CEIWR-HEC Engineering Assistance

Summary of Recent Activities and FY 2017 Outlook

September 2016

Overview

The requested engineering and modeling support for FY 2017 has changed. We added new capabilities to HEC-SSP to accommodate the impending release of Bulletin 17C and we added water quality and sediment transport to the Environmental Analysis Section. In addition, we added a number of pieces of newer software to a few of the other Technical Assistance Categories. FY16 was a big year for software development and the deployment and implementation of the HEC suite of tools. Therefore, each office should review their engineering and modeling voucher closely to make sure they are paying for the services they expect. In addition, we expect new versions of a number of pieces of HEC software, like HEC-WAT, will be released in FY 2017 and thus we expect a high volume of support calls.

The predominant use of the technical assistance funds supports phone and e-mail consultation for engineering and modeling assistance. HEC also uses these funds to correct bugs, update documentation, port and test hydrologic and hydraulic software for new computing platforms and operating systems, and to add user documentation and our software to the HEC website. The number of hot-line consultations for most programs continues to grow. For example, with the release of version 5.0 of HEC-RAS in FY16, we experienced many more requests for RAS support.

Major new releases planned for FY 2017 include: HEC-FIA 3.1 (Flood Impact Analysis) with the capability to perform project benefit accomplishment; a version of HEC-FDA (Flood Damage Reduction Program); and new versions of HEC-RAS, HEC-HMS, HEC-SSP, HEC-ResSim, HEC-EFM and associated products, and HEC-DSS (Data Storage System). Finally, we continue to be excited about our inaugural release of HEC-WAT or the Watershed Analysis Tool, anticipated for the first quarter of FY17. HEC-WAT is an interface and model integration tool designed to streamline and integrate the planning and analysis process using modeling tools commonly applied by a district's multi-disciplinary team. Even though the WAT has not officially been released, the number and types of uses of the WAT continue to grow. Numerous presentations were delivered in FY16 that document the versatility of the WAT and a beta version has been deployed in support of a large-scale district project. The WAT software can be deployed on a case-by-case basis in advance of its official release.

HEC-RAS, HEC-GeoRAS, RAS Mapper, HEC-UNET, HEC-2, HEC-6

Overview

HEC-RAS (River Analysis System) is the most widely used river hydraulics model in the US Army Corps of Engineers. It 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 boundary, steady and unsteady flow principles. The initial version of HEC-RAS was released in 1995, as the successor to HEC-2. Version 2.2 of RAS was released in September 1998 and version 3.0 (with unsteady-flow capabilities) was released in March 2001 as the successor to HEC-UNET. The current version of HEC-RAS is 5.0.3 and it was released in September 2016. HEC UNET provides one-dimensional unsteady flow analyses of river systems, including networks. The latest version of HEC-UNET is 4.0, dated April 2001. Since this April 2001 release, HEC has not added any capabilities to HEC-UNET. The unsteady flow engine in HEC-UNET was used as the basis for the unsteady engine in HEC-RAS. HEC-2 and HEC-6 are also legacy programs providing steady-flow water surface profiles and sediment transport computations, respectively. Sediment transport and water quality capabilities are available within HEC-RAS and will continue to be developed and enhanced. HEC-6T capabilities have been added to HEC-RAS to enhance its sediment modeling capabilities. RAS Mapper is replacing HEC-GeoRAS. RAS Mapper capabilities in HEC-RAS 5.0.3 include results mapping. With the release of HEC-RAS version 5.1, RAS Mapper will include geometric editing tools for defining modeling features, river lines and cross sections, while also extracting geometric properties from a terrain model. HEC-RAS version 5.1 will be released in the winter of FY 17 with continued enhancements to the two-dimensional modeling features, support for extraction of geometric information from terrain datasets using RAS Mapper, new uncertainty analysis capabilities, enhancements to water quality modeling capabilities, and enhancements to the sediment transport capabilities.

Recent Engineering Support Activities Summary:

Primary activities include consultations on program applications, bug fixes, and program documentation updates for HEC-RAS, and HEC-GeoRAS. A significant amount of the technical support calls are focusing on HEC-RAS applications for two-dimensional flow, unsteady-flow computations including dam breach, flood forecasting simulations, and sediment transport. Technical support also includes support on the use of the RAS Mapper. These types of support calls can take a substantial amount of time, as we help the caller understand two-dimensional and unsteady-flow techniques, limitations, capabilities, and mapping methods. Other times it is necessary to diagnose if a problem is a potential bug or if the problem is with the user's input data.

