ADVANCES in Hydrologic Engineering

Spring 2018

Director's Comments

By Christopher N. Dunn, P.E., D.WRE

Welcome to the latest edition of the Institute for Water Resources' Hydrologic Engineering Center (CEIWR-HEC) Newsletter.

While we strive to deliver our newsletter on a more frequent basis, many activities continue to take precedence. One such activity that consumed quite a bit of time was the transition from the Army's long running evaluation system TAPES (Total Army Performance Evaluation System) to the new performance evaluation system DPMAP (DoD Performance Management and Appraisal Program). The closing of TAPES and the opening of DPMAP in the middle of the typical performance cycle generated a lot of work for the entire CEIWR-HEC staff and U.S. Army Corps of Engineers (USACE). While I am not necessarily questioning the need for a new performance evaluation system, the timing of the transition seemed odd, and created a distraction for personnel to meet other work deadlines.

Another activity that has occupied a great deal of my time lately, which is much more germane to this Newsletter, is the development of a collaborative teaming agreement between CEIWR-HEC and ERDC (Engineer Research and Development Center). This draft agreement, the "Implementation Plan for Hydrology, Hydraulics, and

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HEC-MetVue, Meteorological Visualization Utility Engine

By Fauwaz Hanbali

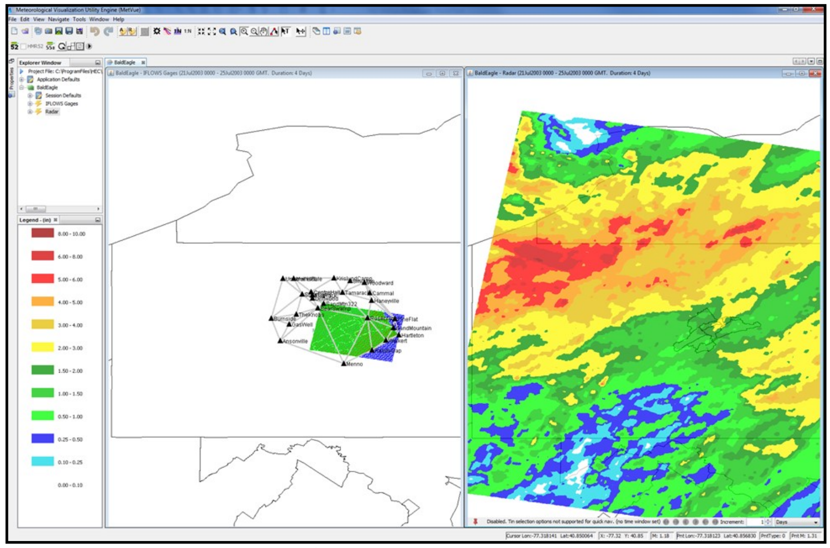

Figure 1. HEC-MetVue Main Window

The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) is developing a new software application, HEC-MetVue (Meteorological Visualization Utility Engine), to support real-time forecasting and dam safety analyses. HEC-MetVue (Figure 1) allows for the display, verification, and editing of spatial data through interactive and visual means. The software is designed to process and edit precipitation and other meteorological datasets including operations such as: temporal and spatial aggregation, spatial extents trimming, spatial translation, temporal shifting, image scaling, image resizing, and animations.

HEC-MetVue currently supports a number of input data formats, including: DSS (HEC's Data Storage System), ASCII_GRID, NEXRAD, XMRG, NetCDF, GRIB, and PRISM's BIL. Reading multiple images, HEC-MetVue aggregates those images temporally and spatially, and computes basin averages for any desired shapefiles loaded in the program. HEC-MetVue operates on Triangulated Irregular Network (TIN) datasets constructed from either time series of gage data inputs, time series of gridded data inputs, or TIN inputs. For output, HEC-MetVue saves multiple images, aggregate images, and re-projected images as gridded datasets (in DSS or ASCII_GRID formats) as well as TINs (the native HEC-MetVue TIN format). HEC-MetVue output options also include basin average time series for select shapefiles and corresponding summary statistics logs.

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In This Issue:

Coastal Engineering (HH&C) Numerical Modeling Products and Analysis" is being written in part to address Mr. James Dalton's, USACE s Director of Civil Works, charge that USACE "*identify opportunities for enhanced product delivery and increased organizational efficiency and effectiveness by reducing redundancies…*". Mr. Dalton's charge was included in his 21 June 2017 Memo "Further Advancing Project Delivery Efficiency and Effectiveness of USACE Civil Works". The intent of the draft agreement is to stimulate collaboration across the HH&C Cop software development teams whenever appropriate.

While an official agreement might be new, CEIWR-HEC and ERDC have already experienced the benefits of collaboration. A primary mission of both CEIWR-HEC and ERDC is to develop engineering tools for USACE. Collaboration between ERDC's laboratories, primarily the Coastal and Hydraulics Laboratory (ERDC-CHL), Environmental Lab (ERDC-EL), and Cold Regions Research and Environmental Lab (ERDC-CRREL), and CEIWR-HEC has been occurring for years. By collaborating on specific tasks, new ideas have been introduced and USACE software has been advanced. Both offices have benefited as capabilities are implemented into multiple pieces of software thus reducing duplication of effort and assuring USACE has consistent technologies across software even when the software has different functionality. As noted, during our initial meeting on this topic, ERDC and CEIWR-HEC leadership quickly identified over twenty examples of existing collaboration between the offices. For example, the introduction of the Markov Chain Monte Carlo uncertainty analysis will benefit multiple pieces of software. Other areas of collaboration include: snow data storage and snowmelt modeling; post fire hydrology; uncertainty modeling; forecast informed reservoir operation; sediment modeling; distributed computing; and, water quality modeling to name a few.

The intent of the HH&C Cop software implementation is not to force collaboration but rather to build relationships over time by picking "low hanging fruit" or easily identifiable tasks to start and then build on those successes. Software development teams are expected to start organically with teams identified as appropriate. These teams can begin to work with one another and build relationships and efficiencies over time. Examples of such teams are those working on HEC-HMS (HEC's Hydrologic Modeling System software), sediment transport, and water quality. Each of these teams began organically, have become or are becoming more efficient, and are developing products that are beneficial across offices. The software development teams started small, identifying particular tasks, products and milestones, and have progressively built themselves into a coherent team. The best example may be the sediment transport team who is now receiving funds from sources outside of the USACE Research and Development (R&D) program. The sediment transport team includes members from USACE District offices, CEIWR-HEC, and ERDC-CHL and the team s products are being directly applied by the field.

It is also understood that while increased collaboration is expected to provide the best opportunity for enhanced product delivery and increased organizational efficiency by reducing redundancies, it also comes at a cost. Most would agree, that two heads are better than one, but getting two heads to think alike takes time, energy, resources, funding, commitment, and a sincere effort. Extra meetings will need to be held, extra travel will need to occur, the time to coordinate will have to be addressed as coordinating schedules takes time and delays are to be expected. The need for enhanced coordination and collaboration would increase the cost of some efforts. The ideas that come from the collaboration may be better, but the idea of additional collaboration must be handled judiciously. For example, both parties would have to understand the software development framework, the source control and testing procedures, Quality Assurance and Quality Control requirements, and bug testing infrastructure and protocols. Additional hardware and software would have to be purchased as well. All these items come at a cost. The extra costs are understood. However, the hope is that over time, the teams will become more coordinated thus reducing the amount of extra collaboration and thus the benefits will eventually outweigh the costs.

The layout of the collaborative teaming agreement includes the motivation of the document, which was explained above. Also described are the objective and vision of future collaboration, and development and support of numerical modeling products. The document includes a life-cycle software development approach that includes four principal areas: research; software development; training and support; and, technical assistance. The document stresses that USACE will continue to push toward the use of fewer, more collaboratively managed tools that are designated as HH&C Cop Preferred software. Worldwide

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Water Resource Systems Chief:
Lea G. Adams, P.E.

application requirements are identified as well. The organizational structure for the collaborative process is defined, as are Five-year Plans for future development across the HH&C CoP. These Five-year Plans identify the major activities that need to be provided to meet field needs for better, faster, more robust software. The agreement also addresses topics other than just software development, and includes the dissemination of products through training, guidance documents, webinars, conference sessions, and technical exchanges. Interaction and coordination with the field is critical to the success of the development of the numerical models. Creating products that are powerful but yet intuitive are what the field is looking for and thus what the software development teams need to deliver. Finally, an example of a working agreement between ERDC-CHL and CEIWR-HEC is provided which outlines how code is shared and multiple developers are expected to work together.

A draft version of the Implementation Plan for HH&C Numerical Modeling Products and Analysis was delivered and presented to the USACE R&D Steering Committee in May/June of 2018. It will be interesting to hear of the committee's reaction and see whether the idea gains support toward true implementation of the plan.

We will see how the relationship grows between the two offices, but it is clear that USACE will continue to strive to become more efficient in the use of our resources. The intent is to have the collaboration document cover not only ERDC-CHL (Coastal Hydraulics Laboratory)and CEIWR-HEC, but include ERDC-EL (Environmental Laboratory), ERDC-CRREL (Cold Regions Research and Engineering Laboratory), ERDC-ITL (Information Technology Laboratory), and perhaps AGC (Army Geospatial Center), Headquarters (HQ), and USACE field offices as well. After all, USACE has amazing people across the Nation.

