Hydrologic Center Engineering

ADVANCES

in Hydrologic Engineering

Summer 2004

Director's Comments

This edition of the HEC Newsletter is another of our aperiodic quarterly reports – the last one was in early FY 2003. We plan to do better in coming quarters. That said, with the substantial time break since the last newsletter, I will summarize in my comments, activities this past year or so. We fielded new versions of our flagship NexGen software products; devoted substantial resources to the implementation of the Corps Water Management System in Corps offices and continued with development of the next version of CWMS; and was engaged in a wide-variety of challenging field projects. All in all, 2003 was a busy, productive, and interesting year for the Hydrologic Engineering Center.

NexGen Software: HEC-HMS (Version 2.2.2) was released. HEC-HMS is the Corps standard watershed model that enables quasi-distributed event and continuous simulation of precipitation-runoff for small and very large watersheds in a Windows environment. An Applications Guide is now available. Intensive work is underway on the next version that will replace the user interface with newly designed functionality, and completes the transition from the proprietary user interface platform of the past. The companion GIS utility package (HEC-GeoHMS) has been updated and new features added. HEC-RAS (Version 3.1.1) was released in March. New features include mixed flow regime for unsteady flow, navigation dam simulation, pumps, additional hydraulic design functions such as uniform flow analysis, and stable channel design. The companion GIS utility package (HEC-GeoRAS) has also undergone improvements and was released simultaneously with HEC-RAS Version 3.1.1. The major flood damage and risk analysis software package, HEC-FDA, continues to be improved, with progress made in integrating the event program HEC-FIA, nonstructural measures and GIS capabilities into the risk analysis program HEC-FDA. The new NexGen software package HEC-ResSim (Version 2.0) was finally released after undergoing significant testing. This is the successor to the legacy reservoir systems program HEC-5. HEC-ResSim features a map-based schematic development environment, simulation of multiple dams and outlets, an operations scheme to define the reservoir's operating goals and constraints in terms of pool zones and zone dependent rules, and simulation of the operation of systems of reservoirs for common goals.

CWMS: The project to modernize the Corps water control management software system, coined the name Corps Water Management System (CWMS) began in FY 1997. The initial version was completed in 2001 and deployed and has undergone two update cycles, now at Version 1.2. CWMS embodies data acquisition, validation, transformation and management; forecasting, simulation and decision support analysis; and information dissemination. Modernizing CWMS was a software improvement project managed under the Army's Life Cycle Management of Information Systems (LCMIS) process. Due out in 2004 will be Version 1.3 featuring the addition of snow-melt modeling, several new additions to HEC-ResSim, the capability of storing, retrieving, and editing rating table information, upgraded data stream processing, new security features, and visualization scaling. Information about CWMS and other HEC software is available on the HEC Web site: http://www.hec.usace.army.mil.

Training: We continued the training program rebound by presenting eleven week-long PROSPECT courses and five field workshops that totaled an additional five weeks of training in FY 2003. The courses covered several hydrologic engineering and planning analysis topics including HEC-RAS, HEC-HMS, GIS applications, watershed/river and wetlands restoration courses, and advanced courses in unsteady flow and HMS applications. Attendance averaged about 25 students per course. The on-site workshops focused on HEC software such as HEC-RAS, HEC-HMS and HEC-DSSVue.

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IN THIS ISSUE:

Training Program

FY 2004 PROSPECT Training Program *by Dunn*

Do You Want H&H Training?
Announcing HEC's FY 2005 Proposed PROSPECT Training Program.

HEC submitted our proposed FY 2005 PROSPECT training program to the Professional Development Support Center (PDSC). The proposed program is provided in the table below. The PDSC, located in Huntsville, AL, will in turn conduct their annual survey to determine the amount of interest in each of the proposed classes. If and only if enough people indicate interest in the classes will they actually be taught. HEC has provided the proposed list in this Newsletter to advertise our intentions and to generate interest. We need your help. If you are interested in one of the classes below, make sure you let the people responsible for the training program in your District or Division know. They can then report to the PDSC who tallies the numbers.