FY 2017 Outlook:

HEC-RAS 5.0.3 was released in FY 2016. Version 5.0.3 includes the following new capabilities: two-dimensional unsteady flow routing, unsteady sediment transport, the USDA-ARS's (Agricultural Research Service) Bank Stability and Toe Erosion (BSTEM) model, and aquatic Nutrient Simulation Module II (NSM II) capabilities. Additional geospatial capabilities were added to HEC-RAS (within RAS Mapper) in a move to lessen the reliance on proprietary GIS products. Version 5.1 is expected to be released in the winter of FY 2017. This version includes enhancements and improvements to RASMapper, sediment transport modeling capabilities, water quality modeling capabilities, and a new uncertainty analysis. Technical support calls for HEC-RAS, and engineering support for river hydraulics, have increased and will continue during FY 2017, as more users perform two-dimensional and unsteady-flow analyses, sediment analyses,

and developing water quality models and apply features in version 5.0.3. Applications and support requirements for GeoRAS are expected to continue during FY 2016; however, support will transition to RAS Mapper after HEC-RAS version 5.1 is released. Additionally, many Districts and the Mapping, Modeling, and Consequence Center, are performing dam breach studies, which rely heavily on RAS for computations and RAS Mapper for visualization of results. HEC has seen an increase in support requests for RAS, RAS Mapper, and GeoRAS in response to 2D modeling, dam breach modeling, and flood forecasting. This trend is expected to continue. With the release of Version 5.0.3, calls for support will continue to increase as the capabilities of HEC-RAS increase.

Hydrologic Analysis

HEC-HMS, HEC-GeoHMS, HEC-1, HMR52

Overview

The Hydrologic Modeling System (HEC-HMS) is the most widely used precipitation-runoff program in the Corps of Engineers. HEC-HMS computes precipitation-runoff from all types of watersheds. The current version of HEC-HMS is 4.2. HEC-HMS 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, HEC-HMR52 (Hydrometeorological Report), it can be used to compute the probable maximum flood for project safety and spillway adequacy studies. HEC-HMS can also 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. It dramatically reduces the staff time necessary to construct models, especially large or complex models. With these large and complex models come numerous questions on how to perform hydrologic modeling studies. An updated version of GeoHMS with additional capabilities was released in FY 2014. Version 4.2 of HEC-HMS was released in FY 2016 and includes new forecasting capabilities and added compute efficiencies to decrease run times. Version 4.3 of HEC-HMS will be released in FY 2017 and will include new GIS capabilities (automatic subbasin delineation directly in the program), new forecasting features, new modeling capabilities, a HMR52 meteorologic model option directly within HEC-HMS that is linked to the new optimization tools, and the new Markov Chain Monte Carlo calibration and uncertainty analysis.

Recent Engineering Support Activities Summary

Technical support requests for hydrologic modeling and HEC-HMS continue to be significant. Hydrologic modeling results are under increasing scrutiny since they are an important part of USACE risk analysis. Support calls requesting model overview and help in applying HEC-HMS capabilities to a specific problem are common. Design, programming, and documentation of new features for HEC-HMS continued through the R&D program. Version 4.2 was released in FY 2016 and user support has been ongoing since then. In addition, support for HEC-GeoHMS has increased. HEC-GeoHMS versions for ArcGIS 10.1 and 10.2 are available on the HEC website. Version 10.2 is compatible with ArcGIS 10.2 and was released in FY 2014. As a side note, we will not be releasing a 10.3 version of GeoHMS that is compatible with ArcGIS 10.3. Our understanding is that the districts do not have an issue with keeping ArcGIS 10.2 on their machines. Support for HEC-1 and HEC-IFH continued even though terminal releases of both programs were made during FY 1999. HEC-IFH is no longer operational due to Microsoft operating system security patches. However, the HEC-IFH capabilities are now available in HEC-HMS.