We hope you enjoy this edition of the HEC Newsletter.

Chris Dunn, P.E., D.WRE
Director

HEC-MetVue, Meteorological Visualization Utility Engine (continued)

By Fauwaz Hanbali

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One of the primary functions of HEC-MetVue is the development of design storms (Figure 2), using the Hydrometeorological Report (HMR) methodology for estimating probable maximum precipitation, and their preparation as input for rainfall runoff models such as HEC-HMS (Hydrologic Modeling System) that are used in dam safety studies. Another primary function of HEC-MetVue is the calibration of radar observed precipitation datasets and merging them with forecast precipitation as inputs for real-time hydrologic modeling through the USACE water management decision-support system, the Corps Water Management System (CWMS) software.

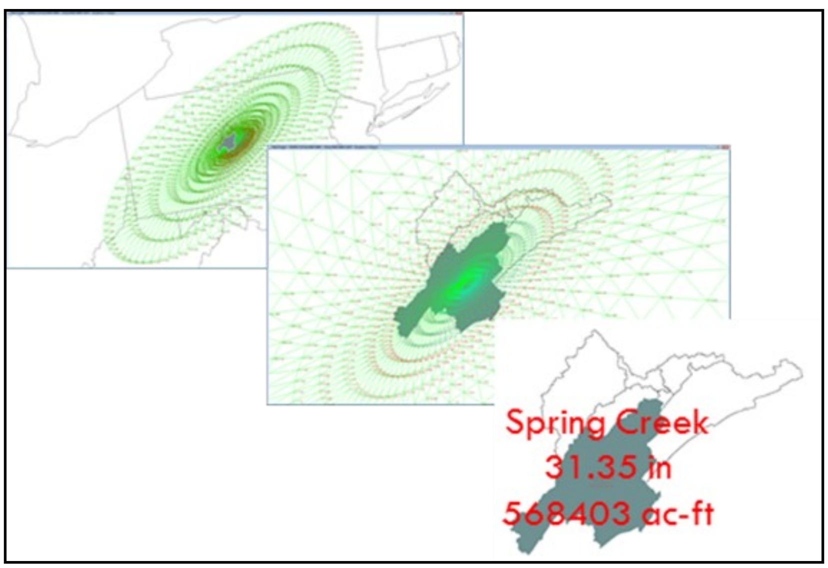

Figure 2 Development of Design Storms

The first public release of the HEC-MetVue software should occur in the next few months and will be available from the HEC website (http://www.hec.usace.army.mil/).

Current Program & FY2019 Proposed PROSPECT Training Program

By Penni Baker

The Hydrologic Engineering Center s (HEC) PROSPECT (Proponent-Sponsored Engineer Corps Training) program for FY 2018 is almost completed with only two classes left. The last class, Course #155, "CWMS Modeling for Real-Time Water Management", was originally scheduled for January 2018, but due to the Government shutdown, is now scheduled for 6-10 August 2018. If you had registered previously, please re-register again.

The table below provides the FY2019 Proposed PROSPECT training program for CEIWR-HEC. The PROSPECT training program is provided through the USACE Learning Center (ULC). The ULC is located in Huntsville, Alabama and if you are interested in one or more of the courses, please let the training program lead in your District/Division know so they can report your interest to the ULC.

To register for our FY 2019 courses (see table below), please contact the appropriate party in your office or contact ULC, http://ulc.usace.army.mil. Registration is handled by Training and Operations (CEHR-P-RG). Course descriptions are provided at the ULC site (http://ulc.usace.army.mil/CrsSchedule.aspx). A short description along with a course agenda is also provided on CEIWR-HEC's web site (http://www.hec.usace.army.mil/training/course_list.html). To obtain enrollment information, please contact the USACE Learning Center. When doing so, please note the course number, name, date, and location, and contact:

USACE Learning Center
550 Sparkman Drive, NW
Huntsville, AL 35816-3416
Phone: (256) 895-7401
FAX: (256) 895-7469

Please note, that ULC has implemented a new policy that if minimum enrollment requirements are not met 90 days prior to the start date of a class it will be cancelled. If you have an interest in a class, you need to get your request in sooner than later.

CEIWR-HEC s FY 2019 Proposed PROSPECT Training Program

Course Number	Course Title (all classes located in Davis, CA)	Dates
155	CWMS Modeling for Real-Time Water Management	14-18 Jan 2019
098	Reservoir Modeling with HEC-ResSim	4-8 Feb 2019
209	Risk-Based Analysis for Flood Damage Reduction Projects	25 Feb-1 Mar 2019
369	Advanced Applications of HEC-HMS	11-15 Mar 2019
161	Hydrologic Analysis for Ecosystem Restoration	1-5 Apr 2019
058	Statistical Methods in Hydrology	8-12 Apr 2019
060	Consequence Estimation with HEC-FIA	6-10 May 2019
114	Steady Flow using HEC-RAS	3-7 Jun 2019
352	Advanced 1D/2D Modeling with HEC-RAS	15-19 Jul 2019
152	Water Data Management with HEC-DSSVue	9-13 Sep 2019

Course #122 "Sediment Transport Analysis with HEC-RAS", was removed from the PROSPECT program, but is available as a workshop through the Hydrologic Engineering Center. If you are interested in this training please contact Dr. Stanford (Stan) Gibson (stanford.a.gibson@usace.army.mil) of the Hydrologic Engineering Center for details on obtaining this training.

HEC-SSP (Statistical Software Package) Version 2.2 Release

By Michael Bartles, P.E.

In January 2017, the Hydrologic Engineering Center CEIWR-HEC released version 2.1.1 of the Statistical Software Package (HEC-SSP). This version contained minor bug fixes such as an updated USGS (U.S. Geological Survey) plugin and recompiled 64-bit Expected Moments Algorithm (EMA) FORTRAN library. While HEC has been supporting usage of Version 2.1.1 since its release, significant development has been underway for nearly two years on a new version of HEC-SSP. This new version (2.2) is planned for release in 2018 and will feature ground-breaking enhancements to existing features, three new analysis types, and bug fixes that will benefit statistical analyses of hydrologic data.

Enhancements have been made to the user interface in an effort to improve usability. For instance, dialogs which were "docked" to the HEC-SSP study have been "undocked" so the dialogs may be individually moved, minimized, and/or maximized. Also, the Open Street Maps framework has been integrated which allows the user to load Internet maps to aid in locating points of interest. The plotting library used within HEC-SSP has also been upgraded. As an example, clicking on a legend item within any plot will cause the selected curve to be highlighted. Finally, when plotting multiple time series, curves that utilize different data types/units will be placed in separate viewports. These two plotting enhancements are demonstrated in Figure 3.

In addition to user interface enhancements, computational enhancements have been made to nearly every single analysis within HEC-SSP. For instance, a JAVA implementation of EMA has been completed. EMA is used within Bulletin 17C methodologies to fit a Log Pearson III analytical distribution to an annual maximum series of flow (England, et al., 2017). Within Versions 2.1 and 2.1.1, the EMA algorithm was applied using a FORTRAN library which was shared with the USGS. By converting the underlying EMA computations from FORTRAN to JAVA, HEC-SSP can utilize more advanced object oriented programming concepts and to handle and manipulate data. One benefit of this conversion is the generation of new output to be generated and displayed for the user. This output consists of the computed variance at each user-defined frequency ordinate, Multiple Grubbs-Beck test p-values, and equivalent record length, which is commonly used within dam and levee safety studies. Another benefit of this conversion is the flexibility to utilize the EMA algorithm within the General Frequency and Volume Frequency analysis. These enhancements are expected to greatly benefit dam and levee safety applications throughout the United States.

Another general enhancement made within Version 2.2 is the ability to filter input data and extract a new dataset for use within HEC-SSP. Users have the option to filter using a specific time window, season, and/or by minimum/maximum threshold. Peak values can be extracted to an annual maximum series (i.e., one value per designated water year) or to a partial duration series (i.e., none or many values per water year). Also, stage datasets can be filtered using an input rate of rise and typical high pool duration to identify plausible initial conditions for use in dam or levee safety studies. For example, 78 years of daily average streamflow data for the Sinnemahoning Creek at Sinnemahoning, PA was downloaded and imported using the USGS plugin. Values outside of 15 April through 30 November were excluded to focus primarily on rainfall-only flood events (i.e., to avoid a mixed population). Finally, independent peaks that were greater than 10,000 cfs and separated from other peaks by seven days were extracted to form a partial duration series, as shown in Figure 4.

