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Hydrologic Engineering Center

Corps Water Management System (CWMS)

June 2000

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14. ABSTRACT
As part of its Civil works mission, the US Army Corps of Engineers designs, builds and operates a variety of water resources projects. Projects include multi-use storage reservoirs, navigation dams and locks, and levee systems with closure structures. Corps Emergency Operations often include re-enforcing or raising levees, sandbagging efforts, and evacuation during flooding. The Corps Water Management System (CWMS) I sued to acquire real-time data on watershed conditions, develop forecasts of project inflows and uncontrolled flows below projects, determine project releases, and evaluate impacts. These tools provide critical information to Corps water managers to make informed engineering decisions under a variety of routine and emergency conditions. An overall description of the modernization project is given, including a discussion of improved spatially disturbed rainfall runoff modeling, reservoir operation modeling, steady and unsteady flow hydraulic routing, inundated area determination, and flow/stage impact analysis.

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Corps Water Management System (CWMS)

Modernization Project
Conceptual Overview

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I - Background

As part of its Civil Works mission the US Army, Corps of Engineers designs, builds and operates a variety of water resource projects. Projects include, for example, multi-user storage reservoirs, navigation dams and locks, and levee systems with closure structures. Corps Emergency Operations often include re-enforcing or raising levees, sandbagging efforts, and evacuation during flooding. The Corps Water Management System (CWMS) is used to acquire real-time data on watershed conditions, develop forecasts of project inflows and uncontrolled flows below projects, determine project releases, and evaluate impacts. These tools provide

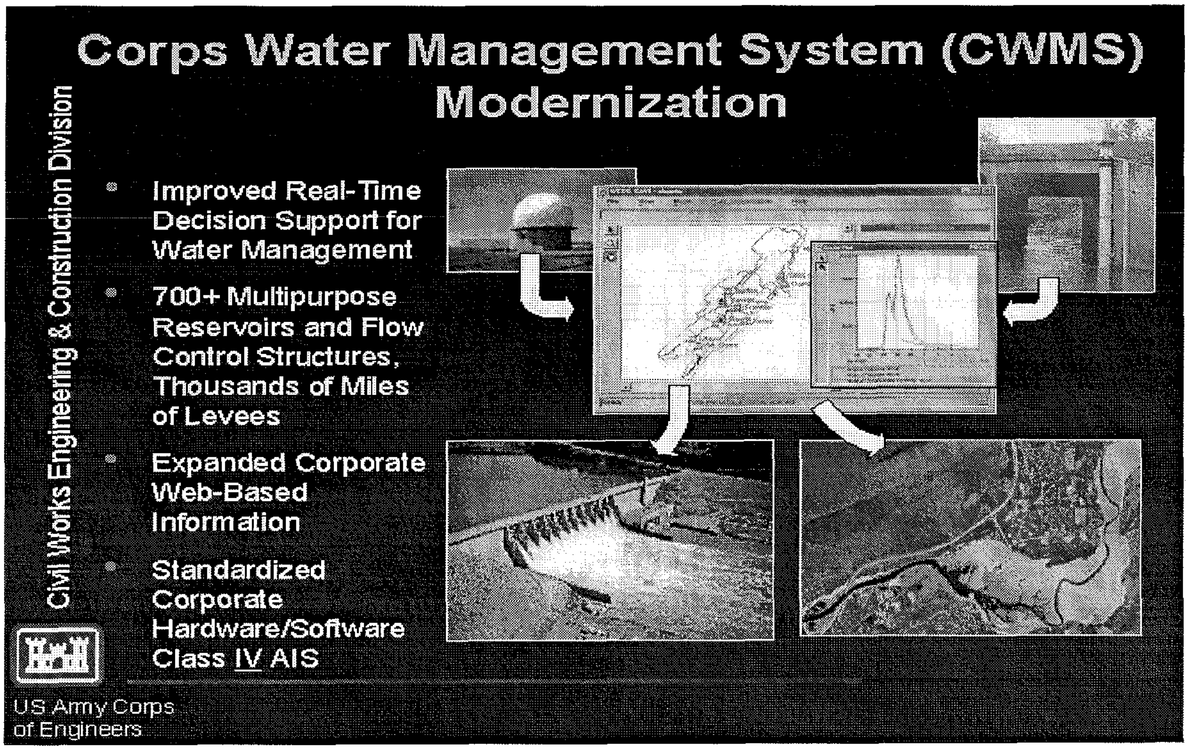

Figure 1 Corps Water Management System (CWMS) concepts.

critical information to Corps water managers to make informed engineering decisions under a variety of routine and emergency conditions. Corps water managers work in close coordination with other Federal (i.e., NWS, USBR, FEMA) , state, and local water and emergency management, organizations to carry out their mission responsibilities.

The CWMS is currently undergoing a major modernization effort to incorporate state-of-the-art hydrologic modeling techniques, real-time data processing, decision support tools and network based information dissemination. An overall description of the modernization project is given. This includes a discussion of improved spatially distributed rainfall runoff modeling, reservoir operation modeling, steady and unsteady flow hydraulic routing, inundated area determination, and flow/stage impact analysis. Concepts of this modeling system are presented. Application of this new technology to a specific test area will be given in another paper.

