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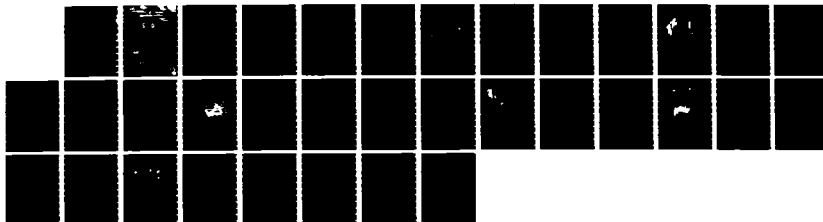
THE HYDROLOGIC ENGINEERING CENTER ANNUAL REPORT 1985
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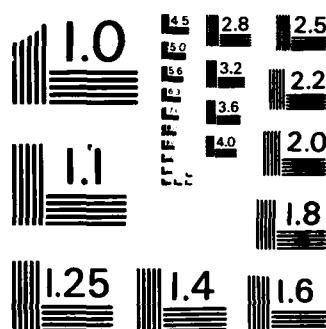
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US Army Corps
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1985 Annual Report

The Hydrologic Engineering Center

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Research

Technical Assistance

Training

This annual report describes the accomplishments of the Hydrologic Engineering Center (HEC) during FY 1985 and the planned program for FY 1986.

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Water Resources Support Center
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DIRECTOR'S MESSAGE

The Center provided substantial technical assistance to 27 Corps offices during FY 1985, including the Office of the Chief of Engineers, the Waterways Experiment Station and the Institute for Water Resources. Technical assistance was also provided to the Bureau of Reclamation and the National Park Service of the Interior Department, the Federal Highway Administration, and the Government of India (through the U. N.). One-fourth of HEC's resources were devoted to direct field assistance projects during FY 1985. Four or more offices were assisted in each of the areas of Real-Time Water Control and Data Management, River Hydraulics, and Planning Analysis. Eleven formal training courses involving eighteen weeks of training were conducted at HEC. Three workshops, totaling two weeks, were also held.

Significant advances were made in improving HEC's library of computer programs during FY 1985. Thirteen new programs were developed; most serving the water control data communications area. Sixteen HEC programs were upgraded to Fortran 77 standards to make them more transportable to other computers. Fourteen HEC programs were added to the five microcomputer versions available in FY 1984 from HEC. The nineteen microcomputer programs that are available from the HEC are in the technical areas of rainfall-runoff, river hydraulics, flood flow frequency, flood damage computations, groundwater analysis, small-scale hydropower costs, and spatial data management. Also utility programs for printing summary output reports, editing files, and assisting in preparing data input for reservoir analysis are also available. Several others will be available next year.

Activity within the Corps and HEC remains high with regard to acquisition and use of microcomputers. Several Corps Hydraulics/Hydrology offices have recently informed us that most of their engineers have IBM PC/AT or equivalent microcomputers on their desks. We have acquired additional microcomputers (twelve now) and hope to have twenty by the end of FY 1986. HEC is planning on having microcomputers dedicated to classroom use for FY 1987. In our first full year of distributing microcomputer versions of our programs, requests were twice that for the mainframe version.

Significant new capabilities were provided to our Corps users in several areas. Several new water control software packages were developed to enhance communications between Corps offices and with the National Weather Service. The HEC Flood Damage Analysis Package was

completed after several years of hard work. This package is comprised of the major HEC rainfall-runoff, river hydraulics, reservoir system and flood damage analysis programs. The programs are linked in a data management sense through our data management system (HEC-DSS). This package represents an integrated way of executing programs and managing data in order to perform damage calculations. In addition, water control computers were delivered to twenty-one sites during FY 1985 as a result of several years of intense work by OCE, HEC and the Huntington District procurement office.

The distribution of workload at HEC during 1985 changed considerably from FY 1984, as can be seen from Table 1, but closely resembled FY 1983, a more normal year. The training program experienced a significant temporary drop in FY 1984. Training activities represented about 15% of HEC's work effort, computer support activities 17%, research 45% and technical assistance 23%. FY 1984 levels of activity in these areas were 9%, 12%, 39% and 40%, respectively. The manpower and funding levels were essentially unchanged for FY 1985 and no significant change is anticipated for FY 1986.

The planned program for FY 1986 includes similar activities to FY 1985 with somewhat fewer formal training courses. Risk analysis for our dam safety research program will test methods for spillway capacity sizing. The very difficult and sensitive issue of rare-flood probability will be addressed in that effort as well as a sensitivity analysis to help quantify the effects of uncertainty in flood estimates, flood routing, dam breaches, and flood damage. Emphasis will continue on advancing the technical capabilities of our programs, modernizing the computer program code, and creating a more friendly environment for our users. We will be concentrating on providing these capabilities for microcomputers, as well as mainframe.

This past year was a sad one for the Corps hydrologic engineering staff and especially for the staff of HEC. The death of Al Cochran, the former Hydraulics and Hydrology Chief in the Corps headquarters for so many years and the creator of HEC in 1964, was an especially sad event. Also, Vern Hagen, the most recent Hydraulics and Hydrology Chief at Corps headquarters, retired. Vern's valuable support and friendship to HEC for more than ten years will be greatly missed. We hope his retirement will be enjoyable and that he will visit his Corps friends often.

Table 1
HEC Activities Based on Funds Expected
(in percent)

	FY 1983	FY 1984	FY 1985	FY 1986*
Training	17	9	15	10
Computer Support	11	12	17	16
Research	44	39	45	40
Technical Assistance	<u>28</u>	<u>40</u>	<u>23</u>	<u>34</u>
Total	100	100	100	100

*Estimated

GOALS OF THE HYDROLOGIC ENGINEERING CENTER

The goals of the Hydrologic Engineering Center (HEC), designed to help achieve the goals of the Chief of the U.S. Army Corps of Engineers, are to support the nation in its water resources management responsibilities by increasing the Corps technical capability in hydrologic engineering and water resources planning and management. An additional goal is to provide leadership in improving the state-of-the-art in hydrologic engineering and water resources planning.

By means of programs in research, training, methods systemization, planning analysis, and technical assistance, every effort is made to be aware of the problems and needs of the Corps and the nation, to keep abreast of the latest developments throughout the profession, and to make use of this information in a manner best suited to the needs of the Corps.

HEC increases the effectiveness of the Corps and the profession by bridging the gap between the academic community and practicing hydrologic engineers and planning professionals. Research or training activities that can be best accomplished by universities are not undertaken. HEC incorporates state-of-the-art procedures and techniques into manuals and comprehensive computer programs, and makes this knowledge available to support the Corps, the nation, and inter-

national professionals through an effective technology transfer system of technical assistance, publications, video tapes, and training courses.

Research supplements relevant research at universities, private industry and other agencies. It develops systematic procedures that produce a quality product and also save time for experienced specialists and enable less-experienced personnel to use procedures effectively.

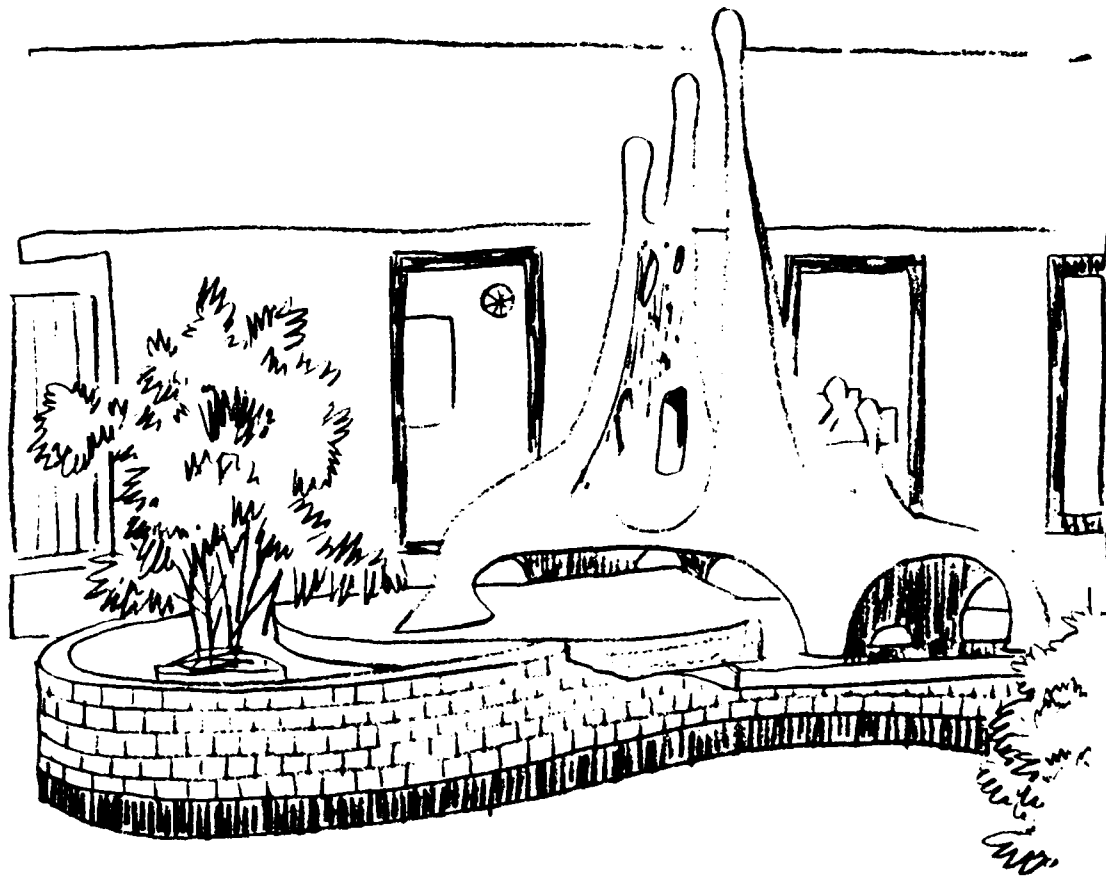
Training efforts develop the USACE work force and reduce the time necessary for young engineers and planning professionals to become proficient in hydrologic analysis, and, in addition, familiarize more-experienced professionals with new developments.

