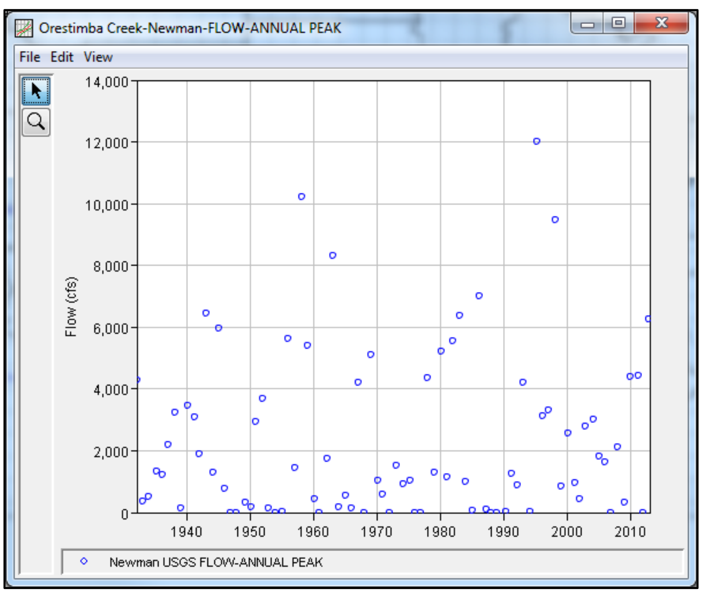


Figure C-8. Orestimba Creek near Newman, CA Annual Peak Flow Record.

Table C-2. Orestimba Creek near Newman, CA Annual Peak Flow Record.

Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
08 Feb 1932	4260	10 Feb 1960	448	30 Nov 1987	0
29 Jan 1933	345	30 Nov 1960	0	30 Nov 1988	0
01 Jan 1934	516	15 Feb 1962	1740	28 May 1990	4
08 Apr 1935	1320	01 Feb 1963	8300	24 Mar 1991	1260
13 Feb 1936	1200	22 Jan 1964	156	15 Feb 1992	888
13 Feb 1937	2180	06 Jan 1965	560	13 Jan 1993	4190
11 Feb 1938	3230	30 Dec 1965	128	20 Feb 1994	12
09 Mar 1939	115	24 Jan 1967	4200	10 Mar 1995	12000
27 Feb 1940	3440	30 Nov 1967	0	19 Feb 1996	3130
04 Apr 1941	3070	25 Jan 1969	5080	23 Jan 1997	3320
24 Jan 1942	1880	01 Mar 1970	1010	03 Feb 1998	9470
21 Jan 1943	6450	21 Dec 1970	584	09 Feb 1999	833
29 Feb 1944	1290	30 Nov 1971	0	14 Feb 2000	2550
02 Feb 1945	5970	11 Feb 1973	1510	05 Mar 2001	958
25 Dec 1945	782	03 Mar 1974	922	03 Jan 2002	425
30 Nov 1946	0	08 Mar 1975	1010	16 Dec 2002	2790
30 Nov 1947	0	30 Nov 1975	0	25 Feb 2004	2990
12 Mar 1949	335	30 Nov 1976	0	16 Feb 2005	1820
05 Feb 1950	175	17 Jan 1978	4360	02 Jan 2006	1630
03 Dec 1950	2920	21 Feb 1979	1270	30 Nov 2006	0
12 Jan 1952	3660	16 Feb 1980	5210	25 Jan 2008	2110
07 Dec 1952	147	29 Jan 1981	1130	17 Feb 2009	310
30 Nov 1953	0	05 Jan 1982	5550	20 Jan 2010	4400
19 Jan 1955	16	24 Jan 1983	6360	24 Mar 2011	4440
23 Dec 1955	5620	25 Dec 1983	991	30 Nov 2011	0
24 Feb 1957	1440	09 Feb 1985	50	24 Dec 2012	6250
02 Apr 1958	10200	19 Feb 1986	6990		
16 Feb 1959	5380	06 Mar 1987	112		

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 2**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 2**" from the list of available analyses. When "B17C Example 2" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-9.

Shown in Figure C-9 are the general settings that were used to perform this Bulletin 17 Analysis. As shown, the **Skew** option was set to use the **Station Skew**.

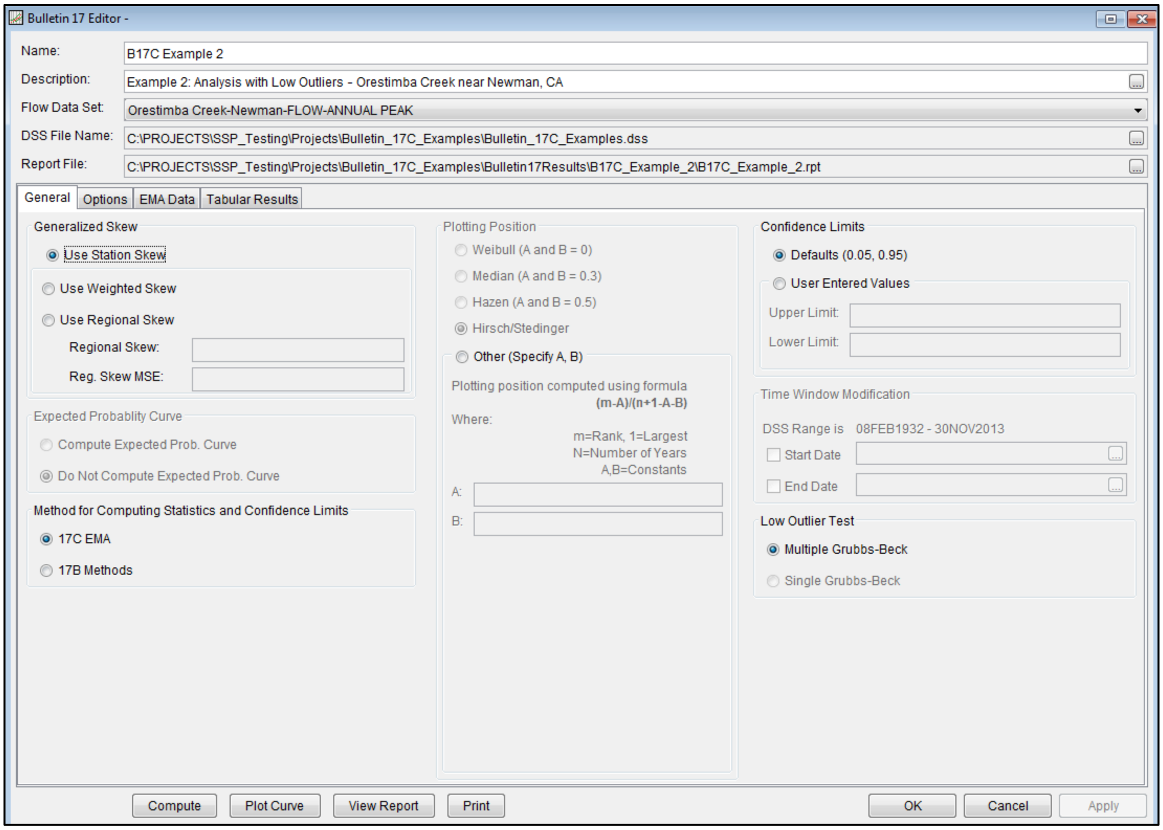


Figure C-9. Bulletin 17 Analysis General Tab for “B17C Example 2”.

No changes to the **Options** tab are necessary.

The **EMA Data** tab for this example is shown in Figure C-10. Since this example uses an annual maximum series consisting entirely of systematic data with a complete record, a single zero – inf perception threshold is adequate. No modifications to the default flow ranges and data types are necessary.

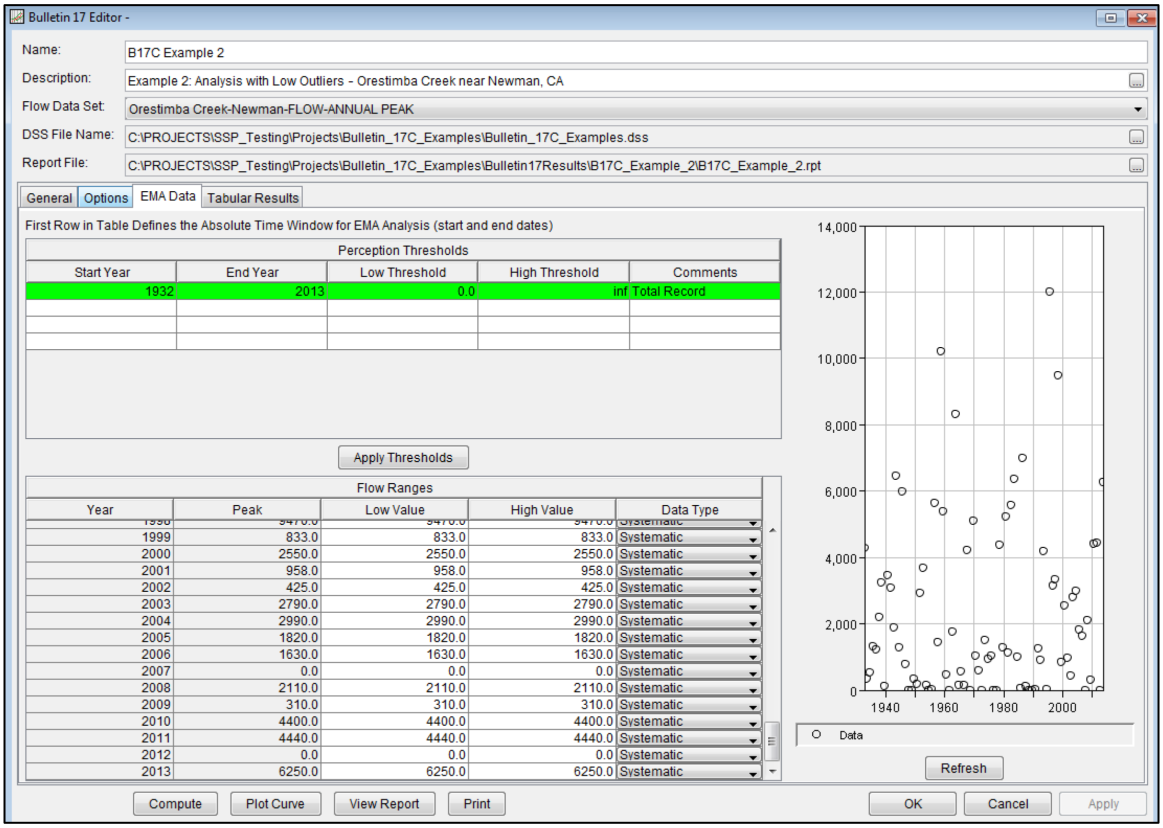
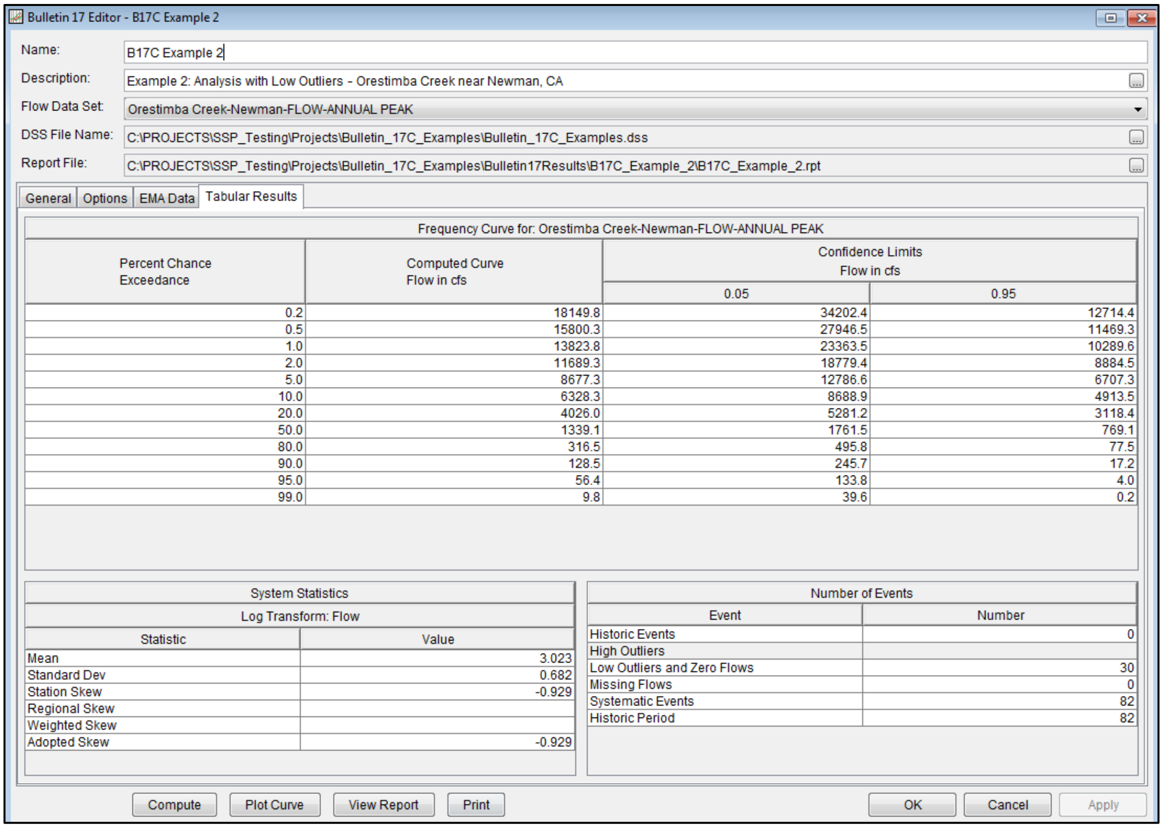


Figure C-10. Bulletin 17 Analysis EMA Data Tab for “B17C Example 2”.

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-11.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger and Median (for low outliers) plotting positions are shown in Figure C-12.



Bulletin 17 Editor - B17C Example 2

Name: B17C Example 2

Description: Example 2: Analysis with Low Outliers - Orestimba Creek near Newman, CA

Flow Data Set: Orestimba Creek-Newman-FLOW-ANNUAL PEAK

DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin_17C_Examples.dss

Report File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_2\B17C_Example_2.rpt

General | Options | EMA Data | Tabular Results

Frequency Curve for: Orestimba Creek-Newman-FLOW-ANNUAL PEAK

Percent Chance Exceedance	Computed Curve Flow in cfs	Confidence Limits Flow in cfs	
		0.05	0.95
0.2	18149.8	34202.4	12714.4
0.5	15800.3	27946.5	11469.3
1.0	13823.8	23363.5	10289.6
2.0	11689.3	18779.4	8884.5
5.0	8677.3	12786.6	6707.3
10.0	6328.3	8688.9	4913.5
20.0	4026.0	5281.2	3118.4
50.0	1339.1	1761.5	769.1
80.0	316.5	495.8	77.5
90.0	128.5	245.7	17.2
95.0	56.4	133.8	4.0
99.0	9.8	39.6	0.2

System Statistics

Log Transform: Flow

Statistic	Value
Mean	3.023
Standard Dev	0.682
Station Skew	-0.929
Regional Skew	
Weighted Skew	
Adopted Skew	-0.929

Number of Events

Event	Number
Historic Events	0
High Outliers	
Low Outliers and Zero Flows	30
Missing Flows	0
Systematic Events	82
Historic Period	82

Compute | Plot Curve | View Report | Print | OK | Cancel | Apply

Figure C-11. Bulletin 17 Analysis Tabular Results Tab for "B17C Example 2".

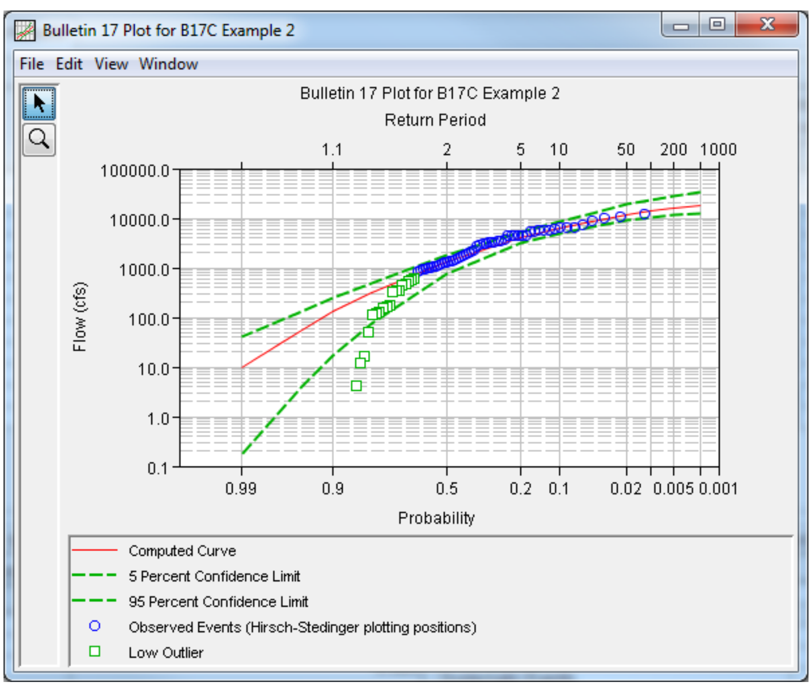


Figure C-12. Plotted Frequency Curves for "B17C Example 2".

As shown in Figure C-12, the Multiple Grubbs-Beck Test identified a low outlier threshold of 782 cfs. Thirty annual peak flows were identified as being less than this threshold, as shown in Figure C-13. These annual peak flows were then recoded to have a flow interval of zero – 782. The perception threshold for the entire historical period was also adjusted to correspond with the Multiple Grubbs-Beck Test low outlier threshold. Consequently, the perception threshold was changed from zero – inf to 782 – inf, as shown in Figure C-14.