II - Scope

The CWMS encompasses steps in the water management process starting from the receipt of environmental and project data, through the modeling of system response and decision support analysis, ending with the dissemination of data and decision results. The incoming real time data include river stage, reservoir elevation, gage precipitation, WSR-88D spatial precipitation, quantitative precipitation forecasts (QPF) and other hydro-meteorological parameters. These data are used to derive the hydrologic response throughout a watershed area, including short-term future reservoir inflows and local uncontrolled downstream flows. The flows are then used by the reservoir operation model to provide proposed releases to meet reservoir and downstream operation goals. Then, based on the total expected flows in the river system, river profiles may be determined, inundated areas may be mapped, and flood impacts may be analyzed. The CWMS allows the water manager to evaluate any number of operation alternatives before coming to the final decision. For example, various alternative future precipitation amounts may be considered, hydrologic response may be altered, reservoir release rules may be investigated, bridge, levee or other river conditions may be evaluated. When an operation decision is made the results, along with supporting environmental data may be disseminated to others via web technology.

The system emphasizes visualization of information in time and space. The primary CWMS user interface is map based to provide clear spatial reference for watershed and modeling information. CorpsView, a Corps developed spatial visualization tool based on commercially available GIS software, provides a direct user interface to GIS products and associated spatial attribute information.

III - Components

Figure 2 shows the major components of the CWMS (counter clockwise from upper left): Data Acquisition (DA), Data Base (DB), Modeling, Control and Visualization Interface (CAVI), Data Dissemination (DD). These components have been developed in a network client-server architecture, permitting each component of the system to be hosted on one or more different hardware platforms. The current server side equipment is Sun Solaris and the client side can be fielded on Windows NT or Sun Solaris. The major portion of the product is written in Java, with Fortran, and C++ used for certain of the model computations.

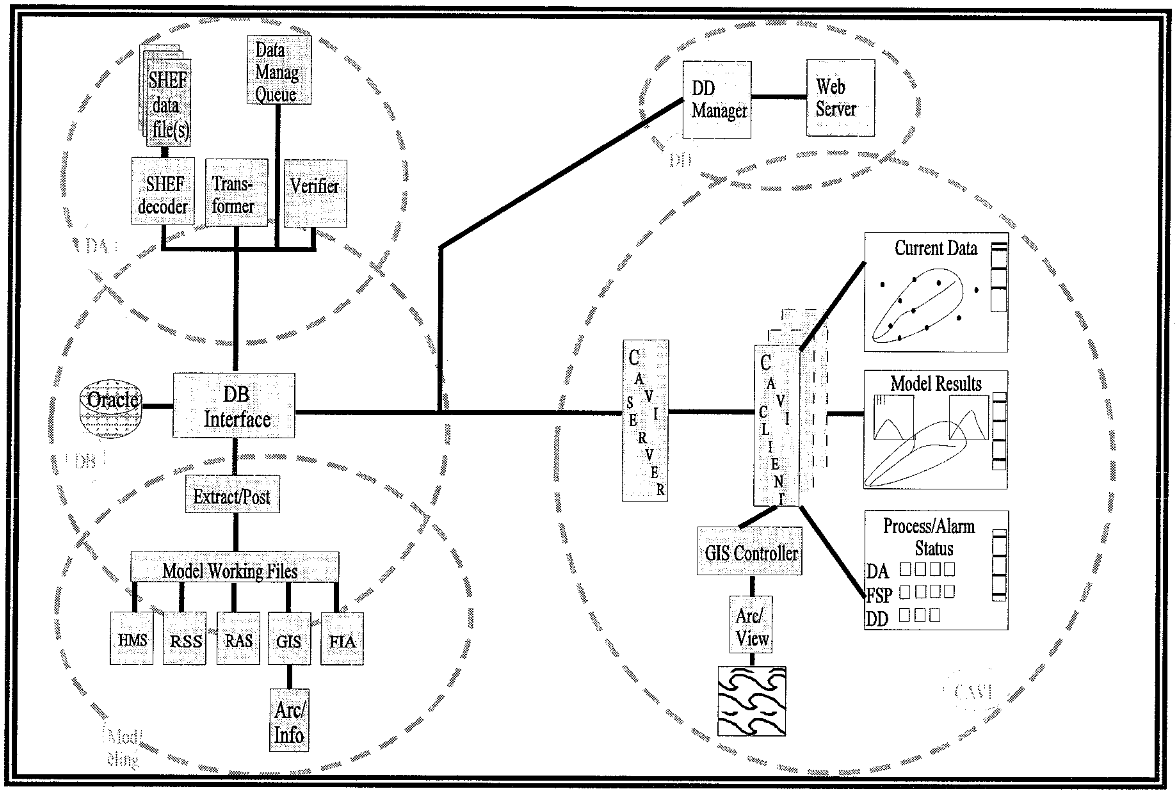

Figure 2 CWMS Components

Data Acquisition - The Data Acquisition(DA) component is responsible for ingesting data from any of the supported data sources. Currently, the primary data streams processed in the Corps are GOES Data Collection Platform (DCP) and National Weather Service SHEF. These and other formatted data may be processed as it is received via FTP or other file transfers, or via point-to-point network socket connections. Either type data is written directly to permanent storage and is then operated upon by the data acquisition software. Two levels of data screening may be performed. "On-the-fly" screening uses only simple magnitude and range checks. The second level of screening can perform tests that consider the rate of change of variables, comparison with neighboring stations, and other statistical tests. The DA component is also responsible for the derivation of secondary parameters. Typical derivations include: reservoir pool elevation to reservoir storage, river stage to flow, and accumulative precipitation to incremental precipitation. All data are stored in the data base during its processing by the DA components.