Additional computational enhancements include numerous new analytical distributions for use

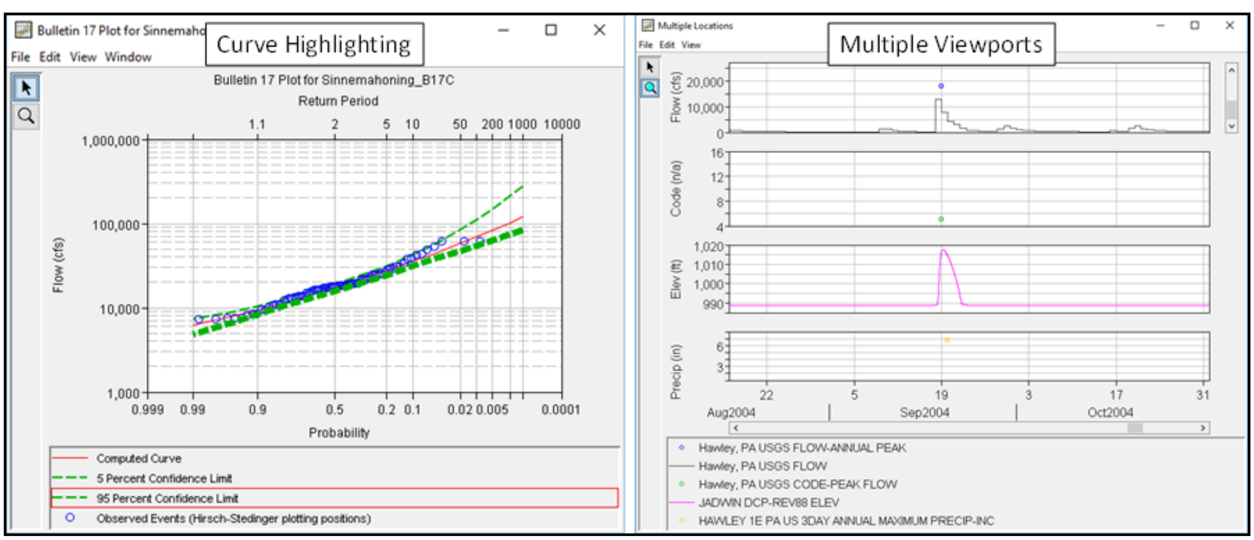

Figure 3 Example of Plotting Enhancements

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By Michael Bartles, PhD, P.E.

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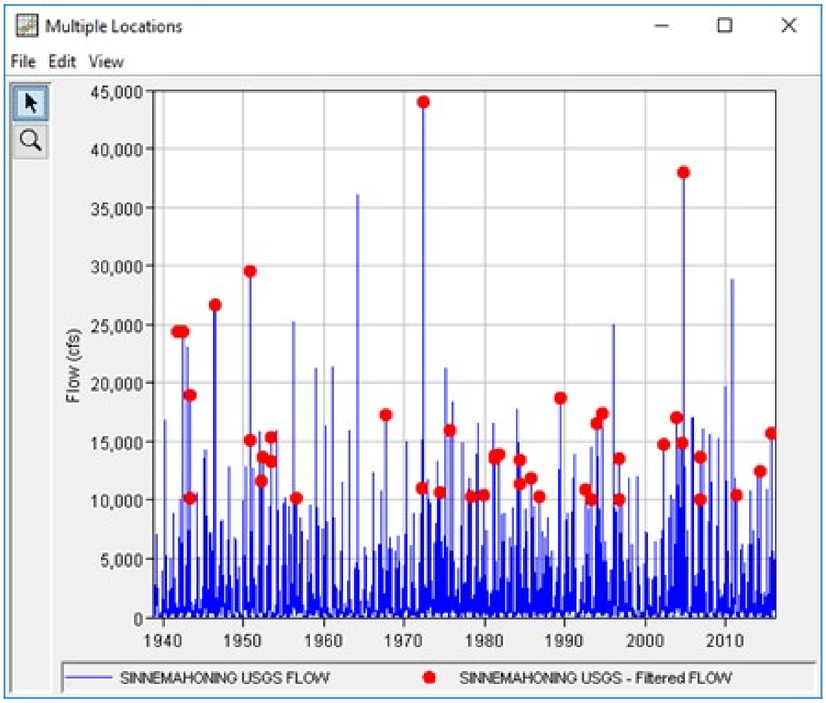

Figure 4 Example Partial Duration Series Created within HEC-SSP.

within the General Frequency analysis (i.e., Log Pearson III – Product Moments, Log Pearson III – EMA, Gumbel, Generalized Extreme Value, Generalized Pareto, Generalized Logistic, etc.). Also, empirical distribution confidence limits are now computed using the same algorithm as HEC-FDA (HEC's Flood Damage Reduction Analysis software) Version 1.4.2. The Balanced Hydrograph analysis has been modified to import frequency distribution information from an already-computed Bulletin 17, General Frequency, or Volume Frequency analysis. If the user elects to import information from a Volume Frequency analysis, the correct information will be imported based upon the desired duration in the Balanced Hydrograph analysis.

A redesigned Curve Combination analysis will be included with Version 2.2, this analysis is meant to aid users in defining a "best fit" empirical distribution using multiple input datasets. For instance, observed annual maximum stages (blue squares) and hydrologic model results using various inputs (red, green, and black squares) can be input and compared to develop a best fit reservoir stage-frequency curve (red line), as shown in Figure 5.

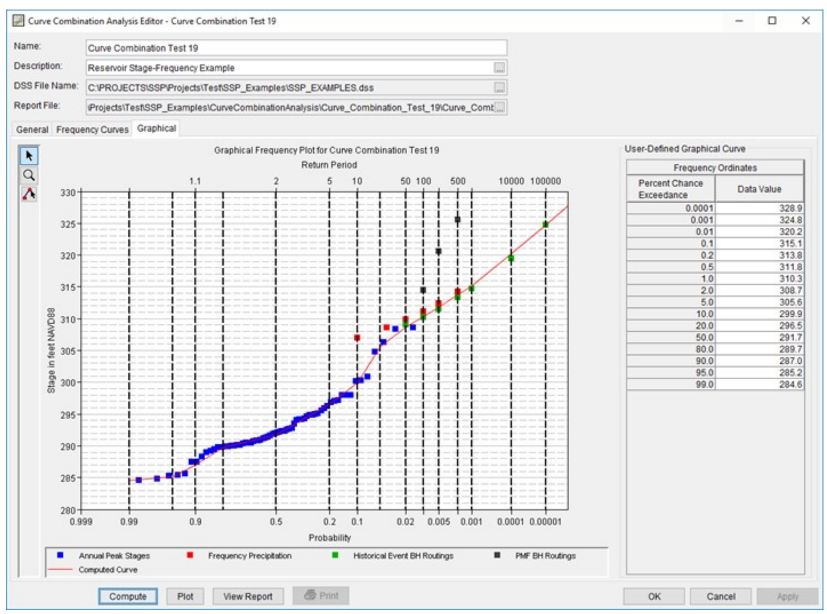

Figure 5 Example Curve Combination Analysis

A brand new Mixed Population analysis will also be included with Version 2.2. Within a hydrologic context, "mixed population" refers to data that stems from two or more different, independent causative conditions. For example, floods within the Susquehanna River watershed in the northeastern United States can be caused by localized thunderstorms, rain-on-snow events, extratropical storms (i.e., nor'easters), and tropical storms (amongst others). When lumping together all possible flood mechanisms in a single series, the resulting population may not be homogenous and violate several key assumptions within probability theory. Also, when plotting on logarithmic-normal probability paper, this mixed population may display sudden changes in slope. When fitting an analytical distribution to this mixed population, the resultant fit will likely display an erroneously large skew coefficient. In these situations, it is best to create separate series for each flood producing mechanism, infer a probability distribution for each mechanism, and combine the multiple distributions using total probability theorem.

The new Mixed Population analysis is meant to compute a combined frequency distribution given multiple input frequency distributions using this theory. For further information on mixed populations, see Bulletin 17C (England, et al., 2017) and Engineer Manual 1110-2-1415 Hydrologic Frequency Analysis(U.S. Army Corps of Engineers, 1993). Within