FY 2017 Outlook

Efforts will include HEC-HMS application support, distribution, new and updated documentation on new features, and bug fixes. Phone and e-mail traffic will continue to be high due to the new capabilities in Version 4.2 and release of new capabilities in Version 4.3. Version 4.3 will incorporate bug fixes and many new features including GIS capabilities, new modeling methods for snowmelt, infiltration, and 2D overland flow, a new optimization and uncertainty capabilities, and forecasting capabilities. Inclusions of these capabilities have kept requests for technical and engineering support high. Support for HEC-1 and HEC IFH will continue but the need is expected to decrease due to increased use of HEC-HMS.

HEC-SSP, HEC-FFA, STATS

Overview

The Statistical Software Package, HEC-SSP includes capabilities in the Flood Frequency Analysis (HEC-FFA) software and some of the capabilities in Statistical Analysis of Time-Series Data (STATS) software. It is planned to include capabilities in programs Regional Frequency Computation (REGFRQ) and Multiple Linear Regression Program (MLRP). Version 2.1 of HEC-SSP can perform flood flow frequency analysis based on guidelines in Bulletin 17B and Bulletin 17C. The new Expected Moments Algorithm (EMA) contained in Bulletin 17C is now available in HEC-SSP. HEC-SSP also 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 balanced hydrograph analysis. HEC-FFA computes the frequency of flood peak and volume discharges from historical annual instantaneous peak flow and mean daily flow data. It performs the flood frequency analysis recommended by Bulletin 17B as the basis for the analysis. As the engineering community transitions to Bulletin 17C, HEC-FFA will no longer be recommended for flow frequency analysis, but HEC-SSP version 2.1 has the necessary capabilities to support 17C procedures. Most of the functionality in STATS and HEC-FFA are included in HEC-SSP. Flow-frequency analysis is a difficult topic and HEC provides many consults on the proper use of HEC-SSP and flow-frequency analysis in general. 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 2.2 of HEC-SSP will be released in FY 2017 and will include a new distribution fitting tool that assists in fitting a number of analytical distributions to any data type. This new analysis type is needed in support of the uncertainty analysis capabilities being added to other HEC software.

Recent Engineering Support Activities Summary

Numerous technical consultations for application of HEC-SSP and statistical analyses support were provided to District offices throughout the country in FY 2016. HEC-SSP is used at many districts and technical support is often requested for data entry, performing a statistical analysis with HEC-SSP, and interpreting results. In addition, technical assistance is often provided illustrating the computational procedure followed by HEC-SSP for general flood frequency analysis problems. These include discussing the appropriate procedure for generating flow and stage frequency curves and the appropriate method for applying the coincident frequency analysis procedure.

FY 2017 Outlook

The capabilities available in HEC-SSP version 2.1 include coincident frequency analysis, duration analysis, and the new EMA option and a balanced hydrograph analysis. Additionally, features from earlier versions continue to been enhanced. As SSP's capabilities increase, the number of consultations is also expected to increase, especially with the new EMA option. Version 2.2 of HEC-SSP will be released in FY 2017, requests for technical support through phone calls and e-mail will increase. New features in version 2.2 will continue to support the dam and levee safety studies; the capabilities include incorporating EMA for determining the LP III frequency curve within the volume-frequency analysis and an analysis for fitting a number of analysis frequency curves to any type of data. These new analysis tools will be included in the software documentation; however, additional technical assistance will be required to assist in application of these new features.

Reservoir System Analysis

HEC-ResSim, HEC-ResFloodOpt, HEC-PRM, HEC-5

Overview

Current reservoir modeling support activities focus primarily on the proper application of and the continued development of HEC's new generation of reservoir programs: HEC-ResSim, HEC-ResPRM, and HEC-ResFloodOpt. HEC technical support to the field offices helps maintain a close relationship between users and the developers of HEC's reservoir modeling software. Training and modeling assistance allow faster development and more defensible reservoir models within the USACE, but just as importantly, it keeps the tools responsive to the needs of the field offices.

HEC-ResSim (Reservoir System Simulation) 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 programs in the current generation of HEC products, ResSim provides a graphical user interface for model building, file management, program execution, and output displays.

The other two "next generation" reservoir-modeling programs are optimization tools. The Prescriptive Reservoir Model (HEC-ResPRM) optimizes reservoir release decisions to maximize multiple system objectives, and is useful in developing operational rules to meet reservoir system goals. HEC-ResFloodOpt 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.