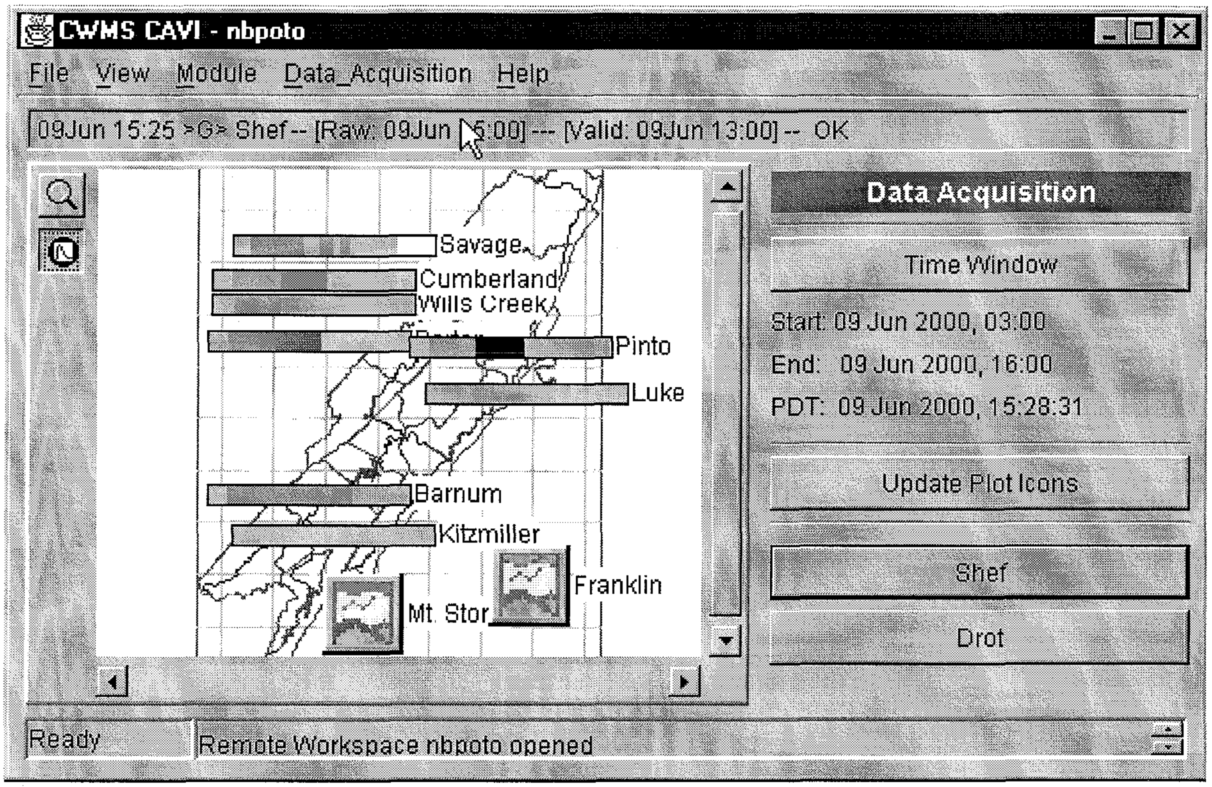

Figure 3 Sample Data Acquisition Status Screen.

Data Base - The Data base (DB) component provides permanent data storage for the system. It is responsible for the management of all data received from the data streams and all data generated as derive and modeling operations are performed. All data written to or read from the data base are controlled by the Data Base Interface (DBI). The DBI provides a single image view of data that is used in the many components of CWMS. All data in the database are stored in Coordinated Universal Time (UTC) in System International (SI) units. Activities requesting data from the DBI receive the information in any units they desire. In all cases time remains in UTC and the application is responsible for displaying the time correctly in the users local time zone. The consistent use of UTC resolves issues where data crosses time zones and the problematic semiannual shifting between standard and daylight time.

Figure 4 shows thumbnail plots of river status for several locations.