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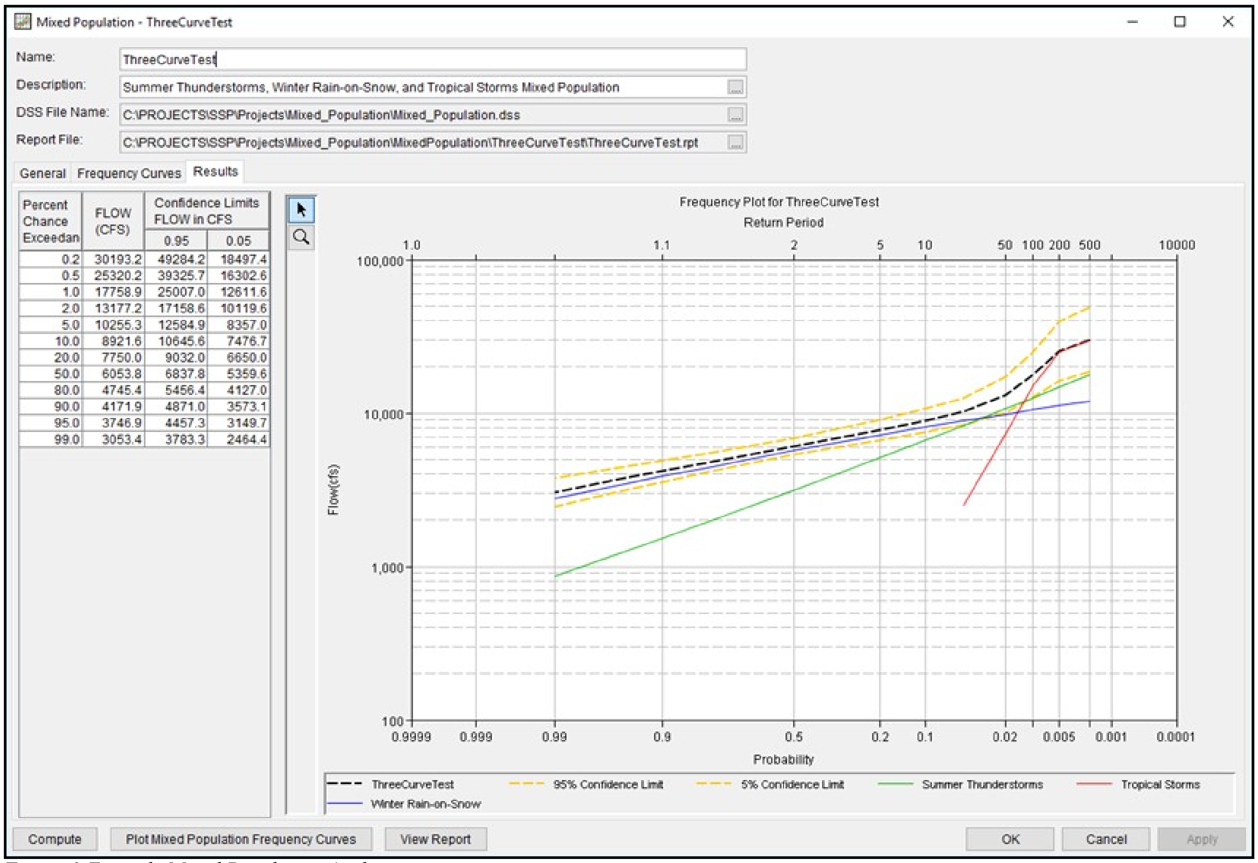
this new analysis, the user can input two or more frequency distributions using one of three options: 1) import results from an existing Bulletin 17 or General Frequency analysis, 2) manually-define the frequency distribution, or 3)select an analytical distribution (Log10Normal, Generalized Extreme Value, or Log Pearson III) and define its parameters. Once the frequency distributions have been entered (green, blue, and red lines), a combined frequency distribution (dashed black line) and confidence limits(dashed orange lines) can be computed, as shown in Figure 6. precipitation, wind speed, etc.) at the 1-percent AEP exists due to multiple sources including measurement error, small samples, and model choice (i.e., fitting a Log Pearson III distribution using EMA to an annual maximum series of peak flow to estimate the 1-percent AEP), amongst others (Asquith, Kiang, and Cohn, 2017). When assessing the performance of critical pieces of infrastructure like nuclear power plants, dams, and levees, quantile estimates at extremely small AEP (i.e., 1E-6 or 1/1,000,000) are often times required. As AEP decreases, the information related to the dataset and model choice. From the HEC -SSP interface, on the Data tab, the user can examine the data set and filter using multiple options. Within Figure 7, a daily average flow dataset has been filtered to an annual maximum series and plotted as a time series. In addition to a time series plot, the user can also plot the data as a cumulative distribution function (CDF) or probability density function (PDF).

On the Analysis tab, the user can inspect different fitting methods



Percent Chance Exceedance	FLOW (CFS)	Confidence Limits FLOW in CFS 0.95	0.05
0.2	30193.2	49284.2	18497.4
0.5	25320.2	39325.7	16302.6
1.0	17758.9	25007.0	12611.6
2.0	13177.2	17158.6	10119.6
5.0	10255.3	12584.9	8357.0
10.0	8921.6	10645.6	7476.7
20.0	7750.0	9032.0	6650.0
50.0	6053.8	6837.8	5359.6
80.0	4745.4	5456.4	4127.0
90.0	4171.9	4871.0	3573.1
95.0	3746.9	4457.3	3149.7
99.0	3053.4	3783.3	2464.4

Figure 6 Example Mixed Population Analysis

Finally, a brand new Distribution Fitting analysis will be featured in HEC-SSP Version 2.2. Within the United States, common floodplain management policies use the peak streamflow or stage at the 1-percent annual exceedance probability (AEP) to demarcate flood zones, restrict development, and place infrastructure. Uncertainty in accuracy about the magnitude of a quantile (i.e., flow, stage, predominant source of uncertainty in quantile estimates can change from sampling error to model choice, for instance.

The new Distribution Fitting analysis is meant to allow users to assess an input dataset, analyze different model choices (distributions and fitting methods), make an informed decision, select a model, and output pertinent and distribution choices given the input/filtered data. Two fitting methods (product moments and linear moments) are currently implemented with plans for a third choice (maximum likelihood estimation) in the near future. Nineteen analytical distributions (along with an option to select the empirical distribution) are provided. Two statistical goodness of fit tests

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By Michael Bartles, P.E.

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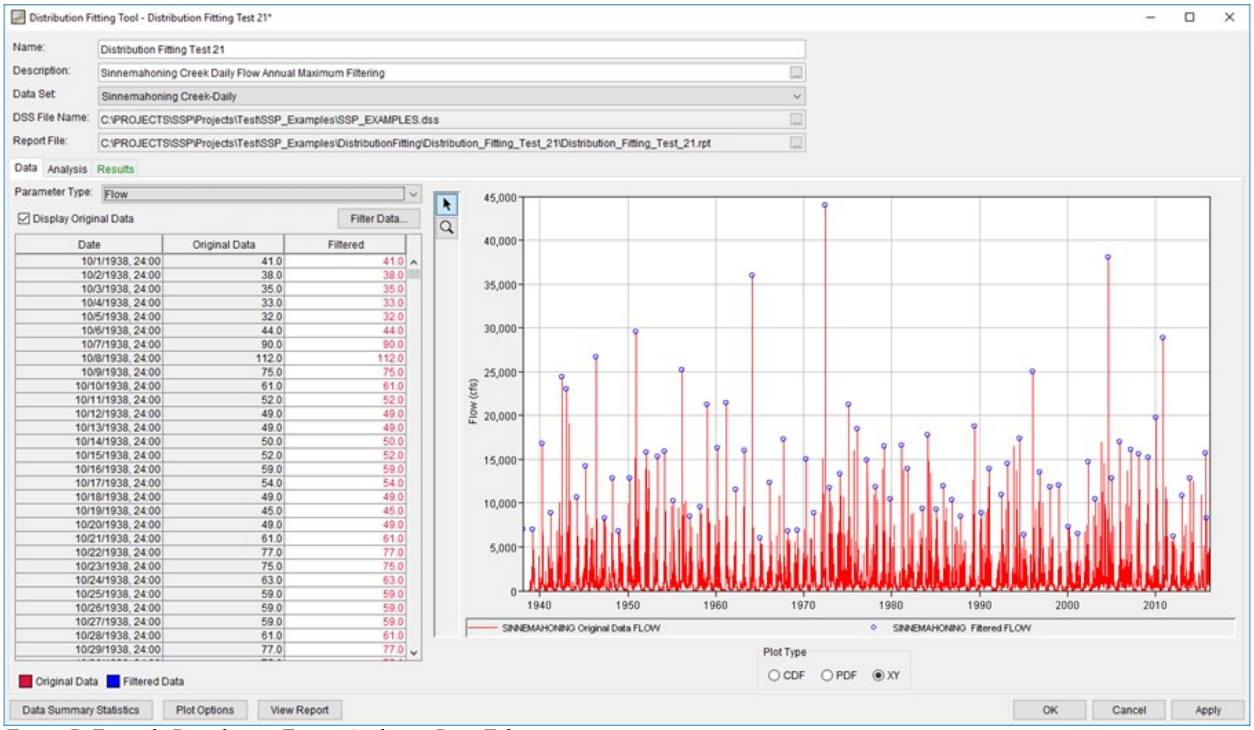

Figure 7 Example Distribution Fitting Analysis - Data Tab

(Kolmogorov-Smirnov and Chi-Square) are currently implemented with plans to add three additional tests (Anderson-Darling, Bayesian Information Criterion, and Akaike Information Criterion). Confidence limits and expected probability (Interagency Advisory Committee on Water Data, 1982) can be computed for each distribution/fitting method. The median curves for each distribution/fitting method can be compared on CDF, PDF, probability-probability, quantile-quantile, and CDF-plotting position plots. Within Figure 8, the filtered dataset previously mentioned has been plotted on a quantile-quantile