Recent Engineering Support Activities Summary

Technical support activities for reservoir modeling typically fall into two categories: real-time decision support modeling and planning studies. On the real-time modeling side, the National CWMS Implementation Program is continuing a multi-year effort assembling a cadre of modelers from districts throughout the USACE to build a suite of CWMS models for basins across the country. Under this program, at least 40 new watersheds were started in FY16. Real-time modeling support demands have continued to vary with the level of complexity of the models as well as the experience level of the modelers.

ResSim support demands for study modelers have been consistent with previous years – with most of the calls coming from those who are working on on-going studies. The support needs of study modelers are often complex and require short term but intensive effort. Some of the complex factors influencing the reservoir models currently being developed for studies include: climate change; recent major flood events or drought conditions; water supply demands & yield; and ecosystem and/or endangered species support.

Several new simulation features have been added to ResSim. These features include: Firm Yield Analysis, Ensemble Alternative Management, Monte Carlo Analysis, and CE-QUAL-W2 "post processing". The funding for the development of these features came from study projects, headquarters support, and USACE R&D (for the CE-QUAL-W2 integration). The supporting study teams have assembled models using these new features and their modelers have become very valuable members of the ResSim testing team.

The optimization models HEC-ResPRM and HEC-ResFloodOpt continue to be used for special project applications. HEC-ResPRM version 1.0 is available on the HEC website along with a quick start guide, but certification is still pending.

HEC-ResSim 3.1 was officially released in FY14. ResSim 3.2, while still in beta, was released to within USACE as part of CWMS 2.1 and was used extensively throughout FY14 and FY15 as part of the National CWMS Implementation Program. In the first quarter of FY16, CWMS 3.0 – which included a beta version of HEC-ResSim 3.3 – was released within the Corps. Modelers for the CWMS Implementation program and real-time water managers have been using this beta version of HEC-ResSim 3.3 throughout most of FY16, which helped validate the program in preparation for release.

Maintenance and Development activities in FY16 followed two parallel tracks. Track one was the final push to get HEC-ResSim 3.3 into release. At the close of the FY, the program was packaged up and submitted for internal review prior to release. Track two was the continued development of HEC-ResSim 4.0 which represents a multi-year effort to enhance the ResSim compute engine to better handle complex system operations, downstream control, and hydropower.

FY 2017 Outlook

Technical Support to modelers using HEC-ResSim is expected to level off in FY17. Although support activities related to CWMS implementation may decrease a bit, the release of HEC-ResSim 3.3 at the beginning of FY17 is likely to cause an increase in support for a significant portion of FY17.

Software maintenance activities are expected to increase in the coming year. Minor to moderate level issues that were not addressed during the final push before completing the 3.3 release are on now the priority list to be addressed along with a host of minor user-suggested enhancements. In addition, final editing and publication of the revised HEC-ResSim 3.3 User's Manual must be completed. The revised manual will reflect the current state of the program and will include three new appendices describing the new analysis features that have been added to the program. The big effort planned for FY17 is to start the development of an Applications Guide and Technical Reference Manual for HEC-ResSim. In FY-16, a design was prepared for a single manual that will combine a collection of example problems, guidance on how to model and analyze the key elements of each problem, and as appropriate, technical descriptions on how relevant facets of the problem are represented and evaluated in ResSim. A small research project was performed in FY16 which resulted in a draft of a section on Routing Method Selection and Calibration. The plan for FY17 is to assemble at least three of the example problems and prepare the associated descriptive text.

Development of ResSim 4.0 will continue in FY17 with the focus being on testing and fine tuning the significant revisions that have been made to the compute engine to improve system operations. In addition, a new Water Quality R&D work unit focused on adding 1-D water quality computations and operational constraints into HEC-ResSim started in FY16. FY16 work on this unit focused on developing a design for the water quality compute engine. Development of a prototype of the compute engine will begin in early FY17 along with design and development of the user interface and data objects to support the water quality input, computations, and analysis. If development proceeds as planned, a beta-test version of the program may be available as early as the 1st quarter of FY 18.

Data Storage

HEC-DSS, HEC-DSSVue

Overview

HEC-DSS (Data Storage System) provides for the management of 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). 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 program graphs and tabulates data in a HEC-DSS database file using simple mouse selections. Over 60 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.