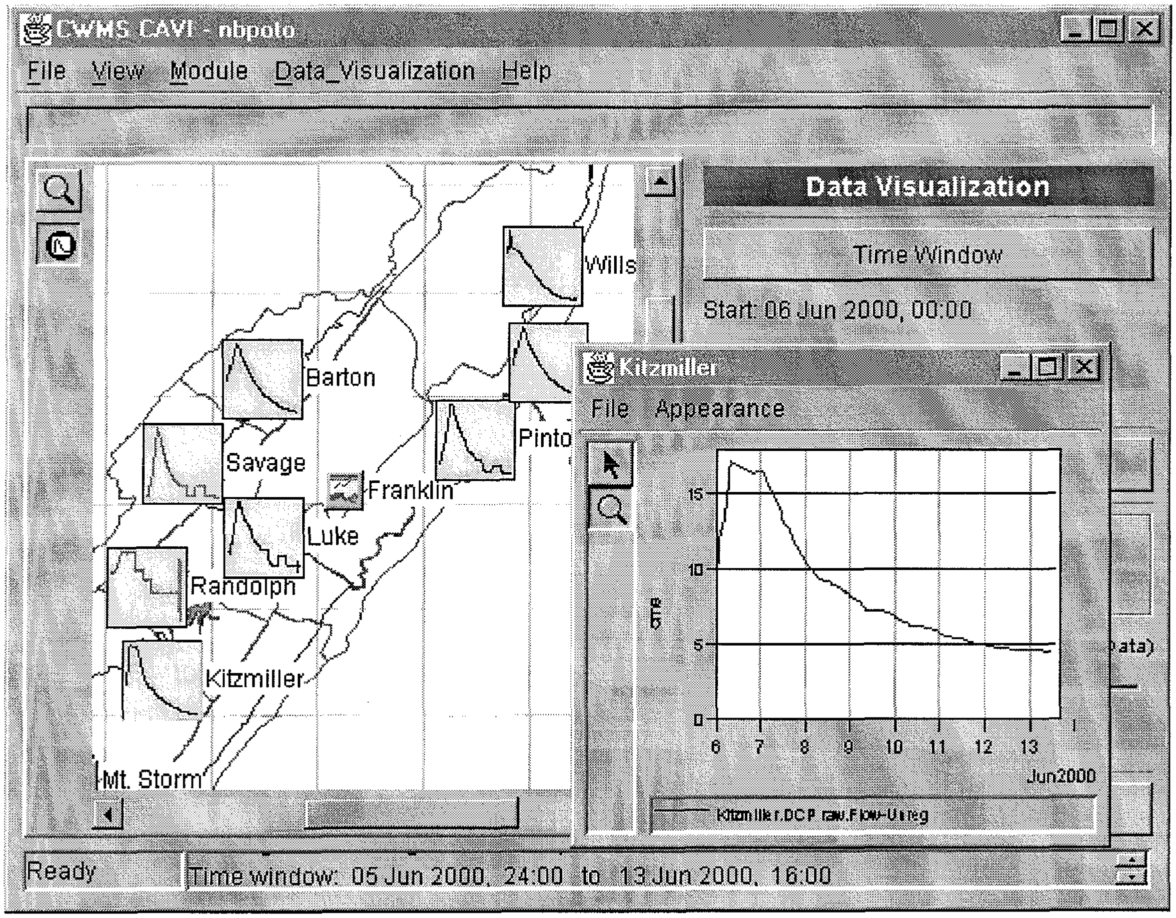

Figure 4 Thumbnail plots of river stage data.

Modeling - The modeling component is responsible for the specification of model alternatives, the execution of model runs, and the display and interpretation of analysis results. The model suite includes precipitation input preparation, hydrologic response modeling, reservoir operation modeling, steady and unsteady flow river profile analysis, inundated area determination, and flood impact analysis. At a user specified forecast time, data pertinent to a watershed area is extracted from the data base and placed in a modeling sub-database. This sub-database is then the source and destination for all model runs and all the alternatives that are evaluated. At completion of the analysis the final operation alternative results are posted back to the master data base for dissemination. The sub-database, the related model parameters, and specific model output and log files can be saved to off-line storage to serve as a complete record of the analysis performed to support the decision process.