We are planning to offer a wide array of classes in the next fiscal year. We are offering a few of our mainstays such as HEC-RAS and HEC-HMS and we are also offering some of our classes with a planning bent such as Hydrologic Engineering for Planning and Risk Analysis for Flood Damage Reduction Projects. Because of the Corps missions and also the popularity of the classes, we teach some classes yearly and others we skip a year between classes. Two of our more popular classes, Water and the Watershed and Hydrologic Analysis for Ecosystem Restoration are again being offered in FY 2005. All in all, we are proposing fifteen classes for FY 2005. If each class receives enough subscriptions, we will have a very busy training calendar.

To register for our classes, please contact the appropriate party in your office or contact the USACE Professional Development Support Center (PDSC), (contact information provided below) who will provide you with updated information about a class. While classes are presented for Corps employees, others are encouraged to register when space is available. Priority is given to Federal, then State and Local agencies, and then the private sector.

Course descriptions are provided in the "Purple Book" at the Professional Development Support Center site. A short description is also provided on HEC's Website. To obtain enrollment information, please contact Huntsville. When doing so, please note: the course number, name, date, and location and contact.

Training and Operations CEHR-P-RG
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FY 2005 PROSPECT Training Program

(All Classes located in Davis, CA)

Course #	Course Title	Proposed Date
114	Basic HEC-RAS	Oct 18-22, 04
98	Reservoir Modeling with HEC-ResSim	Nov 15-19, 04
57	Hydrologic Engineering for Planning	Dec 6-10, 04
178	Basic HEC-HMS	Jan 10-14, 05
219	Hydrologic Engineering Applications for GIS	Feb 7-11, 05
124	Groundwater Hydrology	Feb 28-Mar4, 05
209	Risk Analysis for Flood Damage Reduction Projects	Mar 14-18, 05
188	Unsteady Flow Analysis with HEC-RAS	Apr 4-8, 05
161	Hydrologic Analysis for Ecosystem Restoration	May 2-6, 05

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Publications

Obtaining HEC Publications *by Negrete*

Corps offices may request publications via correspondence, e-mail, fax or telephone. Our contact information is located on the last page of this newsletter. The request must include the recipient's name, office symbol, mailing address and telephone number. Documents should be requested by their HEC number/ document name.

All others may order from NTIS by writing to the National Technical Information Service (NTIS) at 5285 Port Royal Road, Springfield, VA 22161, calling their sales desk at (703) 605-6000 or by accessing their web site at: **www.ntis.gov**.

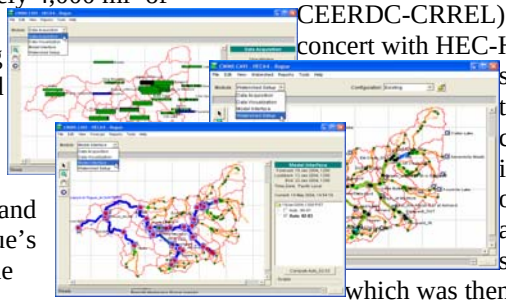
Some documents are available online and may be retrieved from our web site at: **www.hec.usace.army.mil**. These documents are free and available in portable document format (PDF).

Project News

CWMS Implementation for the Rogue River Basin *by Hickey*

In July 2003, the Portland District (NWP) contacted HEC for assistance with Corps Water Management System (CWMS) implementation for the Rogue River Basin, Oregon. CWMS is a real-time information system that incorporates data acquisition (observed and forecast precipitation, reservoir and river elevations, etc.), data visualization, and model forecast simulations. In the simulation process, models are run using observed and forecasted hydrologic conditions to simulate future precipitation and reservoir operations scenarios to evaluate different operational decisions.

Together, NWP and HEC set up the models and networked the data needed to perform forecast-based simulations in real-time for the entire Rogue Basin. The basin drains approximately 4,000 mi^2 of Southwestern Oregon, beginning in the Cascade and Siskiyou Mountains at elevations in excess of 8,000 ft and ending at the Rogue's confluence with the Pacific Ocean. Precipitation in the basin is a mix of rain and snow, most of which falls between late fall and late spring. Four reservoirs regulate the flow of the Rogue: Applegate, Emigrant, Elk Creek, and Lost Creek.