Software maintenance and support for graphing and data tables are included with the support of HEC-DSSVue, as these were originally developed for HEC-DSSVue and are the primary data display components for this program. The graphs and tables are used by most HEC programs and are controlled by either a user interface in each program, or by scripting, using the Jython scripting language.

HEC's technical support to the field offices helps maintain a close relationship between the developers of this tool and the field with respect to successful application for planning studies and water management activities. The support allows faster response to field needs. Data comes in various formats and types and HEC-DSS and HEC-DSSVue need to be flexible enough to accommodate this data in a way that is effective and efficient. Converting meteorological and hydrologic data efficiently for real time forecasting are paramount in real time operations. Effectively processing large amounts of data within a HEC-WAT framework or HEC-FDA or HEC-RAS models, to name a few, is also of high importance.

Recent Engineering Support Activities Summary

HEC-DSS version 7 is undergoing in-house beta testing. The primary user of version 7 during testing is the program HEC-WAT. WAT is storing large amounts of data, for which version 7 has been specifically designed. Also, WAT is being tested in a distributed compute environment, which has multiple processes writing data to HEC-DSS on a shared network drive, another fundamental function of HEC-DSS that other systems often do not support. Both HEC-DSS and HEC-WAT have benefited from the dual testing of these components.

HEC-DSS version 7 has been tested with database files with a size of 100 GB, on the order of 50,000,000 pathnames. (Version 6 was originally limited to file sizes of 2 GB, then upgraded to 8 GB). So far, the test results have been quite impressive for storing and retrieving data from such large files. The time it takes to retrieve a dataset from a 100 GB file is only slightly more than from a 1 GB file, and something that an interactive user would not notice. For example, the time it takes to retrieve a dataset from a 100 GB file is about 0.1% of the time it takes to build and display a plot of the data.

HEC-DSS Version 7 will be part of the next cycle of program releases, starting in CY 2017.

FY 2017 Outlook

Early in FY 2017, HEC-DSS version 7 beta testing and documentation is expected to be completed. The software library will be incorporated with HEC programs that are scheduled to be released after that time. Those programs will not need any code modifications to use version 7 with the current capabilities. However, version 7 has several additional capabilities that programs are expected to want to use, such as storing time series profile data, such as lake thermocline data, and time series notes, optional character strings that usually used to describe individual data items. In addition, version 7 can store spatial TIN (Triangulated Irregular Network) data (often precipitation), and large sets of curves stored as paired data, currently being used by HEC-WAT. Time is planned to work with the various programs implementing these new capabilities.

Flood Risk and Consequence Analysis

HEC-FDA, HEC-FIA, HEC-WAT, HEC-LifeSim, HEC-GeoFDA

Overview

By evaluating the consequences of flooding, HEC-FDA and HEC-FIA support flood risk assessment. HEC-FDA allows teams to perform integrated hydrologic engineering and economic analyses during the formation of flood risk management plans. It is the Corps' most widely-used tool for supporting the evaluation and selection of flood risk management plans. HEC-FIA was developed for the Corps Water Management System modernization project in the early 2000's. It is widely used to estimate consequences in Corps Dam and Levee Safety Risk Assessments.

HEC's technical and planning analysis support to field offices help developers of tools maintain a close relationship with users that are tasked with successfully applying those tools to analyze Corps projects following Corps policy. Risk analysis is one of the highest priority activities for the Corps and HEC engineers. The frequent council we provide to Corps projects, studies and teams ensures dam and levee safety analyses and planning studies are completed with rapid and defensible analyses. It also ensures that the tools these analyses demand remain responsive to the needs of Corps field offices and requirements of new guidance.