Technical assistance provides advice and assistance to Corps field personnel in the application of new or unfamiliar procedures to solve unusual water resources problems and to more effectively utilize USACE resources.

Planning analysis develops and enhances analytical techniques and procedures to be applied in the water resources planning activities in Corps field offices to enable the production of a quality product.



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ADMINISTRATION/FUNDS

The Hydrologic Engineering Center is located in Davis, California. Facilities include office space for the staff and visiting personnel, a well-equipped classroom for 36 students, a library, a publications and video tapes distribution/storage center, and a computer center. The computer center hardware consists of a Harris 1000 computer, and a variety of supporting video, graphics and printing terminals. Nineteen IBM personal computers, twelve graphical terminals (for classroom use), and an HP-9000 computer are also available.

Responsibilities

The HEC was established in 1964 to provide applied research, training and technical assistance in hydrologic engineering to Corps field offices. In 1971, HEC's responsibilities were expanded to include analytical planning so that activities of the HEC now address a wide range of hydrologic engineering and analytical planning concerns.

The annual program of HEC is based on: (1) program direction from the Office of the Chief of Engineers, Civil Works Directorate, Planning, and Hydraulics and Hydrology Divisions; (2) the Corps Research and Development Directorate's "Research Needs" program; (3) the Corps Training Needs Survey; (4) requests for assistance by Corps field offices; (5) cooperative work with other Corps research laboratories; and (6) cooperative work with other government and professional organizations. This program is reviewed at an annual conference held with personnel from the Office of Chief of Engineers, the Corps R&D Directorate, the Water Resources Support Center, and interested Corps field offices.

The HEC is a field operating agency of the Water Resources Support Center located in Fort Belvoir, Virginia. The Water Resources Support Center coordinates Corps-wide water resources support services for the Directorate of Civil Works,

Office of the Chief of Engineers. The HEC has been granted authority, within the approved program, to deal directly with field offices on technical matters.

Organization and Staff

The HEC is organized into six functional units as shown on the accompanying organization chart. HEC was authorized 36 full-time equivalent positions during FY 1985 and for FY 1986. Those persons employed on permanent status at the end of FY 1985 are shown on the organization chart. The HEC also employs temporary employees in professional, technician and clerical capacities. Five students were employed through an internship program conducted in cooperation with the American Society of Civil Engineers' Student Chapter at the University of California, Davis during FY 1985. An Intergovernmental

Personnel Appointment position was occupied by a Utah State faculty member who provided special hydrologic and engineering technical expertise to the HEC.

Funding

HEC funding is provided by three main sources: the Civil Works R&D program, Corps-sponsored training program, and reimbursable services provided to Corps and other agency offices. Reimbursable assistance includes work for Corps District and Division offices, research and development laboratories, the Water Resources Support Center, the Planning and Hydraulics and Hydrology Divisions, Civil Works Directorate, Office of the Chief of Engineers, and other government agencies. Income and expenditure summaries for FY 1985 and projections for FY 1986 are shown in the following table.

Income and Expenses Summary, FY 1985
(\$1,000s)

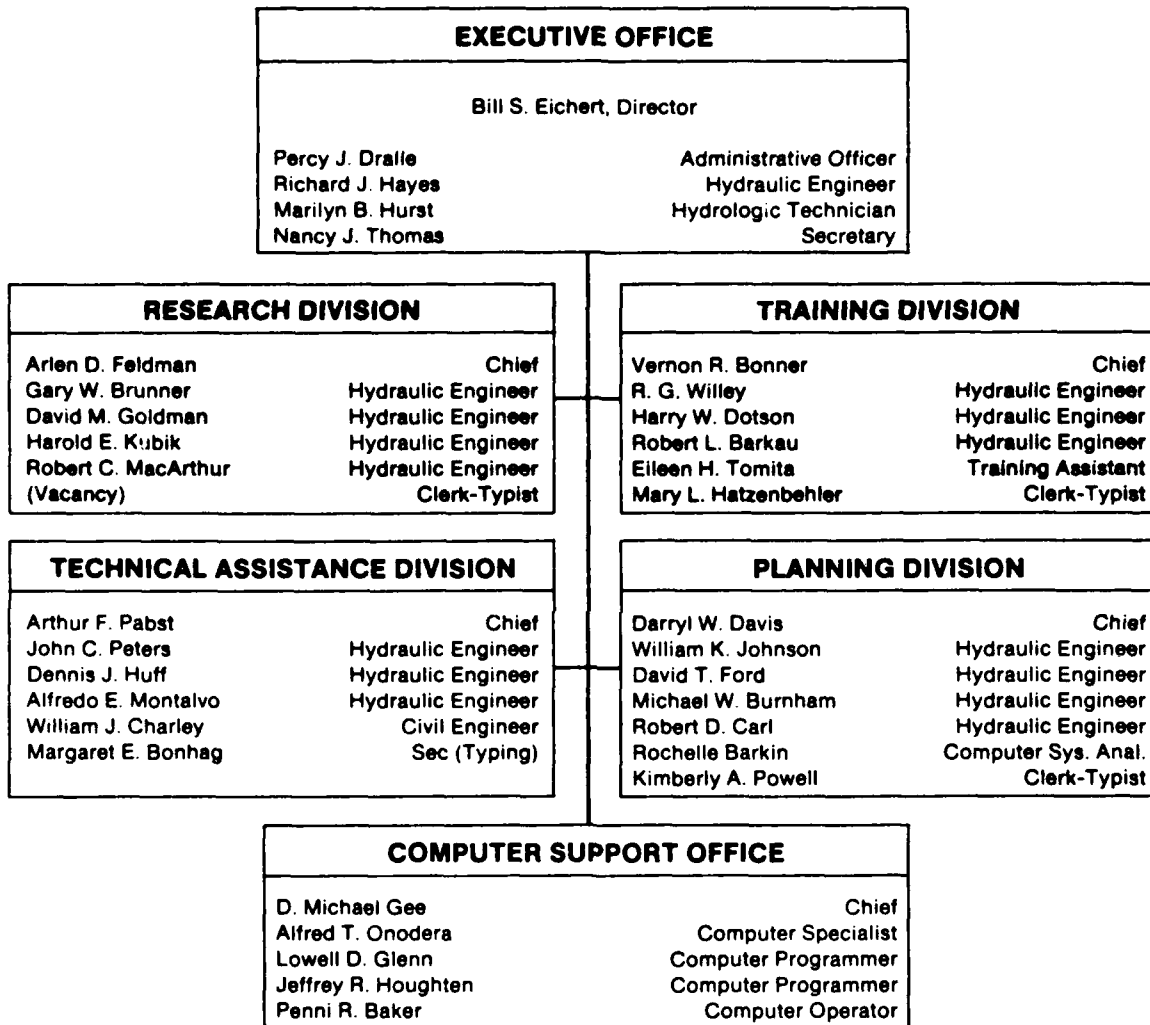
	FY 1985	Estimated FY 1986
Income		
R&D, Direct	\$1,135	\$1,110
R&D, Reimbursable	45	35
Training	414	267
Technical Assistance	664	600
Floodplain Management	55	60
Computer Program Support (GE funds)	185	185
Publications and Computer Program Income	238	240
Carry-over from Previous FY	<u>376¹</u>	<u>504</u>
	\$3,112	\$3,001
Expenses		
Salaries and Benefits	\$1,550	\$1,575
Travel and Per Diem	80	75
Research Contracts	198	200
Professional Services	32	30
Computer Time and Equipment	171	165
ADP Maintenance	50	50
Reproduction	80	80
Services and Supplies	82	125
Space Rental	100	100
Administrative Services ²	<u>265</u>	<u>265</u>
Subtotal	\$2,608	\$2,665
Carry-over to Next FY	<u>504</u>	<u>336</u>
Total	\$3,112	\$3,001

¹Includes \$49,000 R&D carryover.

²Provided by Sacramento District.

HYDROLOGIC ENGINEERING CENTER STAFF

Permanent Employees





RESEARCH

The technology needs of Corps field offices drive HEC's research program. New research needs are also indicated by Corps headquarter offices, as well as other Federal agencies. Most of HEC's research effort is technique-oriented and emphasizes a generalized solution to specific field problems. Research results are transferred to the field through HEC training and technical assistance programs as well as through Corps manuals and regulations.