Models integrated in the CWMS suite include HEC-HMS (Hydrologic Modeling System - translates rainfall to runoff), HEC-ResSim (Reservoir System Simulation - simulates the influence of reservoir operations on stream flows), HEC-RAS (River Analysis System - performs hydraulic routings of stream flow), and HEC-FIA (Flood Impact Analysis - translates stream flows and stages to flood impacts). Applications of all of these models were developed for, or incorporated into, this CWMS implementation.

DSPM (Distributed Snow Process Model - models snowfall, snow accumulation and snowmelt) was also applied (modeling performed by CEERDC-CRREL) in concert with HEC-HMS to simulate the combined influence of rainfall and snowmelt, which was then translated to runoff by HMS.An automated data management system (in support of the CWMS models) was also set up for the Rogue. Data, transmitted from gages in the basin, are processed with automated routines to combine redundant data streams, validate data, and perform computations to prepare data for use in modeling (e.g., translate gaged stream stages to flows for use in model verification). This system was not intended to provide comprehensive data processing, rather to be a framework that future data checks and validation procedures can be built into.

In January 2004, the CMWS application for the Rogue was put into service on Portland District computer servers. The Rogue, with its combination of rainfall and snowmelt, data availability, and range of topography, is also an excellent learning basin for new CWMS users nationwide. It has been selected as a test basin for CWMS Version 1.3, which, among other enhancements, integrates snowmelt modeling capabilities into HEC-HMS. We look forward to making the Rogue one of our classroom examples.

A report discussing this implementation project is currently under review and will be available soon. HEC thanks NWP for sponsoring this joint effort.

Project News

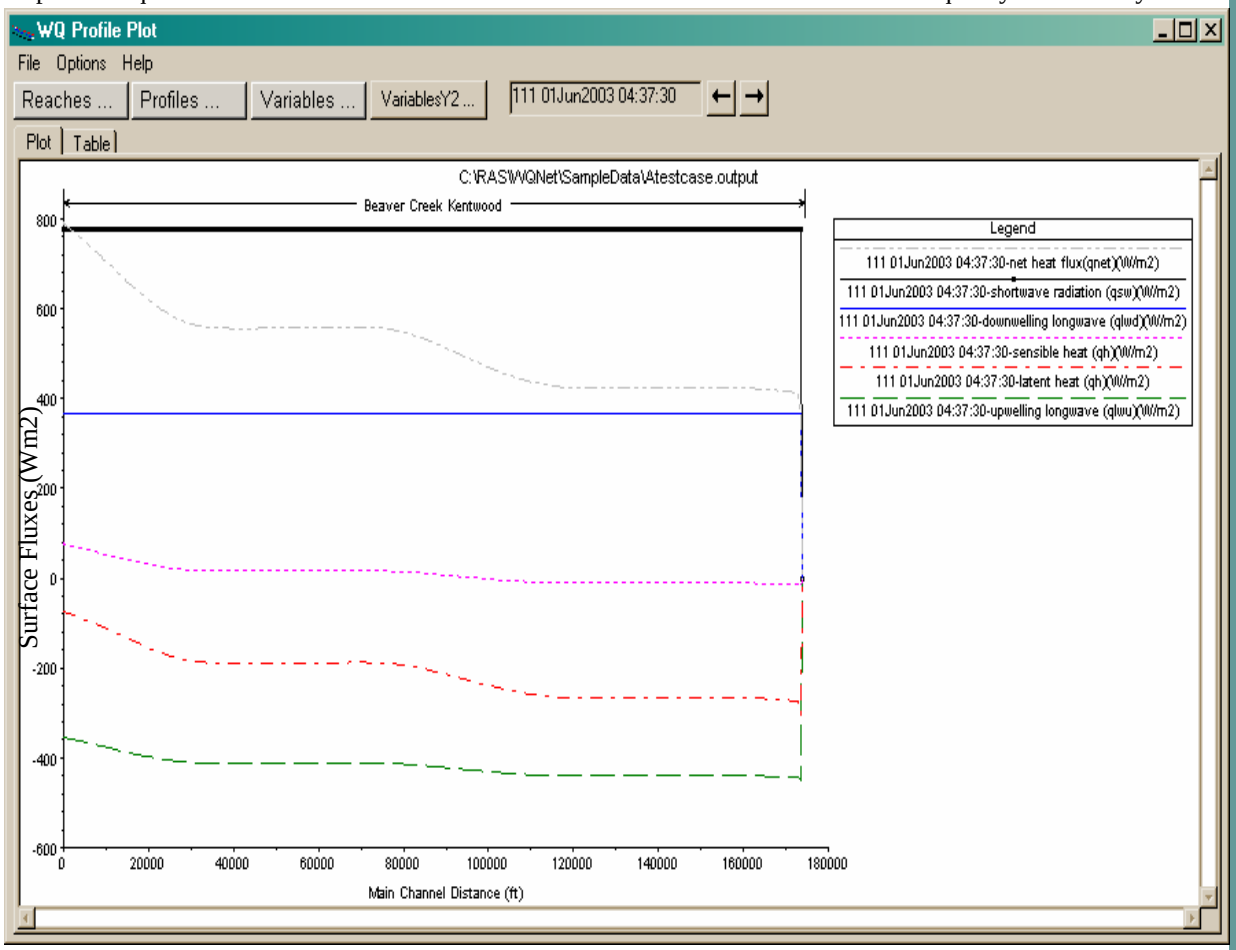
HEC-RAS and Water Quality Modeling *by Jensen*