Recent Engineering Support Activities Summary

Development and testing of HEC-FIA versions 2.2 and 3.0 are complete. Both are currently used to support dam and levee studies being conducted by field offices and the USACE Modeling and Mapping Consequence Center (MMC). Certification of HEC-FIA 2.2 by USACE headquarters and the flood risk management planning center of expertise (FRM-PCX), the final barrier to Corps-wide release has happened. In addition, a provisional (uncertified) version of HEC-FIA 3.0 is available on the HEC website. These releases include many new or enhanced features, including expansion of the software's geospatial tools and its ability to incorporate uncertainties into its analyses. HEC-FIA version 3.1, which improves warning diffusion and reconstruction calculations, is nearly complete and will be released in early FY17. Finally, development of HEC-FIA 4.0 was initiated during FY16. This version merges the life loss evaluation capabilities of HEC-LifeSim with the economic evaluation capabilities of HEC-FIA. Development of HEC-GeoFDA, a geospatial preprocessor for FDA supporting two-dimensional hydraulic analyses and computational requirements of geospatially referenced structure inventories, is complete. The software has been beta tested by approximately a dozen Corps project delivery teams (PDTs) and will be released on the HEC website by the end of FY16. HEC-FDA version 1.4 was certified in FY15, and was adopted Corps-wide in FY16. A minor update to address bug fixes, version 1.4.1, was also completed and released in FY16. Progress overhauling HEC-FDA's user interface and computational libraries was made as part of the HEC-FDA version 2.0 project. The HEC-GeoFDA user interface will serve as a template in the development of the new HEC-FDA 2.0 user interface.

FY 2017 Outlook

HEC-FIA versions 3.0 and later will continue to be integrated into the Corps Water Management System (CWMS) and development will continue on the forthcoming Watershed Analysis Tool (HEC-WAT) software in FY17. The WAT is an interface and model integration tool designed to streamline and integrate the planning and analysis process using modeling tools commonly applied by a district's multi-disciplinary team. Beta versions are already being used on a number of planning type and dam safety studies. An official release is expected in the first quarter of FY17. HEC-FIA 3.0 certification efforts will continue in FY17 as well. HEC-FIA 3.1 will be released in the first quarter of FY17. HEC-FIA version 4.0 will

significantly upgrade the scalability and depth of its life loss computations by merging with the HEC-LifeSim software; a provisional release is expected by the end of FY17. Development of HEC-FDA version 2.0 will also continue. Major new features will include an updated user interface with geospatial mapping and preprocessing capabilities, support for Bulletin 17C hydrologic analyses, and a new more stable and modern computational engine. An alpha version is expected in the third quarter of FY 2017. Since flood risk management studies will require risk analysis calculations, we can continue to expect to provide increased support for these studies and our consequence tools.

HEC-RPT, HEC-EFM, HEC-EFM Plotter, HEC-GeoEFM, HEC-EFMSim, Sediment Transport, and Water Quality Modeling

Overview

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 a new program 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. In addition, water quality and sediment transport tools and capabilities will be supported through the environmental analysis tools as well.

The purpose of HEC-RPT is to help different interest groups reach consensus about how rivers should be managed. It 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, 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 EFM applications. HEC-GeoEFM is an extension for ArcMap 9.3+ that provides four primary capabilities for users planning ecosystem restoration projects or water management scenarios: 1) management of spatial data sets, 2) computation of habitat areas, 3) assessment of habitat connectivity, and 4) investigation of habitat functionality.

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. It is being designed to simulate ecosystems for large spatial areas and long time periods.

Both HEC-HMS version 4.2 and HEC-RAS version 5.0.3 contain sediment transport modeling capabilities. HEC-HMS models sediment detachment and transport from the watershed using the MUSCLE method. The HEC-HMS river reach element simulates erosion and deposition in the channel using standard transport functions along with sediment routing options. Finally, the HEC-HMS reservoir element contains methods for simulating deposition in a reservoir. HEC-RAS 5.0.3 contains quasi-steady and unsteady sediment transport capabilities that simulate the erosion and deposition processes, and geometric changes to channel geometry. Streambank failure and reservoir flushing capabilities are included as well.

Both HEC-HMS version 4.2 and HEC-RAS version 5.0.3 contain water quality modeling capabilities. The water quality modeling capabilities in HEC-HMS version 4.2 are limited to the channel element and are limited to the nutrients nitrogen and phosphorus. HEC-RAS version 5.0.3 simulates the fate and transport of water temperature, conservative and non-conservative constituents, dissolved nitrogen and phosphorus, algae, CBOD, and dissolved oxygen within the one-dimensional river reach.

Recent Engineering Support Activities Summary

Support in FY 2016 has focused on direct engineering assistance to Corps offices, bug fixes, and improvements to the structure and behavior of these tools.