B17C_Example_2.rpt

File Edit Search Format

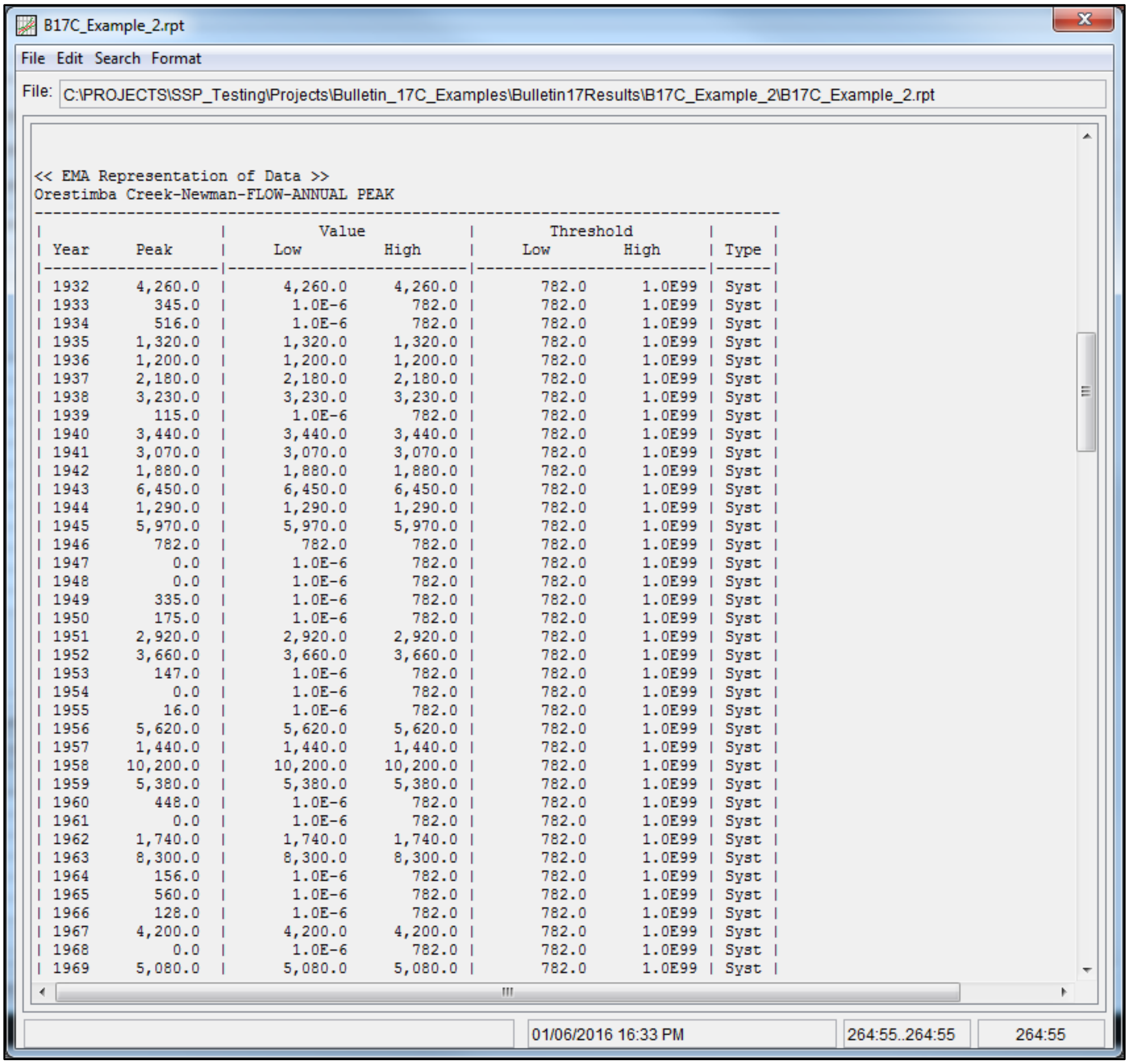
File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_2\B17C_Example_2.rpt

```
|  08 Mar 1975     1,010.0  |   44      1981     1,130.0   52.65   |
|  30 Nov 1975         0.0  |   45      1975     1,010.0   53.84   |
|  30 Nov 1976         0.0  |   46      1970     1,010.0   55.04   |
|  17 Jan 1978     4,360.0  |   47      1984       991.0   56.24   |
|  21 Feb 1979     1,270.0  |   48      2001       958.0   57.43   |
|  16 Feb 1980     5,210.0  |   49      1974       922.0   58.63   |
|  29 Jan 1981     1,130.0  |   50      1992       888.0   59.83   |
|  05 Jan 1982     5,550.0  |   51      1999       833.0   61.02   |
|  24 Jan 1983     6,360.0  |   52      1946       782.0   62.22   |
|  25 Dec 1983       991.0  |   53      1971       584.0*  63.96   |
|  09 Feb 1985        50.0  |   54      1965       560.0*  65.17   |
|  19 Feb 1986     6,990.0  |   55      1934       516.0*  66.38   |
|  06 Mar 1987       112.0  |   56      1960       448.0*  67.60   |
|  30 Nov 1987         0.0  |   57      2002       425.0*  68.81   |
|  30 Nov 1988         0.0  |   58      1933       345.0*  70.02   |
|  28 May 1990         4.0  |   59      1949       335.0*  71.24   |
|  24 Mar 1991     1,260.0  |   60      2009       310.0*  72.45   |
|  15 Feb 1992       888.0  |   61      1950       175.0*  73.67   |
|  13 Jan 1993     4,190.0  |   62      1964       156.0*  74.88   |
|  20 Feb 1994        12.0  |   63      1953       147.0*  76.09   |
|  10 Mar 1995    12,000.0  |   64      1966       128.0*  77.31   |
|  19 Feb 1996     3,130.0  |   65      1939       115.0*  78.52   |
|  23 Jan 1997     3,320.0  |   66      1987       112.0*  79.73   |
|  03 Feb 1998     9,470.0  |   67      1985        50.0*  80.95   |
|  09 Feb 1999       833.0  |   68      1955        16.0*  82.16   |
|  14 Feb 2000     2,550.0  |   69      1994        12.0*  83.37   |
|  05 Mar 2001       958.0  |   70      1990         4.0*  84.59   |
|  03 Jan 2002       425.0  |   71      2012         0.0*  85.80   |
|  16 Dec 2002     2,790.0  |   72      2007         0.0*  87.01   |
|  25 Feb 2004     2,990.0  |   73      1989         0.0*  88.23   |
|  16 Feb 2005     1,820.0  |   74      1988         0.0*  89.44   |
|  02 Jan 2006     1,630.0  |   75      1977         0.0*  90.66   |
|  30 Nov 2006         0.0  |   76      1976         0.0*  91.87   |
|  25 Jan 2008     2,110.0  |   77      1972         0.0*  93.08   |
|  17 Feb 2009       310.0  |   78      1968         0.0*  94.30   |
|  20 Jan 2010     4,400.0  |   79      1961         0.0*  95.51   |
|  24 Mar 2011     4,440.0  |   80      1954         0.0*  96.72   |
|  30 Nov 2011         0.0  |   81      1948         0.0*  97.94   |
|  24 Dec 2012     6,250.0  |   82      1947         0.0*  99.15   |
|---------------------------|-------------------------------------|
                                                 * Outlier
* Low outlier plotting positions are computed using Median parameters.


<< Frequency Curve >>
```

01/06/2016 16:33 PM | 264:55..264:55 | 264:55

Figure C-13. Report File for “B17C Example 2” showing censored low outliers and zero flows.



<< EMA Representation of Data >>
Orestimba Creek-Newman-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1932	4,260.0	4,260.0	4,260.0	782.0	1.0E99	Syst
1933	345.0	1.0E-6	782.0	782.0	1.0E99	Syst
1934	516.0	1.0E-6	782.0	782.0	1.0E99	Syst
1935	1,320.0	1,320.0	1,320.0	782.0	1.0E99	Syst
1936	1,200.0	1,200.0	1,200.0	782.0	1.0E99	Syst
1937	2,180.0	2,180.0	2,180.0	782.0	1.0E99	Syst
1938	3,230.0	3,230.0	3,230.0	782.0	1.0E99	Syst
1939	115.0	1.0E-6	782.0	782.0	1.0E99	Syst
1940	3,440.0	3,440.0	3,440.0	782.0	1.0E99	Syst
1941	3,070.0	3,070.0	3,070.0	782.0	1.0E99	Syst
1942	1,880.0	1,880.0	1,880.0	782.0	1.0E99	Syst
1943	6,450.0	6,450.0	6,450.0	782.0	1.0E99	Syst
1944	1,290.0	1,290.0	1,290.0	782.0	1.0E99	Syst
1945	5,970.0	5,970.0	5,970.0	782.0	1.0E99	Syst
1946	782.0	782.0	782.0	782.0	1.0E99	Syst
1947	0.0	1.0E-6	782.0	782.0	1.0E99	Syst
1948	0.0	1.0E-6	782.0	782.0	1.0E99	Syst
1949	335.0	1.0E-6	782.0	782.0	1.0E99	Syst
1950	175.0	1.0E-6	782.0	782.0	1.0E99	Syst
1951	2,920.0	2,920.0	2,920.0	782.0	1.0E99	Syst
1952	3,660.0	3,660.0	3,660.0	782.0	1.0E99	Syst
1953	147.0	1.0E-6	782.0	782.0	1.0E99	Syst
1954	0.0	1.0E-6	782.0	782.0	1.0E99	Syst
1955	16.0	1.0E-6	782.0	782.0	1.0E99	Syst
1956	5,620.0	5,620.0	5,620.0	782.0	1.0E99	Syst
1957	1,440.0	1,440.0	1,440.0	782.0	1.0E99	Syst
1958	10,200.0	10,200.0	10,200.0	782.0	1.0E99	Syst
1959	5,380.0	5,380.0	5,380.0	782.0	1.0E99	Syst
1960	448.0	1.0E-6	782.0	782.0	1.0E99	Syst
1961	0.0	1.0E-6	782.0	782.0	1.0E99	Syst
1962	1,740.0	1,740.0	1,740.0	782.0	1.0E99	Syst
1963	8,300.0	8,300.0	8,300.0	782.0	1.0E99	Syst
1964	156.0	1.0E-6	782.0	782.0	1.0E99	Syst
1965	560.0	1.0E-6	782.0	782.0	1.0E99	Syst
1966	128.0	1.0E-6	782.0	782.0	1.0E99	Syst
1967	4,200.0	4,200.0	4,200.0	782.0	1.0E99	Syst
1968	0.0	1.0E-6	782.0	782.0	1.0E99	Syst
1969	5,080.0	5,080.0	5,080.0	782.0	1.0E99	Syst

Figure C-14. Report File for “B17C Example 2” showing recoded perception threshold.

Example 3: Broken Record – Back Creek near Jones Springs, WV

Example 3 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of a broken record of systematic flood peaks.

For this example, USGS gage 01614000 Back Creek near Jones Springs, West Virginia is used. Back Creek is a tributary to the Potomac River; the 235 square mile watershed lies within the Valley and Ridge province in West Virginia (England, et al., 2015). Gage 01614000 has an annual peak record consisting of 56 peaks beginning in 1929 and ending in 2012. There are three “broken record” periods where the gage was discontinued: 1932-1937, 1976-1991, and 1999-2003. Thus, there are 28 years of missing data at this gage during the period 1929-2012. There is a historic flood that occurred outside the period of gaging record on March 17, 1936. This flood is noted in the USGS Annual Water Data Report for this gage, available in the peak-flow file, and there is historical information available for this large flood (Grover, 1937).

The Back Creek near Jones Springs, WV stream gage has an annual peak record consisting of 56 annual peaks. Of the 56 annual peaks, the October 1942 flood slightly exceeds the March 1936 historic flood peak. Based on the historical flood information in Grover (1937) for the 1936 flood, and the large regional floods and historical floods described by Wiley and Atkins (2010) in West Virginia for the period 1888-1996, information from the March 1936 flood can be used as a perception threshold to represent the 28 years of missing information. The annual maximum series is plotted in Figure C-15 and tabulated in Table C-.

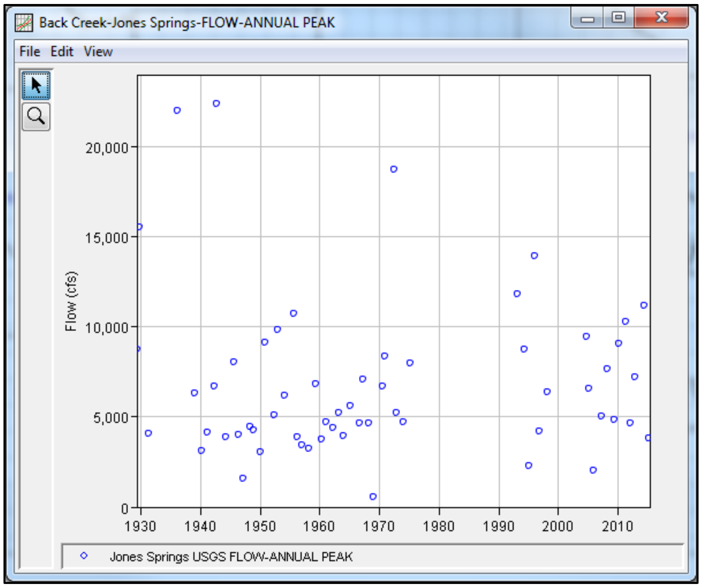


Figure C-15. Back Creek near Jones Springs, WV Annual Peak Flow Record.

Table C-3. Back Creek near Jones Springs, WV Annual Peak Flow Record.

Date	Flow (cfs)	Date	Flow (cfs)
17 Apr 1929	8750	20 Mar 1963	5190
23 Oct 1929	15500	10 Jan 1964	3960
08 May 1931	4060	06 Mar 1965	5600
17 Mar 1936	22000	21 Sep 1966	4670
04 Feb 1939	6300	08 Mar 1967	7080
20 Apr 1940	3130	17 Mar 1968	4640
06 Apr 1941	4160	02 Feb 1969	536
22 May 1942	6700	10 Jul 1970	6680
15 Oct 1942	22400	13 Nov 1970	8360
24 Mar 1944	3880	22 Jun 1972	18700
18 Sep 1945	8050	09 Dec 1972	5210
03 Jun 1946	4020	27 Dec 1973	4680
15 Mar 1947	1600	20 Mar 1975	7940
14 Apr 1948	4460	05 Mar 1993	11800
31 Dec 1948	4230	08 May 1994	8730
02 Feb 1950	3010	16 Jan 1995	2300
05 Dec 1950	9150	19 Jan 1996	13900
28 Apr 1952	5100	09 Nov 1996	4190
22 Nov 1952	9820	21 Mar 1998	6370
02 Mar 1954	6200	29 Sep 2004	9460
19 Aug 1955	10700	29 Mar 2005	6560
15 Mar 1956	3880	30 Nov 2005	2000
10 Feb 1957	3420	16 Apr 2007	5040
27 Mar 1958	3240	21 Apr 2008	7670
03 Jun 1959	6800	05 May 2009	4830
09 May 1960	3740	14 Mar 2010	9070
19 Feb 1961	4700	17 Apr 2011	10300
22 Mar 1962	4380	01 Mar 2012	4650

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 3**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 3**" from the list of available analyses. When "B17C Example 3" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-16.

Shown in Figure C-16 are the general settings that were used to perform this Bulletin 17 Analysis. As shown, the **Skew** option was set to use the **Station Skew**.

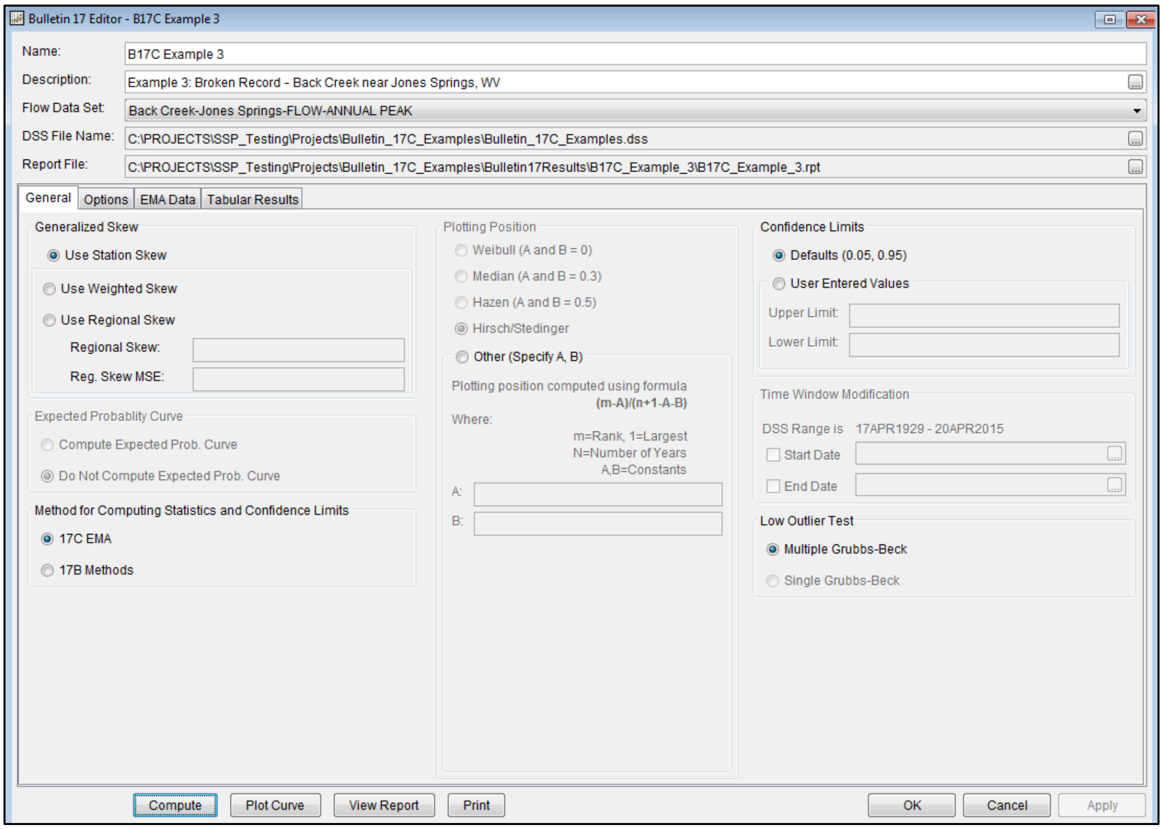


Figure C-16. Bulletin 17 Analysis General Tab for "B17C Example 3".

No changes to the **Options** tab are necessary.

The **EMA Data** tab for this example is shown in Figure C-17. This example uses an annual maximum series consisting of both systematic data along with an historical event in March 1936. Also, the record is broken with multiple periods of missing with a complete record. Since 17C EMA requires a **non** zero – inf perception threshold for all periods of missing data, a total of five perception thresholds are required. In this case, the March 1936 event can be used to inform the perception thresholds for the periods of missing annual peak flow data. The use of a perception threshold of 21000 – inf for these periods of missing data implies that had a flood event occurred with a peak flow greater than 21,000 cfs, someone would have measured and recorded it. Once all five perception thresholds have been entered as shown in Figure C-17, click the **Apply Thresholds** button to assign the complementary flow ranges for the periods of missing data.

Finally, the March 1936 Event should be set to the historical data type, as denoted by a USGS peak flow rate qualification code of "7".

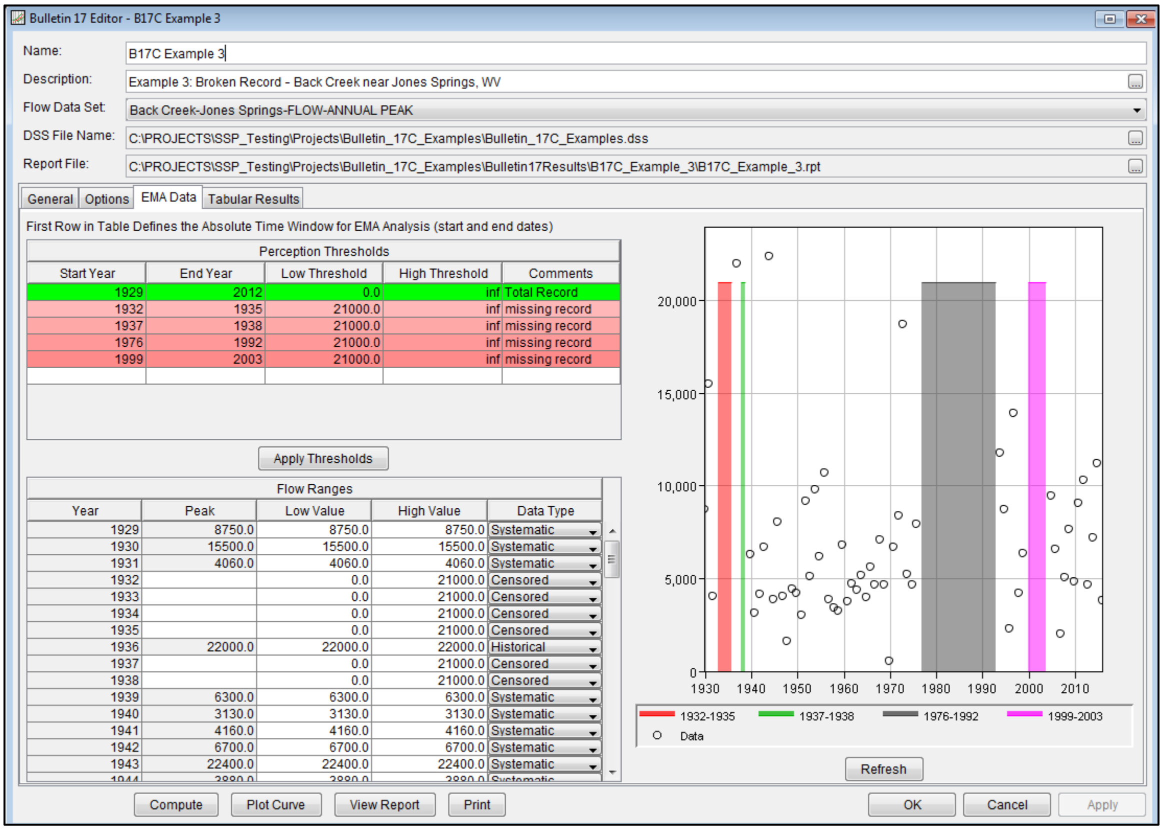
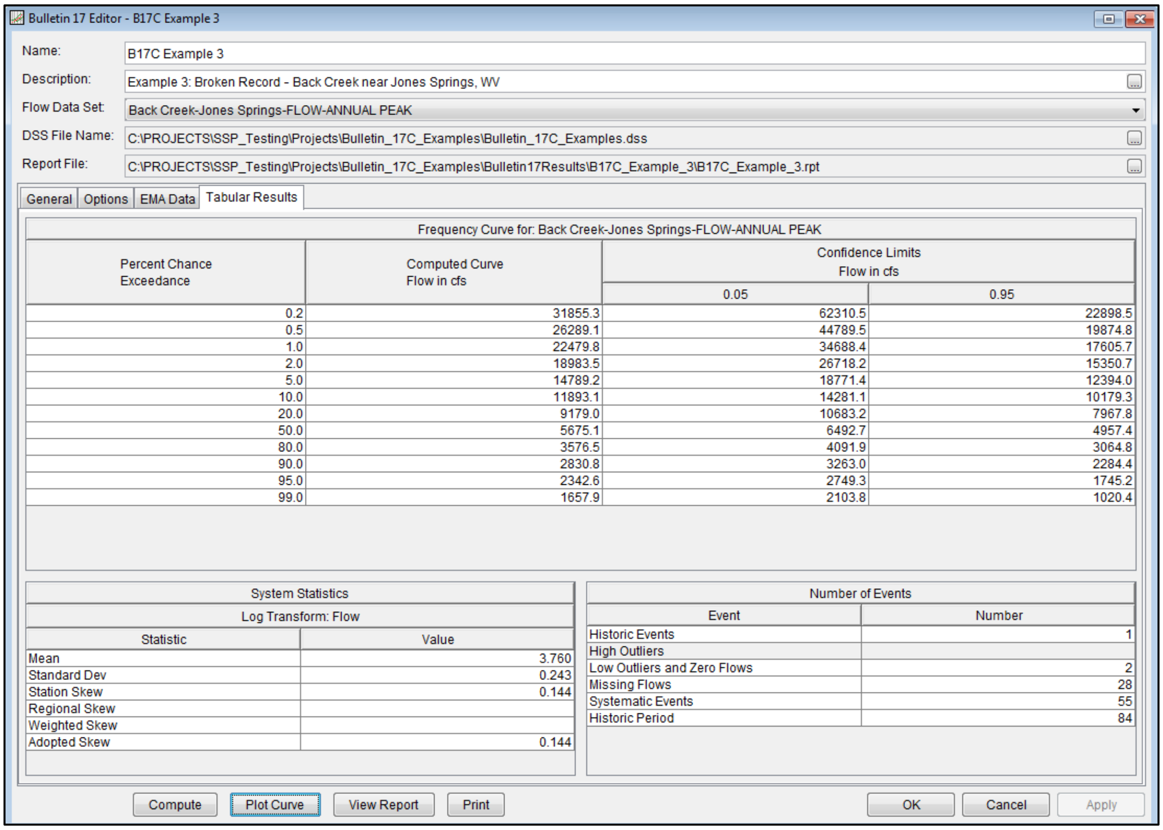


Figure C-17. Bulletin 17 Analysis EMA Data Tab for "B17C Example 3".