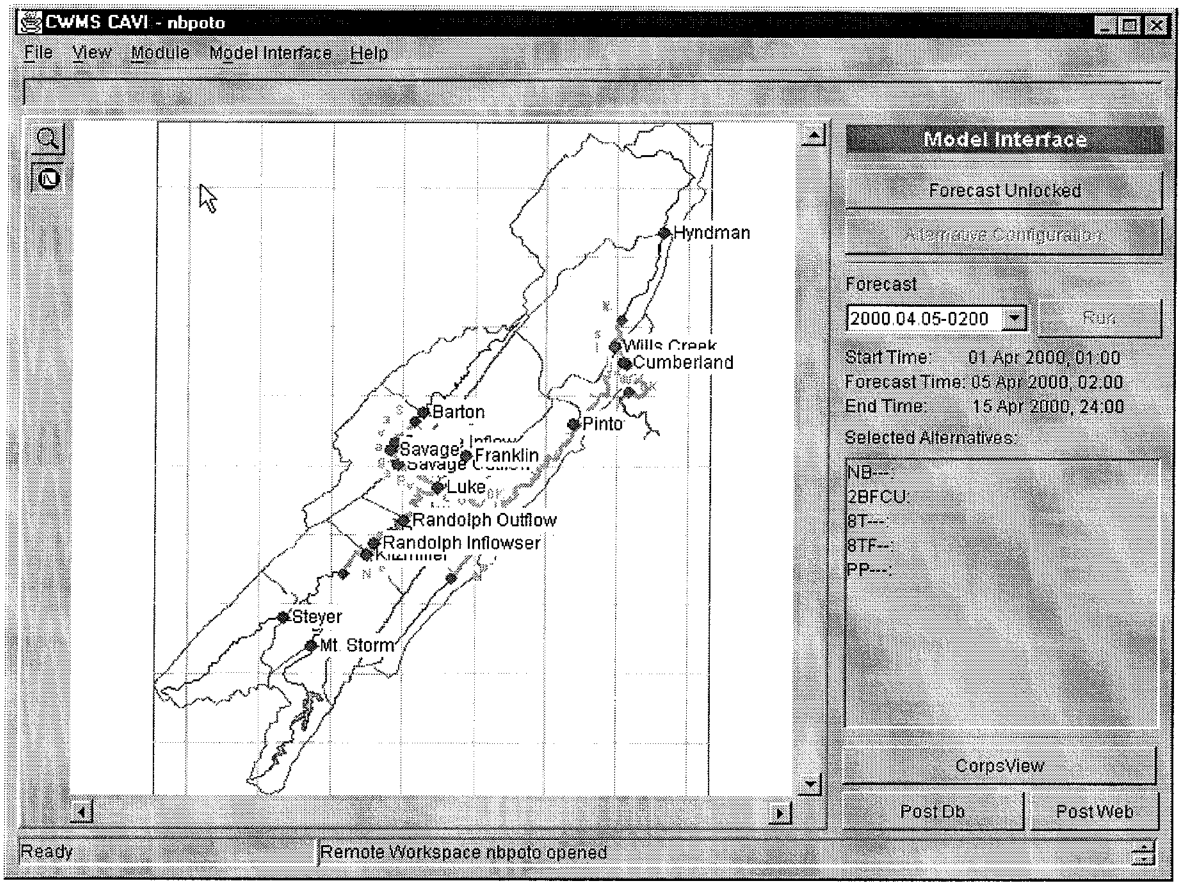

Figure 5 CAVI - Model Interface Screen.

Hydrologic modeling - The hydrologic response of the watershed is modeled using spatially distributed precipitation. The HEC-HMS accepts gridded precipitation from both radar and point precipitation gage sources. Digital Elevation Model (DEM) data is used to develop model parameters. Runoff excess from each grid cell is determined and is routed using the Modified Clark procedure to provide runoff at the sub-basin outlet. Sub-basin hydrographs are then routed down through the channel network to develop flow into reservoirs, and local flow at downstream locations.

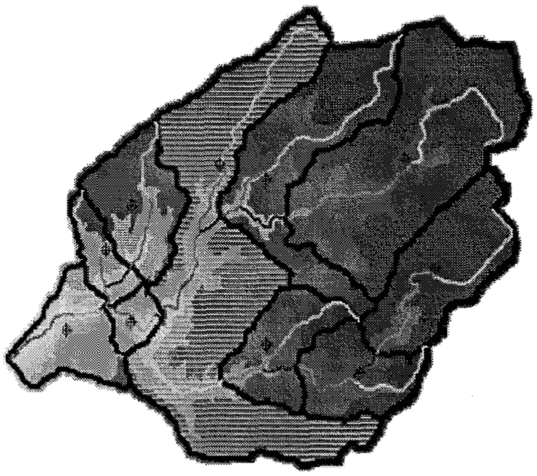

Figure 6 Geo-Spatial defined basin characteristics

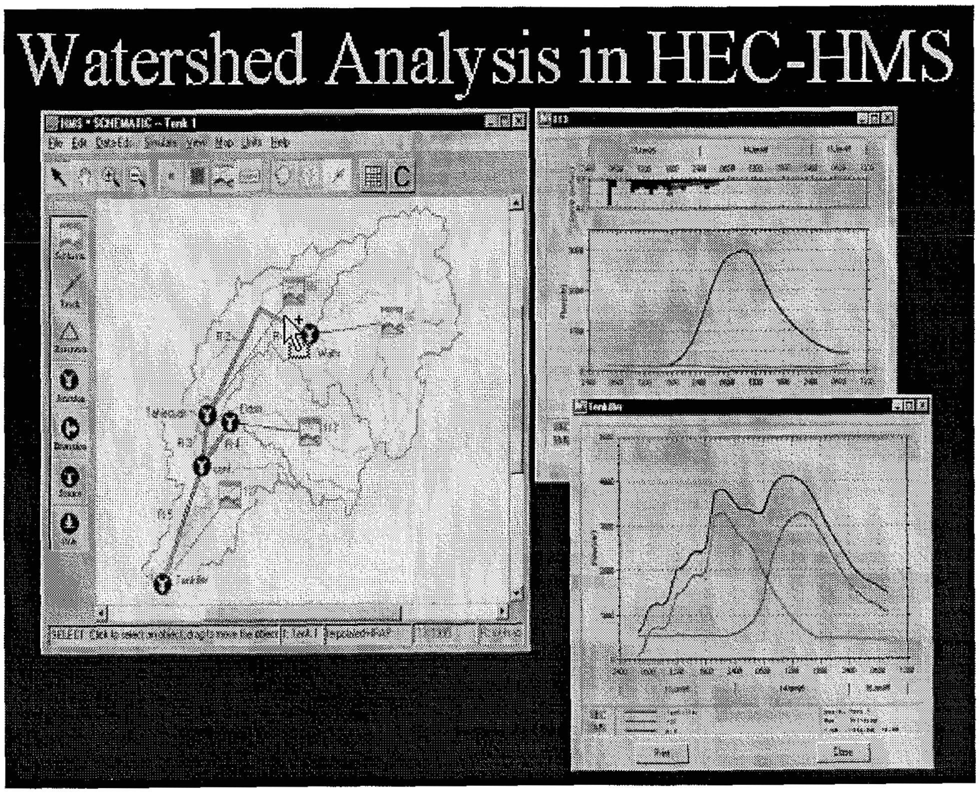

Figure 7 HMS Model schematic and typical model results.

Reservoir modeling - The analysis of reservoir operations is performed using HEC-ResSim. This newly developed reservoir simulation program determines project releases based on a set of user supplied operation rules. This rule-based approach allows good flexibility in describing desired behavior for individual reservoirs operating for multiple local and downstream goals, as well as when reservoirs must operate as a system. The reservoir model uses inflows generated from the hydrologic model runs. Initial pool elevation, its corresponding reservoir storage and known project releases must be available to properly initialize the model. In cases where different rules lead to a conflict in determining releases, a rule priority is used to resolve the conflict. The determined releases are then combined with local uncontrolled flows from the hydrologic model to provide total flows throughout the watershed.