Planning, design, construction, operation and maintenance of today's multiple-purpose water projects requires complex interdisciplinary analyses. These complex problems present major

methodological and computational tasks to the water resources planner and engineer. The HEC seeks solutions to these problems through development of systematic methods and the use of the computational power of computers.

Research Program Accomplishments, FY 1985

Research activities were carried out in 12 work units. These work units represent specific technical areas that have been identified in the Corps R&D program. The HEC's primary research area is entitled "Analytical Techniques in Water Resources Planning Studies." The HEC is also

involved in the Corps research programs in water conservation and supply, planning methodologies, remote sensing, and environmental quality. The FY 1985 work units are listed below.

RESEARCH WORK UNITS, FY 1985

Improvements in Methods of Evaluating Hydrologic Phenomena

Computer Methods for Water Resources Planning

Water Resource Data Storage System

Spatial Data Management and Analysis System

Flood Forecasting for Use During Flood Emergencies

Real-Time Reservoir Regulation

Analytical Techniques for Evaluating Reservoir Systems

Modernization of Computer Programs

Hydrologic Methods for Determining Water Supply Potential

Groundwater Recharge and Storage

Remote Sensing and Spatial Data Applications

Hydrologic/Hydraulic Risk Assessment of Dams

The **Improvements in Methods of Evaluating Hydrological Phenomena** work unit addresses basic studies in hydrology, statistical methods and river mechanics. Work items include simulation of rainfall/snowmelt/runoff processes, flow frequency analysis, stochastic hydrology, water surface profiles, unsteady flow flood routing and sediment transport.

A terrain-based hydrologic model was successfully tested using both unit graph and kinematic wave land surface runoff techniques. New capabilities were added to HEC-1 Flood Hydrograph Package and released to users together with updated documentation. A "Computer Implementation Guide" for HEC-1 was also distributed. A draft Engineering Manual on Flood Frequency Analysis was completed and distributed to field offices by OCE for review. Documentation for the

DWOPER unsteady flow model was improved including a new analysis capability for representation of channel geometry. The "CORPS" erosion and channel stability software was converted to the IBM PC. A modified 2-D hydrodynamics math model for analysis of floodplain inundation was obtained.

Computer Methods in Water Resources Planning work unit emphasizes the development of procedures and tools for automated flood damage analysis, nonstructural flood damage reduction studies, risk and uncertainty in planning, and other general aspects of water supply planning. This is a continuing work unit that has contributed to the following accomplishments: (1) refinement of computer code for Flood Damage Analysis package; (2) completion of development and documentation of a computer program for estimating agricultural flood damage, compatible with other HEC computer programs; (3) completion and publication of a flood control system formulation strategy using the systems analysis technique of branch and bound; (4) improvements to and revised documentation for the Expected Annual Damage Computation program; and, (5) conversion of several popular computer programs to micro-computers.

The **Water Resources Data Storage System (DSS)** work unit provides for the development of a data storage and retrieval system that allows hydrologic engineering/planning simulation models to communicate with one another. Such a data system eliminates redundant capabilities (such as graphics and statistics) in the individual programs, and makes the software more modular and easier to support.

The DSS library was adapted to FORTRAN77 standards to allow the system to be more easily implemented on several different computer systems. A generalized report generator program was developed to allow formatted reports to be prepared containing data from DSS files as well as other sequential text files. Access performance was improved by a factor of 2 to 4 depending on job mix by use of HARRIS system input-output routines. DSPLAY product was enhanced with field office assistance to support new TEKTRONIX 4100 series graphics terminals. All major DSS products are undergoing extensive field testing. Use is being made in planning studies, hydrologic analysis, and real-time data systems.

The **Spatial Data Management and Analysis (SAM)** work unit supports development of a geographic information system for use in the Corps engineering and planning activities. Geographic information, characterized in grid cells or irregular polygons, can be used to formulate parameters for hydrologic models, structural damage information, or benefit analysis, as well as habitat or land characteristics for use in environmental planning.

This continuing work unit contributed to the following accomplishments: (1) refinement of capability for creating data files and for display of spatial graphics; (2) complete testing and assessment of triangular terrain technology for spatial analysis; (3) completion of improvements to computer program code for the linked spatial-flood damage analysis for urban and agricultural applications; (4) completion of working draft flood damage analysis package illustrated example and guidance; (5) completion of example application documentation for planning dredged-material disposal systems; (6) one-stop user support, several technology transfer documents, and spatial data management family of computer programs maintenance; and, (7) successful completion of improvements to and preliminary conversion of several spatial programs to microcomputer applications.

The **Flood Forecasting Models for Use During Flood Emergencies** work unit is directed toward developing a package of programs to use in forecasting the hydrologic response of a river basin. The forecasting techniques developed under this work unit were applied to additional basins for operational use by HEC and district office personnel. Based on input from several field test locations, modifications were made to expand the number of zones to which subbasins may be assigned. During the forecast the capability was added to automatically access QPF values determined by NWS personnel. The PRECIP program documentation was revised and distributed to field offices. The NWS-Sacramento model moisture algorithms were acquired for incorporation in the PRECIP program. The procedures for utilizing radar images in conjunction with a precipitation gage network were documented.

The **Real-Time Reservoir Regulation** work unit emphasizes the development of reservoir regulation simulation programs and management infor-

mation display for water control activities. Software for transferring real-time data from District water control Harris computers to OCE/DIVISIONS was developed, tested, and made operational. A new March 1985 mailout version of HEC-5, containing the modularized source code, was distributed to all Corps offices and was made available to non-Corps offices. This new version incorporates new routing methods and other improvements including those for the 32-bit HP-9000 microcomputer. The HEC-5 program storage requirement for the March 1985 mailout version was substantially reduced to allow faster turnaround for Corps Harris 500 computer systems. The maximum limits for number of reservoirs was cut from 35 to 15 and for number of control points from 55 to 25. The dynamic dimension code in HEC-5 was rewritten to simplify the user input requirements and the program logic.

The **Analytical Techniques for Evaluating Reservoir Systems** work unit develops improved techniques for formulating and evaluating multipurpose and multi-reservoir systems. This unit addresses the planning, design and regulation aspects of reservoir systems. Regulation aspects refer to the scheduling of releases from proposed projects, not real-time regulation of existing systems. The reservoir system computer program "Simulation of Flood Control and Conservation Systems" (HEC-5) was enhanced to better simulate the operation strategies of several Corps reservoir systems. More detailed hydropower simulation was evaluated with new test case studies. Program restructuring is continuing and program documentation was updated.

The **Modernization of Computer Programs** work unit seeks to reduce software maintenance costs, improve reliability of production runs, and facilitate future improvements in HEC's hydrologic engineering and analytical planning computer programs. The HEC-5 program modernization continued on the simulation part of the program (HEC5A) and was initiated on the output portion (HEC5B); work was completed on restructuring the COMMON block for HEC5A for the June 1984 version; modifications were made to improve use of the program on different systems including the 32-bit HP9000 microcomputer; and, to make code pure FORTRAN77 for transportability to other computers. Work was begun on restructuring the largest subroutine of HEC-2 and internally documenting the code for the entire program. HEC-1 subroutine ROUTE was restructured and internal

documentation of the program code was begun. The structure of the HEC software library, containing general purpose mathematical and statistical utility programs and subroutines, was analyzed. These routines will be integrated into the new and existing software packages as necessary to reduce maintenance. Existing routines will be updated to full FORTRAN77 in accordance with HEC programming standards.

The Hydrologic Methods for Determining Water Supply Potential work unit is designed to improve existing analytical techniques to determine water supply potential. Several publications have been printed to date. Also completed was a simplified water supply analysis data preparation procedure. This consisted of developing a stand-alone interactive data input program for HEC-5. The research document "Stochastic Analysis of Drought Phenomena" has been completed and published. A draft report that documents risk and reliability project analysis methods for a number of recent studies has been completed. A training document illustrating HEC-5 model application to water supply/surface yield analysis was published.

The Groundwater Recharge and Storage work unit is designed to document concepts and analytical techniques useful in performing groundwater investigations. The groundwater analysis package is essentially complete. The package is comprised of a preprocessor, a simulation model (USGS 2-D groundwater model) and post processor components. The computer programs are operational on the Harris 1000 computer system and microcomputers. An update of the draft documentation (user manual) is available. Additional research has been done on the hydrology and hydraulics of recharge and a draft document has been prepared. Research reported previously (A Comparative Analysis of Groundwater Model Formulation) was integrated into an HEC training course on water supply using lectures and workshops.

The Remote Sensing and Spatial Data Applications work unit seeks to investigate how remotely sensed data can be incorporated into a spatial data management system for hydrologic and environmental analyses. A document entitled "A Tutorial on Creating a Grid Cell Land Cover Data File from Remote Sensing Data" was published. The document describes the procedures involved in linking a remote sensing system and a spatial data management system. Work continued on the analysis of rainfall, runoff and soil moisture data

from an Agricultural Research Service watershed. Adequate definition of the spatial variation of precipitation was the key issue for a detailed description of the runoff process.

The Hydrologic/Hydraulic Risk Assessment of Dams work unit was begun to analyze the benefits from improved spillway capacities to prevent dam failure as compared to the cost of much larger spillways. A draft technical report describing potential methods for determining the relative frequency of the probable maximum flood was completed. Methods for estimating catastrophic flood damage from dam breaks were reviewed and plans were made for an additional analysis through a contractor. Several workshops with OCE and field offices were held to refine the scope of this project. One case study, Cochiti Dam, was begun and the hydrologic and hydraulic models completed.