Water temperature is the first constituent to be modeled with a new water quality module being developed for HEC-RAS. The water quality model uses the advection dispersion equation to determine concentrations at computational nodes placed mid-way between cross-sections. HEC-RAS uses the QUICKEST (Quadratic Upstream Interpolation for Convective Kinematics with Estimated Streaming Terms) scheme together with the ULTIMATE (Universal Limiter) algorithm, both developed by Leonard, (Computer Methods in Applied Mechanics and Engineering, 1979) to solve the advection-dispersion equation. The QUICKEST ULTIMATE scheme has been successfully implemented in the water quality models CE-QUAL-ICM and CE-QUAL-W2. The USACE Environmental Lab started the conversion of this transport scheme with their 1-D river model CE-QUAL-RIV1, but have transferred this effort to work with HEC to incorporate 1-D water quality modeling in HEC-RAS.

The water temperature model is implemented with a full energy budget. Surface fluxes, shortwave and longwave radiation are computed individually and are available model output (see figure below).

The model includes specialized tools for water temperature modeling such as humidity expression conversion, and solar radiation estimation from time, date, location and atmospheric parameters.

Hydrodynamics (stage and flow) are computed as a separate step prior to execution of the water quality model. Data exchange between the hydrodynamic and water quality model is accomplished within the HEC-RAS interface. Data input and simulation output for the water quality model will be handled with standard RAS interface tools so that results from both the hydrodynamic and water quality models may be



Model simulation of surface fluxes

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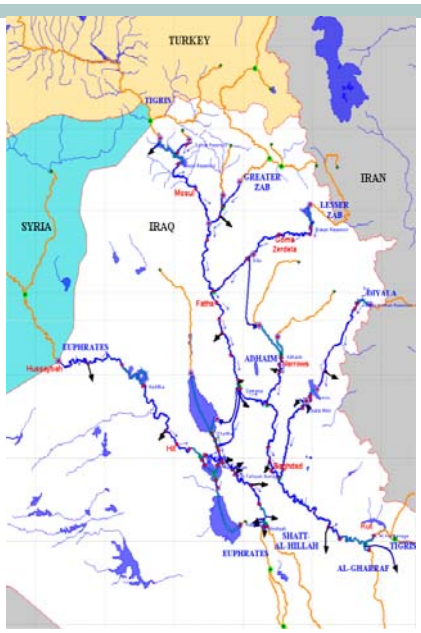
Project News

HEC-ResSim Reservoir Simulation Model for the Tigris and Euphrates River Basins in Iraq *by Hanbali*

HEC has developed a preliminary reservoir simulation model for the Tigris and Euphrates river systems in Iraq. This task was part of HEC's partnership with Development Alternatives, Inc., on USAID-supported reconstruction efforts in Iraq. The Iraq Ministry of Water Resources (MoWR) is undergoing substantial rehabilitation after suffering considerable post-war losses, especially technical references and computer resources, due to fire damage and looting. HEC's role was key in compiling and archiving significant information to construct and supply a decision support tool using state-of-the-art software to aid the MoWR in its operation of the complex water management system that exists in Iraq.