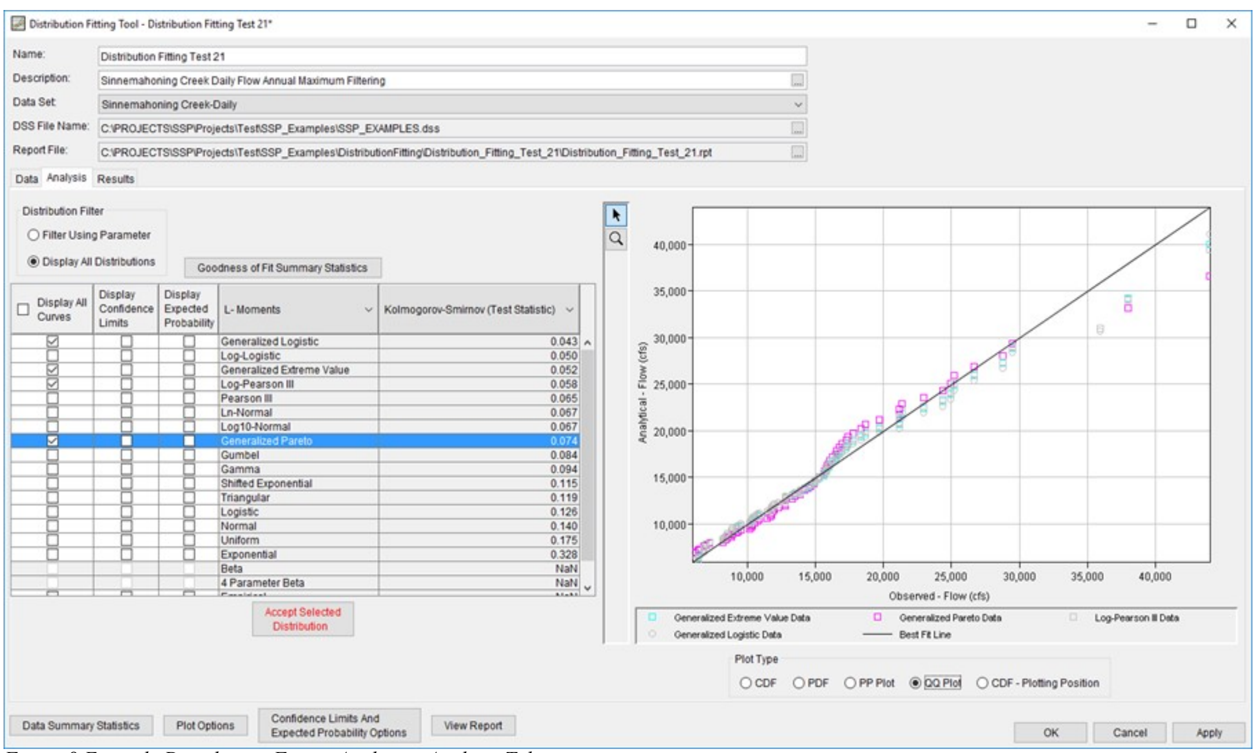

Figure 8 Example Distribution Fitting Analysis - Analysis Tab

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HEC-SSP (Statistical Software Package) Version 2.2 Release (continued)

By Michael Bartles, P.E.

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plot along with the Generalized Extreme Value, Generalized Pareto, Log Pearson III, and Generalized Logistic fit using linear moments.

On the Results tab, various information related to the dataset and selected distribution/fitting method are shown. Statistical information pertinent to the original dataset as well as the filtered dataset (if used) includes sample size, minimum, maximum, median, mode, mean, standard deviation, skew, kurtosis, L-Mean, L-CV, L-Skew, and L-Kurtosis. Information pertinent to the selected distribution/fitting method include parameter (i.e., location, scale, shape), goodness of fit test statistic, median, confidence limits, and expected probability. The user can view the selected distribution within CDF, PDF, or CDF-plotting position plots. Within Figure 9, the Generalized Extreme Value distribution fit using linear moments to the previously mentioned data set is shown.

HEC-SSP Version 2.2 is currently in beta testing. Once Beta testing and documentation updates are completed, HEC will add the new version to the HEC website, under the HEC-SSP webpage. A full release of Version 2.2 is anticipated in 2018.

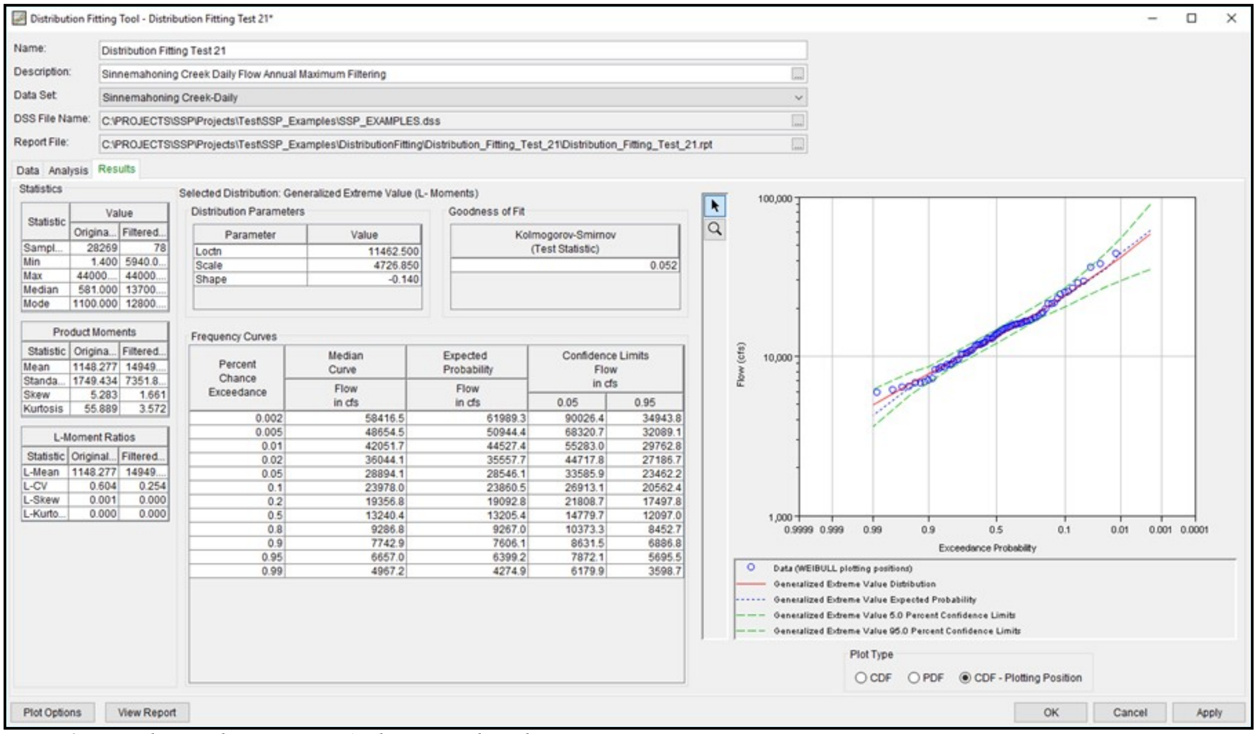

Figure 9 Example Distribution Fitting Analysis—Results Tab

HEC s Flood Damage Reduction Analysis Software, HEC-FDA Version 2.0

By John Kucharski

Since HEC-FDA's (Hydrologic Engineering Center (HEC), Flood Damage Reduction Analysis software) initial release nearly twenty years ago, the software has been the workhorse for USACE (U.S. Army Corps of Engineers) riverine flood risk reduction project teams. Over time, the software has been pressed into service on an increasingly broad array of projects. Today HEC-FDA outputs are trusted to support millions and sometimes billions of dollars in flood risk management decisions each year. HEC-FDA results appear in Civil Works Review Boards reports, emergency repairs, watershed assessments, levee safety studies, budget submissions and more. The most recent Planning Center of Expertise-certified Version 1.4.2 was released on July 2017 (http://www.hec.usace.army.mil/software/hec-fda/documentation.aspx).

Despite the trust placed in this USACE tool and the software s heavy use, HEC-FDA has not received a major update in several years. Twists of fate over the past decade have made it difficult to modernize the software with an updated architecture or add new capabilities or features. For instance, the products that support the software's graphical user interface and internal database structures were sold by companies that no longer exist, making many updates difficult or impossible. Each major Microsoft Windows® update also generates concern that HEC-FDA will no longer function in the latest Microsoft Windows® environment. Recognizing these limitations and the affects that might occur to the USACE Flood Risk Management mission, HEC decided to pursue a major update to the HEC-FDA software.

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HEC s Flood Damage Reduction Analysis Software, HEC-FDA Version 2.0 - continued

By John Kucharski

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A major overhaul (Version 2.0) of the current HEC-FDA software has been under development at HEC for a little more than a year. At the core of HEC-FDA is an innovative computational process that turns engineering and economic data into outputs which support clear plan evaluation and selection decisions. This computational process, was pioneered by Messrs. David Goldman and Robert Carl – will remain unchanged in the major overhaul. However, Version 2.0 is being built from the ground up and will feature: an entirely new look and feel, support for modern geospatial data types, several computational enhancements, improved data visualization capabilities, and a more robust architecture. HEC hopes that HEC-FDA Version 2.0 will serve the next decade of USACE flood risk management teams as well as the current version of HEC-FDA has served past generations of USACE teams.

Revising software is a process that does not happen overnight, but progress has been made over the past year. The HEC-FDA Version 2.0 main window is shown in Figure 10. Users of other modern HEC software applications, like HEC-FIA (Flood Impact Analysis), will notice a familiar layout with a study tree on the left and map window on the right. Geospatial data elements like structure inventories, hydraulic grids and terrain can be edited and/or displayed in the map window. Version 2.0 will also provide enhanced display of data inputs. For example, Figure 11 shows how an impact area s hydrologic, hydraulic and economic data inputs are linked together to produce a damage frequency curve, from which Expected Annual Damage (EAD) can be computed. The addition of new compute options, and structure reconstruction and abandonment will resolve specific computational limitations faced by modern teams. Finally, Figure 12 shows how uncertainty about annual exceedance probabilities (AEP), EAD and damage frequency curves has been added to support more robust discussions about project performance and risk reduction metrics.