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-18.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger and Median (for low outliers) plotting positions are shown in Figure C-19.



Percent Chance Exceedance	Computed Curve Flow in cfs	Confidence Limits Flow in cfs	
		0.05	0.95
0.2	31855.3	62310.5	22898.5
0.5	26289.1	44789.5	19874.8
1.0	22479.8	34688.4	17605.7
2.0	18983.5	26718.2	15350.7
5.0	14789.2	18771.4	12394.0
10.0	11893.1	14281.1	10179.3
20.0	9179.0	10683.2	7967.8
50.0	5675.1	6492.7	4957.4
80.0	3576.5	4091.9	3064.8
90.0	2830.8	3263.0	2284.4
95.0	2342.6	2749.3	1745.2
99.0	1657.9	2103.8	1020.4

System Statistics

Log Transform: Flow

Statistic	Value
Mean	3.760
Standard Dev	0.243
Station Skew	0.144
Regional Skew	
Weighted Skew	
Adopted Skew	0.144

Number of Events

Event	Number
Historic Events	1
High Outliers	
Low Outliers and Zero Flows	2
Missing Flows	28
Systematic Events	55
Historic Period	84

Figure C-18. Bulletin 17 Analysis Tabular Results Tab for "B17C Example 3".

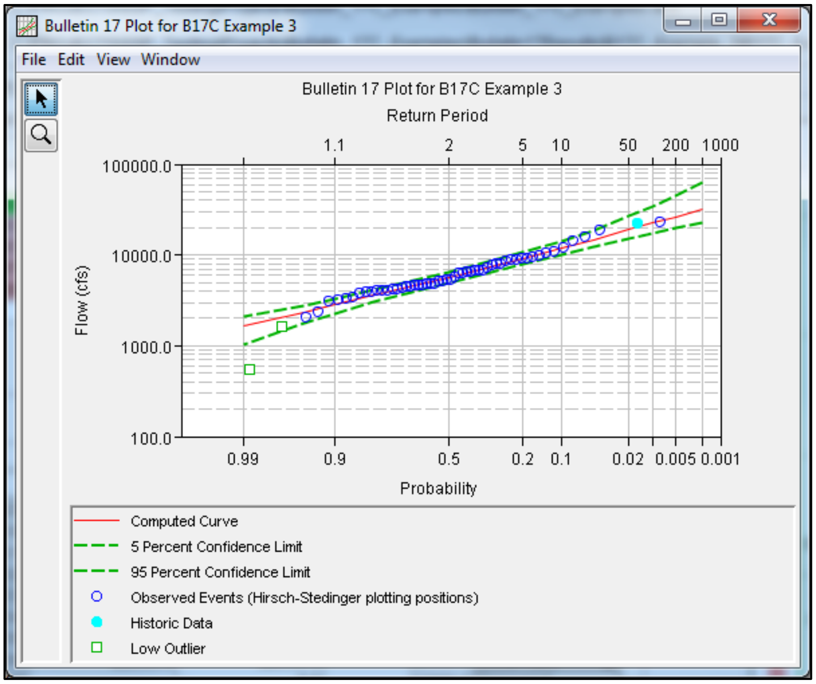
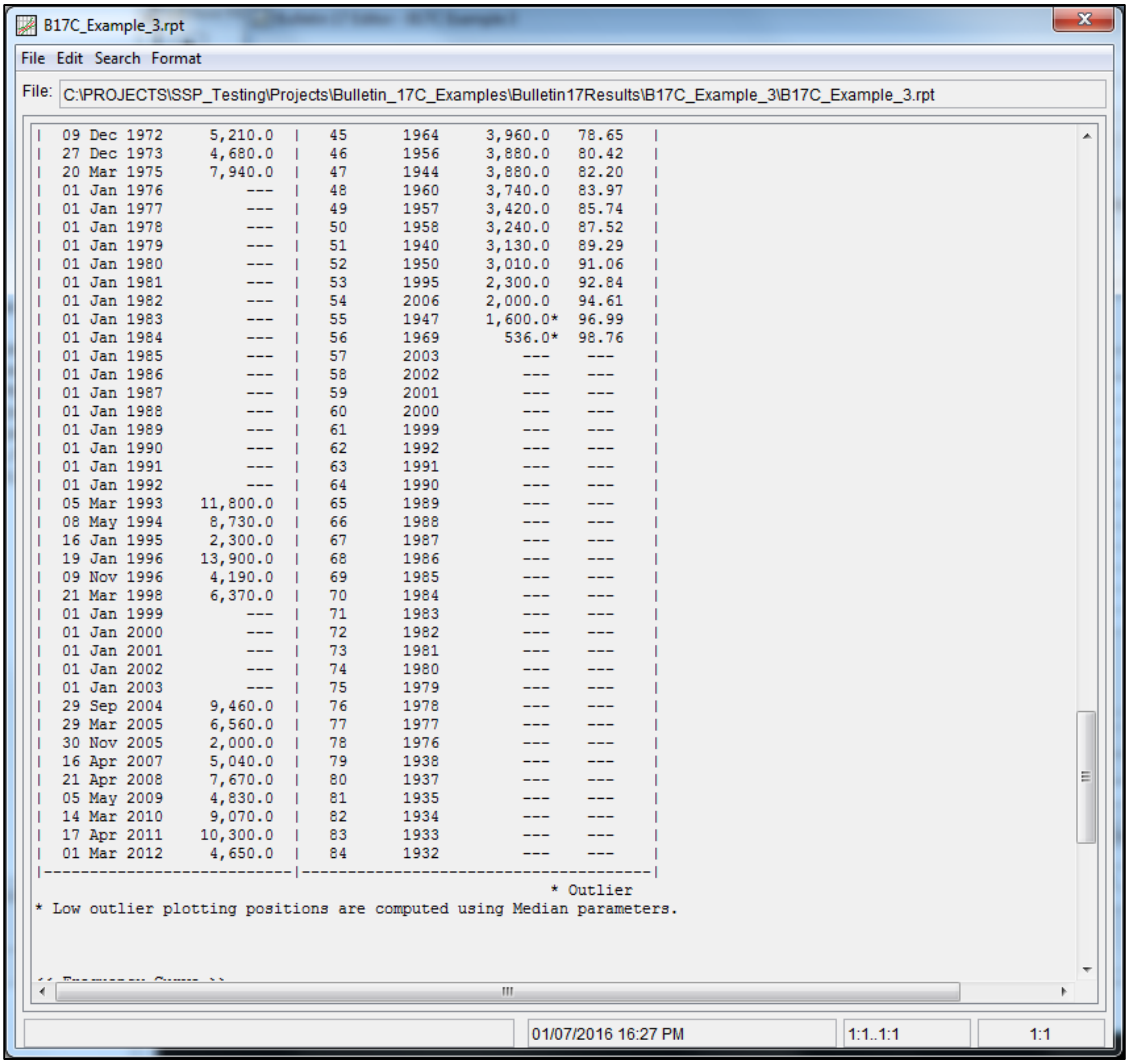


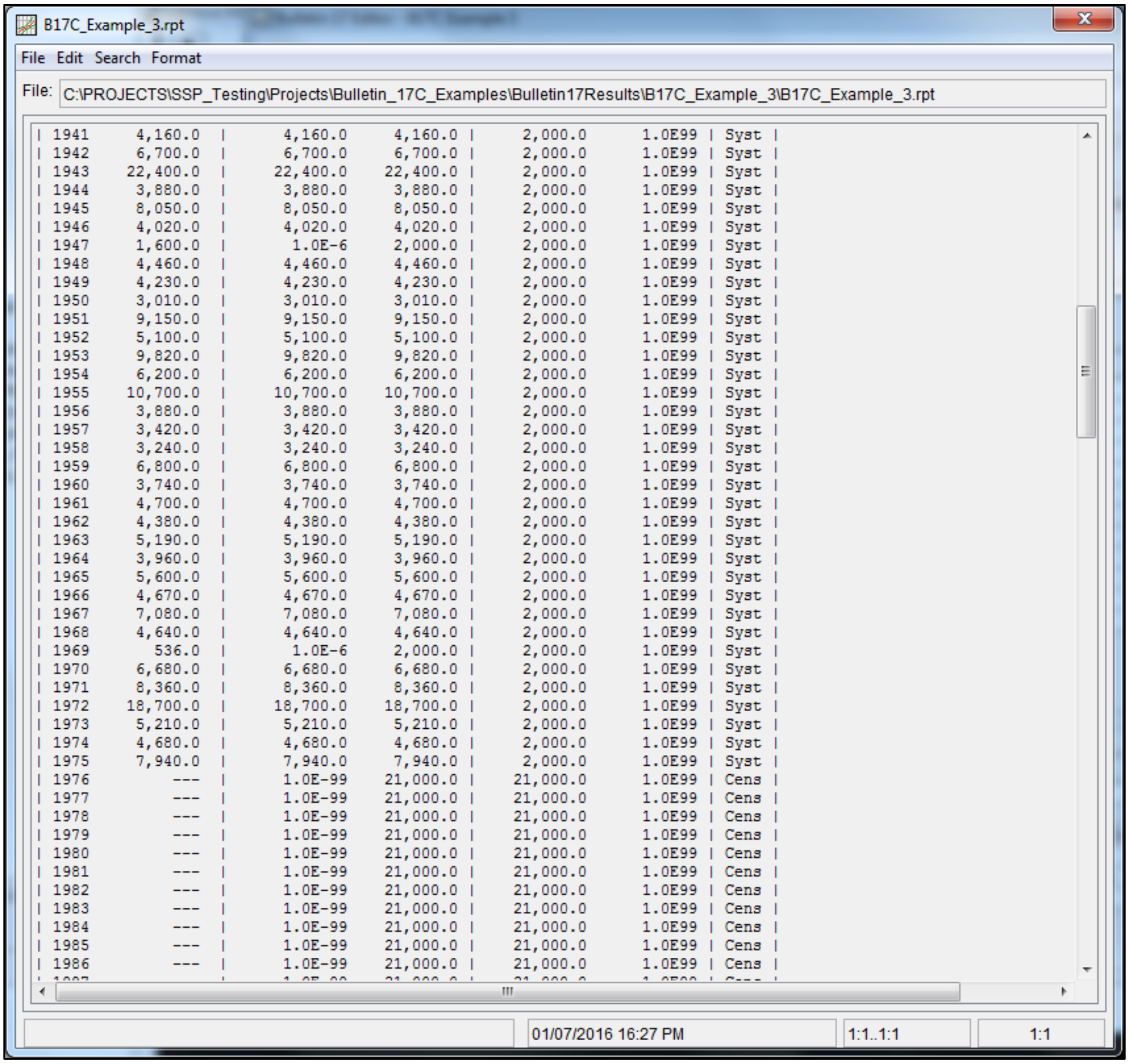
Figure C-19. Plotted Frequency Curves for “B17C Example 3”.

As shown in Figure C-19, the Multiple Grubbs-Beck Test identified a low outlier threshold of 2000 cfs. Two annual peak flows were identified as being less than this threshold, as shown in Figure C-20. These annual peak flows were then recoded to have a flow interval of zero – 2000. The perception thresholds for the years in which an annual peak flow was recorded were also adjusted to correspond with the Multiple Grubbs-Beck Test low outlier threshold. Consequently, these perception thresholds were changed from zero – inf to 2000 – inf, as shown in Figure C-21.




```
|  09 Dec 1972     5,210.0  |  45      1964     3,960.0   78.65   |
|  27 Dec 1973     4,680.0  |  46      1956     3,880.0   80.42   |
|  20 Mar 1975     7,940.0  |  47      1944     3,880.0   82.20   |
|  01 Jan 1976         ---  |  48      1960     3,740.0   83.97   |
|  01 Jan 1977         ---  |  49      1957     3,420.0   85.74   |
|  01 Jan 1978         ---  |  50      1958     3,240.0   87.52   |
|  01 Jan 1979         ---  |  51      1940     3,130.0   89.29   |
|  01 Jan 1980         ---  |  52      1950     3,010.0   91.06   |
|  01 Jan 1981         ---  |  53      1995     2,300.0   92.84   |
|  01 Jan 1982         ---  |  54      2006     2,000.0   94.61   |
|  01 Jan 1983         ---  |  55      1947     1,600.0*  96.99   |
|  01 Jan 1984         ---  |  56      1969       536.0*  98.76   |
|  01 Jan 1985         ---  |  57      2003         ---    ---    |
|  01 Jan 1986         ---  |  58      2002         ---    ---    |
|  01 Jan 1987         ---  |  59      2001         ---    ---    |
|  01 Jan 1988         ---  |  60      2000         ---    ---    |
|  01 Jan 1989         ---  |  61      1999         ---    ---    |
|  01 Jan 1990         ---  |  62      1992         ---    ---    |
|  01 Jan 1991         ---  |  63      1991         ---    ---    |
|  01 Jan 1992         ---  |  64      1990         ---    ---    |
|  05 Mar 1993    11,800.0  |  65      1989         ---    ---    |
|  08 May 1994     8,730.0  |  66      1988         ---    ---    |
|  16 Jan 1995     2,300.0  |  67      1987         ---    ---    |
|  19 Jan 1996    13,900.0  |  68      1986         ---    ---    |
|  09 Nov 1996     4,190.0  |  69      1985         ---    ---    |
|  21 Mar 1998     6,370.0  |  70      1984         ---    ---    |
|  01 Jan 1999         ---  |  71      1983         ---    ---    |
|  01 Jan 2000         ---  |  72      1982         ---    ---    |
|  01 Jan 2001         ---  |  73      1981         ---    ---    |
|  01 Jan 2002         ---  |  74      1980         ---    ---    |
|  01 Jan 2003         ---  |  75      1979         ---    ---    |
|  29 Sep 2004     9,460.0  |  76      1978         ---    ---    |
|  29 Mar 2005     6,560.0  |  77      1977         ---    ---    |
|  30 Nov 2005     2,000.0  |  78      1976         ---    ---    |
|  16 Apr 2007     5,040.0  |  79      1938         ---    ---    |
|  21 Apr 2008     7,670.0  |  80      1937         ---    ---    |
|  05 May 2009     4,830.0  |  81      1935         ---    ---    |
|  14 Mar 2010     9,070.0  |  82      1934         ---    ---    |
|  17 Apr 2011    10,300.0  |  83      1933         ---    ---    |
|  01 Mar 2012     4,650.0  |  84      1932         ---    ---    |
|---------------------------|--------------------------------------|
                                                      * Outlier
* Low outlier plotting positions are computed using Median parameters.
```

Figure C-20. Report File for "B17C Example 3" showing censored low outliers.



B17C_Example_3.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_3\B17C_Example_3.rpt

1941	4,160.0	4,160.0	4,160.0	2,000.0	1.0E99	Syst
1942	6,700.0	6,700.0	6,700.0	2,000.0	1.0E99	Syst
1943	22,400.0	22,400.0	22,400.0	2,000.0	1.0E99	Syst
1944	3,880.0	3,880.0	3,880.0	2,000.0	1.0E99	Syst
1945	8,050.0	8,050.0	8,050.0	2,000.0	1.0E99	Syst
1946	4,020.0	4,020.0	4,020.0	2,000.0	1.0E99	Syst
1947	1,600.0	1.0E-6	2,000.0	2,000.0	1.0E99	Syst
1948	4,460.0	4,460.0	4,460.0	2,000.0	1.0E99	Syst
1949	4,230.0	4,230.0	4,230.0	2,000.0	1.0E99	Syst
1950	3,010.0	3,010.0	3,010.0	2,000.0	1.0E99	Syst
1951	9,150.0	9,150.0	9,150.0	2,000.0	1.0E99	Syst
1952	5,100.0	5,100.0	5,100.0	2,000.0	1.0E99	Syst
1953	9,820.0	9,820.0	9,820.0	2,000.0	1.0E99	Syst
1954	6,200.0	6,200.0	6,200.0	2,000.0	1.0E99	Syst
1955	10,700.0	10,700.0	10,700.0	2,000.0	1.0E99	Syst
1956	3,880.0	3,880.0	3,880.0	2,000.0	1.0E99	Syst
1957	3,420.0	3,420.0	3,420.0	2,000.0	1.0E99	Syst
1958	3,240.0	3,240.0	3,240.0	2,000.0	1.0E99	Syst
1959	6,800.0	6,800.0	6,800.0	2,000.0	1.0E99	Syst
1960	3,740.0	3,740.0	3,740.0	2,000.0	1.0E99	Syst
1961	4,700.0	4,700.0	4,700.0	2,000.0	1.0E99	Syst
1962	4,380.0	4,380.0	4,380.0	2,000.0	1.0E99	Syst
1963	5,190.0	5,190.0	5,190.0	2,000.0	1.0E99	Syst
1964	3,960.0	3,960.0	3,960.0	2,000.0	1.0E99	Syst
1965	5,600.0	5,600.0	5,600.0	2,000.0	1.0E99	Syst
1966	4,670.0	4,670.0	4,670.0	2,000.0	1.0E99	Syst
1967	7,080.0	7,080.0	7,080.0	2,000.0	1.0E99	Syst
1968	4,640.0	4,640.0	4,640.0	2,000.0	1.0E99	Syst
1969	536.0	1.0E-6	2,000.0	2,000.0	1.0E99	Syst
1970	6,680.0	6,680.0	6,680.0	2,000.0	1.0E99	Syst
1971	8,360.0	8,360.0	8,360.0	2,000.0	1.0E99	Syst
1972	18,700.0	18,700.0	18,700.0	2,000.0	1.0E99	Syst
1973	5,210.0	5,210.0	5,210.0	2,000.0	1.0E99	Syst
1974	4,680.0	4,680.0	4,680.0	2,000.0	1.0E99	Syst
1975	7,940.0	7,940.0	7,940.0	2,000.0	1.0E99	Syst
1976	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1977	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1978	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1979	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1980	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1981	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1982	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1983	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1984	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1985	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens
1986	---	1.0E-99	21,000.0	21,000.0	1.0E99	Cens

01/07/2016 16:27 PM 1:1..1:1 1:1

Figure C-21. Report File for "B17C Example 3" showing recoded perception thresholds.

Example 4: Historical Data – Arkansas River at Pueblo, CO

Example 4 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of systematic and historical flood events as well as paleoflood information. The largest historic floods are described as interval data, and multiple thresholds are needed to effectively extend the discontinued stream gaging record after the dam was built.

A paleohydrologic bound of about 840 years (before water year 2004) was estimated at this site for inclusion in the flood frequency curve. No estimates of individual paleofloods were made at this site, due to the relatively wide channel geometry and the lack of apparent stratigraphic evidence of large paleofloods during a limited field study (England, et al., 2015).

When fitting the Log Pearson Type III distribution using either Bulletin 17B or Bulletin 17C procedures, an unregulated annual maximum series is required. However, peak flow rates downloaded from the USGS website do not always reflect unregulated conditions, as is the case with the Arkansas River near Pueblo, CO (07099500) gage. Pueblo Dam, which creates one of the largest reservoirs within Colorado, is immediately upstream of this gaging station. The dam was constructed between 1970 and 1975 and began impacting the annual maximum series due to flood control and water supply storage in water year 1974. As such, the annual maximum series downloaded from the USGS website was altered to reflect unregulated conditions for water year 1974 and 1975.

The modified annual maximum series is plotted in Figure C-22 and tabulated in Table C-.

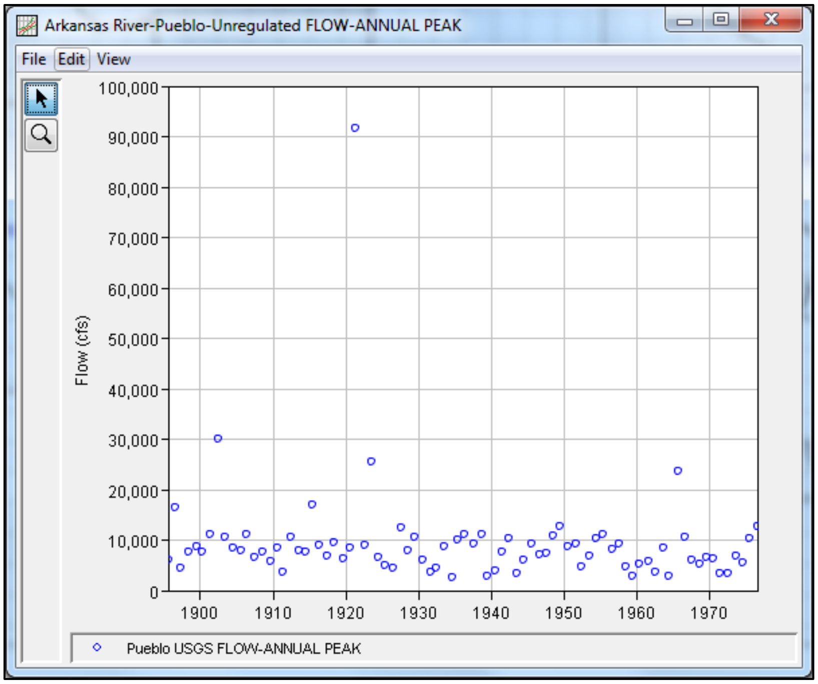


Figure C-22. Arkansas River near Pueblo, CO Annual Peak Flow Record (Modified).