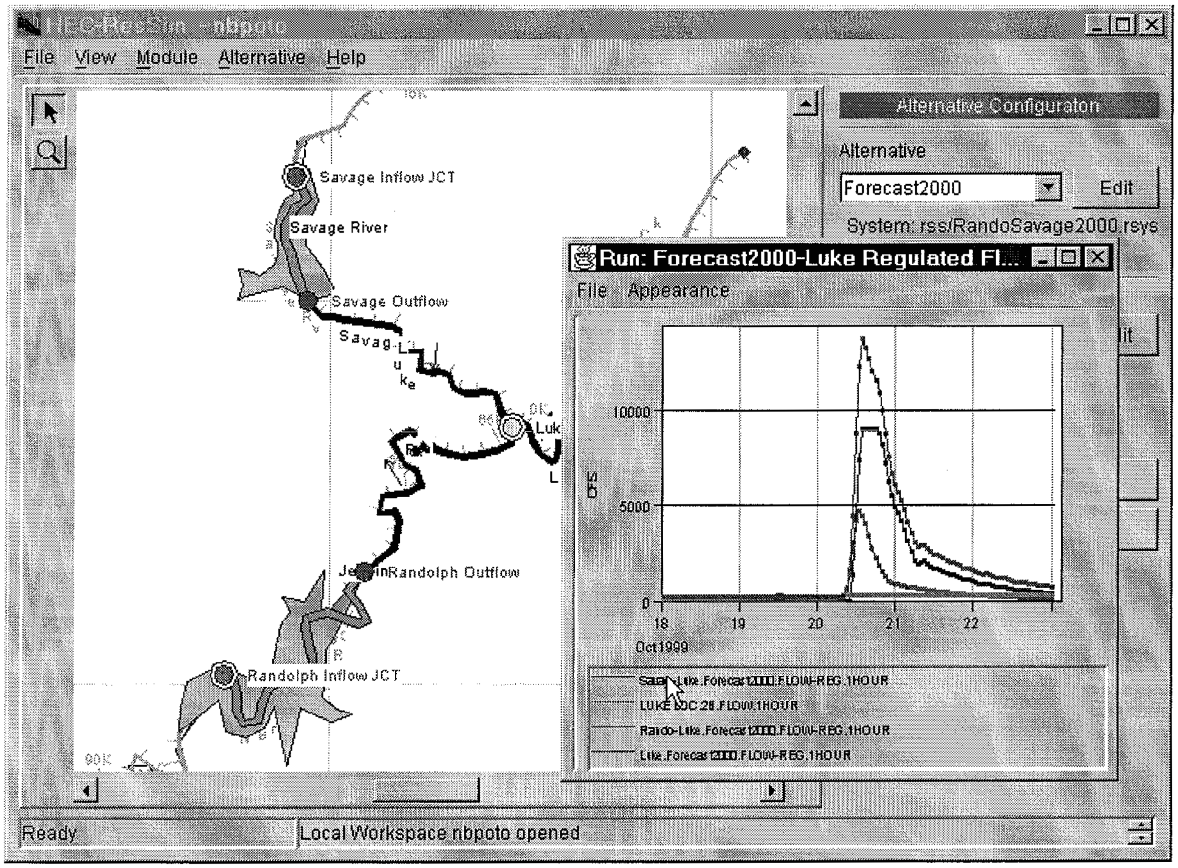

Figure 8 Reservoir Simulation Model schematic and plot.

River Profile modeling - The total river flow for each of the alternatives is used to determine the water surface profiles above, through, and downstream of the reservoirs. The HEC-RAS model is capable of generating both steady and unsteady flow profiles. Each of these determinations is based on cross-section geometry. Geo-spatial tools may be used to assist in generating the necessary cross-sections from triangular irregular network (TIN) files. Because this operation can be performed with spatially registered cross-sections, the resulting water surface profiles can be used to map inundated areas.