HEC researched public sources and coordinated with other USACE teams, including members from the Mobile District, ERDC/CHL, and USACE Senior Advisors to the MoWR, in order to obtain necessary data for developing the reservoir model. We accumulated essential publications, reports, and data relating to the hydrology of the Tigris and Euphrates watersheds as well as physical characteristics and functions of water control projects. In addition, daily and monthly historical stream flow records, dating back to 1930, for eighteen principal gage locations have been digitally archived into the HEC Data Storage System (HEC-DSS).

Using the maiden public release version of the HEC-ResSim software, a geographically referenced network of the multi-reservoir system in Iraq was constructed. The model consists of



six major reservoirs, three massive off-stream storage reservoirs, seven chief barrages (low head water control structures), and many diversions to reflect water withdrawals along different reaches of the Tigris, its tributaries, and the Euphrates. Basic model input incorporates reservoir storage capacity curves, individual outlet capacities, power plant characteristics, river reach flow routing parameters, water demand diversion requirements, reservoir seasonal target levels, and rules of operation.

HEC hosted two Iraqi engineers from the MoWR to complete the preliminary reservoir model. A comprehensive review of the watershed layout was conducted and the reservoir network connectivity was verified. The MoWR water control management plan was discussed and used accordingly in implementing operating rules into the HEC-ResSim model. The majority of the reservoirs in the model are multi-purpose with primary objectives to supply water for Irrigation and mitigate floods, while hydropower generation is a byproduct. The greater part of the runoff, mainly driven by snow melt, for the Tigris and Euphrates river systems typically occur in the spring. Therefore storage operation is carried into the early summer months, when reservoir inflows begin to steadily decrease and flow augmentation measures are carried out to mainly satisfy irrigation water requirements in downstream areas. The HEC-ResSim model was used to simulate historical events, in particular extreme flood and drought periods. Initially applied operational requirements and constraints performed well especially in flood control situations, balancing maximum storage in reservoirs while meeting channel capacity constraints at downstream control points, most importantly at Baghdad along the Tigris. The model simulations provided suitable analysis for water balance evaluation and hydropower generation. Using best available data and incorporating the Iraqi engineers' system knowledge, the preliminary reservoir model accounts for all major projects and primary functions considered by the MoWR in the regulation of their water control system.

It is interesting to note that Iraq is about the same size and latitude as California, experiences roughly the same runoff volume, and has a population of about twenty-five million compared to California's thirty-five million. Like California, most of the water diversions are used for irrigation.

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Project News

HEC-RAS and Water Quality Modeling -*continued*

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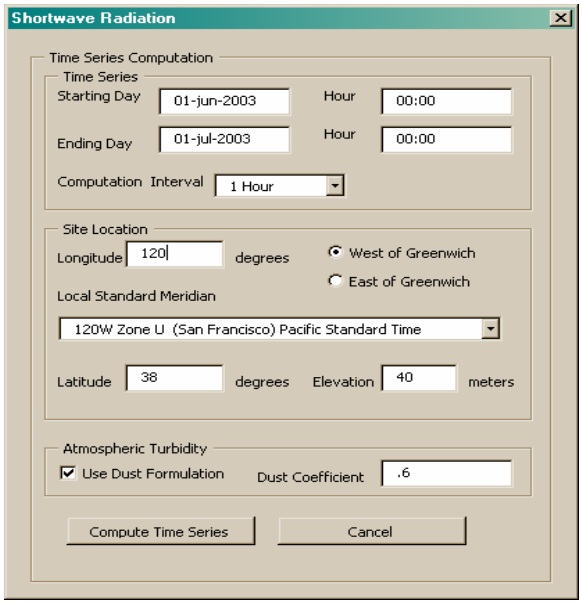
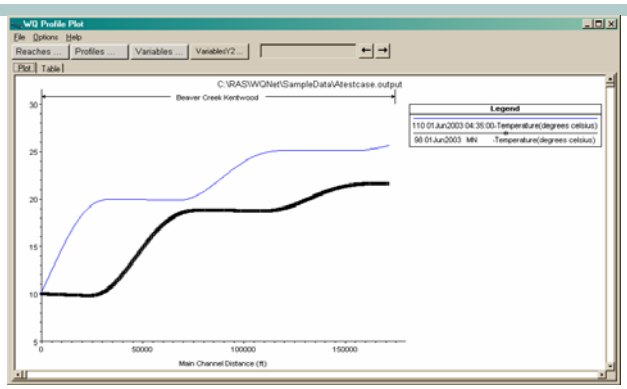


Solar Radiation Tool



Profile plot of modeled water temperature

The new water temperature module will be available as a beta release later this year.