Table C-4. Arkansas River near Pueblo, CO Annual Peak Flow Record (Modified).

Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
31 Jul 1895	6100	12 Jul 1923	25600	03 Aug 1951	9300
18 Aug 1896	16500	15 Jun 1924	6510	08 Jun 1952	4740
02 Jun 1897	4300	03 Jul 1925	4930	21 Jul 1953	6770
13 Jul 1898	7500	14 Jun 1926	4520	30 Jun 1954	10200
14 Aug 1899	8800	22 Jul 1927	12400	19 May 1955	11100
20 May 1900	7600	21 Jul 1928	7800	01 Aug 1956	8010
21 May 1901	11100	28 Jul 1929	10500	29 Jun 1957	9070
05 Aug 1902	30000	28 Aug 1930	6050	05 Jun 1958	4540
09 Jun 1903	10500	01 Sep 1931	3560	17 Jun 1959	2820
15 Aug 1904	8500	26 Jun 1932	4380	08 Jun 1960	5260
06 Aug 1905	8000	02 Aug 1933	8630	02 Aug 1961	5760
13 Jun 1906	11000	03 Aug 1934	2580	08 Jul 1962	3540
28 Jul 1907	6600	18 May 1935	9880	14 Aug 1963	8360
01 Aug 1908	7600	24 May 1936	11200	27 May 1964	2840
18 Aug 1909	5800	29 Aug 1937	9300	22 Aug 1965	23500
29 Jul 1910	8400	26 Aug 1938	11200	01 Aug 1966	10600
28 May 1911	3700	01 Jun 1939	2910	18 Jul 1967	5870
31 Jul 1912	10500	19 Aug 1940	3860	10 Aug 1968	5190
23 Jul 1913	7800	19 Jul 1941	7560	23 Aug 1969	6620
03 Aug 1914	7500	08 Jun 1942	10300	11 Aug 1970	6300
24 Jun 1915	17000	18 Aug 1943	3320	07 Jun 1971	3360
17 Jun 1916	8900	05 Jul 1944	5980	28 Jun 1972	3360
19 Jun 1917	6800	14 Aug 1945	9290	30 Jul 1973	6760
23 Jun 1918	9600	27 Aug 1946	7050	23 Jul 1974	5440
04 Sep 1919	6300	09 Jul 1947	7280	10 Jul 1975	10200
18 Jul 1920	8500	13 Jun 1948	10900	10 Jul 1976	12800
03 Jun 1921	91500	06 Jun 1949	12800		
06 Aug 1922	8850	26 Jul 1950	8700		

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 4**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 4**" from the list of available analyses. When "B17C Example 4" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-23. As shown, the **Skew** option was set to use the **Station Skew**.

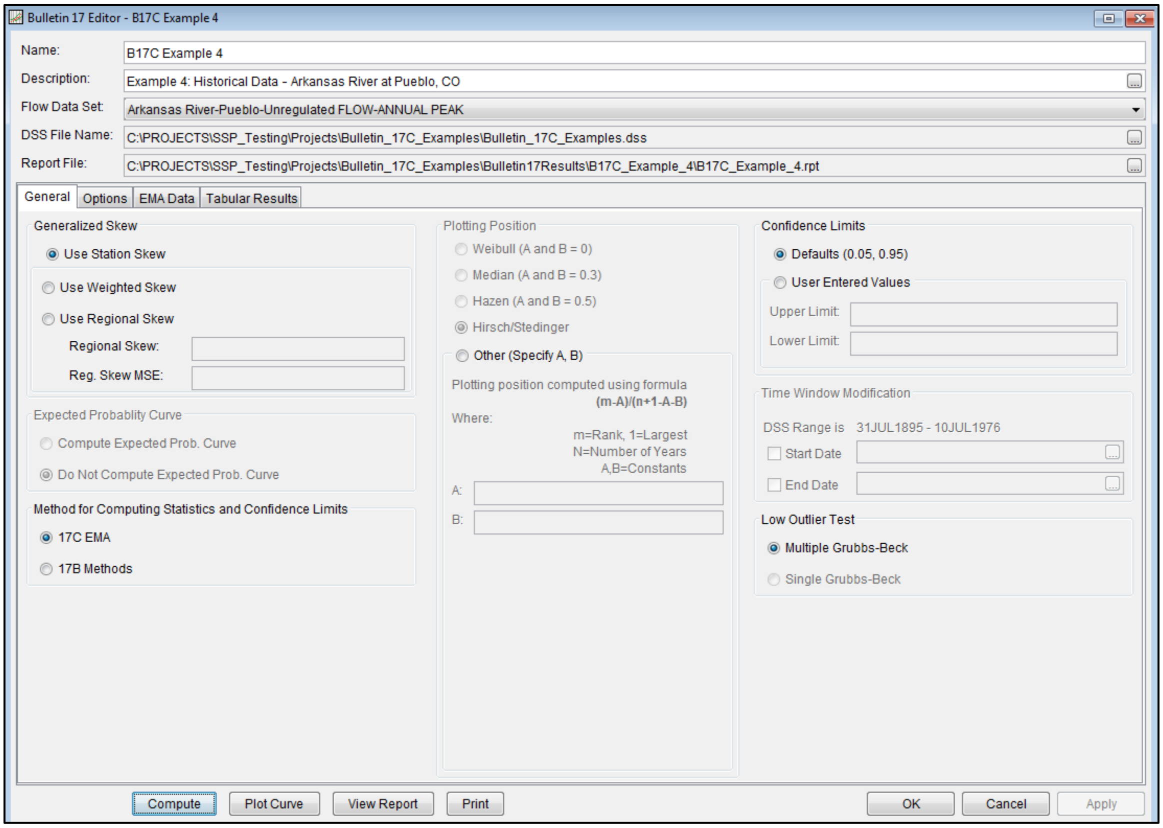


Figure C-23. Bulletin 17 Analysis General Tab for "B17C Example 4".

Commonly, within dam safety studies, estimates of flow or volume frequency are required at extremely small exceedance probabilities. As such, additional frequency ordinates (0.1- and 0.01-percent annual chance exceedance probabilities) were specified on the **Options** tab, as shown in Figure C-24.

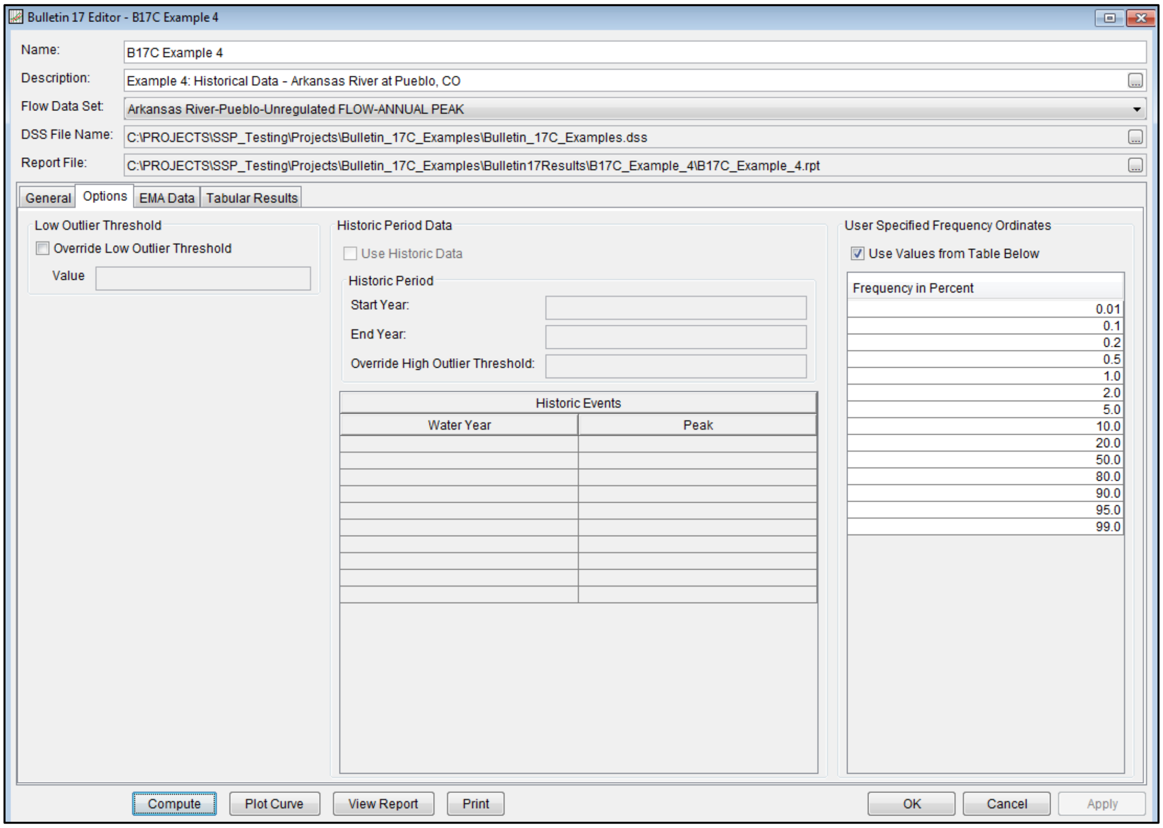


Figure C-24. Bulletin 17 Analysis Options Tab for "B17C Example 4".

The **EMA Data** tab for this example is shown in Figure C-25. This example uses an annual maximum series consisting of both systematic data along with historical events and paleoflood information. Multiple perception thresholds are needed to reasonably incorporate the various historical and paleoflood information.

The default "Total Record" perception threshold should be modified to reflect the additional paleoflood and post Pueblo Dam construction information. A start year of 1165 and end year of 2004 along with a perception threshold of zero – inf should be entered on the first line.

The second perception threshold relates to the non-exceedance information obtained through the paleoflood analysis. A start and end year of 1165 and 1858 should be entered, respectively, along with a 150,000 – inf perception threshold. This implies that no floods exceeded a peak flow rate of 150,000 cfs from 1165 – 1858 even though there were no gages present.

The third and fourth perception thresholds represent a period of historical information from 1859 – 1892 where floods in excess of 40,000 cfs would have been recorded had they occurred. Since a historical event was recorded in 1864, two perception thresholds should be used, one from 1859 – 1863 and one from 1865 – 1892. Both perception thresholds should span from 40,000 – inf. Additionally, a historical flow event that occurred in 1864 should be entered in the Flow Ranges table with a low and high flow value of 41,000 and 60,000 cfs, respectively, to denote uncertainty around the best-estimate of 50,500 cfs. The data type for this event should be set to Historical.

The fifth perception threshold represents an additional period of historical information from 1893 – 1894. A perception threshold of 19,900 – inf should be entered for these two years. Two events that aren't part of the gage record occurred in 1893 and 1894. The 1893 event had a low and high flow value of 20,000 and 25,000, respectively, with a best-estimate of 22,500. The 1894 event had a low and high flow value of 35,000 and 40,000, respectively, with a best-estimate of 37,500. Both events should be entered in the Flow Ranges table and the data types should be set to Historical.

The 1921 event should be entered as an historical event with uncertainty around the best estimate of 91,500 cfs. A low and high value of 80,000 and 103,000 should be used.

The sixth and final perception threshold represents the period when the stream gage was discontinued after the construction of Pueblo Dam. It is known that floods in excess of 20,000 cfs would have been recorded had they occurred. Therefore, a perception threshold of 20,000 – inf should be entered for these years.

Once all six perception thresholds have been entered as shown in Figure C-25, click the **Apply Thresholds** button to assign the complementary flow ranges for the periods of missing data.

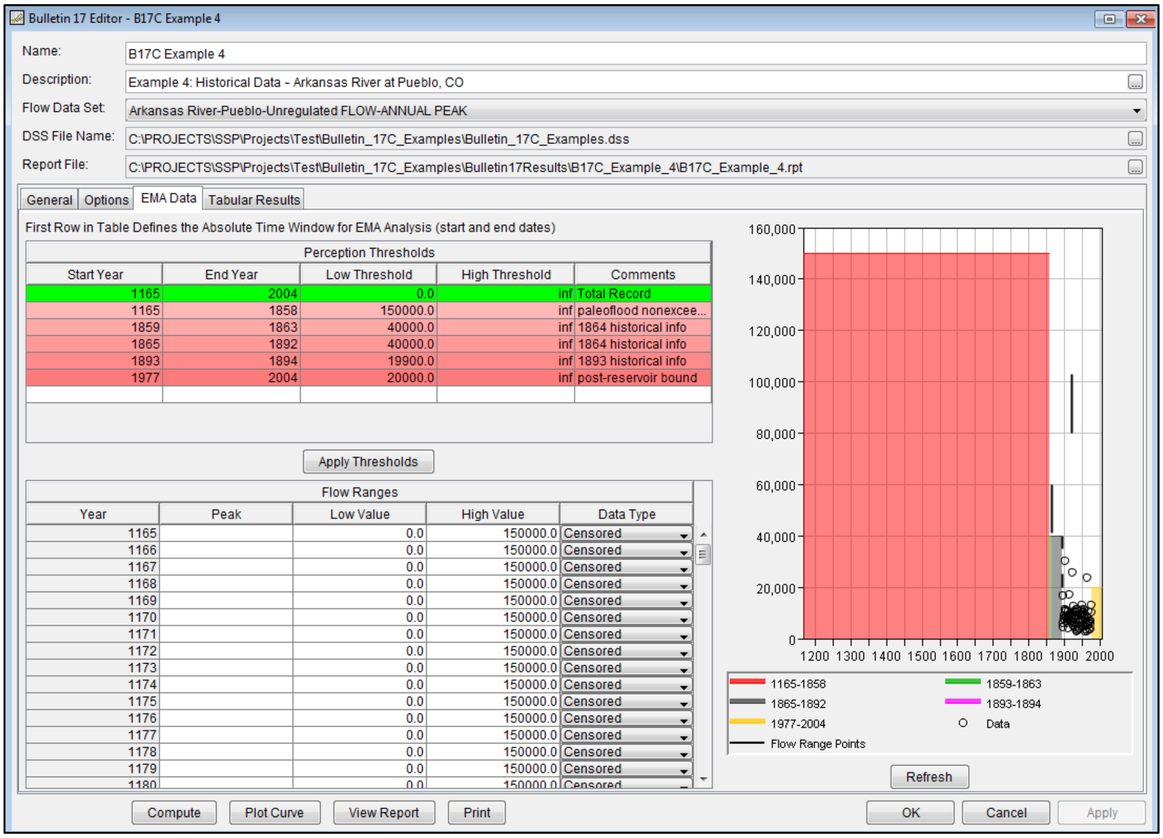
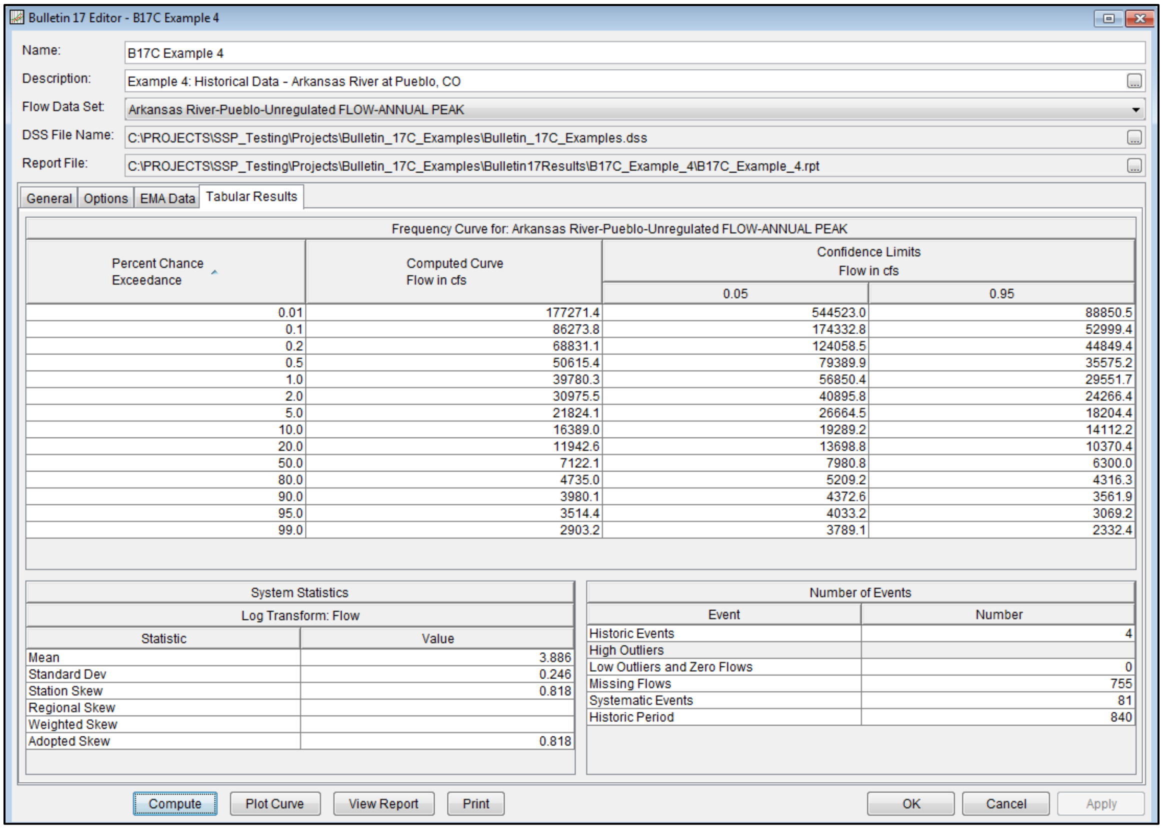


Figure C-25. Bulletin 17 Analysis EMA Data Tab for "B17C Example 4".

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-26.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger and Median (for low outliers) plotting positions are shown in Figure C-27.



Bulletin 17 Editor - B17C Example 4

Name: B17C Example 4

Description: Example 4: Historical Data - Arkansas River at Pueblo, CO

Flow Data Set: Arkansas River-Pueblo-Unregulated FLOW-ANNUAL PEAK

DSS File Name: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin_17C_Examples.dss

Report File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_4\B17C_Example_4.rpt

General | Options | EMA Data | Tabular Results

Frequency Curve for: Arkansas River-Pueblo-Unregulated FLOW-ANNUAL PEAK

Percent Chance Exceedance	Computed Curve Flow in cfs	Confidence Limits Flow in cfs 0.05	Confidence Limits Flow in cfs 0.95
0.01	177271.4	544523.0	88850.5
0.1	86273.8	174332.8	52999.4
0.2	68831.1	124058.5	44849.4
0.5	50615.4	79389.9	35575.2
1.0	39780.3	56850.4	29551.7
2.0	30975.5	40895.8	24266.4
5.0	21824.1	26664.5	18204.4
10.0	16389.0	19289.2	14112.2
20.0	11942.6	13698.8	10370.4
50.0	7122.1	7980.8	6300.0
80.0	4735.0	5209.2	4316.3
90.0	3980.1	4372.6	3561.9
95.0	3514.4	4033.2	3069.2
99.0	2903.2	3789.1	2332.4

System Statistics — Log Transform: Flow

Statistic	Value
Mean	3.886
Standard Dev	0.246
Station Skew	0.818
Regional Skew	
Weighted Skew	
Adopted Skew	0.818

Number of Events

Event	Number
Historic Events	4
High Outliers	
Low Outliers and Zero Flows	0
Missing Flows	755
Systematic Events	81
Historic Period	840

Compute | Plot Curve | View Report | Print | OK | Cancel | Apply

Figure C-26. Bulletin 17 Analysis Tabular Results Tab for “B17C Example 4”.

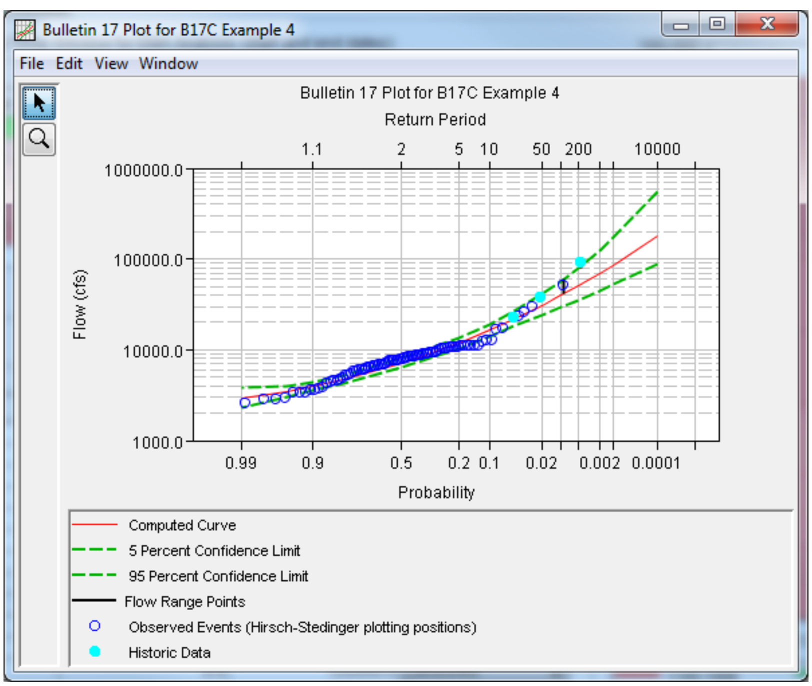


Figure C-27. Plotted Frequency Curves for “B17C Example 4”.