HEC believes that Version 2.0 will pair the best of the current HEC-FDA software with sensible updates and useful enhancements. An Alpha Version of the HEC-FDA Version 2.0 software has been built and HEC is about halfway through the development cycle in pursuit of a Beta Version by the end of the fiscal year. This Beta Version will be subject to extensive testing and review and followed by a public release. In the meantime, stay tuned.

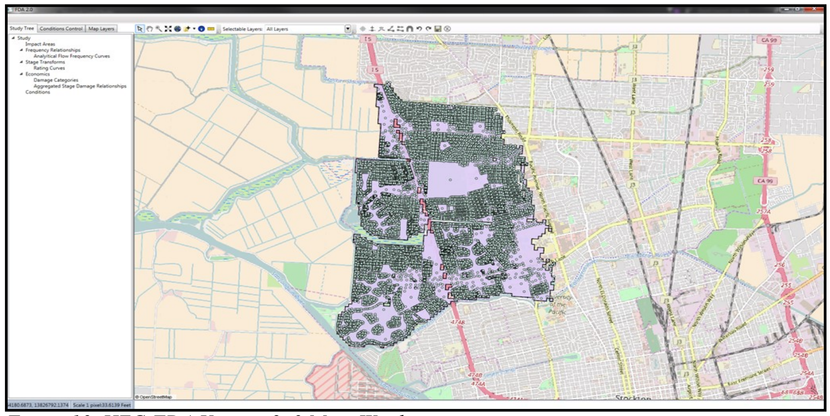

Figure 10 HEC-FDA Version 2 .0 Main Window

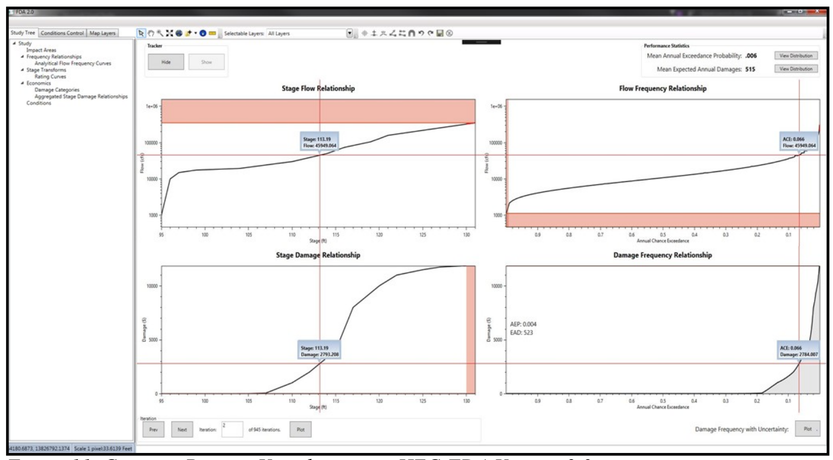

Figure 11 Compute Process Visualization in HEC-FDA Version 2.0

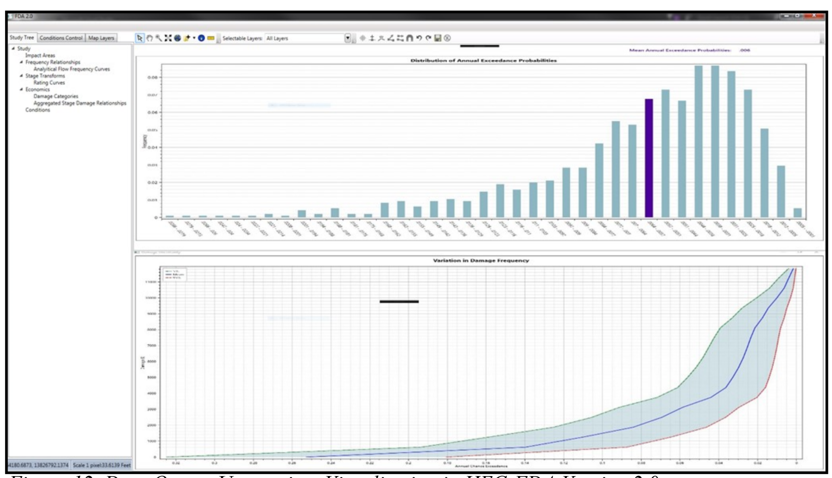

Figure 12 Data Output Uncertainty Visualization in HEC-FDA Version 2.0

Watershed Analysis Tool (HEC-WAT), Version 1.0

By Lea Adams, P.E.

The Hydrologic Engineering Center (HEC) is pleased to announce that HEC-WAT Watershed Analysis Tool Version 1.0 was released at the end of FY 2017, and is now available on the HEC website. HEC-WAT was developed to address USACE (U.S. Army Corps of Engineers) policy requirements for analysis of water resources projects, including flood risk management projects, by using a risk framework that incorporates watershed and systems approaches.

HEC-WAT is a model integration tool that orchestrates analyses across multiple pieces of water resources and consequence software to streamline study efforts for multi-disciplinary teams (Figure 13). Many of the HEC suite of software applications are implemented within HEC-WAT, thus allowing a study team to perform many of the necessary hydrologic, hydraulic, and planning/consequence analyses from a single interface. HEC-WAT currently incorporates HEC-HMS (hydrology), HEC-ResSim (reservoir operations), HEC-RAS (hydraulics), and HEC-FIA (flood consequences).

HEC-WAT is intended to help study teams perform alternative analysis in an intuitive and collaborative manner by involving technical staff across all disciplines early in the study process. Integrating multiple software packages into a common framework helps eliminate data handling issues that might arise when one modeler provides model output for others to use.

HEC-WAT also supports risk-based analyses and risk-informed decision-making via application of the Flood Risk Analysis (FRA) compute type. FRA uses event-based Monte Carlo-style uncertainty sampling to evaluate the full range of possible conditions across a watershed or within a system, which in turn provides a more complete picture of flood risk in a watershed. Sampling of input hydrology (precipitation or flows) and fragility data occurs within HEC-WAT, while sampling other model

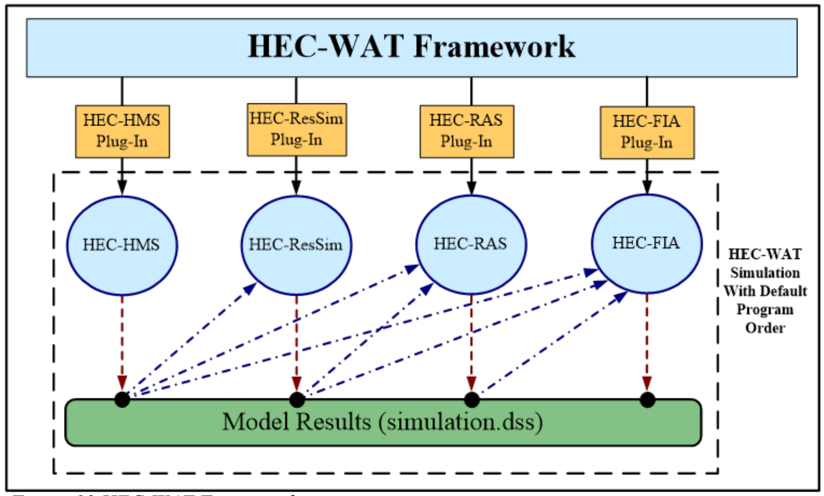

Figure 13 HEC-WAT Framework

parameters and initial conditions occurs within the individual applications. This functionality (parameter sampling) is partially implemented in the applications now, and will be fully implemented in the future. With the FRA compute option, HEC-WAT advances USACE's ability to perform risk analyses, and can be used to support levee certification, dam and levee safety assessments, and planning and design studies.

HEC-WAT has been used on a number of studies to help address a range of challenging issues. The Columbia River Treaty Review (CRT) study (Figure 14) is by far the largest application of HEC-WAT, as it encompasses the entire Columbia River basin (258,000 square miles).

Figure 14 Columbia River Treaty Study

The technical analysis supported evaluation of current and potential future reservoir operations. Through a strong partnership with CENWD (USACE, Northwestern Division), HEC was able to make substantial enhancements to HEC-WAT in support of an initial 2014 deadline, and the study continues on today. Another study completed in 2017, the Russian River Forecast Informed Reservoir Operations (FIRO) study (Figure 15), evaluated the effects on flood risk in downstream communities that could result from proposed changes to reservoir operation in the upper watershed.

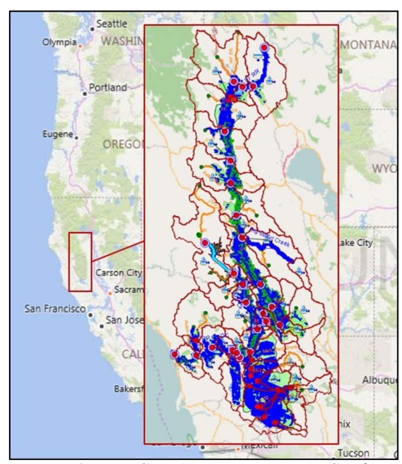

Figure 15 HEC-WAT Russian River Study

One of the more exciting capabilities of HEC-WAT is its ability to support SMART planning. By being able to directly import the suite of water resource and consequence models currently under development as part of the Corps Water Management System (CWMS), HEC-WAT can shorten

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planning analysis timelines while still using high fidelity models. HEC-WAT and CWMS share an underlying framework, thus allowing the CWMS models to be easily imported into HEC-WAT. This capability allows CWMS real-time focused models to be repurposed into HEC-WAT study (i.e., alternatives analysis) models.