In the future, HEC plans to incorporate other water quality constituents such as cabonaceous biological oxygen demand, nitrogen interactions, algae, macrophytes, oxygen, phosphorus interactions, iron, manganese, coloform bacteria and general conservative transport. These features are scheduled to be released in June 2007 (with beta in June 2006).

HEC-ResSim Improvements *by Klipsch*

Since the release of Version 2.0 in September 2003, rapid strides have been made in the development of the HEC Reservoir Simulation Modeling Software, HEC-ResSim. Several new features have been added that will significantly enhance ResSim's ability to model complex reservoir systems. The list of new features includes coordinated reservoir operation for a system hydropower requirement, pumps and pumpback storage operation, release allocation options for outlet prioritization and use, user-defined (scripted) state variables, and if-then-else logic for determination of rule applicability.

The new *system* hydropower schedule rule describes a system hydropower requirement as an amount of energy that a set of reservoirs must operate to meet. The time of day and days of the week during which each reservoir may generate power to meet its requirements is based on a schedule that can vary monthly or seasonally. The system hydropower rule is specified at each participating reservoir in the system, and their releases are determined based on the energy potential in each reservoir and a storage balancing scheme already used for system operation for a downstream objective.

Pumps and Reversible turbines were added to ResSim as outlet types to enable the program to simulate "pump-back" storage operation. Pump-back storage operation is typically used at 'peaking' hydropower facilities that have a tailwater pool to capture the power releases. The objective is to use the water in storage in the upper pool to generate energy when energy is expensive (high demand) and then to pump the water back into storage in the upper pool when energy is cheap (low demand). A pumping schedule rule is used to describe the pumping objective and the schedule during which the pumps are allowed to operate.

With the addition of user-defined state variables and conditional (if-then-else) logic for describing rule applicability, many complex operational objectives dependent on multiple parameters can now be represented. For example, in the Savannah River system, a series of three reservoirs are operated together to meet several, often competing, objectives, including hydropower, fish and wildlife requirements for in-stream flow, and water supply.

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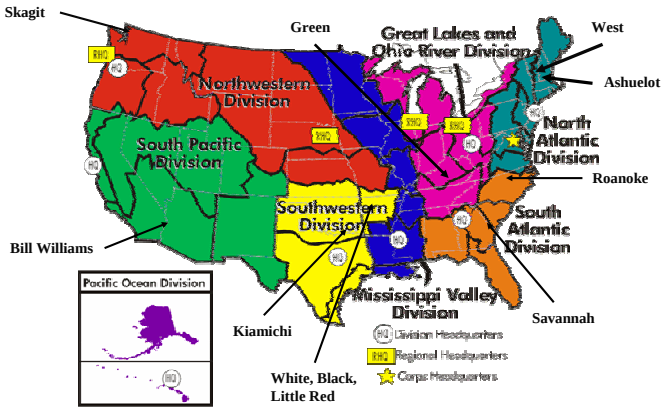
Project News

The Hydrologic Engineering Center and The Nature Conservancy *by Hickey*

In February 2004, the Hydrologic Engineering Center (HEC) and The Nature Conservancy (TNC) began an Interagency Personnel Agreement that assigned John Hickey, hydraulic engineer at HEC, to the Sustainable Rivers Project (SRP).

The SRP partners the U.S. Army Corps of Engineers (Corps) and TNC in an ongoing effort to identify opportunities and implement plans to reoperate Corps dams to achieve more ecologically sustainable flows, while meeting human needs. Being carried out under a memorandum of understanding between the Corps and TNC signed in 2000, the SRP is building on a collaboration to improve habitat along the Green River in Kentucky by changing the water release schedule from Green River Dam. The SRP currently involves ten rivers with thirteen dams as candidate sites for reoperation and hopes to expand this list in the future.