As is shown in Figure C-27, the Log Pearson Type III distribution is well fit to the majority of the data. However, the largest flood event (June 1921) is underfit by the EMA-computed Log Pearson Type III curve. This is likely due to the influence of the paleoflood information which lengthens the historical record from 85 years to 840 years. Consequently, the at-station skew coefficient is reduced which primarily affects the upper end of the computed curve. Had the paleoflood information not been included, a larger at-station skew coefficient would have been computed.

Example 5: Crest Stage Gage Censored Data – Bear Creek at Ottumwa, IA

Example 5 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of censored data with variable perception thresholds due to the presence of a crest stage gage.

A crest stage gage is a simple, reliable device used to obtain the elevation of the flood peak of a stream. Most commonly, a crest stage gage consists of a vertical metal pipe containing a wood or aluminum staff held in a fixed position with relation to a datum reference. At the bottom of the pipe is a perforated cap containing regranulated cork. When the water in the stream reaches and exceeds the height of the bottom cap (commonly referred to as the gage base), water is able to enter the pipe. As the water rises up the pipe, the cork floats on the water surface and as the water reaches its peak and starts to recede, the cork adheres to the staff thereby retaining the crest stage of the flood (England, et al., 2015). As a result, crest stage gages provide a censored record of peak flows, as no annual peak flow that results in a flood stage below the bottom cap of the pipe will be recorded.

For this example, USGS gage 05489490 Bear Creek at Ottumwa, IA is used. This gage is a crest stage gage and has a drainage area of 22.9 square miles. It is located in southeast Iowa in the Southern Iowa Drift Plain land-form region which is characterized by rolling hills and deeply carved stream channels (Prior, 1991). The stream banks and channel bed are comprised of sand, silt, and clay materials that are prone to shifting from hydrologic events.

The Bear Creek at Ottumwa, IA stream gage has an annual peak record consisting of 50 annual peaks. The historical record for this gage spans from 1965 – 2014. The annual maximum series is plotted in Figure C-28 and tabulated in Table C-.

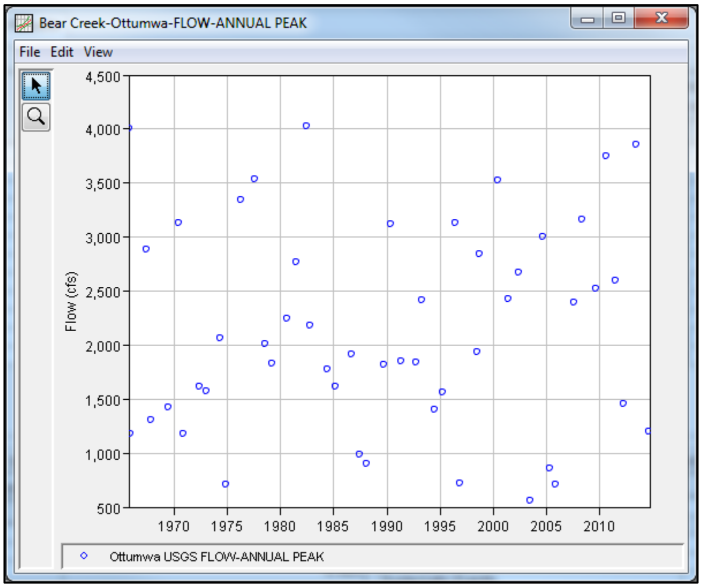


Figure C-28. Bear Creek at Ottumwa, IA Annual Peak Flow Record.

Table C-5. Bear Creek at Ottumwa, IA Annual Peak Flow Record.

Date	Flow (cfs)	Date	Flow (cfs)
21 Sep 1965	4000	25 May 1990	3120
30 Nov 1965	1180	18 Apr 1991	1850
09 Jun 1967	2880	15 Sep 1992	1840
15 Oct 1967	1310	07 May 1993	2410
05 Jul 1969	1420	23 Jun 1994	1400
24 Jun 1970	3130	11 Apr 1995	1560
30 Nov 1970	1180	28 May 1996	3130
08 May 1972	1620	30 Nov 1996	714
19 Jan 1973	1570	18 Jun 1998	1940
19 May 1974	2060	05 Oct 1998	2840
30 Nov 1974	705	23 Jun 2000	3520
24 Apr 1976	3340	15 May 2001	2430
07 Aug 1977	3530	11 May 2002	2670
21 Jul 1978	2010	26 Jun 2003	560
29 Mar 1979	1830	27 Aug 2004	3000
17 Aug 1980	2240	12 Apr 2005	859
04 Jul 1981	2770	30 Nov 2005	710
03 Jul 1982	4030	23 Aug 2007	2390
08 Oct 1982	2180	11 May 2008	3160
08 Jun 1984	1780	27 Aug 2009	2520
04 Mar 1985	1610	09 Aug 2010	3750
19 Sep 1986	1910	14 Jun 2011	2600
31 May 1987	990	14 Apr 2012	1450
20 Feb 1988	899*	28 May 2013	3850
09 Sep 1989	1820	10 Sep 2014	1200

*gage height affected by backwater

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 5**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 5**" from the list of available analyses. When "B17C Example 5" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-29. As shown, the **Skew** option was set to use the **Station Skew**.

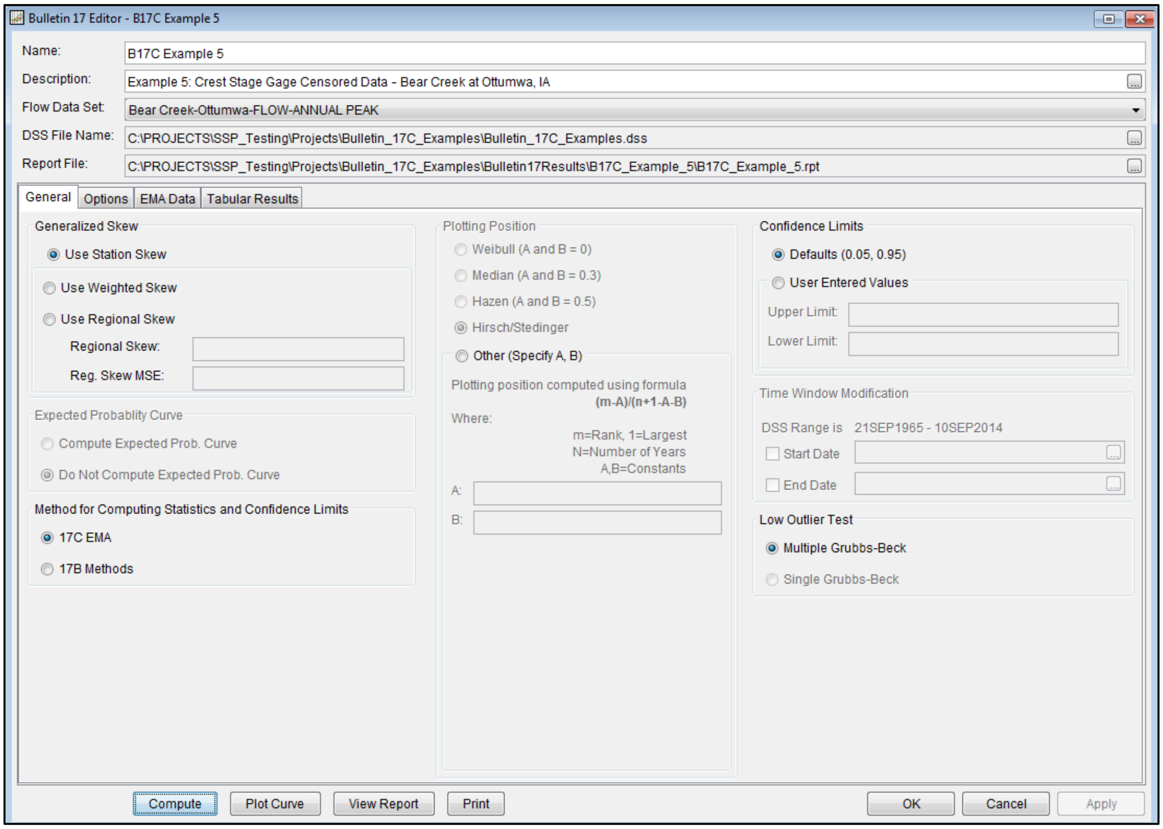


Figure C-29. Bulletin 17 Analysis General Tab for "B17C Example 5".

No changes to the **Options** tab are necessary.

The **EMA Data** tab for this example is shown in Figure C-30. This example uses an annual maximum series consisting entirely of systematic data. However, physical changes to the actual gage base (i.e. minimum recordable flow rate) occurred in 1973, 1992, 2002, 2003, 2004, 2006, 2010, and 2013. To take the possibility of annual peak flows occurring below the gage base into account within the EMA framework, perception thresholds are required for each change in the gage base. For instance, the gage base was lowered from the initial setting of 1180 cfs to a gage base of 705 cfs in 1973. The next gage base change occurred in 1992. This requires a perception threshold of 705 – inf for water year 1973 – water year 1991. For information related to a specific crest stage gage, such as the gage base, consult your local USGS office. A total of nine different gage bases have been in effect for this gage. Including the first perception threshold (which sets the start and end year of the analysis), this requires a total of 10 perception thresholds. Once all five perception thresholds have been entered as shown in Figure C-30, click the **Apply Thresholds** button to assign the complementary flow ranges for the periods of missing data.

A peak flow rate below the gage base occurred in 1966, 1971, 1975, 1997, and 2006, as signified by the USGS qualification code of 4. This implies that the actual annual peak flow rate could have been between zero and whatever the gage base was at the time. This requires a change to the flow range table. For each of these years, a low value of zero and high value of whatever the gage base was at the time should be entered. For instance, in water year 1966, the annual peak flow rate was below the gage base of 1180 cfs. Therefore, the flow range for that year should be entered as zero – 1180, as shown in Figure C-30. The other four water years in which an annual peak flow was below the recordable limit should be entered in a similar fashion within the flow range table.

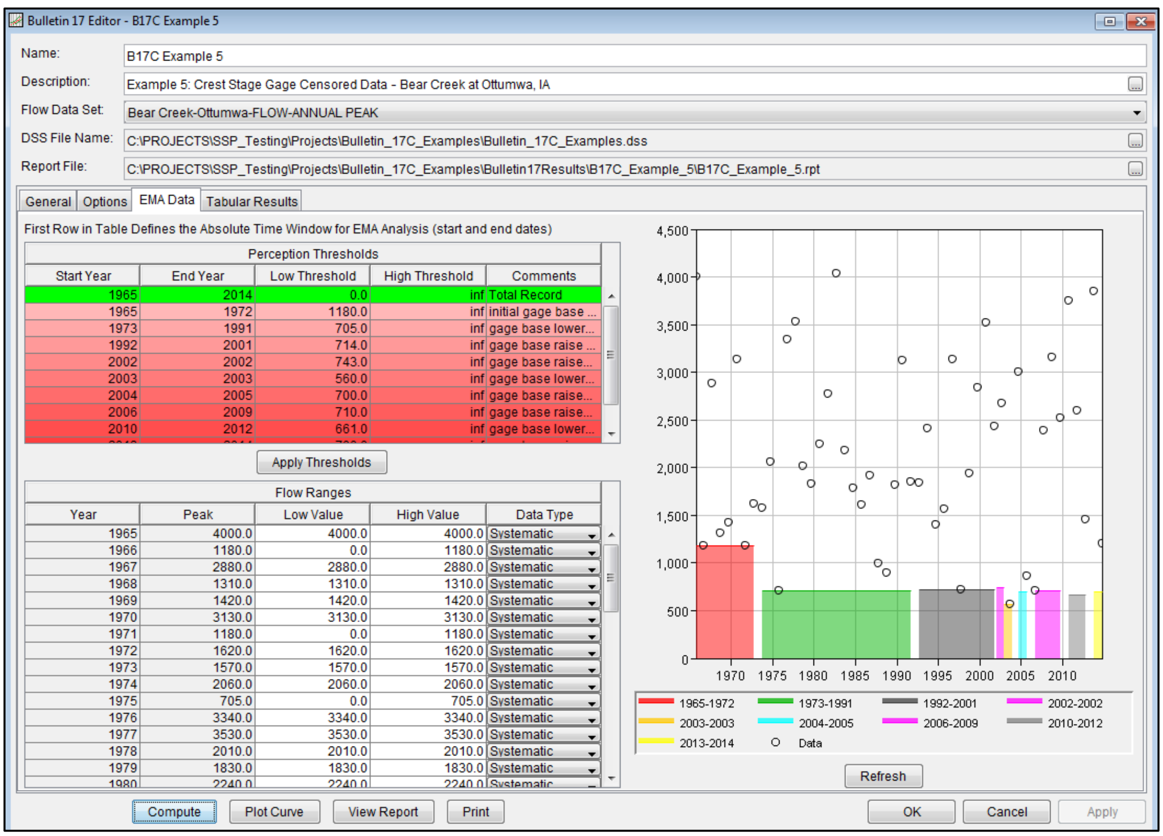


Figure C-30. Bulletin 17 Analysis EMA Data Tab for “B17C Example 5”.

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-31.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger and Median (for low outliers) plotting positions are shown in Figure C-32.

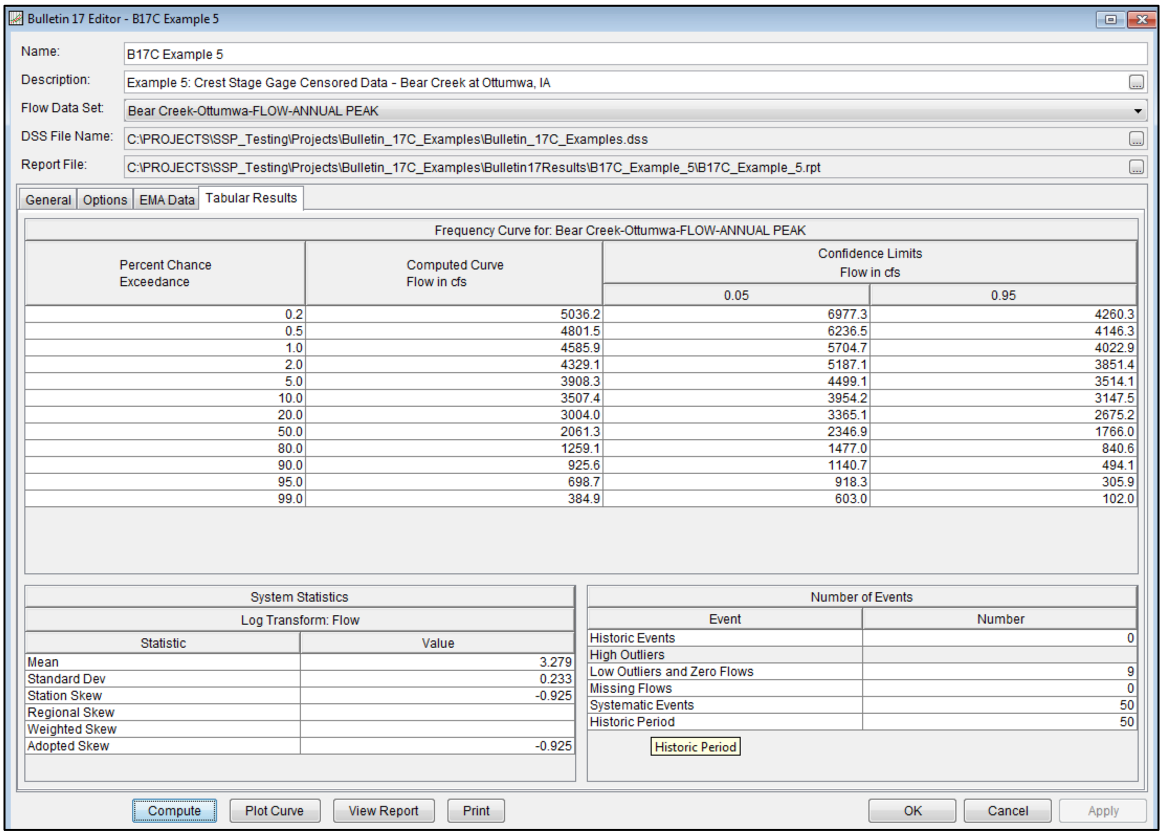


Figure C-31. Bulletin 17 Analysis Tabular Results Tab for "B17C Example 5".

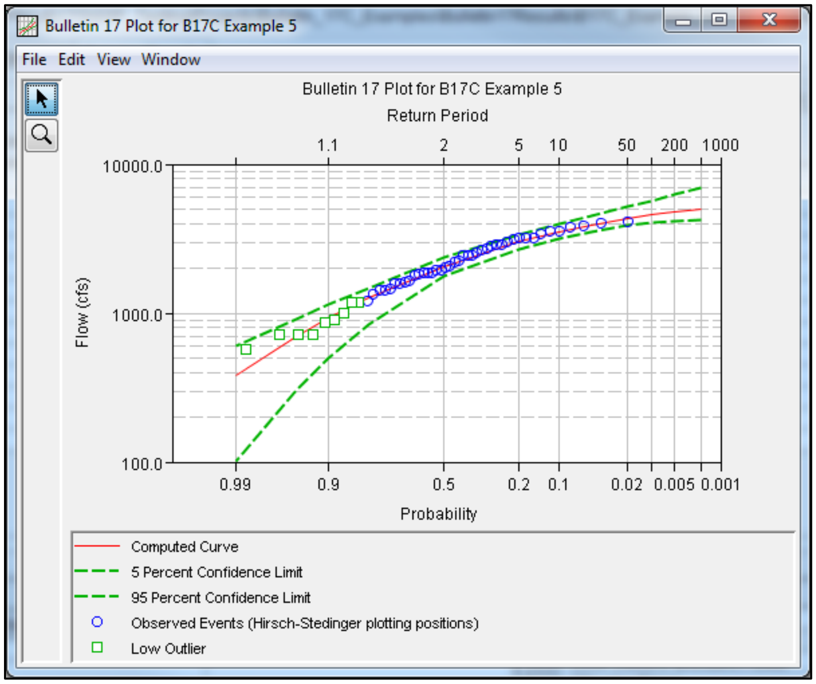
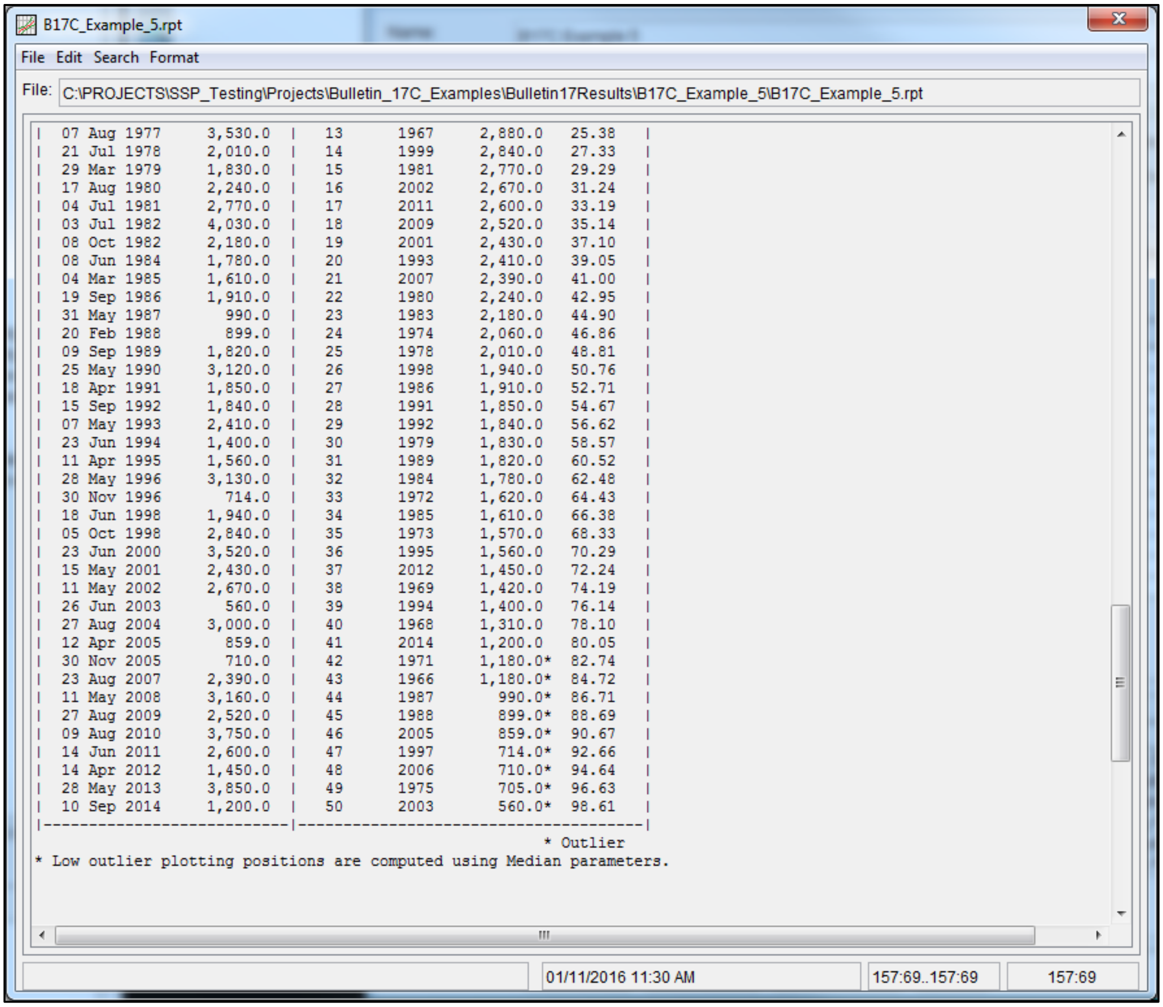


Figure C-32. Plotted Frequency Curves for "B17C Example 5".