Most recent activities are related to the EFM suite of software. Version 2.0 of HEC-RPT was released in summer 2012 and has no known issues – RPT is highlighted in a recent River Research and Application entitled "HEC-RPT – Software for facilitating development of river management alternatives", RRA 31:392-401 (2015).

Version 3.0 and 3.0. NET of HEC-EFM as well as version 1.1 of HEC-EFM Plotter were released in winter 2013. Completed enhancements for HEC-EFM in response to user requests include use of 2D river hydraulics and ecological simulation data stored in HDF, input management to handle large ecologic, hydrologic, and hydraulic data sets, and output management that allows users to customize formats and the types of results stored to disk. Per user suggestions, HEC-EFM also incorporated many options for output formatting that improve the appearance, usability, and customizability of HEC-EFM applications. All of these advances are included in version 4.0 of HEC-EFM. An article entitled "Decision support system for water and environmental resources in the Connecticut River Basin" in the Journal of Water Resources Planning and Management (2015) describes the use of several of these new features. A public release candidate of EFM 4.0 is now in the review process at HEC.

Versions 1.0 of HEC-GeoEFM for ArcMap 10.0 and 10.1 were released in spring 2013. GeoEFM is being developed through a partnership between the Hydrologic Engineering Center (HEC) and the Environmental Systems Research Institute, Inc. (ESRI). Development of GeoEFM 2.0 focuses on creating composite habitat maps (e.g., spatial merging of habitat provided in tributaries and main stem reaches), visualization of spatial flow statistics, spatial application of habitat suitability indices, and implementation of new approaches for assessing habitat functionality.

In spring 2015, HEC-EFM 2.0, 3.0, and HEC-GeoEFM 1.0 were formally certified for national use as part of the model certification process for Corps Planning tools. EFM, EFM Plotter, and GeoEFM are highlighted in a recent Journal of Environmental Modelling and Software article entitled "Using habitat to quantify ecological effects of restoration and water management alternatives", JEMS 70:16-31 (2015).

HEC-HMS version 4.2 was released in August 2016 and contains both sediment transport and water quality model capabilities. Training material, including lectures, workshops, and an application chapter are available for the sediment transport tools. Development for the HEC-HMS sediment transport capabilities is ongoing, with a new effort to add two-dimensional overland flow and sediment transport options. The new two-dimensional capabilities will allow for a wide range of modeling options that support different levels of study.

HEC-RAS version 5.0.3 was released in September of 2016 and includes new unsteady sediment transport capabilities. Extensive training material is available, as well as conference papers and project reports where the new reservoir flushing and unsteady sediment transport capabilities have been applied. New two- dimensional sediment transport capabilities are being developed in HEC-RAS, which includes updating the geometric properties of each two-dimensional cell and cell face.

FY 2017 Outlook

It is anticipated that support requests for this collection of software tools will continue to increase, especially given the recent planning model certification of HEC-EFM and HEC-GeoEFM and the pending releases of new versions of HEC-EFM, HEC-GeoEFM, and HEC-EFMSim. Development of HEC-EFMSim is also progressing. Its latest versions are capable of establishing, growing, and moving ecological communities. Animations in EFMSim, which several modelers reported as problematic, were improved. This is an exciting time for these tools, especially HEC-EFM. It is being used and considered for use by several organizations, within and outside of the Corps, for a wide range of projects, including dam removal, reservoir reallocations, river restoration, endangered species management, levee setbacks, and watershed assessments of ecosystem functions. Two-Dimensional flow routing capabilities have been added to HEC-RAS and are in the process of being added to HEC-HMS. This new development in flow routing has led to new capabilities being added for sediment transport (and eventually water quality). Both HEC-HMS and HEC-RAS teams will have beta versions of two-dimensional sediment transport available in FY 2017. In addition there will be new sediment transport features in HEC-RAS that support one-dimensional unsteady flow studies. New water quality modeling capabilities are being added to HEC-RAS and will be available in a version 5.1 release scheduled for February 2017. The new capabilities support larger studies, an improved interface, and results visualization. A new R&D effort will begin in FY 2017 for HEC-HMS water quality modeling that will add capabilities to model water temperature from the watershed as well as in the channel and reservoir. Those interested in learning more about our environmental products are encouraged to contact HEC