Future HEC-WAT development includes full implementation of life cycle modeling to address rehabilitation, repair and flood recovery; adding several new compute types; and expanding parameter sampling capabilities. Other goals for HEC-WAT development include making the software more intuitive; improving compute speeds; enhancing graphics and reporting capabilities; and ensuring that it remains stable and robust under ever-increasing computational demands.

HEC-WAT Version 1.0 is now available from the HEC website http://www.hec.usace.army.mil/software/hec-wat/. HEC-WAT is approved for use on USACE studies as an engineering software application, but the software is considered provisional as a planning software tool while HEC seeks official Planning Certification. Software documentation includes the HEC-WAT User s Manual; HEC-WAT Quick Start Guide; and, a Hydrologic Sampling User's Manual is also available from the HEC website. HEC requests that suggestions, comments, and reports on issues be sent to hec.wat@usace.army.mil.

Comments and suggestions on the usability of HEC-WAT and recommendations for additional results reporting would be greatly welcomed. For further information regarding HEC-WAT, contact Lea Adams (lea.g.adams@usace.army.mil) at (530) 756-1104.

HEC Personnel

Retirement - Penni R. Baker

By Penni Baker

Well, its time for me to retire from the current job I have with the Hydrologic Engineering Center (HEC). Throughout my forty-four years I have had several different jobs, which are described in the following paragraphs. Yes, I have shamelessly hijacked my own article from about four years ago. No never got the Mustang, you all know how life goes.

I started work at HEC 3 September 1974. I was three months out of high school, had been a Teacher's Assistant for a Business Teacher who encouraged me to take a test to get on a list for Federal jobs. Fortunately, I made the list and received two initial job offers right away. The offer from HEC was the third one and in those days if you turned down number three you were removed from the list.

I didn t drive and my interview was in August, so my father drove me to Davis and my brother tagged along. After climbing the stairs to my interview, I was greeted by John Dralle who gave me an overview of HEC, and then I was interviewed by John Peters. While the interview was going on, other HEC staff entertained my Dad and brother. My brother was allowed to play on a computer terminal, funny thing he became a Network Administrator for a major medical facility in Sacramento designing networks. HEC hired me and my first day of work was 3 September 1974, I was part-time and was hired to finish (typing) the IHD (International Hydrologic Decade) volumes (twelve). I worked for the Training and Methods Branch. Soon I was assisting in the mailing out of publications, training course materials, and HEC software. In those days, we mailed software on computer cards, one piece of software could be eight boxes of computer cards. After three years of doing this and finishing the IHD volumes, I was hired permanently.

I almost didn t stay, about a month after I was hired one of the programmers got into an argument with the computer operator. She was about 8 ½ months pregnant at the time and he made her cry. I was very shy for the first six months of work and I thought what kind of a horrible place I had gone to work for. That turned out to be a bump in the road. People like John Peters, Ken Brooks, Art Pabst, and John Dralle treated each other with respect and were very helpful to me. My first mentor was John Peters, he was able to tell me I was doing a good job, but at the same time provided me with constructive criticism that helped me immensely in my work ethic without making me feel like a failure.

When I first started working, the HEC family did a lot of things outside of work together. Most of the Center went to lunch on Fridays; bowling leagues were organized; tennis tournaments were organized; company picnics; camping trips;

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hiking adventures; excursions to South Lake Tahoe; and, more. This enhanced the family feel and at the time the staff size was small, about twenty-five people. Over the years this has changed, just like the downtown core of Davis has changed. Now the HEC family gets together at picnics and holiday parties.

I have worked under three of the four HEC Directors; I have had about a dozen Division Chiefs for direct supervisors; and, I have gone from Clerk Typist, to Computer Operator, to Computer Programmer, and now to IT (Information Technology) Specialist in forty-four years. My duties included typing manuals; mailing software; assisting in HEC training classes; managing an in-house mini-computer; keypunching during workshops; and, assisting the Administrative Officer with the accounting software. I also wrote and tested software code; developed graphical user interfaces (GUI) for HEC-FDA (Flood Damage Reduction Analysis) and HEC-PBA (Project Benefit Analysis); was involved with the initial deployment and testing (four USACE sites) of the Corps Water Management System (CWMS); was responsible for HEC-FIA (Flood Impact Analysis); writing and reviewing user documentation; and providing training. I have also performed the administration of HEC s servers Exchange, website, UNIX ; provided assistance to HEC individual user workstations loading software, using software, fixing hardware issues ; and maintained the HEC website. I did not stop there. I managed the HEC Newsletter; was the overseer of the development of the HEC-WAT (Watershed Analysis Tool) software, including the FRA (Flood Risk Analysis) compute option; responsible for wrote papers for professional journals, and presented the information at conferences, meetings, and training sessions; created Performance Work Statements (PWS) and managed the funds associated with the work; and, was part of the PDT for the Columbia River Treaty (CRT) 2014/2024 Review. All of this and much more are the opportunities that were been provided to me.

The second mentor in my career here at HEC is Christopher Dunn. Chris was my Division Chief for about five years in the Water Resource Systems Division. During that time there was a great deal of staff turnover in the Division, with a great deal of work to be done. Up to that point, I wasn t thrilled about speaking in public. I like to write (Chris has helped me immensely with my writing skills), but speaking in public, I tried to avoid that ordeal. Well, Mr. Dunn thought I needed a shove out of my "comfort zone" and being the boss he shoved. At first, it was pretty rocky, but soon I got the hang of it, and I think I do a pretty decent job giving presentations. Without Chris's patience, calmness, and his caring, I would not have the skills or the confidence that I have to meet the challenges of being part of a PDT team like the CRT. So once again, late in my career I was afforded guidance that enhanced my work ethic and my character.

So has the forty-four years all been wonderful? Is it ever wonderful all the time in a family - nope. I am not what you would call a pliable person. When I feel the need to stick up for myself I do. I have worked in an environment of mainly men and engineers and at times being a non-engineer and not as highly educated as most, I have been left with injured feelings. One of my lowest points at HEC was when a job became available that I wanted, but was not even considered by management for the job. John Dralle told me you really don t want that job, you will be much more

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successful staying on your present path and he was right. But moments like that have been far and few between. Why haven't I left? Well one thing, I don t like change (big change) but HEC gave me the ability to be able to make small changes, that allowed me to stay at HEC. I was eighteen years old when I started on this path and when you are surrounded by people who work the same way you do and are afforded the opportunities that I have been given (Iwould not have gotten anywhere else) one does not leave. I once was the youngest person at HEC, now I am one of the "old-timers".

Since I'm an old-timer, it is time for me to retire from my present job. I have seen a lot of changes in USACE, especially with the process of doing business and not all of it for the better. But hey, USACE took a chance on me and provided me with job experiences I would never have gotten anywhere else. Life is not a "rose garden", but I would not change a thing.

I m not saying good-bye I have been rehired as a "Rehired Annuitant".

So maybe another year or two working, and then depending on how life goes, and it is the coast of Southern Oregon for me.

CEIWR-HEC Engineering/Software Technical Support to USACE

By Diane Cuming

The Hydrologic Engineering Center (CEIWR-HEC) is responsible for creating and maintaining various pieces of software that can be categorized in seven different engineering modeling areas:

1) River Hydraulics
2) Hydrologic Analysis
3) Hydrologic Statistical Analysis
4) Reservoir Systems
5) Data Storage
6) Flood Risk and Consequence Analysis, and
7) Environmental Analysis

By assigning CEIWR-HEC software to one of these seven areas, CEIWR-HEC can provide engineering and technical support to U.S. Corps of Engineers (USACE). USACE offices can voluntarily elect any of the areas and then purchase technical support. The HEC request is sent to field offices in the August time frame of an FY. This engineering and technical support provides USACE offices with access to the CEIWR-HEC developers of individual pieces of software. USACE offices that have questions bout this support should contact the HEC POC: Dawn Palma (dawn.r.palma@usace.army.mil).

Unfortunately, CEIWR-HEC is not funded to provide support to those outside of USACE. Non-USACE individuals and organizations should search the Internet to locate a vendor that can provide support for the CEIWR-HEC software of interest.

For those new to CEIWR-HEC software, an overview of each of the categories is discussed in the following paragraphs.