As shown in Figure C-33, the Multiple Grubbs-Beck Test identified a low outlier threshold of 1200 cfs. Nine annual peak flows were identified as being less than this threshold, as shown in Figure C-32. These annual peak flows were then recoded to have a flow interval of zero – 1200. The perception thresholds for the years in which an annual peak flow was recorded were also adjusted to correspond with the Multiple Grubbs-Beck Test low outlier threshold. Consequently, these perception thresholds were changed from zero – inf to 1200 – inf, as shown in Figure C-34.



```
B17C_Example_5.rpt
File  Edit  Search  Format
File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_5\B17C_Example_5.rpt

|  07 Aug 1977     3,530.0  |   13      1967     2,880.0   25.38    |
|  21 Jul 1978     2,010.0  |   14      1999     2,840.0   27.33    |
|  29 Mar 1979     1,830.0  |   15      1981     2,770.0   29.29    |
|  17 Aug 1980     2,240.0  |   16      2002     2,670.0   31.24    |
|  04 Jul 1981     2,770.0  |   17      2011     2,600.0   33.19    |
|  03 Jul 1982     4,030.0  |   18      2009     2,520.0   35.14    |
|  08 Oct 1982     2,180.0  |   19      2001     2,430.0   37.10    |
|  08 Jun 1984     1,780.0  |   20      1993     2,410.0   39.05    |
|  04 Mar 1985     1,610.0  |   21      2007     2,390.0   41.00    |
|  19 Sep 1986     1,910.0  |   22      1980     2,240.0   42.95    |
|  31 May 1987       990.0  |   23      1983     2,180.0   44.90    |
|  20 Feb 1988       899.0  |   24      1974     2,060.0   46.86    |
|  09 Sep 1989     1,820.0  |   25      1978     2,010.0   48.81    |
|  25 May 1990     3,120.0  |   26      1998     1,940.0   50.76    |
|  18 Apr 1991     1,850.0  |   27      1986     1,910.0   52.71    |
|  15 Sep 1992     1,840.0  |   28      1991     1,850.0   54.67    |
|  07 May 1993     2,410.0  |   29      1992     1,840.0   56.62    |
|  23 Jun 1994     1,400.0  |   30      1979     1,830.0   58.57    |
|  11 Apr 1995     1,560.0  |   31      1989     1,820.0   60.52    |
|  28 May 1996     3,130.0  |   32      1984     1,780.0   62.48    |
|  30 Nov 1996       714.0  |   33      1972     1,620.0   64.43    |
|  18 Jun 1998     1,940.0  |   34      1985     1,610.0   66.38    |
|  05 Oct 1998     2,840.0  |   35      1973     1,570.0   68.33    |
|  23 Jun 2000     3,520.0  |   36      1995     1,560.0   70.29    |
|  15 May 2001     2,430.0  |   37      2012     1,450.0   72.24    |
|  11 May 2002     2,670.0  |   38      1969     1,420.0   74.19    |
|  26 Jun 2003       560.0  |   39      1994     1,400.0   76.14    |
|  27 Aug 2004     3,000.0  |   40      1968     1,310.0   78.10    |
|  12 Apr 2005       859.0  |   41      2014     1,200.0   80.05    |
|  30 Nov 2005       710.0  |   42      1971     1,180.0*  82.74    |
|  23 Aug 2007     2,390.0  |   43      1966     1,180.0*  84.72    |
|  11 May 2008     3,160.0  |   44      1987       990.0*  86.71    |
|  27 Aug 2009     2,520.0  |   45      1988       899.0*  88.69    |
|  09 Aug 2010     3,750.0  |   46      2005       859.0*  90.67    |
|  14 Jun 2011     2,600.0  |   47      1997       714.0*  92.66    |
|  14 Apr 2012     1,450.0  |   48      2006       710.0*  94.64    |
|  28 May 2013     3,850.0  |   49      1975       705.0*  96.63    |
|  10 Sep 2014     1,200.0  |   50      2003       560.0*  98.61    |
|---------------------------|---------------------------------------|
                                                    * Outlier
* Low outlier plotting positions are computed using Median parameters.

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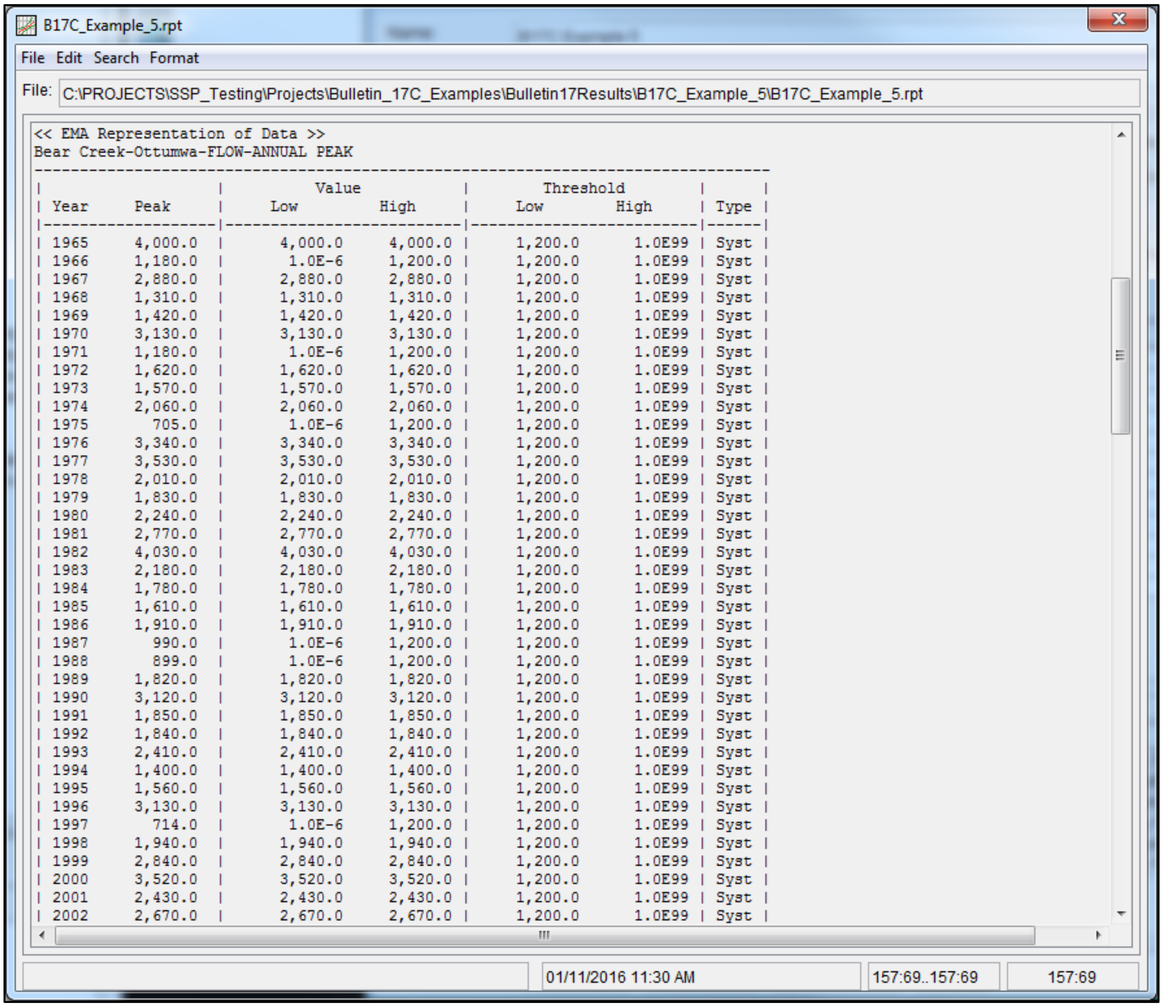
Figure C-33. Report File for "B17C Example 5" showing censored low outliers.



B17C_Example_5.rpt

File Edit Search Format

File: C:\PROJECTS\SSP_Testing\Projects\Bulletin_17C_Examples\Bulletin17Results\B17C_Example_5\B17C_Example_5.rpt

<< EMA Representation of Data >>

Bear Creek-Ottumwa-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1965	4,000.0	4,000.0	4,000.0	1,200.0	1.0E99	Syst
1966	1,180.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1967	2,880.0	2,880.0	2,880.0	1,200.0	1.0E99	Syst
1968	1,310.0	1,310.0	1,310.0	1,200.0	1.0E99	Syst
1969	1,420.0	1,420.0	1,420.0	1,200.0	1.0E99	Syst
1970	3,130.0	3,130.0	3,130.0	1,200.0	1.0E99	Syst
1971	1,180.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1972	1,620.0	1,620.0	1,620.0	1,200.0	1.0E99	Syst
1973	1,570.0	1,570.0	1,570.0	1,200.0	1.0E99	Syst
1974	2,060.0	2,060.0	2,060.0	1,200.0	1.0E99	Syst
1975	705.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1976	3,340.0	3,340.0	3,340.0	1,200.0	1.0E99	Syst
1977	3,530.0	3,530.0	3,530.0	1,200.0	1.0E99	Syst
1978	2,010.0	2,010.0	2,010.0	1,200.0	1.0E99	Syst
1979	1,830.0	1,830.0	1,830.0	1,200.0	1.0E99	Syst
1980	2,240.0	2,240.0	2,240.0	1,200.0	1.0E99	Syst
1981	2,770.0	2,770.0	2,770.0	1,200.0	1.0E99	Syst
1982	4,030.0	4,030.0	4,030.0	1,200.0	1.0E99	Syst
1983	2,180.0	2,180.0	2,180.0	1,200.0	1.0E99	Syst
1984	1,780.0	1,780.0	1,780.0	1,200.0	1.0E99	Syst
1985	1,610.0	1,610.0	1,610.0	1,200.0	1.0E99	Syst
1986	1,910.0	1,910.0	1,910.0	1,200.0	1.0E99	Syst
1987	990.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1988	899.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1989	1,820.0	1,820.0	1,820.0	1,200.0	1.0E99	Syst
1990	3,120.0	3,120.0	3,120.0	1,200.0	1.0E99	Syst
1991	1,850.0	1,850.0	1,850.0	1,200.0	1.0E99	Syst
1992	1,840.0	1,840.0	1,840.0	1,200.0	1.0E99	Syst
1993	2,410.0	2,410.0	2,410.0	1,200.0	1.0E99	Syst
1994	1,400.0	1,400.0	1,400.0	1,200.0	1.0E99	Syst
1995	1,560.0	1,560.0	1,560.0	1,200.0	1.0E99	Syst
1996	3,130.0	3,130.0	3,130.0	1,200.0	1.0E99	Syst
1997	714.0	1.0E-6	1,200.0	1,200.0	1.0E99	Syst
1998	1,940.0	1,940.0	1,940.0	1,200.0	1.0E99	Syst
1999	2,840.0	2,840.0	2,840.0	1,200.0	1.0E99	Syst
2000	3,520.0	3,520.0	3,520.0	1,200.0	1.0E99	Syst
2001	2,430.0	2,430.0	2,430.0	1,200.0	1.0E99	Syst
2002	2,670.0	2,670.0	2,670.0	1,200.0	1.0E99	Syst

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157:69

Figure C-34. Report File for “B17C Example 5” showing recoded perception thresholds.

Example 6: Historic Data and Low Outliers – Santa Cruz River at Lochiel, AZ

Example 6 illustrates the computation of a peak flow frequency curve using EMA and Bulletin 17C procedures with an annual maximum series comprised of systematic data and historical flood information that can be used to extend the historical period.

For this example, USGS gage 09480000 Santa Cruz River near Lochiel, AZ is used. The stream gage in question has an approximate 82.2 sq. mi. contributing watershed with an annual peak record consisting of 65 peaks beginning in water year 1949 and ending in water year 2013. A large flood event occurred on October 9, 1977. This flood is noted in the USGS Annual Water Data Report for this gage and there is historical information available for this large flood indicating that this flood is the largest since 1927 (Aldridge & Eychaner, 1984).

Of the 65 annual peaks, the August 15, 1984 flood is equal to the October 1977 historic flood peak. Based on information contained within Aldridge and Eychaner (1984) for the October 1977 flood, this event can be used as a perception threshold to represent the 22 years of missing information from 1927 to 1946. The annual maximum series is plotted in Figure C-35 and tabulated in Table C-.

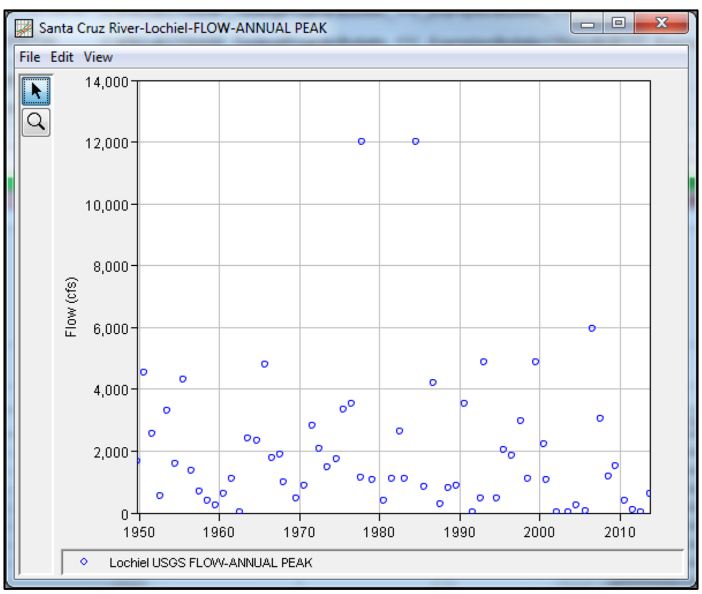


Figure C-35. Santa Cruz River at Lochiel, AZ Annual Peak Flow Record.

Table C-6. Santa Cruz River at Lochiel, AZ Annual Peak Flow Record.

Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
13 Sep 1949	1650	10 Aug 1971	2830	18 Jan 1993	4880
30 Jul 1950	4520	16 Jul 1972	2070	30 Aug 1994	478
02 Aug 1951	2560	30 Jun 1973	1490	12 Jul 1995	2020
16 Aug 1952	550	04 Aug 1974	1730	10 Jul 1996	1860
14 Jul 1953	3320	22 Jul 1975	3330	11 Sep 1997	2970
22 Jul 1954	1570	22 Jul 1976	3540	07 Jul 1998	1110
06 Aug 1955	4300	05 Sep 1977	1130	28 Jul 1999	4870
17 Jul 1956	1360	09 Oct 1977	12000	06 Aug 2000	2240
09 Aug 1957	688	25 Jan 1979	1060	22 Oct 2000	1080
07 Aug 1958	380	30 Jun 1980	406	04 Mar 2002	2
14 Aug 1959	243	15 Jul 1981	1110	14 Aug 2003	22
30 Jul 1960	625	11 Aug 1982	2640	05 Aug 2004	256