Outlook for FY 1986

Research funding is expected to remain about the same next year. The previously discussed work units will continue and two new work units addressing Flood Warning Systems and Reservoir Regulation for Water Quality will begin.

Improvements in Hydrologic Methods work unit will concentrate on the design of an HEC library of hydrologic analysis software. A variable computation-time interval capability will be investigated for HEC-1. The first phase of a hydrologic statistics software library will be completed. Improvements to the HEC-6 Sediment Transport model will be made utilizing components of the emerging fluvial hydraulics software library.

Computer Methods in Planning work unit will concentrate on the following: (1) implement flood control system formulation branch and bound algorithm for an HEC computer program; (2) complete documentation and test example for HEC flood damage package; (3) initiate upgrade of user interface with flood damage analysis package; and, (4) complete adaptation of a data management system to microcomputer to enable full implementation of flood damage analysis package.

Data Storage System work unit will include adapting standardized DSS library routines to FORTRAN77 standards and then being moved to specified new computer systems. Record types

will be extended to support text and spatial data information. Tests of data compaction methods will be made.

Spatial Data System work unit will continue the development, testing and documentation of software and procedures for digitizing, editing, storage, retrieval, display and update of geographic data. Some microcomputer implementation and upgrading of graphics software and digitizing hardware will also be accomplished. Development of techniques and example documentation to effectively utilize spatial data banks in the Corps water resource planning and management will continue. Experimentation with triangular spatial data representation, that has proven to be promising, will also continue.

Flood Forecasting work unit will incorporate better low-flows in watershed runoff. Present methods for representing low (base) flow conditions are not adequate for long periods of drought. The capability to integrate radar precipitation patterns with gage values will be field tested. Snowmelt flood forecasting procedures will also be field tested. A training course covering key aspects of real-time flood forecasting will be held in December 1985. Several documents will be updated for use in the training course and in support of field office use of forecasting procedures.

Real-Time Reservoir Regulation work unit will test the new HEC-5 source code on numerous reservoir systems. The new COMMON block structure under development for HEC5A will be incorporated in the March 1985 source code and tested. Additional user options requested by field offices for use of HEC-5 will be incorporated as appropriate. One such option is to improve the user interface to HEC-5 to allow the user to override some of HEC-5 release schedules and to be able to quickly display the results. The HEC-5 program for real-time operation will be finalized, and appropriate documentation for users and programmers manuals will be developed.

The **Reservoir Systems** work unit will continue to expand the capability of the reservoir simulation program, HEC-5. The expansion of the system power analysis for rule curve operation is planned.

The work efforts for **Modernization of Computer Programs** work unit will continue to improve the software development guidelines. For the pro-

grams HEC-1, HEC-2 and HEC-5, rewriting/revising existing subroutines in accordance with new design structure will be continued. For programs HEC-1 and HEC-2, the development of new interactive input preparation programs will begin. The HEC subroutine library (HECLIB) will be implemented on various machines and tested for portability. Emphasis will be placed on converting HEC programs to Fortran 77.

Hydrologic Methods for Water Supply work unit will: (1) continue development and testing of reservoir system simulation capability for water supply, that includes initiation of expanding HEC-5 capabilities to include automatic storage yield analysis for a system of reservoirs; (2) continue refinement of a user-oriented interactive interface for HEC-5; and, (3) investigate and document concepts, present practices and suggested guidelines for considering drought and reliability in water supply plans.

Groundwater activities will continue on preparing documentation for the groundwater simulation package, on desk-top analysis procedures and example applications. The hydrology and hydraulics of recharge will be documented. Testing and application of both the Harris and microcomputer versions of the simulation programs will continue.

Remote Sensing tasks include an evaluation of the current capability to remotely sense soil moisture. Data from research watersheds will be used to define sources of error in watershed modeling and their relative importance. Documentation will be made about which sensors and observable phenomena (mainly soil moisture versus precipitation) offer the best information for watershed modeling. HEC's Land Use Classification Procedure will undergo continued applications testing on the Harris computer.

The **Hydrologic/Hydraulic Risk Assessment of Dams** work unit will concentrate on a technical report on flood damage estimating methods for the hydrologic and hydraulic uncertainty analysis. The hydrologic, hydraulic and flood damage analysis for the two case studies will be completed. A data bank for Corps dam safety analyses will be recommended.

The new work unit on **Flood Warning Systems** will undertake an investigation of Corps needs for flood warning systems. The role, purpose, functions and attributes of an idealized system will be

identified. This investigation will be coordinated with the National Weather Service and others so that the Corps role can be clearly identified. Current development plans and research interests will also be exchanged among interested agencies. Existing flood forecasting systems will be evaluated for their hydrologic effectiveness and data monitoring and processing needs.

The new work unit **Water Quality Procedures for Water Control Management** will include two demonstration applications, and WQRRS and HEC-5Q model modifications for improved multi-level intake port operation using the water quality index approach. The existing documentation of field tests will be updated with the new program changes and demonstration applications.

PLANNING ANALYSIS



The goal of planning analysis activities is to develop and implement analytical techniques for use by the Corps in water resources management investigations. Areas of emphasis include: development of systematic methodology for the formulation and evaluation of alternatives; development of computer programs capable of integrating objectives, performance, costs, benefits, and other important planning factors; development of strategies for using the variety of analytical methods in planning studies; and the integration of computerized information processing into planning. Significant efforts are devoted to consolidating research results into field-usable products that include computer programs, applications documentation, and information dissemination. Work efforts in FY 1985 were conducted in several areas:

Flood Control Planning
Damage Computations and Data Management

Spatial Data Management
Water Supply Planning
Dredged-Material Disposal Management
Water Surface Profile Accuracy Research

Focus continues on the development of practical computer programs and companion user materials for use by field office professional staff. Areas that received particular emphasis this past year include water supply, damage computations and data management, spatial data management, and water surface profile accuracy. Significant accomplishments are highlighted below.

FLOOD CONTROL PLANNING

Activities in this technical area are concerned with the strategies and technology for formulating flood control plans, managing planning data, and providing information on significant policy issues.

The technical assistance project begun last fiscal year for the Los Angeles District continued. The District study is a comprehensive basin-wide investigation of needed improvements to the flood control system that serves the major metropolitan area of downtown Los Angeles. The HEC was asked to advise on selection of analytical tools needed for the study and suggest appropriate strategies that would enable their efficient use in formulating plans. The HEC provided suggestions for selecting computer programs, managing important planning data, and using the programs in a systematic way to assist in formulating optimal plans.

The recommendation, adopted by the District, was to use the family of HEC programs known as the Flood Damage Analysis Package. The family of computer programs recommended had been previously developed for the Passaic Basin Study that was described in previous annual reports. As an additional service, HEC developed an interactive computer program to enable efficient insertion of data into the adopted data management system. The systematic plan formulation strategy developed is based on the branch and bound enumeration procedure. Its application is documented for an example problem and printed as an HEC training document. A workshop was held for District staff in program use and plan formulation strategy.

The HEC also provided technical assistance to the Sacramento District for a Phase I reconnaissance investigation of the Dry Creek area near Sacramento. The area is presently sparsely developed but is projected to undergo significant urbanization, particularly industrial development, in the form of electronics manufacturing plants. The investigation focused primarily on nonstructural flood damage mitigation measures. The HEC provided advisory services on: (1) the types of nonstructural measures that would be appropriate for the nature of the flood hazard; (2) evaluation procedures; and, (3) usage of HEC computer programs for performing technical analysis. The study was completed and found that structural measures would not likely be justified but that vigorous flood plain management actions could significantly reduce future damage. The HEC-1 program hydrologic modeling features and basic flood damage analysis capabilities were used extensively for the analysis.

A significant research milestone was achieved with the publication of Training Document No. 23 "Flood-Damage-Mitigation Plan Selection with Branch-and-Bound Enumeration." Adaptation of this system analysis method to flood control plan formulation resulted from several years of modest research efforts coupled with the specific request by the Los Angeles District for a documented formulation procedure for use in the LACDA study. The method structures a flood control plan formulation problem as a decision tree and then provides an efficient, systematic approach for solving the tree. The training document describes in detail the procedure for selecting the optimal combination of flood-damage-mitigation measures and illustrates how the HEC programs can be used in the analysis. An example is presented in which the optimal plan is determined for a hypothetical catchment.

A two-week course in "Flood Plain Management Planning" was presented to a full house of Corps professionals. The course covered present flood control planning policy, cost sharing for planning studies, and usage of a variety of analytical tools for the formulation and evaluation of flood control projects.

The use of microcomputers to assist in flood control planning is receiving increased attention. Several important HEC planning computer programs, reported later, are now available for microcomputer applications and increased field office usage is expected.

DAMAGE COMPUTATIONS AND DATA MANAGEMENT

The HEC has been working, for a number of years, toward the packaging into an integrated whole, programs needed for flood damage computations and associated data management. The major goal has been achieved with the completion of the computer code and procedural methods embodied in the HEC Flood Damage Analysis Package. The system has evolved into a relatively stable state and is in use in a number of Corps field offices. The package has been presented in a number of HEC and other agency sponsored courses. It was the focus of a special workshop presented for the Districts and Division staff of the Ohio River Division. A significant start has been made in making the package operational on microcomputers with the goal within the next year of having a microcomputer work station

based capability to perform complete, integrated flood damage analysis.