Through this personnel agreement, John is contributing to ongoing Corps District and TNC efforts. He is becoming more familiar with the needs of the SRP and other restoration efforts that seek to restore more natural flow regimes to improve ecosystem health while continuing to provide services such as flood damage reduction, hydropower, and water supply. His experiences will improve HEC's understanding of the challenges faced by these projects and thus accelerate development of improved techniques, capabilities, guidance, training, and software features designed to better empower Corps personnel to meet our water resources management responsibilities.

Over the next year, John will visit several SRP sites to participate in ongoing TNC and District efforts. In fact, John just returned from Savannah where he was involved with the Savannah River Basin Comprehensive Study, which is a Corps study to address current and future needs for flood damage prevention and reduction, water supply, fish and wildlife enhancement, drought control, water quality, recreation, and other related purposes.

TNC became involved with the Comprehensive Study through discussions with the Savannah District regarding conservation hopes for the river. The Corps and TNC later agreed to enroll the Savannah River in the SRP and the Corps invited TNC to participate in the Comprehensive Study's planning process, especially by helping to develop ecosystem flow recommendations for the Savannah. In April 2003, TNC led and facilitated a workshop with 47 scientists from over 10 different agencies (including the Corps) to create initial flow recommendations for the Savannah River, floodplain, and estuary system.

These flow recommendations are now one of more than 50 water management alternatives proposed by stakeholders in the Savannah Basin. In support of a tradeoff analysis that considers flood damage reduction, water supply, hydropower, and ecology, the study team, led by Savannah's water management group, has developed an HEC-ResSim model to simulate the alternatives. While in Savannah, John, together with engineers and scientists from Savannah District, TNC, and University of Georgia, started an HEC-EFM (Ecosystem Functions Model) application. HEC-EFM is a new software package that helps translate changes in the flow regime to ecosystem responses. The Savannah District and TNC plan to use the EFM to analyze the alternative flow regimes (to be produced by ResSim) from an ecological perspective.

In March 2004, the Corps released a pulse flow (as part of the ecological flow recommendations) from J. Strom Thurmond Dam, the largest and most downstream dam on the Savannah. Scientists from South Carolina Department of Nature Resources and University of Georgia worked downstream to collect data through electro-fishing and monitoring of groundwater levels in the floodplain. This pulse release was a great example of interagency

Continued on Page 8

Project News

HEC-ResSim Reservoir Simulation Model for the Tigris and Euphrates River Basins in Iraq -*continued*

Currently, a second phase of support work for the MoWR is underway. HEC is leading a multi-task venture to re-establish and modernize water management in Iraq, refine the reservoir model, and coordinate with interested parties in addition to MoWR in tackling pressing water management needs. Main objectives include assisting MoWR with water management organizational and infrastructure issues; an onsite assessment of the state of the stream flow gage network in Iraq; preparing a standard set of flow data that includes estimates of water depletion in Iraq and its upstream riparian nations; and evaluating various alternatives for water allocation and planning studies using the HEC-ResSim model, particularly to address anticipated water shortages and possible restoration of the desiccated Mesopotamian Marshes. Phase II participants include Portland District, Mobile District, Detroit District, HQUSACE, USGS and USBR.

Training Program—*continued*

FY 2005 PROSPECT Training Program

(All Classes located in Davis, CA)

Course #	Course Title	Proposed Date
369	Advanced HEC-HMS	May 23-27, 05
155	Real Time Water Management Modeling with CWMS	Jun 6-10, 05
58	Statistical Methods in Hydrology	Jul 11-15, 05
320	Hydrology and Hydraulics for Dam Safety	Aug 1-5, 05
164	Water and the Watershed	Aug 22-26, 05
152	Water Data Management with HEC-DSSVue	Sep 12-16, 05

The Hydrologic Engineering Center and The Nature Conservancy — *continued*

cooperation and coordination.

Future plans call for John to visit the Bill Williams River in Arizona and the Asheulot and West Rivers in New Hampshire and Vermont, where he will be working with the Los Angeles District and New England District, respectively.

Another aspect of this assignment that John has really enjoyed is the opportunity to share ideas and strategies with people in different offices, including the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, University of Georgia, and Savannah, Jacksonville, Louisville, and Pittsburgh Districts. If you are interested in the SRP, John's personnel agreement, emerging HEC technologies, or if you have ideas for a river in your backyard, please give John or HEC a call.