08 Aug 1961	1120	04 Mar 1983	1120	23 Aug 2005	73
29 Jul 1962	8	15 Aug 1984	12000	08 Aug 2006	5940
25 Aug 1963	2390	19 Jul 1985	850	19 Jul 2007	3060
09 Sep 1964	2330	29 Aug 1986	4210	23 Jul 2008	1180
12 Sep 1965	4810	10 Aug 1987	291	01 Jul 2009	1530
18 Aug 1966	1780	23 Aug 1988	804	31 Jul 2010	392
03 Aug 1967	1870	04 Aug 1989	871	13 Aug 2011	95
20 Dec 1967	986	17 Jul 1990	3510	28 Jul 2012	12
05 Aug 1969	484	26 Jul 1991	17	08 Sep 2013	612
03 Aug 1970	880	01 Aug 1992	483		

A Bulletin 17 Analysis using EMA and Bulletin 17C procedures has been developed for this example. To open the analysis, either double-click on the analysis labeled "**B17C Example 6**" from the Study Explorer or from the **Analysis** menu select open, then select "**B17C Example 6**" from the list of available analyses. When "B17C Example 6" is selected, the Bulletin 17 analysis editor will appear as shown in Figure C-36. As shown, the **Skew** option was set to use the **Station Skew**.

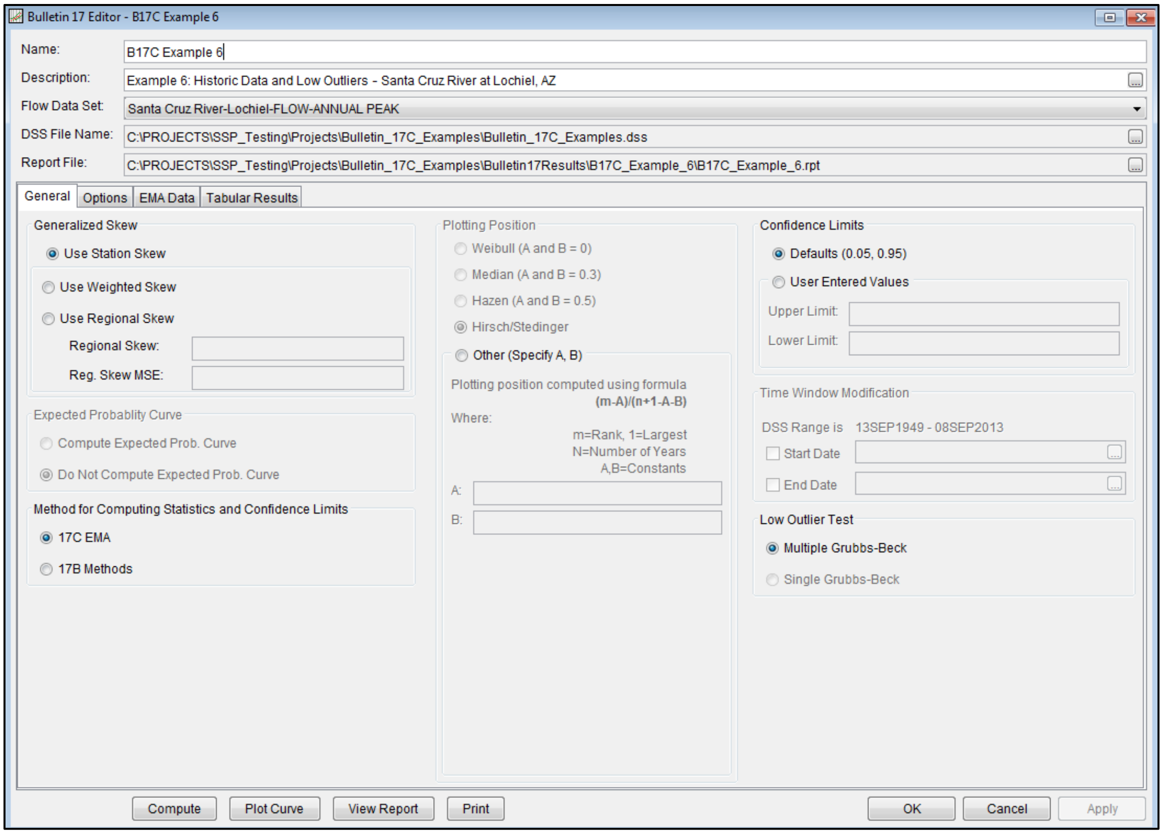


Figure C-36. Bulletin 17 Analysis General Tab for "B17C Example 6".

No changes to the **Options** tab are necessary.

The **EMA Data** tab for this example is shown in Figure C-37. This example uses an annual maximum series consisting entirely of systematic data along with historical information. As was previously mentioned, historical information indicates that the October 1977 flood event was the largest since at least 1927. This information can be used within EMA to extend the historical record to a longer period through the use of a perception threshold. Specifically, the first perception threshold should be modified to start at water year 1927. Then, a second perception threshold of 12000 – inf should be added for the period of missing data spanning water years 1927 through 1948, as shown in Figure C-37. Once both perception thresholds have been entered, click the **Apply Thresholds** button to assign the complementary flow ranges for the periods of missing data. No further changes to the flow range table are necessary.

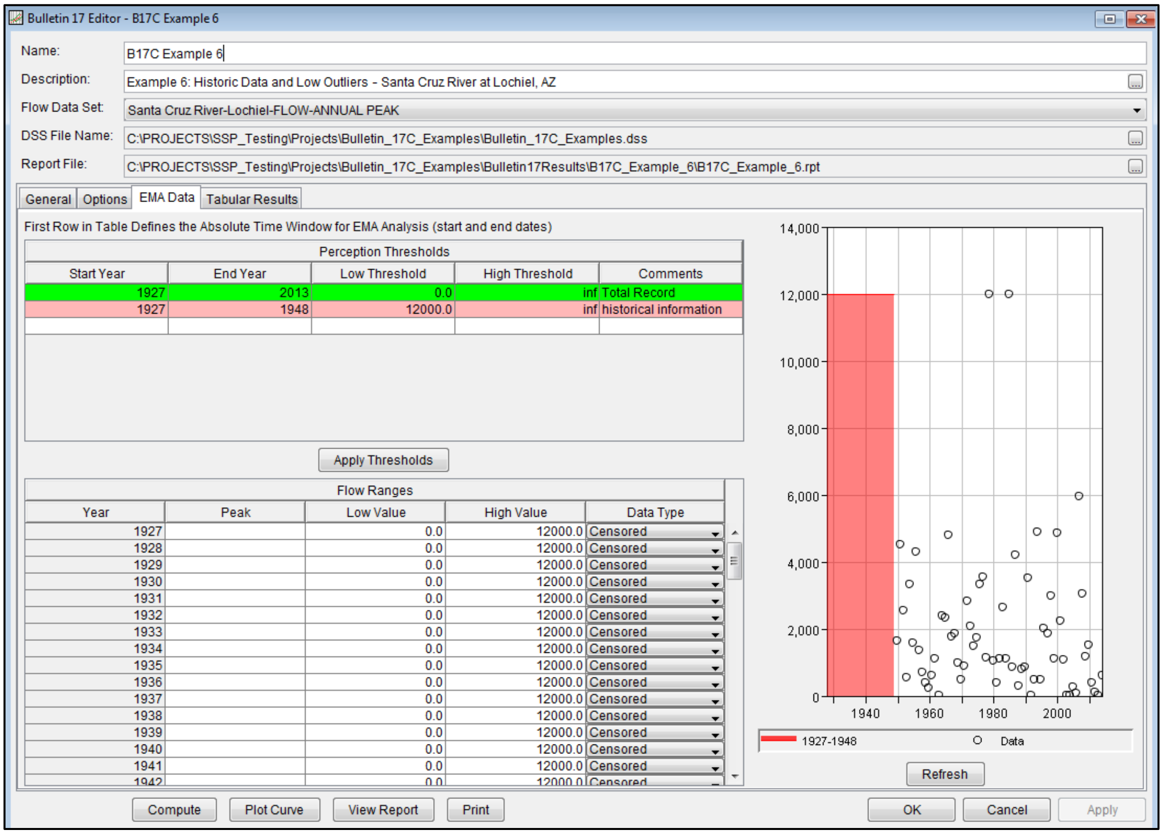


Figure C-37. Bulletin 17 Analysis EMA Data Tab for "B17C Example 6".

Once all of the **General** and **EMA Data** tab settings are set or selected, the user can press the **Compute** button to perform the analysis. Once the computations have been completed, a message window will open stations **Compute Complete**. Close this window and then select the **Tabular Results** tab. The analysis window should look like Figure C-31.

In addition to the tabular results, a graphical plot of the computed frequency curves can be obtained by pressing the **Plot Curve** button at the bottom of the analysis window. The Log Pearson Type III distribution fit using EMA to the input annual maximum flow data set, the 5% and 95% confidence limits, and the annual maximum flow data set Hirsch/Stedinger and Median (for low outliers) plotting positions are shown in Figure C-32.

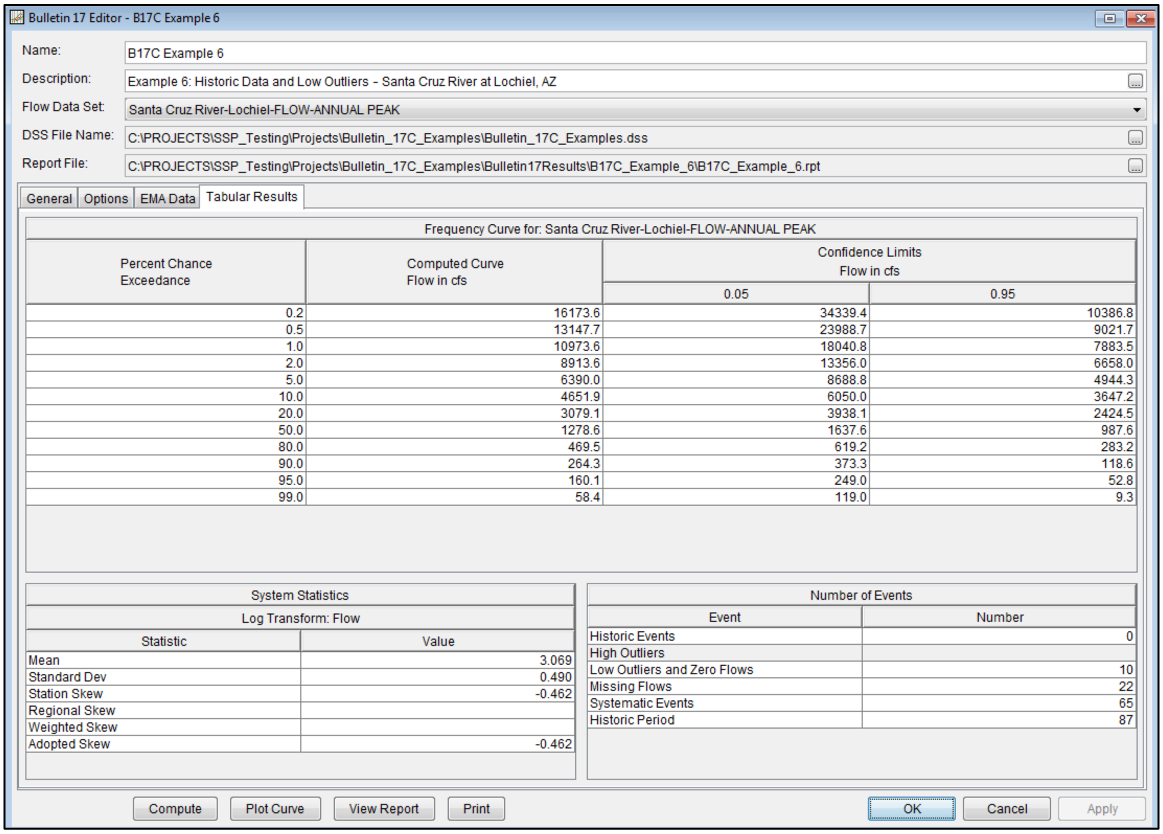


Figure C-38. Bulletin 17 Analysis Tabular Results Tab for “B17C Example 6”.

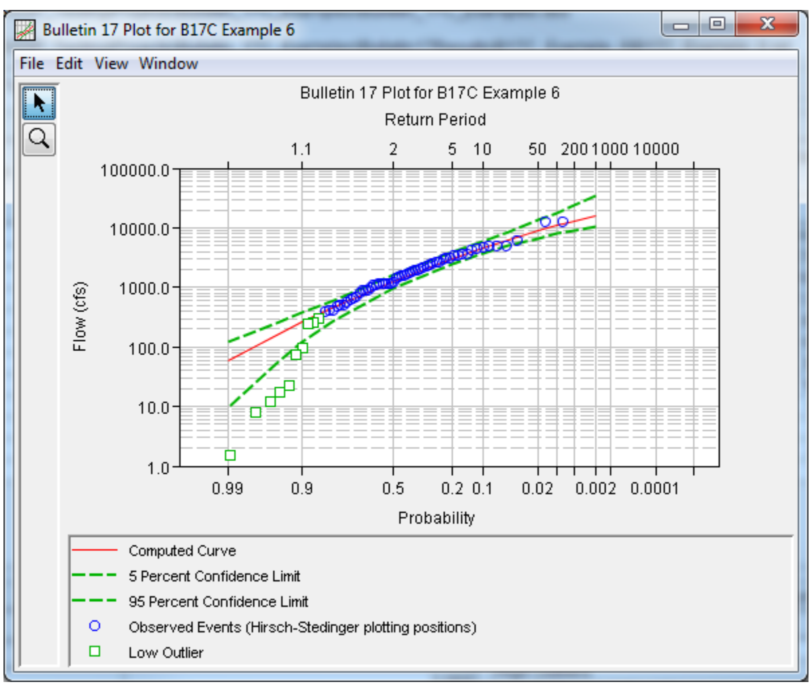
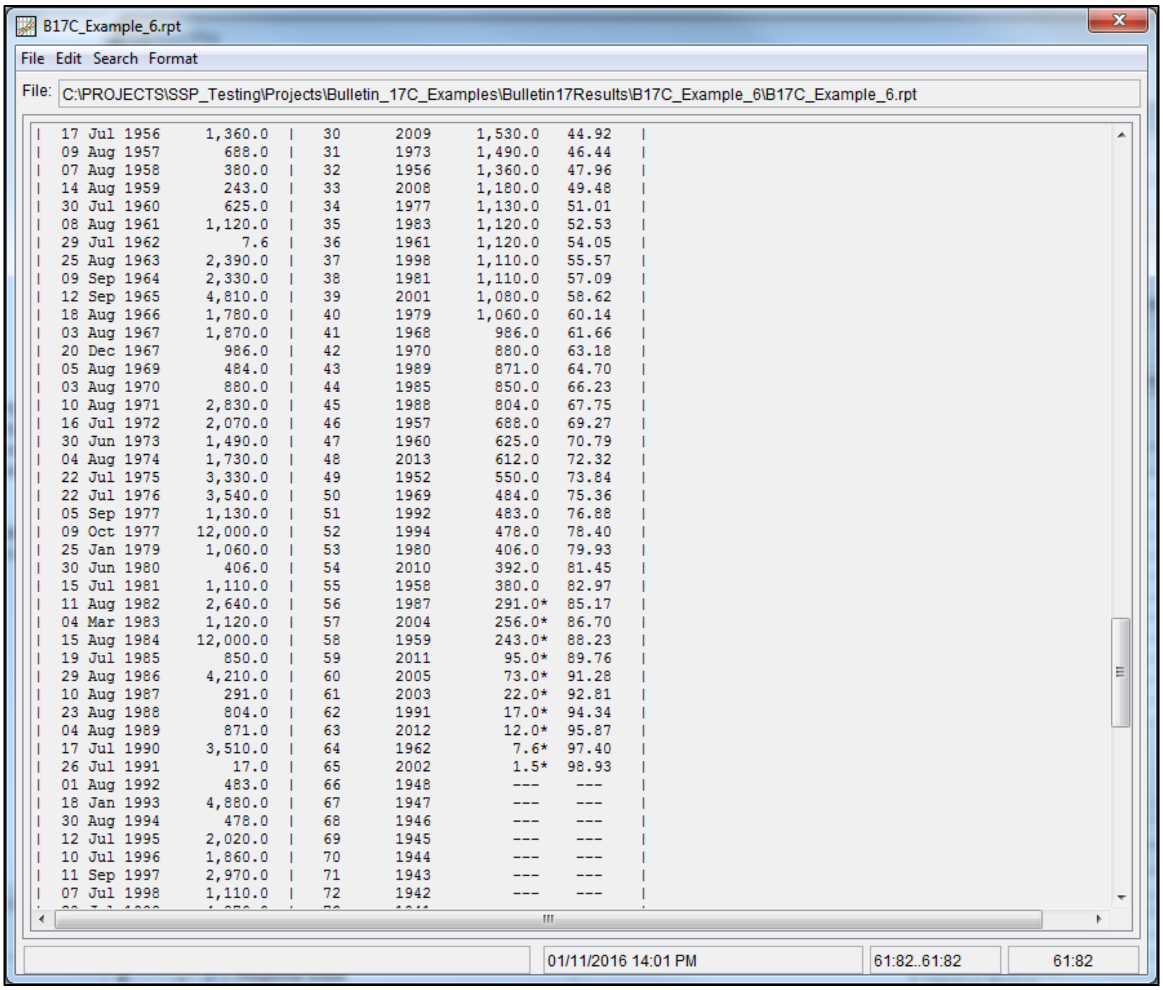


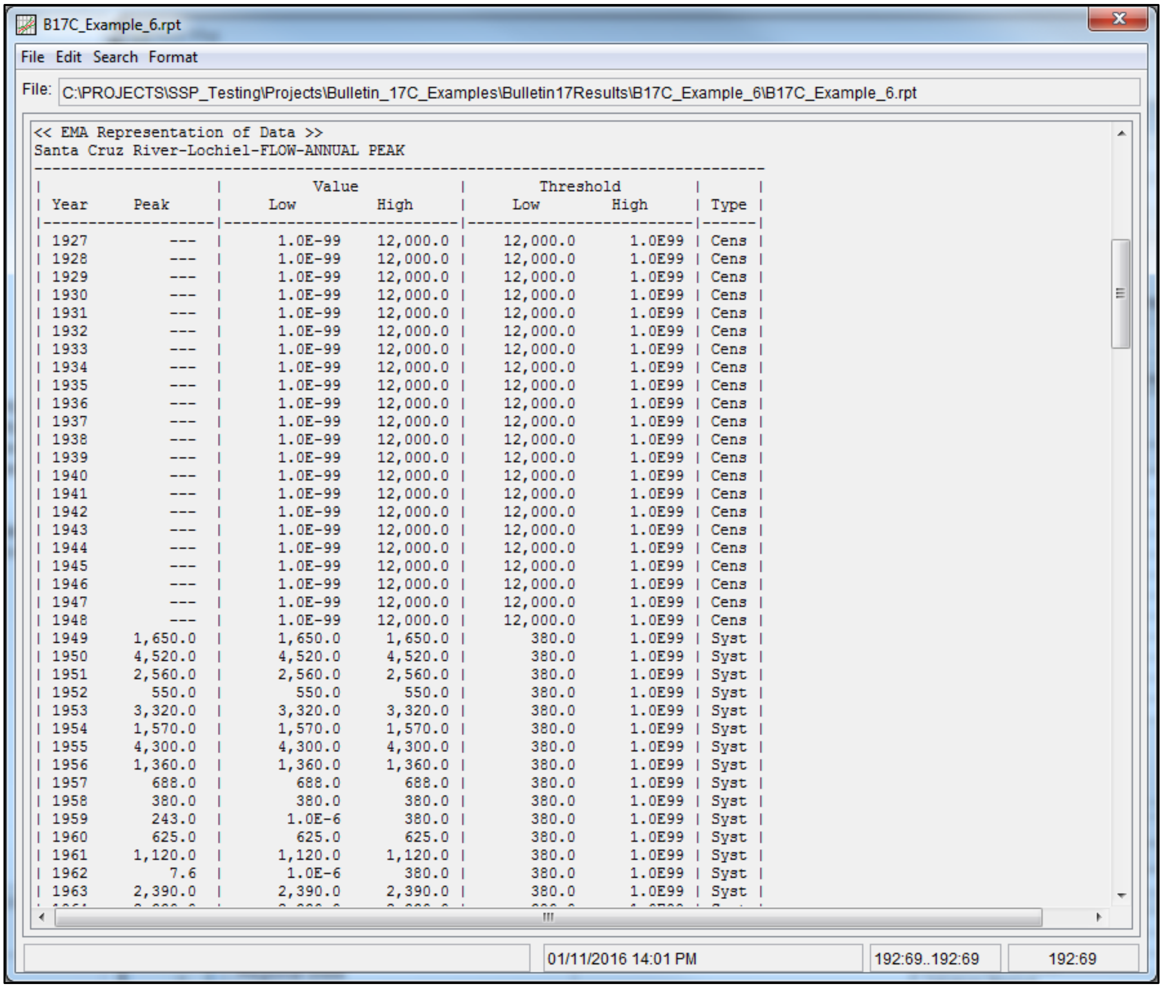
Figure C-39. Plotted Frequency Curves for “B17C Example 6”.

As shown in Figure C-40, the Multiple Grubbs-Beck Test identified a low outlier threshold of 380 cfs. Ten annual peak flows were identified as being less than this threshold, as shown in Figure C-39. These annual peak flows were then recoded to have a flow interval of zero – 380. The perception thresholds for the years in which an annual peak flow was recorded were also adjusted to correspond with the Multiple Grubbs-Beck Test low outlier threshold. Consequently, these perception thresholds were changed from zero – inf to 380 – inf. The perception threshold for the years in which there is only historical nonexceedance data (i.e. 1927 – 1948) were left at 12,000 - inf, as shown in Figure C-41.



17 Jul 1956	1,360.0	30	2009	1,530.0	44.92
09 Aug 1957	688.0	31	1973	1,490.0	46.44
07 Aug 1958	380.0	32	1956	1,360.0	47.96
14 Aug 1959	243.0	33	2008	1,180.0	49.48
30 Jul 1960	625.0	34	1977	1,130.0	51.01
08 Aug 1961	1,120.0	35	1983	1,120.0	52.53
29 Jul 1962	7.6	36	1961	1,120.0	54.05
25 Aug 1963	2,390.0	37	1998	1,110.0	55.57
09 Sep 1964	2,330.0	38	1981	1,110.0	57.09
12 Sep 1965	4,810.0	39	2001	1,080.0	58.62
18 Aug 1966	1,780.0	40	1979	1,060.0	60.14
03 Aug 1967	1,870.0	41	1968	986.0	61.66
20 Dec 1967	986.0	42	1970	880.0	63.18
05 Aug 1969	484.0	43	1989	871.0	64.70
03 Aug 1970	880.0	44	1985	850.0	66.23
10 Aug 1971	2,830.0	45	1988	804.0	67.75
16 Jul 1972	2,070.0	46	1957	688.0	69.27
30 Jun 1973	1,490.0	47	1960	625.0	70.79
04 Aug 1974	1,730.0	48	2013	612.0	72.32
22 Jul 1975	3,330.0	49	1952	550.0	73.84
22 Jul 1976	3,540.0	50	1969	484.0	75.36
05 Sep 1977	1,130.0	51	1992	483.0	76.88
09 Oct 1977	12,000.0	52	1994	478.0	78.40
25 Jan 1979	1,060.0	53	1980	406.0	79.93
30 Jun 1980	406.0	54	2010	392.0	81.45
15 Jul 1981	1,110.0	55	1958	380.0	82.97
11 Aug 1982	2,640.0	56	1987	291.0*	85.17
04 Mar 1983	1,120.0	57	2004	256.0*	86.70
15 Aug 1984	12,000.0	58	1959	243.0*	88.23
19 Jul 1985	850.0	59	2011	95.0*	89.76
29 Aug 1986	4,210.0	60	2005	73.0*	91.28
10 Aug 1987	291.0	61	2003	22.0*	92.81
23 Aug 1988	804.0	62	1991	17.0*	94.34
04 Aug 1989	871.0	63	2012	12.0*	95.87
17 Jul 1990	3,510.0	64	1962	7.6*	97.40
26 Jul 1991	17.0	65	2002	1.5*	98.93
01 Aug 1992	483.0	66	1948	---	---
18 Jan 1993	4,880.0	67	1947	---	---
30 Aug 1994	478.0	68	1946	---	---
12 Jul 1995	2,020.0	69	1945	---	---
10 Jul 1996	1,860.0	70	1944	---	---
11 Sep 1997	2,970.0	71	1943	---	---
07 Jul 1998	1,110.0	72	1942	---	---

Figure C-40. Report File for “B17C Example 6” showing censored low outliers.



<< EMA Representation of Data >>
Santa Cruz River-Lochiel-FLOW-ANNUAL PEAK

Year	Peak	Value Low	Value High	Threshold Low	Threshold High	Type
1927	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1928	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1929	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1930	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1931	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1932	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1933	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1934	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1935	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1936	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1937	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1938	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1939	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1940	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1941	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1942	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1943	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1944	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1945	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1946	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1947	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1948	---	1.0E-99	12,000.0	12,000.0	1.0E99	Cens
1949	1,650.0	1,650.0	1,650.0	380.0	1.0E99	Syst
1950	4,520.0	4,520.0	4,520.0	380.0	1.0E99	Syst
1951	2,560.0	2,560.0	2,560.0	380.0	1.0E99	Syst
1952	550.0	550.0	550.0	380.0	1.0E99	Syst
1953	3,320.0	3,320.0	3,320.0	380.0	1.0E99	Syst
1954	1,570.0	1,570.0	1,570.0	380.0	1.0E99	Syst
1955	4,300.0	4,300.0	4,300.0	380.0	1.0E99	Syst
1956	1,360.0	1,360.0	1,360.0	380.0	1.0E99	Syst
1957	688.0	688.0	688.0	380.0	1.0E99	Syst
1958	380.0	380.0	380.0	380.0	1.0E99	Syst
1959	243.0	1.0E-6	380.0	380.0	1.0E99	Syst
1960	625.0	625.0	625.0	380.0	1.0E99	Syst
1961	1,120.0	1,120.0	1,120.0	380.0	1.0E99	Syst
1962	7.6	1.0E-6	380.0	380.0	1.0E99	Syst
1963	2,390.0	2,390.0	2,390.0	380.0	1.0E99	Syst

Figure C-41. Report File for "B17C Example 6" showing recoded perception thresholds

APPENDIX D

Creating a Partial Duration Series