At present the programs and attendant data management software are available on all Corps Harris computers and also operable on the Corps teleprocessing vendor CDC computer system. All the programs included within the package have individual high-quality user manuals available. A working final draft of an illustrated example/tutorial training document is also available. The remaining task for the major computer system based package is completion of the training document, expected momentarily. Completion of the microcomputer work station based system awaits successful conversion of the HEC Data Storage System (DSS) to the microcomputer. Once completed — and it is expected within the next year — the programs already converted will be linked to the DSS and the initial phase completed.

Suggestions for enhancements to the system by users have already identified several useful additions. These will be undertaken this next year also and include such items as automatic structure referencing to River Mile and thus HEC-2 generated files, addition of current policy allowances for including growth in value of structure contents, often referred to as affluence, and smoothing the user interface with the system of programs and data files by implementing interactive menu oriented control of processing.

The Package is comprised of the computer programs HEC-1 (Flood Hydrograph Package), HEC-2 (Water Surface Profiles), HEC-5 (Reservoir Systems Analysis), SID (Structure Inventory for Damage Analysis), SIDEDT (Editor for SID program), DAMCAL (Damage Reach Stage Damage Calculation), EAD (Expected Annual Flood Damage Computation), and the HEC-DSS (Hydrologic Engineering Center Data Storage System). The programs are automatically linkable through the HEC-DSS thus enabling highly efficient processing of data from original field inventories through integration of hydrologic and hydraulic data into the damage computation process. Program utilities are available with the HEC-DSS so that tabulation, plots, and other special reports can be developed from the computerized data sets.

The essential roles of each of the computer programs in the package are: HEC-1 — development of flow-frequency functions for existing,

future, and certain proposed project modified conditions based on rainfall-runoff and physical system simulation; HEC-2 — development of elevation-flow rating functions for natural stream reaches reflecting with and without proposed project conditions; HEC-5 — development of the same flow-frequency functions as with HEC-1 except that consideration of complex reservoir operation procedures is possible; SID — development of elevation-damage relationships by damage category and reach based on an inventory of floodplain structures and policies regarding non-structural measures (if any); SIDEDT — structure and damage function file editor companion for SID; DAMCAL — identical to SID except based on concepts of spatial units instead of detailed structure inventory; EAD — integration of damage, hydrologic, and hydraulic data to compute annual damage and benefits for flood damage mitigation plans; and HEC-DSS — computer based data base management system for HEC computer programs.

An agricultural flood damage computer program entitled AGDAM was completed and released. The program performs a detailed assessment of agricultural flood damage using an event-frequency concept as an alternative to the period-of-record approach that is presently in common usage. The program has been linked throughout the HEC-DSS to a spatial data bank and the needed hydrologic and hydraulic analysis programs. The program was the topic of a lecture and workshop in the Flood Plain Management Planning course.

SPATIAL DATA MANAGEMENT

Spatial data management activities have focused on three areas: improvement of computer code and upgrading of user documentation; adaptations and conversions of computer code with the goal of evolving a microcomputer based spatial data management, display and analysis system; and exploration of new technology in the areas of spatial data structures and interfaces with remote sensing technology. The basic family of computer programs are in the process of being converted to a FORTRAN77 standard simultaneously while being upgraded in terms of capability. Of the ten active programs comprising the HEC-SAM (HEC's spatial data management system), four are proprietary to the Corps and are primarily graphic display programs.

Upgrades may be performed as permitted by the original vendor. Three have completed upgrading (HYDPAR, RIA, and BANK) and the remaining three (lesser graphics and utility programs) are actively being worked on. A new user manual has been published for the major hydrologic engineering program (HYDPAR), and the spatially based flood damage analysis program (DAMCAL) is currently being revised and updated. Both documents reflect the advances made in automated program linkage and data management that has evolved over the recent years.

Upgrading of the three primary data bank creations, line printer graphics, resource and hydrologic analysis programs was performed while simultaneously converting the programs to IBM compatible microcomputers. This basic set of programs is now available to Corps field offices and the general public. Efforts this next year will focus on making available a microcomputer based set of spatial graphics programs to complement the existing programs. A microcomputer compatible digitizing and associated data bank creation capability will be investigated, and the remaining analysis program (DAMCAL) will be upgraded and converted. Interest in microcomputer applications is on the increase and the HEC intends to service that interest. At the same time, continued advances in applications of the technology for both mainframe systems and microcomputers will be pursued in a balanced manner.

The HEC has been experimenting for several years with triangular based terrain data management concepts primarily for the superior topographic data representation features it offers. This past year a trial application was completed in the area of erosion analysis (it was quite successful) and a project initiated in the applications area of hydrologic modeling. This project will be completed early next year and looks quite promising. The system being used is the ADAPT system acquired from commercial sources a few years ago. Additional experimentation is planned and movement toward trial release to the Corps of a small selected set of the ADAPT technology and associated analysis capability will continue.

WATER SUPPLY PLANNING

Adequate water supply is a national concern. The HEC is committed to developing study methods and analytical procedures to aid in water

supply analysis. Work in this area has grown this past year.

The work commitments by HEC this past year include: two research projects undertaken by HEC, participation in one jointly with IWR, a training course and a major technical assistance project for a Corps field office. Products this year include improved input and analysis routines for the HEC-5 program to perform water supply yield analysis and publication of examples that illustrate the use of HEC-5 for water supply studies. Also published is the document "Stochastic Analysis of Drought Phenomena." Draft reports prepared by contractors describing water supply reliability analysis methods, and various aspects of conjunctive water supply planning are under review.

The HEC has adopted the United States Geological Survey (USGS) groundwater simulation model as the tool to analyze groundwater withdrawal and recharge. The HEC has subsequently developed a preprocessor program to aid in automating preparation of input data and has prepared linkages that direct output to graphics display routines to enable effective analysis of model results. Documentation of these enhancements to the USGS model is in preliminary draft form. The software has been made operational on the Corps Harris system.

The HEC is performing a preliminary basin-wide water supply/use analysis of the Upper Coosa Basin. For this study, the HEC is developing microcomputer based data bases and procedural analysis using commercial PC based software packages to perform the analysis. The system of packages and procedures will be made general and turned over to the District and local agency contact (state) at the conclusion of the project. The capability developed will also be considered for Corps-wide distribution. The project is about fifty-percent completed.

DREDGED MATERIAL DISPOSAL MANAGEMENT

The Dredged Material Disposal Management Model (D2M2) reported in previous years continues to be used and improved. Financial support was provided by the Philadelphia District (original sponsor) and the Waterways Experiment Station. The model is designed as a planning tool to enable study of such questions as where to dispose of dredged material over time, when and

where to acquire new sites, the viability of management actions such as site dewatering or material rehandling, and the quantitative impact of unavailable existing or future sites, restriction of routing materials due to contaminants, etc. An updated version of the program (and user documentation) is available to Corps users. Recent improvements include addition of capability to "rest" sites, expansion of data error checking and diagnostics, and improvement in the capacity expansion solution algorithm (branch and bound enumeration). The model is now an operational component of the WES dredged-material disposal analysis computer software package (ADDAMS). Additional enhancements are planned for FY 1986.

WATER SURFACE PROFILE ACCURACY RESEARCH

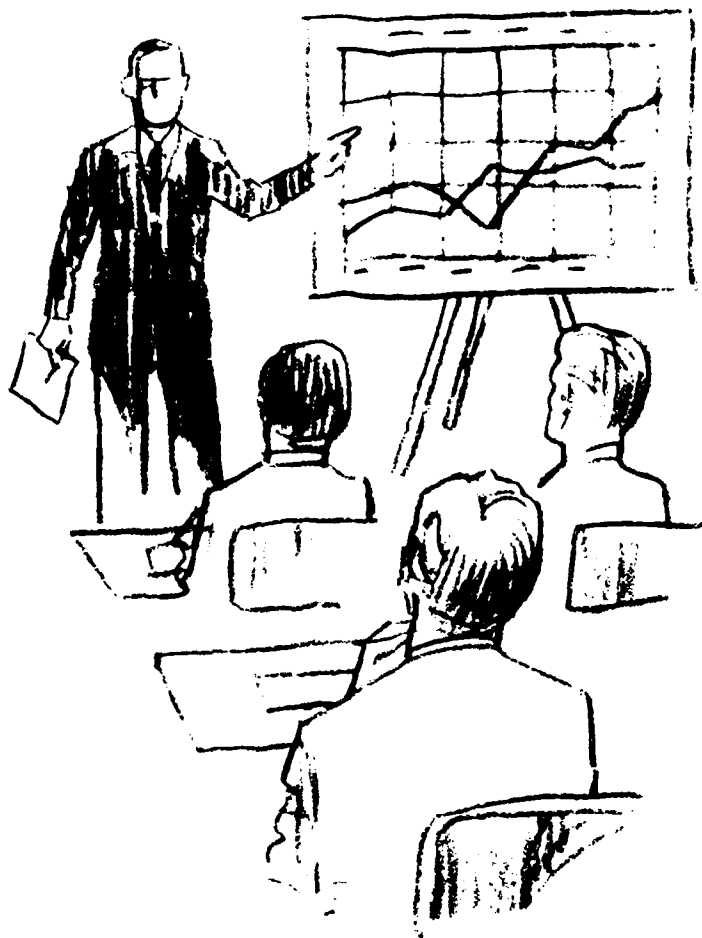
The HEC is performing an in-depth research assessment of survey and hydraulic parameter effects on the accuracy of water surface profiles at highway bridge crossings. The study is scheduled for completion by the end of FY 1986 and is being funded by the Federal Highway Administration (FHWA). The primary objective of the study is to develop a guidance manual for state highway engineers and others which will define procedures and parameter requirements needed to obtain a desired water surface profile accuracy. The guidance manual will also describe commercially available survey procedures, and associated

accuracies and costs. The manual is intended to be of value to Corps personnel involved in calculating water surface profiles, and similar analysis involving use of topographic map data.