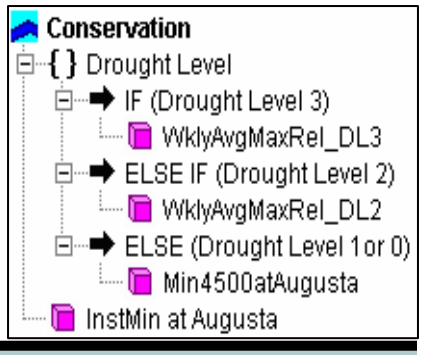
Project News

HEC-ResSim Improvements —*continued*

The values of these requirements are defined in the regulations as a function of the pool elevations in all three reservoirs in the system, not just on one. To represent this, a state variable representing the "drought trigger" was developed. The drought trigger variable is set based on the current pool elevation in each reservoir at the start of the decision interval. Then, an if-then-else block (whose conditions test the drought trigger state variable) was defined with a set of varying downstream flow and release rules. The condition that evaluates to "true" within each decision interval then identifies which set of rules applies in determining the release.

Outlet allocation was added to describe how the release(s) from the reservoir should be allocated among the reservoir's available outlets. This is often necessary when modeling hydropower facilities because they are typically operated to maximize power production while still meeting their other in-stream objectives. To do this, they typically make all releases through the power plant (up to plant capacity) before releasing from any other outlet. Three methods for outlet allocation have been developed – sequential (use outlet A until it has reached capacity, then use outlet B, etc), balanced (use outlet A at the same time as outlet B, but use a weighting scheme to apportion the release between them), and stepped (allocation of flow across outlets is determined by a table relating flow from each outlet to total release from the group of outlets).

Milestones in the 2004 ResSim development plan includes completion of on-going development-level testing of the new features at the end of February, at which point release-testing and documentation development will begin, followed by a general release of Version 3.0 which is currently targeted for Fall 2004.



Director's Comments — *continued*

TechnicalAssistance/ ReimbursableProjects: Reimbursable project work was undertaken for Corps field offices as well as HQUSACE civil works planning and engineering, Engineering Research and Development Center – Coastal and Hydraulics and Environmental Labs, the Federal Emergency Management Agency, the National Institute for Building Sciences, and the US Bureau of Reclamation. Projects include watershed and reservoir system modeling, water quality, risk analysis, river hydraulics, wetlands hydrology, water control management, regional statistical analysis, flood damage analysis, flood warning response systems, GIS applications in hydrology and hydraulics, groundwater modeling and water supply. Projects were undertaken in Santa Claus Alaska, Sacramento-San Joaquin Basins, Lake Tahoe, Upper Mississippi, Anacostia Maryland, Jefferson Parish, Louisiana, Tooele Air Force Base, Utah, Ft. Huachuca, Susquehanna Basin, Tigris-Euphrates Basins in Iraq, Savannah River, Rio Grande, and a number of other locations throughout the US. The total reimbursable project program was about $1.0 million with individual projects ranging from a few thousand dollars to upwards of $150,000.

We are in a position to undertake new reimbursable work this year. We are interested in applying new methods and tools to Corps and other water resource problems, and in developing new or adapted tools for project studies and water control management.

Outlook for 2004: We will continue developing and fielding new versions of the NexGen software packages noted above. We are excited about our new agreement with The Nature Conservancy (TNC) to work collaboratively on Sustainable River Projects throughout the country, a joint Corps-TNC activity. Training activity is expected to moderate somewhat with fewer courses likely in FY 2005 due to overall Corps budget impacts. We expect that civil works research and development funding, the base funding for improvement in hydrologic engineering methods and HEC software, may continue to decline along with the overall decline of the Corps R&D budget; software maintenance and support will stay about the same to slightly increase; CWMS modernization, maintenance and funding will stabilize (as planned) at about half what it was at its peak three years ago; and reimbursable technical assistance and special projects will increase.

Darryl W. Davis

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Published Quarterly by
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ADVANCES in Hydrologic Engineering is published quarterly as a service to the Corps of Engineers and others interested in recent accomplishments of the Center. This bulletin is published in accordance with AR 25-30.

DEPARTMENT OF THE ARMY
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