To use the partial duration frequency curve estimation options within a General Frequency analysis, a partial duration series of flow rates or stages must be constructed outside of HEC-SSP. This type of analysis is commonly called "Peaks over Threshold". The Find Peaks tool within HEC-DSSVue is a useful tool that can be used to construct a partial duration dataset from an input continuous dataset. The creation of a partial duration series from a daily flow dataset is provided to illustrate the use of the Find Peaks tool within HEC-DSSVue as well as the differences between a partial duration series and an annual maximum series.

The data for this example is from Delaware River near Delaware Water Gap, PA (gage number 01440200). This stream gage is located near the site of a previously authorized but unconstructed large dam and reservoir named Tocks Island, which, if constructed, would have provided flood control, water supply, and hydropower benefits to the lower Delaware River watershed. However, negative environmental concerns ultimately derailed the construction of the Tocks Island Dam and Reservoir. Property and flowage easements that were acquired in anticipation of construction and impoundment of water was turned over to the National Park Service in 1979 thereby creating the Delaware Water Gap National Recreation Area. The project was officially deauthorized by Congress in July 1992.

The Find Peaks tool can analyze any data set with a continuous record. Commonly, data sets consisting of daily, hourly, or sub-hourly (i.e. 15-minute) observations are used to derive partial duration series. For the purposes of this example, a daily flow data series can be downloaded for the Delaware River near Delaware Water Gap, PA gage from the USGS website within HEC-SSP. Select a period spanning from 01Oct1939 – 01Jan2015, as shown in Figure D-1. However, it is important to note that data sets originating from different locations (i.e. USACE water control databases) can be used by as well.

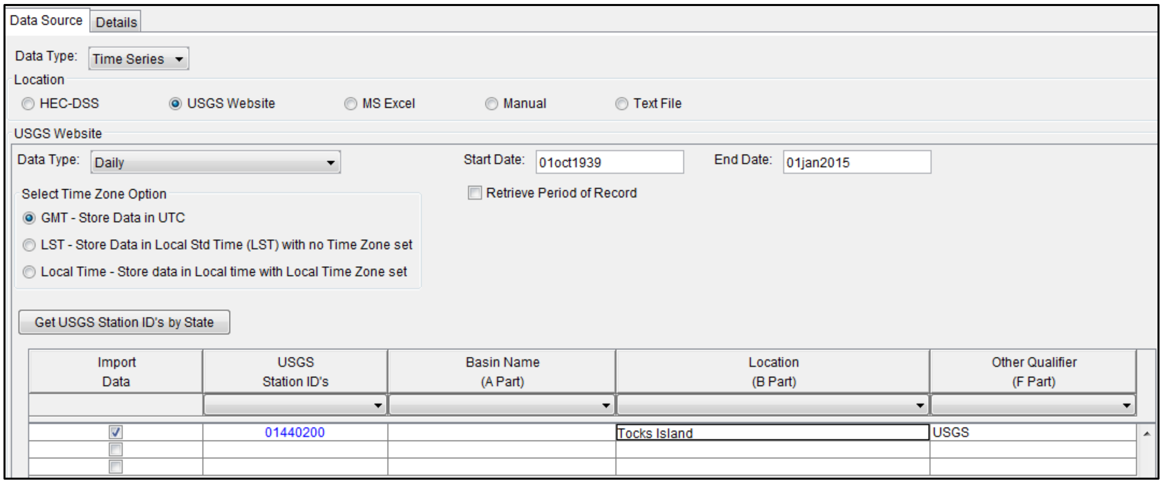
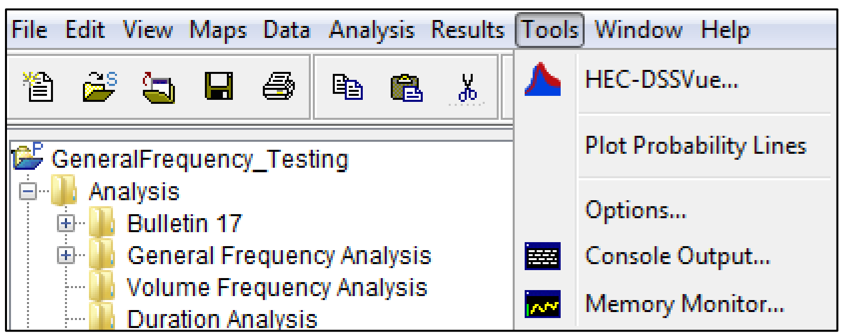


Figure D-1. Downloading Daily Flow Data.

To use the Find Peaks tool, the appropriate Java plug-in (“Peaks.jar”) must be present within the “..HEC-DSSVue\Plugins\” directory. By default, this directory is located at either “C:\Program Files\HEC\HEC-DSSVue\Plugins” (for 32-bit versions of Windows XP, Vista, or 7) or “C:\Program Files (x86)\HEC\HEC-DSSVue\Plugins” (for 64-bit versions of Windows XP, Vista, or 7). The “Peaks.jar” file can be found on HEC’s website here: http://www.hec.usace.army.mil/software/hec-dssvue/plugins.aspx. Once the daily flow dataset has been downloaded and the “Peaks.jar” file has been placed within the appropriate directory, the DSS file associated with the HEC-SSP project can be by selecting **Tools | HEC-DSSVue** within the HEC-SSP project. Alternatively, the DSS file can be opened independently of HEC-SSP. Once the DSS file is opened within HEC-DSSVue, there will be a record created with the following part names: \\TOCKS ISLAND\FLOW\\1DAY\USGS.



There cannot be missing values within the data set for the selected Time Window. The Estimate Missing Values tool within HEC-DSSVue’s Math Functions can be used to fill in data gaps, if necessary.

Select the daily flow data set and then select **Tools | Find Peaks,** as shown in Figure D-2.

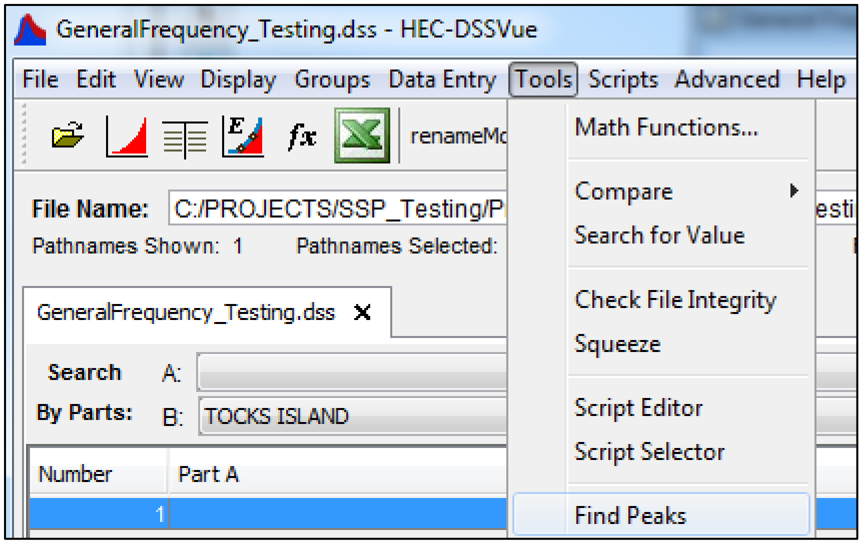


Figure D-2. Find Peaks Tool Location within HEC-DSSVue.

The Find Peaks tool requires multiple user inputs in order to determine "hydrologically independent" peaks (or troughs), as described within EM 1110-2-1415 "Hydrologic Frequency Analysis". For example, Figure D-3 shows a flow hydrograph at the Delaware Water Gap stream gage (drainage area = 3,850 sq mi). The peak flow at 09Dec1950 is not hydrologically independent; this peak was dependent upon the peak on 05Dec1950. The peak on 26Nov1950 can be considered hydrologically independent. However, it is up to the user to decide whether the peak on 05Dec1950 is hydrologically independent.

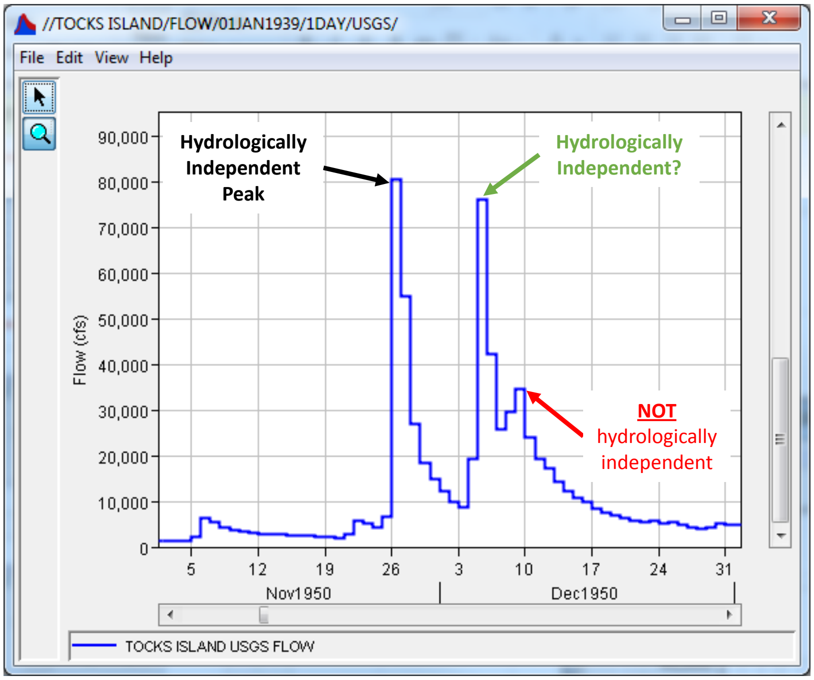


Figure D-3. Example of Hydrologically Independent Peaks.

The first user input within the Find Peaks tool asks whether the user wishes to find peak values (maximums) or troughs (minimums), as shown in Figure D-4. Select "Peaks", which will display a new window asking the user to specify a threshold (minimum) value. By default, the Find Peaks tool will estimate a threshold value based upon the values contained within the selected data set. The user may also leave the field blank which will enable all values to be discernable as peak values.

The threshold value can be set to the minimum peak contained within the associated annual maximum series in order to capture a large number of peaks. However, this threshold value is watershed (and study) dependent. For this example, enter 30000 within this field, indicating that all peak values greater than 30,000 cfs will be carried forward as potential peaks, as shown in Figure D-5.

The next dialog will require the user to input a minimum magnitude and time differential. These two inputs preliminarily determine whether a peak is truly "independent". In order for a peak to be independent, the flow/stage hydrograph must decrease (or increase when determining independent minimums) by a certain magnitude or below a certain threshold. Also, a certain amount of time must elapse before the peak can be classified as independent. These values are location dependent as well as reliant upon the study purposes. By default, the Find Peaks tool will estimate a minimum magnitude and time differential based upon the values contained within the selected data set.

For the Delaware River near Delaware Water Gap, PA stream gage, the drainage area is large. The contributing watershed requires approximately one week (i.e. seven days) to return to baseflow. For smaller watersheds, such as highly urbanized streams that exhibit an extremely fast rise and fall in flow or stage, the time required to return to an approximate baseflow may be on the order of hours, not days. For this example, the minimum magnitude and time differential can be set to 10000 and 240, as shown in Figure D-6. This implies that the hydrograph must decrease by 10,000 cfs and 10 days must elapse before a new peak can be considered independent of a previous peak. Figure D-7 displays the threshold value, minimum magnitude, and minimum time differential values for a three-month time span at the stream gage in question.

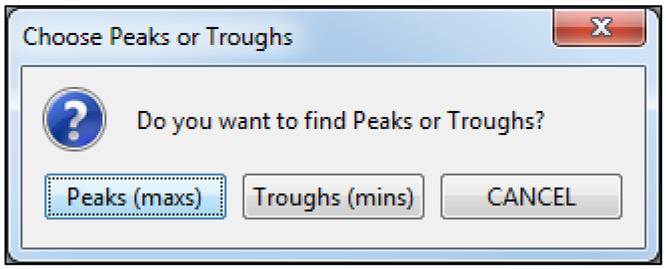


Figure D-4. Selection of Either Peaks or Troughs.

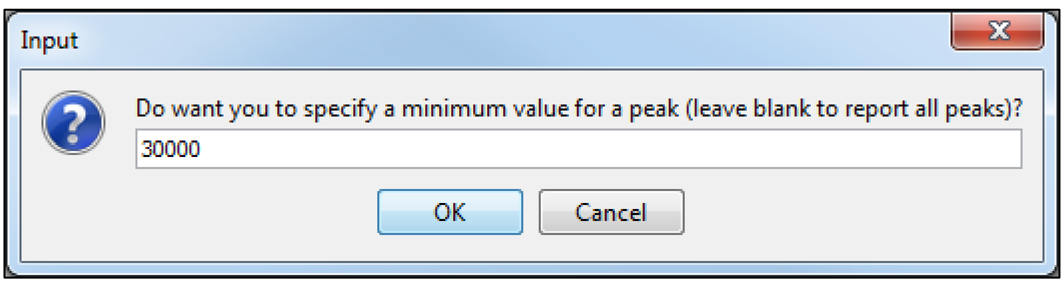


Figure D-5. Threshold Value Selection.

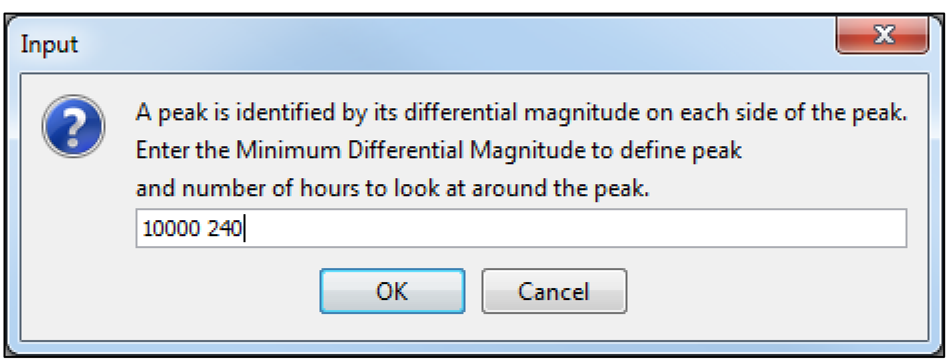


Figure D-6. Minimum Magnitude and Time Differential Selection.

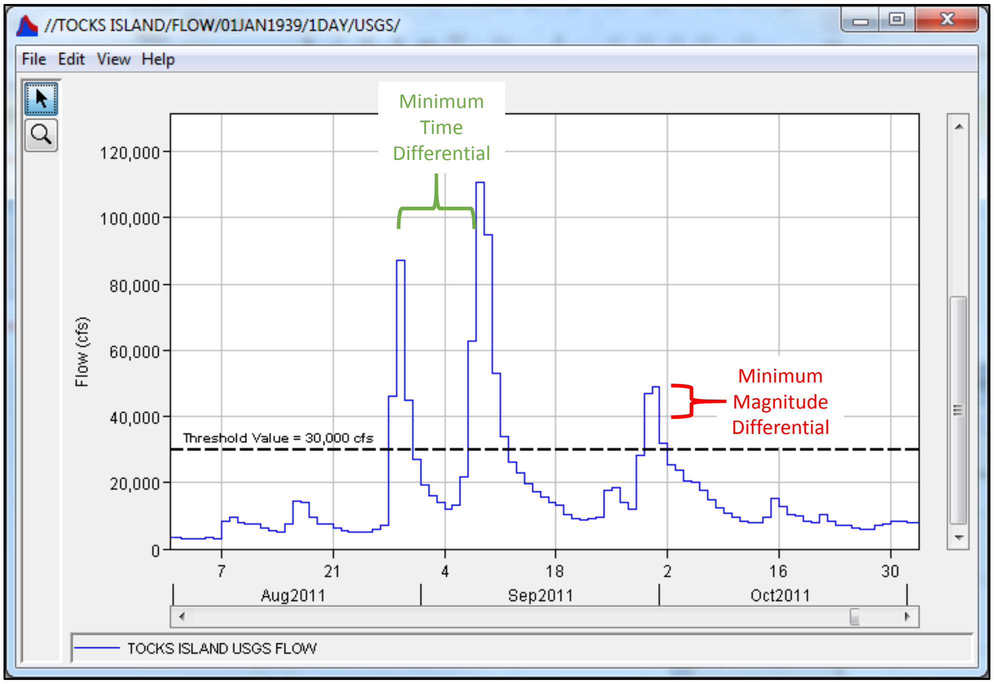


Figure D-7. Threshold Value, Minimum Magnitude, and Minimum Time Differential.

Clicking OK results in the creation of an irregular time series record (i.e. the date-time of occurance is saved along with the data value) that is usable by HEC-SSP. The flow data set and peak data set are shown in a separate window, as shown in Figure D-8.

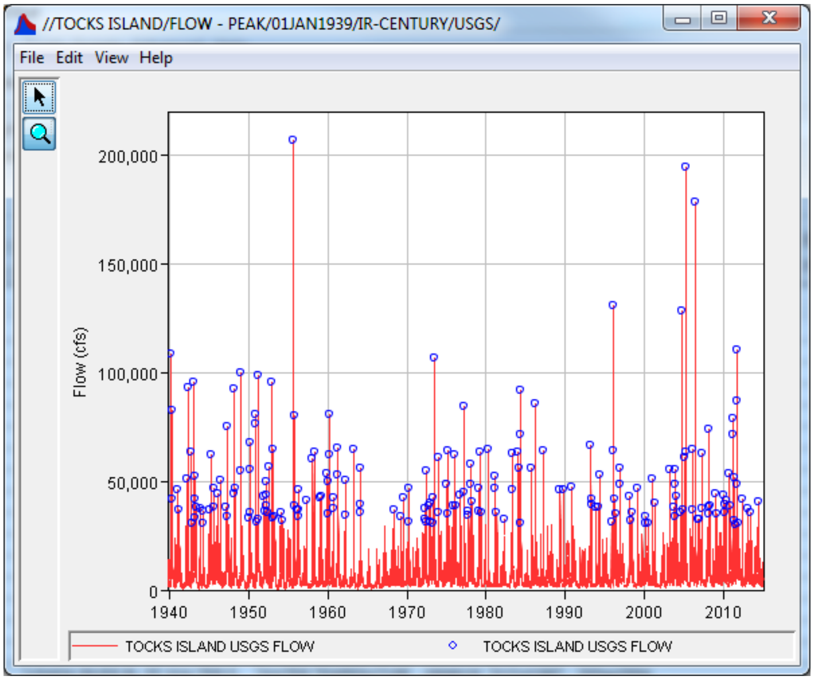


Figure D-8. Resulting Peak Flow Partial Duration Series.

As is shown in Figure D-9, this partial duration series contains peak flow rates for multiple peak flow rates including the two extremely large peaks that occurred in late August and early September, 2011 (corresponding to the passage of Tropical Storm Irene and Tropical Storm Lee). By definition, an annual maximum series only records a single peak flow rate for each water year. Therefore, only the larger event (September 2011) is stored within an annual maximum series.

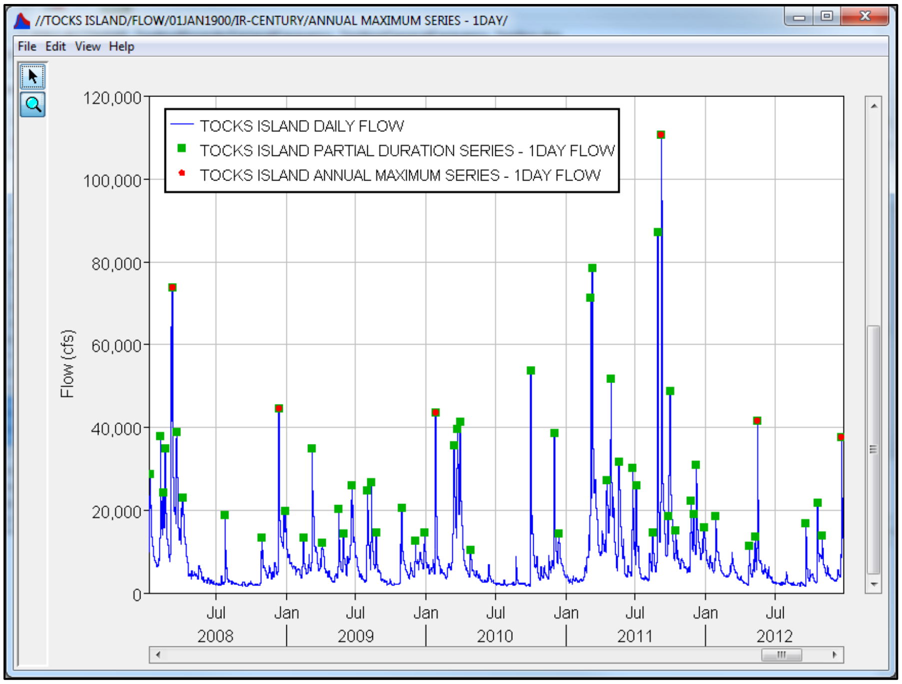


Figure D-9. Resulting Peak Flow Partial Duration Series and Annual Maximum Series for 2008 - 2012.

This peak flow partial duration series data set can now be used within a General Frequency analysis in HEC-SSP. However, it is up to the user to review the peak flow partial duration series. The three criteria (threshold, magnitude differential, and time differential) may not be adequate to completely define all independent peaks for a given data set; some non-independent peaks may need to be deleted while others may need to be added.