The profile accuracy assessment is being performed using Corps of Engineers HEC-2 data sets used in actual studies. Data have been obtained from the Jacksonville, St. Louis, Ft. Worth, Sacramento, and Los Angeles Districts. The 100 data sets have been edited and processed into base models for analysis.

The profile accuracy analysis investigates the effects of various field and aerial survey cross-section spacings and map accuracies on the calculated water surface profile accuracy. Comparisons are being made of the computed and base condition profiles to determine the average and maximum reach profile errors. Statistical results of the effects of cross-section spacings and survey accuracy on profile accuracy will be displayed using nomographs, charts, and tables.

Data management techniques used enable an orderly processing of the profile data sets, comparison of modified and base profiles, and the statistical assessment and display of results. It is estimated that 36,000 HEC-2 program executions will be required to perform the analysis. The data management process is being performed in a manner that will enable future access to the data and results by researchers and others.



TRAINING

The training activities of the Hydrologic Engineering Center (HEC) are designed to increase the technical capabilities of the Corps field offices to meet needs and solve problems in hydrologic engineering and water resource planning. The training effort is designed to assist field offices in their application of computer technology to the complex problems associated with water resource management. This technology transfer is carried out through a regularly scheduled set of training courses, special workshops designed to meet specific needs, state-of-the-art seminars, training assignments of individuals, and distribution of training course video tapes and a variety of technical publications. The emphasis is on practical applications such as utilizing appropriate technology to solve real-world problems.

Training Courses. About ten courses are conducted per year under the Proponent Sponsored Engineer Corps Training (PROSPECT) Program. Courses are one or two weeks in duration, and include formal lectures and practical problem-

solving workshop sessions. Guest instructors from other Corps offices, universities and private industry are invited to participate. These instructors supplement the capabilities of the Center's staff.

Workshops. Special workshops are conducted each year at the request of individual District or Division offices. The requested workshop may be similar in content to one of the regular courses, or it may focus on a particular need for which training is not available elsewhere. The duration of these workshops range from one day to one week. They are usually held at the requester's office to allow greater participation by the staff of the requesting Corps office, as well as local, state and other federal agencies.

Seminars. Seminars provide a forum for discussion of field problems and current solutions and for identification of needs for new techniques. The papers presented by participants are published as seminar proceedings.

Individual Training. A District or Division may request individualized training for one or more persons on prearranged topics. Also, training arrangements may provide for the individual to work under the direction of HEC personnel on a problem that he has brought from the home office.

Video Tapes. Over the past ten years, HEC has made video tapes of selected training course lectures. These tapes (with supporting lecture notes) are loaned on request. The tapes are intended to supplement the training program by providing the course material to those unable to attend courses.

Training Materials. Materials prepared and distributed as part of HEC's training program include training course manuals and training documents which illustrate procedures for solving technical problems or for applying computer programs.

Training Program Accomplishments, FY 1985

The HEC conducted a total of 20 weeks of training during FY 1985. Courses and workshops conducted were:

Formal Courses (18 weeks — 11 courses)

Basic HEC-2 (15-19 Oct 84)

Reservoir System Analysis (3-14 Dec 84)

Sediment Transport in Rivers and Reservoirs
(14-25 Jan 85)

Hydrologic Engineering for Planning (11-15
Feb 85)

Water Quality Modeling (25 Feb-1 Mar 85)

Flood Plain Hydrology (18-29 Mar 85)

Unsteady Flow Analysis (6-17 May 85)

Flood Plain Management Planning (3-14 Jun
85)

Hydrologic Analysis of Floods (15-26 Jul 85)

Water Supply Hydrology (19-23 Aug 85)

Statistical Methods in Hydrology (9-20 Sep 85)

Workshops (2 weeks — 3 workshops)

Flood Damage Analysis Using HEC-FDA Pack-
age, 3 days, Pittsburgh, PA

Density Floodway, 2 days, Portland, OR

World Meteorological Organization Reservoir
Control, 4 days, Davis, CA

Video Tapes

With the increased numbers of ½ inch video tape equipment in the Corps and in other offices, the decision was made to duplicate our current active library of tapes onto the VHS format. All current tapes are being recorded in the VHS format. Starting in FY 1986, all loan tapes will be available in the ¾ inch UMATIC and the ½ inch VHS format.

Training Program for FY 1986

The training program planned for FY 1986 is based on a survey of training needs conducted by the CE Training Management Division in Huntsville and on the recommendations of OCE course proponents on the technology transfer needs required to serve Corps missions. Twelve HEC training courses were surveyed for Corps-wide participation during FY 1986. Only nine received sufficient enrollment to justify conducting the course.

FY 1986 Training Program

Course Title	Weeks	Date
Flood Plain Hydrology and Hydraulics	2	21 Oct-1 Nov 1985
Real Time Water Control	2	2-13 Dec 1985
Interior Flooding Hydrology	1	10-14 Feb 1986
Planning for Hydrologic Engineers	1	10-14 Mar 1986
Flood Frequency Analysis	1	21-25 Apr 1986
Hydrologic Engineering for Planning	1	12-16 May 1986
Water Resources Data Management	1	19-23 May 1986
Water Surface Profile Computation Using HEC-2 (Advanced)	1	2-6 Jun 1986
Ground Water Hydrology	1	18-22 Aug 1986



COMPUTER PROGRAM SUPPORT

The Computer Program Support program at HEC is designed to provide user assistance and to produce and distribute documentation of newly developed and applied programs to aid users in solution of hydrologic engineering problems. The HEC focuses a substantial portion of its resources on the development and documentation of "generalized" computer programs. Documentation includes users and programmer manuals for computer programs, technical papers, research and project reports, and seminar proceedings. During FY 1985 HEC distributed approximately

7,000 of its publications, not including those sent with computer programs or distributed during training courses.

New and revised documentation issued during FY 1985 are listed below. A catalog of HEC publications is available on request.

Computer Program Documentation

SIDEDT (Structure Inventory For Damage Analysis Edit Program) (New Users Manual)

HMR52 Probable Maximum Storm (Eastern United States) (New Users Manual)

HEC-5 Simulation of Flood Control and Water Conservation Systems (Exhibit 8 — Input Description)

Technical Papers

No. 100 Probable Maximum Flood Estimation — Eastern United States

No. 101 Use of Computer Program HEC-5 for Water Supply Analysis

No. 102 Role of Calibration in the Application of HEC-6

No. 103 Engineering and Economic Considerations in Formulating Nonstructural Plans

No. 104 Modeling Water Resources Systems for Water Quality

No. 105 Use of a Two-Dimensional Flow Model to Quantify Aquatic Habitat

No. 106 Flood-Runoff Forecasting with HEC1F

No. 108 Role of Small Computers in Two-Dimensional Flow Modeling

Research and Project Reports

Research Document No. 23 — Modified-Puls Routing in Chiquatonchee Creek

Research Document No. 24 — Comparative Analysis of Flood Routing Methods

Training Documents

Training Document No. 20 — Water Supply Simulation Using HEC-5

Training Document No. 22 — A Tutorial on Creating a Grid Cell Land Cover Data File from Remote Sensing Data

Training Document No. 23 — Flood-Damage-Mitigation Plan Selection with Branch-and-Bound Enumeration

Current HEC Computer Programs

Source code and test data for the HEC computer programs listed below are available from HEC. These programs are written in FORTRAN and provided on magnetic tape or floppy diskettes. Many have been modified to run on the Harris 500, and these Harris versions are being distributed to Corps offices. The programs are also available to Corps offices via access to the Control Data Cybernet (CDC) system. Many are now available in Fortran 77 and many are also available on microcomputers.

The HEC has also been delegated authority by the Department of the Army to release hydrologic engineering computer programs to public agencies and private firms. This delegation of authority was granted to minimize delays which occurred in processing requests for programs through the several approval levels normally required by the Corps and Department of the Army.

While the Government is not responsible for the results obtained when these programs are used, assistance in resolving any malfunction of the programs is furnished by HEC to the extent that time and funds are available. The following is a list of programs that are currently available. Brief descriptions and computer hardware/software requirements for the programs may be obtained from the Hydrologic Engineering Center.

Hydrologic Analysis

HEC-1 Flood Hydrograph Package

HEC1CV HEC-1 Input Converter

HEC1F Modified HEC-1 for Real-Time Water Control Systems

HMR52 Probable Maximum Storm (Eastern U.S.)