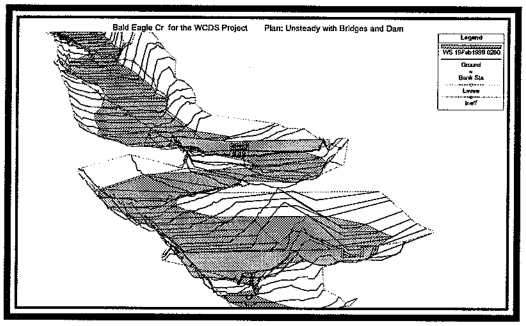

Figure 9 Geo-Spatial Cross-Sections

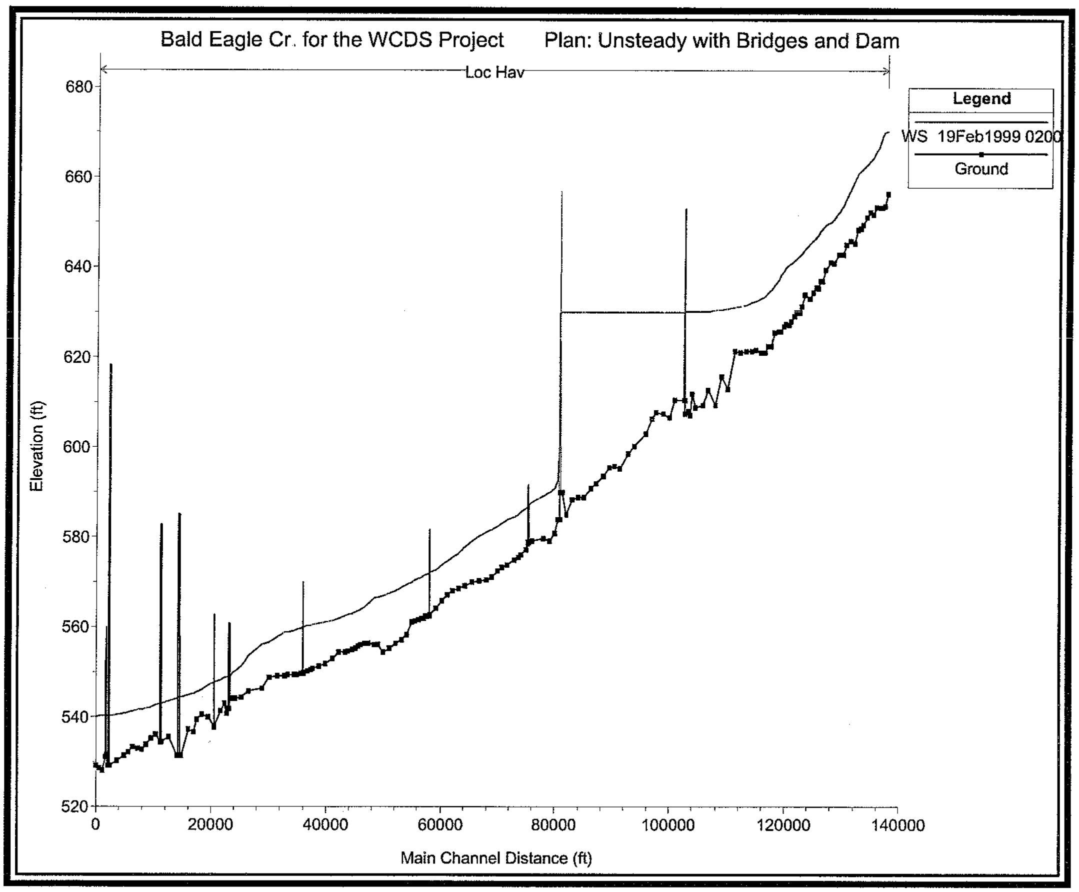

Figure 10 River Profile

Flood Impact Analysis - Based on the information available from the preceding model steps the impacts of flows and stages may be evaluated. This evaluation is based on relationships between flow and/or stage and damage functions. The damage functions may reflect urban, suburban, and agricultural conditions. Impacts are evaluated for any number of impact areas defined by the user. Impact areas may be aggregated by county, state, congressional district, or other desired spatial entity.