1. **River Hydraulics** (HEC-RAS, HEC-GeoRAS, HEC-UNET, HEC-2, HEC-6). HEC-RAS (River Analysis System) is the most widely used river hydraulics model in USACE offices. The software is used in every USACE District office for studies ranging from risk analysis to dam breach scenario simulation and is one of the main tools used by the Mapping, Modeling, and Consequences Center (MMC). HEC-RAS computes water surface profiles based on one and two-dimensional, rigid and mobile boundary, steady and unsteady flow principles. HEC -RAS Version 5.0.3, is the current version and is available from the CEIWR-HEC website. HEC-2 (Water Surface Profiles), HEC-6 (Sediment Transport), and HEC-UNET (One-Dimensional Unsteady Flow Through a Full Network of Open Channels) are legacy software that provides steady-flow water surface profiles, sediment transport computations, and, unsteady flow analysis, respectively. Most, if not all of the legacy software s features have been superseded by the capabilities found in HEC-RAS. HEC-RAS Version 5.0.3 includes: two-dimensional modeling features, sediment transport and water quality capabilities which will continue to be developed and enhanced. RAS Mapper is a tool that is available in HEC-RAS Version 5.0.3, which provides the capability to handle large terrain data sets, for inundation mapping. For the future, Version 5.1 will continue with enhancements to the two-dimensional modeling features, support for extraction of geometric information from terrain datasets using the RAS Mapper Tool, and include uncertainty analysis capabilities.

2. **Hydrologic Analysis** (HEC-HMS, HEC-GeoHMS, HEC-1, HMR52). The Hydrologic Modeling System (HEC-HMS) is the most widely used precipitation-runoff program in USACE. Version 4.2.1 is the current version of HEC-HMS available from the CEIWR-HEC website and computes precipitation-runoff from all types of watersheds. The software can be applied to studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir

spillway design, flood risk management reduction, floodplain regulation, systems operation, sediment transport, and water quality. In conjunction with the probable maximum storm generator software, HMR52 (Probable Maximum Storm - Eastern United States), HEC-HMS can be used to compute the probable maximum flood for project safety, spillway adequacy studies, and perform spatially distributed precipitation-runoff analysis and continuous simulation. HEC-GeoHMS is a GIS extension that can be used to rapidly develop HEC-HMS basin models from digital elevation models. The extension dramatically reduces staff time necessary to construct models, especially large or complex models. Version 4.2.1 includes new GIS capabilities (automatic subbasin delineation directly in the program), new forecasting features, new modeling capabilities (including an energy balance snowmelt method), and a HMR52 meteorologic model option directly within HEC-HMS.

3. **Hydrologic Statistical Analysis** (HEC-SSP, HEC-FFA, STATS). Version 2.1 of the Statistical Software Package, HEC-SSP, includes capabilities from the Flood Frequency Analysis (HEC-FFA) software and some of the capabilities available from the Statistical Analysis of Time-Series Data (STATS) software. HEC-SSP also plans to include capabilities found in the Regional Frequency Computation (REGFRQ) and Multiple Linear Regression Program (MLRP) software packages in a future version. The software can perform flood flow frequency analysis based on guidelines in Bulletin 17B,

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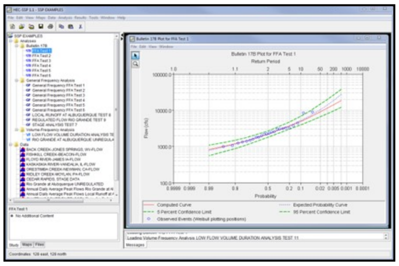
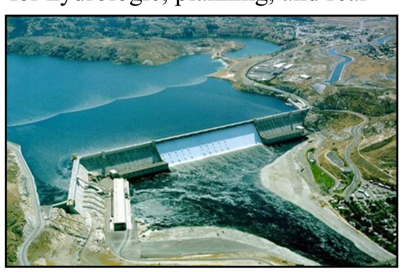


"Guidelines for Determining Flood Flow Frequency" (1982). Also, HEC-SSP contains tools for developing a generalized frequency analysis using other hydrologic data types, a volume frequency analysis on high and low flows, a duration analysis, a coincident frequency analysis, and a curve combination analysis. Flow-frequency is an integral part of USACE risk analysis and proper development of flow-frequency curves is an instrumental piece of the risk analysis procedure. Version 2.1 of HEC-SSP will be released in FY 2016 and will include a new Balanced Hydrograph analysis along with the Expected Moments Algorithm for computing flow frequency analyses.

4. **Reservoir Systems** (HEC-ResSim, HEC-ResFloodOpt, HEC-PRM, HEC-5, HEC-5Q). The HEC-ResSim (Reservoir System Simulation) software can simulate the operation of complex reservoirs and reservoir systems for both planning studies and real-time water management needs. Like the other engineering modeling software in the current generation of CEIWR-HEC products, HEC-ResSim provides a graphical user interface for model building, file management, program execution, and output displays. Version 3.1 is the current release of HEC-ResSim and is available from the CEIWR-HEC website. The two other available reservoir-modeling programs are optimization tools. The Prescriptive Reservoir Model (HEC-ResPRM) software optimizes reservoir release decisions to maximize multiple system objectives, and is useful in developing operation rules to meet reservoir system goals. HEC-ResFloodOpt (Reservoir Flood Control Optimization) optimizes single-objective flood event operations. Both HEC-ResPRM and HEC-ResFloodOpt combine the physical system model from HEC-ResSim with a linear programming or mixed-integer programming optimization solver. HEC-5 (Simulation of Flood Control and Conservation Systems) is CEIWR-HEC's legacy reservoir simulation model and can determine reservoir releases for flood reduction, water supply, and electric energy demands. HEC-5 can simulate the operation of multiple-purpose reservoir systems using time intervals from minutes to months. A companion program, HEC 5Q (HEC-5, Water Quality Analysis), provides water quality analysis for reservoir and river systems.

5. **Data Storage** (HEC-DSS, HEC-DSSVue). HEC-DSS (Data Storage System) provides for the management of time series data used in studies and water management activities. Data may be entered, edited, tabulated, graphed, and exchanged between a variety of hydrologic engineering and planning analysis-modeling programs. In particular HEC-DSS plays a role in ensuring data is managed in a way that is efficient for hydrologic, planning, and real



time operations. For example, HEC-DSS is an integral part of the HEC-WAT (Watershed Analysis Tool) and CWMS (Corps Water Management System) pieces of software. The primary user interface for HEC-DSS is HEC-DSSVue, a Java-based graphical interface that is supported both on UNIX and Windows computers. The software plots and tabulates data in an HEC-DSS database file using simple mouse selections. Over sixty mathematical manipulation functions are available for operations on data sets within a HEC-DSS file, as well as data entry functions, and several utility and database maintenance functions. Data can be displayed from a selection of data set names or from spatially referenced locations with a map background. Common data stored in HEC-DSS include time series data, such as hourly or daily flow, stages, precipitation, elevation, and storage data; curve data, such as rating tables and frequency curves; gridded data, such as NexRad data; and a variety of other data types.

6. **Flood Risk and Consequence Analysis** (HEC-FDA, HEC-FIA). The Flood Impact Analysis (HEC-FIA) software was developed for the CWMS modernization project in the early 2000s. The current version of HEC-FIA is an improved GIS-enabled version, which is also used to support consequence estimates for USACE Dam and Levee Safety Risk Assessments. These improvements were made to assist the USACE Modeling Mapping and Consequences (MMC) in evaluating the risk associated with various failure scenarios for dams and levees. Some of the improvements were associated with modifying the capability to model warning issuance, adding the capability of using arrival time grids, duration grids, and depth x velocity grids. Improvements include the ability to use higher resolution data, such as parcel level inventories, to represent the structures within the floodplain. The Flood Damage Reduction Analysis (HEC-FDA) software provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of flood risk management plans. HEC-FDA is USACE's number one tool for the formulation and evaluation of flood risk management measures. The software is designed to assist study team members in using risk analysis procedures for formulating and

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evaluating flood risk management measures and analyzing the economics of flood risk management projects.

7. Environmental Analysis (HEC-RPT, HEC-EFM, HEC-GeoEFM, HEC-EFMSim). The Regime Prescription Tool (HEC-RPT), the Ecosystem Functions Model (HEC-EFM), with its accessories for statistical (HEC-EFM Plotter) and spatial analyses (HEC-GeoEFM), and new software known as HEC-EFMSim, comprise a suite of tools designed for use in ecosystem restoration projects, water allocation studies, and efforts to improve the ecological sustainability of land and water management practices. The purpose of HEC-RPT is to help interest groups reach consensus

about how rivers should be managed. The software does this by plotting and comparing desired river flows from a range of perspectives (e.g., flood risk management, water supply, hydropower, navigation, and ecosystem maintenance). These flows are defined by the interest groups and presented in a common format, which provides a foundation for resolving areas of conflict. Flows created in HEC-RPT are exported for analysis in other programs, including reservoir simulations, river hydraulics, and ecosystem functions. HEC-EFM is a planning tool that analyzes ecosystem response to changes in river flow and stage. Using a combination of statistical and spatial features, HEC-EFM enables project teams to define existing ecologic conditions, highlight promising restoration sites, and rate alternatives according to their relative changes in ecosystem aspects. HEC-EFM Plotter allows users to display and assess the statistical analyses performed in HEC-EFM applications. HEC-GeoEFM is an extension (ESRI ArcMap Version 9.3) that provides three primary capabilities for users planning ecosystem restoration projects or water management scenarios: 1) management of spatial data sets, 2) computation and comparisons of habitat areas, and 3) assessment of habitat connectivity. HEC-EFMSim performs continuous simulations (spatially and temporally) of ecosystems. Applications of HEC-EFMSim can be as simple as one community for one location and as complex as the user would like to simulate. The software is being designed to simulate ecosystems for large spatial areas and long time