PRECIP Basin Precipitation Computations

CHANOP* Channel Structures Operation

STORM Storage, Treatment, Overflow, Runoff Model

INTDRA Interior Drainage Flood Routing

*Proprietary programs that are only distributed by HEC to Corps of Engineers offices

BASINC Basin Rainfall and Snowmelt Computation

UHC Unit Graph and Hydrograph Computation

UHLRO Unit Graph and Loss Rate Optimization

HYDCR Hydrograph Combining and Routing

SFRO Streamflow Routing Optimization

BALHYD Balanced Hydrograph

FORCST Forecast River Flows by Regression

UHCOMP Interactive Unit Hydrograph and Hydrograph Computation

HECWRC Flood Flow Frequency Computation

REGFQ Regional Frequency Computation

HEC-4 Monthly Streamflow Simulation

OPROUT Stream Routing Optimization by Negative Local Flows

PDILFE Partial Duration Independent Low Flow Events

Hydraulic Analysis

HEC-2 Water Surface Profiles

EDIT2 HEC-2 Data Editor

SUMPO Interactive Summary Printout Using HEC-2

HEC-6 Scour and Deposition in Rivers and Reservoirs

USTFLO Gradually Varied Unsteady Flow Profiles

GEDA Geometric Elements from Cross Section Coordinates

SHP Stream Hydraulics Package

SSYLD Suspended Sediment Yield

FEMFLO Finite Element Solution of Steady State Potential Flow Problems

HGP Hydraulics Graphics Package

DAMBRK NWS Dam Break Model

DAMPRE Pre-Processor for DAMBRK Program

DWOPER* NWS Unsteady Flow

CMPFLRT Comparative Analysis of Flood Routing Methods

RMA1 Finite Element Network Generator

RMA2 2-D Finite Element Hydrodynamics (Horizontal)

RMA7* 2-D Finite Element Hydrodynamics (Vertical)

RMA8* 3-D Finite Element Hydrodynamics

VECTOR Vector Plotting Program for RMA2

CONTUR* Contour Plotting Program for RMA2

PATH* Pathline Plotting Program for RMA2

Water Quality Analysis

WQRRS Water Quality for River-Reservoir Systems

RESTEMP Reservoir Temperature Stratification

HEATX Heat Exchange Program

THERMS Thermal Simulation Program

HEC-5Q Simulation of Flood Control and Conservation Systems (Including Water Quality Analysis)

WQSTAT Statistical Analysis of Stream Water Quality Data

WQPLOT Time Series Plot of Stream Water Quality Data

WQPROF Profile Plot of Stream Water Quality Data

*Proprietary programs that are only distributed by HEC to Corps of Engineers offices

RWQM Receiving Water Quality Model
RMA4* 2-D Finite Element Water Quality

Water Control Systems Analysis

HEC-5 Simulation of Flood Control and Conservation Systems
CKHEC5 HEC-5 Input Data Checking
INFIVE HEC-5 Interactive Input Preparation Program
INCARD Flow Conversion for HEC-5
HEC-3 Reservoir System Analysis for Conservation
SWRFR Spillway Rating and Flood Routing
SWRPTG Spillway Rating Partial Tainter Gate Openings
SWGRC Spillway Gate Regulation Curve
RESYLD Reservoir Yield
RESACT Reservoir Area-Capacity Table by Conic Method
DELTAS Reservoir Delta Sediment
DEPOSS Deposit of Suspended Sediment
HYDUR Hydropower Analysis Using Stream-flow Duration Procedures

Planning Analysis

RIA Resource Information and Analysis Using Grid Cell Data Banks
HYDPAR Hydrologic Parameters
DAMCAL Damage Reach Stage Damage Calculation
GRIPS* Polygon to Grid Conversion Program
AUTOMAP II* Line Printer Graphics for Polygon Data Program

FOURV Three Dimensional Pen Plot Program for Grid Data

GRIDPLOT* Pen Plot of Grid Cell Data

POLYPLOT* Pen Plot of Polygon Data

BANK Data Bank Manager

REGISTER Data Registration Program

EAD Expected Annual Flood Damage Computation

SID Structure Inventory of Damages

SIDEDT Structure Inventory of Damage Analysis Edit

INONSTR Interactive Nonstructural Analysis Package

DEMAND Water Demand Model

HYCOST Small-Scale Hydroelectric Power Cost Estimates

D2M2 Dredged-Material Disposal Management Model

AGDAM Expected Annual Agricultural Damage

PBA Project Benefit Analysis (Including PPBA)

GWSP Groundwater Simulation Package

Utility Programs

REVISE Free Format Data Entry and Revision

MLRP Multiple Linear Regression

FSIR Fortran Source Inventory and Renumbering

DSSUTL HEC DSS Utility Routines

DSPLAY Display DSS

DSSIN Time Series Data to DSS

STATS Statistical Analysis of Time Series Data

*Proprietary programs that are only distributed by HEC to Corps of Engineers offices.

SHFDSS Load SHEF Data in DSS

CONVRT Convert Data to Stage, Including
Precipitation

EXTRCT Extract Data from DSS File

GOESLD Load GOES Data — DSS

MATHPK Mathematical and Statistical Analysis
of Data Stored in a DSS File

NWSDSS Load NWS Data Tapes in DSS

WATDSS Load WATSTORE Data in DSS

DATMAN Daily Time Series Data Management
Program — DSS

MISFOR LMVD Forecast Program — DSS

APEX Initiate Clock Schedule Tasks

ASYNC Asynchronous Communication —
Real-Time

ASYNCI Interactive Asynchronous Communi-
cation

COED Corps Editor

HECLIB HEC Subroutine Library

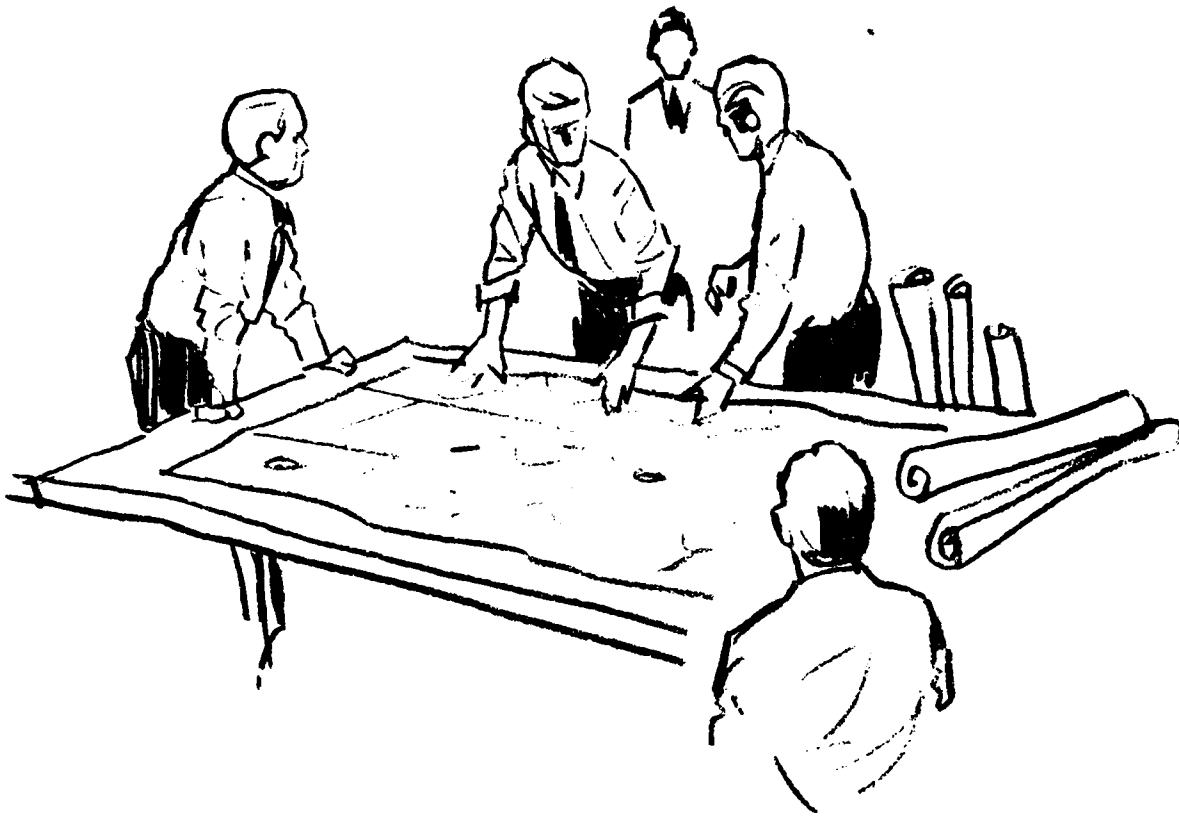
MODCON Interactive Executive for Model Con-
trol

MONWS Monitor NWS Dedicated Line

VUENWS View NWS Products

PIP Paired Function Input Program

RDVAR Read and Print Variable Locations from
FSIR File



TECHNICAL ASSISTANCE

The primary objective of the technical assistance program is to provide assistance and guidance to requesting Corps field offices in the application of hydrologic engineering and planning techniques to solve water resource problems. Technical assistance activities are conducted jointly on a cooperative and reimbursable basis. These activities enable HEC's technical staff to maintain close contact with Corps personnel in District and Division offices and to evaluate the effectiveness of new technology in a "project application" mode. This collaboration results in more complete and efficient solutions to complex problems, a continual improvement in methods, the testing and appraising of new approaches, and the recognition of needs for new research and training.