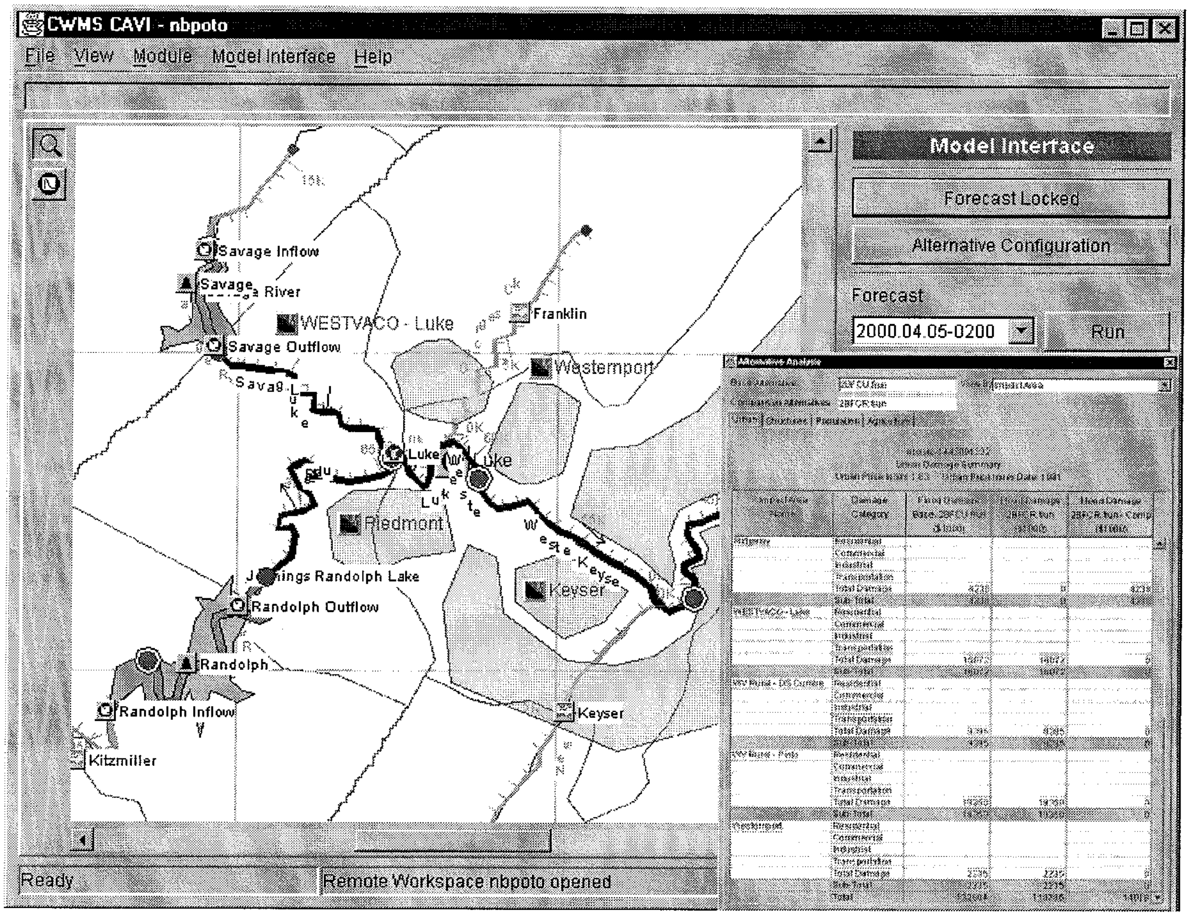

Figure 11 Model schematic showing impact areas and summary table of damages.

Data Dissemination - Internet Web and other automated technology are used to provide information from the CWMS to interested parties. Data received from the data acquisition components, derived data, and final project operation data are available for dissemination to other Corps offices, cooperating Federal, state and local agencies, and other public and private interests. A close working relationship exists between the Corps of Engineers and the National Weather Service (NWS). Information that the Corps of Engineers disseminates is solely associated with its mission to operate water projects, and to perform emergency flood fight activities. Public dissemination of flood alerts, flood warnings, and other weather information is the responsibility of the NWS.

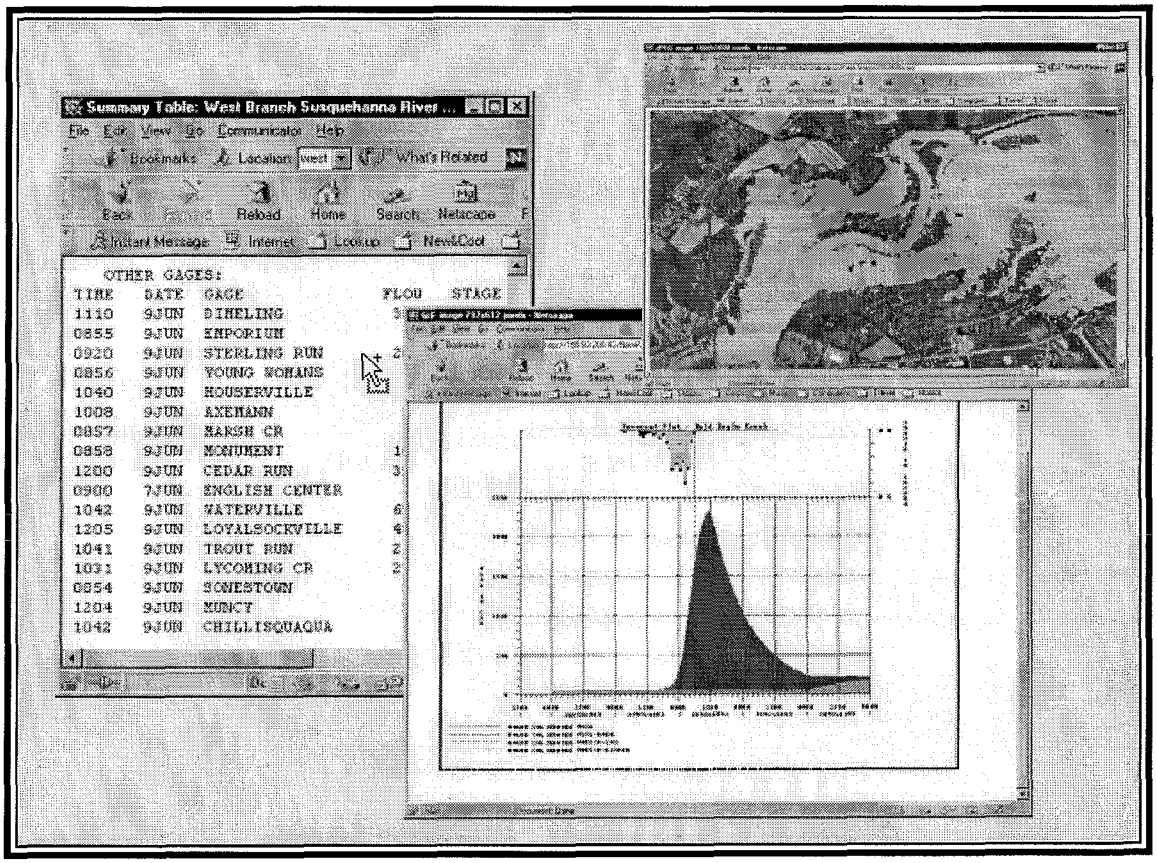

Figure 12 Sample Dissemination Web Products.

IV - Summary

The Corps of Engineers is modernizing the tools it uses in carrying out its water management mission. This includes decision support for reservoir project release determination, and emergency operation activities requiring hydrologic and hydraulic analysis. The modernized products utilize network based client-server architecture. One or more clients may be run from any location in a wide or local area network to access data and models. Any number of alternative scenarios may be evaluated including: various possible future precipitation inputs, reservoir operation alternatives, and river hydraulic or levee conditions. The capabilities described herein are part of the last stage of a three-stage development cycle. Four Corps field offices are being used to test and evaluate the modernized product at each stage in its development. The final product is scheduled for completion in the third quarter of 2001.

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