Each division of HEC helps Corps offices to apply models and to meet special needs with new developments, and acts in an advisory capacity in a number of technical subjects and A-E contracts

depending on technical specialties and work load. Studies range in scope from brief reviews of work done by others to major studies requiring a team effort by several members of the HEC staff.

FY 1985 Accomplishments

About \$950,000 in technical assistance was provided to 27 offices during FY 1985. The offices included: 20 Division and District offices; the Office of the Chief of Engineers (OCE); the Waterways Experiment Station (WES); the Bureau of Reclamation; the National Park Service; the Federal Highway Administration (FHWA); and the Institute for Water Resources (IWR). The largest single amount was \$190,640 for a portion of the \$300,000 FHWA Water Surface Profiles Accuracy Research Study. Major projects are described below and in the accompanying table. Comprehensive Project Reports were prepared for four of the studies.

HEC PROJECT REPORTS FY 1985

Number	Title	Date
85-1	Two-Dimensional Flow Modeling at Lock and Dam No. 8, Upper Mississippi River	Jan 1985
85-2	Evaluation of Proposed Modification Mojave River Dam, California	Jul 1985
85-3	Toutle River Mudflow Investigation	Jul 1985
84-4	La Junta, Colorado Local Protection Project, Phase I GDM Sediment Study	Sep 1985

Technical assistance projects involving the development of systems for real-time water control and data management continued to be a major emphasis of reimbursable work. About one-third of funding was for real-time water control systems. Work for the Huntington and Pittsburgh Districts involved the development of models for forecasting runoff and evaluating operations alternatives in major river basins. Assistance was provided to Rock Island District in implementing real-time data acquisition and management systems.

Continuing assistance was provided to OCE in procuring water control computer equipment and in negotiations with the National Weather Service to establish a data exchange agreement and a generalized data exchange procedure between field offices. Testing of NWS-COE data exchange in Standard Hydrometeorological Exchange Format (SHEF) was accomplished.

Projects in rainfall-runoff analysis accounted for about 5 percent of all FY 1985 technical assistance work. Assistance was provided to the Chicago District in regional analysis of pilot-area basement flooding data for the Chicago Underflow Plan Study. A project involving the hydrologic evaluation of proposed modifications to the Mojave River Dam was performed for the Los Angeles District.

Projects involving river hydraulics comprised about one-third of the FY 1985 technical assistance work. About two-thirds of the work in river hydraulics involved the FHWA project dealing with water surface profile accuracy. A mud and debris flow routing study for the North Fork of the Toutle River was done for the Portland District. A study

of the hazards of mudflow was done for the Omaha District.

Other reimbursable projects in river hydraulics included: modifications to HEC-2 utility programs SUMPO and HGP, and development of micro-computer versions of the programs for OCE; and a dam-break flood potential study for the National Park Service.

About 5 percent of the technical assistance work involved reservoir systems analysis. Work was done on Howard Hanson Dam for the Seattle District, which consisted of modifications to HEC-5 and the HEC Data Storage System (DSS) to allow for semi-monthly data.

Modifications were also made to HEC-5, and to the generalized reservoir system models that were funded by the Portland District. These modifications provided for the inclusion of stream-flow routing procedures from the North Pacific Division's Streamflow Synthesis and Reservoir Regulation computer program.

Technical projects involving water quality problems comprised about 4 percent of the FY 1985 technical assistance work. Assistance in developing multi-purpose data files, for simulating water quality with HEC-5Q, was provided to the Huntington and Pittsburgh Districts.

One project involved statistical analysis. A statistical analysis of the errors in the forecasted runoff into Lake Powell and Lake Mead on the Colorado River was made for the Los Angeles District.

Projects emphasizing unsteady flow and two-dimensional hydrodynamics accounted for about 3 percent of the total technical assistance work. Assistance was provided the Sacramento District in an unsteady flow analysis on Morrison Creek. An on-going unsteady flow analysis of Birds Point Floodway is being done for the Memphis District. A project report was completed concerning the San Francisco Breakwater Study.

Other projects not falling into any of the foregoing categories comprised about 8 percent of the total. This included the Pakistan USAID assistance done for the Bureau of Reclamation, and the film documentary on the Fisherman's Wharf study done for the South Pacific Division.

Technical assistance work in planning analysis accounted for 9 percent of the total. Consultation was continued with the Los Angeles District in formulating a strategy for the Los Angeles County Flood Control Study, which is a basin-wide investigation of needed improvements to the flood control system that serves the major metropolitan area of central Los Angeles. Consultations were continued with the Institute for Water Resources dealing with the Water Supply Cooperative Project. A preliminary basin-wide water supply/use analysis of the Upper Coosa Basin, utilizing microcomputer based databases and procedural analysis with commercial PC based software packages, was done for the Mobile District.

**TECHNICAL ASSISTANCE PROJECTS
MAJOR PROJECTS
FY 1985**

Real-Time Water Control and Data Management

- Rock Island (Data Acquisition and Management)
- Huntington District (Muskingum River Basin Model)
- Pittsburgh District (Monongahela River Basin Model)
- Water Resources Support Center (Software Support)
- OCE (SHFDSS Software Support)
- North Pacific Division (Place HECDSS on NPD Computer)

Rainfall-Runoff Analysis

- Chicago District (CUP Technical Assistance)
- Los Angeles District (Mojave River Forks Dam Study)
- OCE (Hydrologic Engineering Guidance)

River Hydraulics

- Omaha District (Mudflow Hazards Study)
- Portland District (Mud and Debris Flow Routing)
- OCE (Flood Plain Management)
- Federal Highway Administration (Water Surface Profile Accuracy Research Study)
- National Park Service (Tsaile Dam Flood Potential Study)

Reservoir Systems Analysis

- Huntington District (Kanawha River Water Quality Study)
- Pittsburgh District (Monongahela River Water Quality Study)

Hydrodynamics

- Sacramento District (Morrison Creek Unsteady Flow)
- San Francisco District (San Francisco Breakwater Study)
- Memphis District (Birds-Point Floodway Study)

Planning Analysis

- Mobile District (Coosa Basin Water Supply Study)
- Los Angeles District (LACDA Project Investigation)
- Institute for Water Resources (Water Supply Cooperative Project)
- Sacramento District (Dry Creek Investigation)

Other

- Bureau of Reclamation (Pakistan USAID Assistance)
- South Pacific Division (Film Documentary on Fisherman's Wharf Study)

ACKNOWLEDGEMENTS

Excellent support and cooperation were received by the HEC from numerous Corps offices. Colonel George R. Kleb, Commander and Director, Water Resources Support Center, provided very helpful program and administrative guidance. Mr. Vernon K. Hagen, Chief, Hydrology and Hydraulics and Mr. William Donovan, Chief, Flood Plain Management and Coastal Resources Branch, Planning Division, Civil Works Directorate, and Mr. Jesse Pfeiffer of the Directorate of Research and Development were particularly helpful in matters related to HEC's technical program.

Several Corps offices made significant contributions to HEC's training program. Greatly appreciated assistance was provided by the following offices:

Office of the Chief of Engineers
Los Angeles District
Sacramento District
Waterways Experiment Station
Ohio River Division
North Pacific Division
Missouri River Division
South Pacific Division
St. Louis District
New York District
Mobile District

Excellent support in the solution of hydrologic engineering and planning problems was obtained through technical assistance projects performed cooperatively with Division and District offices. These technical assistance projects were funded by field offices and provided the Hydrologic Engineering Center with valuable experience in developing and testing new technologies.

The active exchange of information and ideas with other federal agencies, universities, state and local governments, private industry, and professional societies is greatly appreciated by HEC. Through these contacts, HEC staff is able to keep abreast of current technological advances that may be applied to Corps problems. Dr. Daniel H. Hoggan, Utah State University, made valuable contributions to the Center's hydraulic and hydrologic capability through his presence as an Intergovernmental Personnel Appointment.

HEC is especially appreciative of the support received from temporary personnel. The temporary staff, listed below, provided a valuable extension to the Center's productivity in FY 1985.

Barbara A. Bauer	Civil Engineer
Teresa H. Bowen	Hydraulic Engineer
Jacqueline B. Brown	Clerk
Trudy L. Conley	Clerk
Ajit K. Dulai	Clerk
Daniel Edwards	Civil Engr Tech
Douglas L. Hamilton	Civil Engineer
Derek Hilts	Hydraulic Engineer
Carol A. Johnson	Clerk
Keith B. Knight	Clerk
Cathy J. Lewis	Clerk Typist
Rodney K. Lutz	Civil Engineer
Keith Nelson	Civil Engr Tech
Madeline E. Roach	Clerk
Margaret Schroeder	Civil Engr Tech
Adrienne Stirling	Civil Engr Tech
Christine E. Tougas	Clerk Typist
John C. Tracy	Civil Engineer
Nicole Williams	Clerk
Clay H. Willis	Civil Engr Tech
Rodney E. Wright	Clerk

END

DT/C

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