

**U.S. GEOLOGICAL SURVEY NATIONAL
COMPUTER TECHNOLOGY MEETING:
PROGRAM AND ABSTRACTS,
NORFOLK, VIRGINIA,
MAY 17-22, 1992**

Compiled by Barbara H. Balthrop and Eva G. Baker

U.S. GEOLOGICAL SURVEY

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U.S. GEOLOGICAL SURVEY

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FOREWORD

The U.S. Geological Survey is in the second year of implementing the Distributed Information System-II (DIS-II) program, which provides state-of-the-art computer technology to meet the Survey's mission of providing the hydrologic information and understanding needed for the optimum use and management of the Nation's water resources. In order to facilitate exchange of information among the many scientists, computer programmers, and systems administrators working in support of the DIS-II program, a series of technical meetings have been held in Denver, Colorado (1984), Hyannis, Massachusetts (1985), Atlanta, Georgia (1987), Phoenix, Arizona (1988), and San Antonio, Texas (1990). The Sixth National Computer Technology (NCTM '92) meeting, which was held in Norfolk, Virginia, in May 1992, focuses primarily on the transition from the current (1992) Distributed Information System-I program, which is a distributed base of minicomputers connected by a wide area network, to DIS-II, which is an expanded distributed system using file-servers and workstations connected by local area networks and the wide area networks.

This report contains abstracts presented at the NCTM '92 meeting in Norfolk. The abstracts are of technical papers, posters, and demonstrations of newly developed software running in the DIS-II computing environment presented at the meeting. The status of newly developed software for the hydrologic data bases, administrative and financial data bases, and application software also were presented. Interdivisional participation is a major thrust of NCTM '92 and presentations were made by personnel from all divisions in the U.S. Geological Survey.

Training continues to be a major part of the National Computer Technology Meeting. This year's meeting includes training on computer security, data-base techniques, UNIX system administration, application software, and changes to the UNIX operating systems.



Colleen A. Babcock
Technical Coordinator

CONTENTS

	Page
Foreword	iii
Program listing	ix
Plan for evaluating the transfer process of the new National Water Information System	
I.E. Arroyo and J.R. Kirk	1
Interactive vectorization of scanned data	
W.R. Barron, Jr.	2
Prototyping the transfer process to the National Water Information System-II	
S.D. Bartholoma and C.R. Baxter	3
Macros for editing geographic information system spatial data bases	
K.D. Cartier	4
Relational data-base-management system for Nevada water-rights information	
K.D. Cartier and J.C. Watson	5
Design and development of a graphical user interface for the National Water Information System-II	
S.J. Cauller, D.W. Stewart, T.E. McKallip and S.M. Trapanese	6
Use of computer-aided software engineering tools in the design and development of the National Water Information System-II	
J.D. Christman, S.F. Siwiec, S.E. Hammond, and N.E. Williams	7
Public domain software for UNIX Systems	
R.G. Clark	8
Metamorphosis—from personal computers to Distributed Information Systems-II	
J.P. Crisci, W.S. Sockriter, III, and M.J. Vaught	9
Multiscale characterization of topographic complexity in Colorado	
Lee De Cola	10
An interactive environment for hydrologic applications	
K.M. Flynn and M.Y. Gozé	11
Computer equipment and software tracking system	
E.L. Ford, G.E. Gasser, and R.L. Pierce	12
An interactive scientific data visualization environment within the X window system	
G.J. Granger and M.F. Johnson	13
Checking for coding errors in the Master Water Data Index using a geographic information system	
H.E. Harrison, M.E. Darling, and B.J. Fisher	14
Local area network/wide area network telecommunications	
R.D. Heilbron	15
Manuscript preparation and Distributed Information System-II—A state-of-the-art approach	
T.J. Lane	16
A new approach to software testing in the National Water Information System program	
L.W. Lenfest, J.C. Briggs, and R.L. Moffatt	18
Display and query of a “near real-time” hydrologic alert network	
T.D. Liebermann, J.C. Ciegler, and S.C. Lambert	19

	Page
Comparison of the National Water Information System-I and the National Water Information System-II	
L.E. Lopp, J.C. Schornick, M.L. Clark, and J.L. Kiesler	20
Using a geographic information system to describe the environmental setting of the Red River of the North Basin	
D.L. Lorenz	21
Building hydrologic software with partnerships	
A.M. Lumb and M.E. Blalock	22
Moving from a command line user interface to a graphical user interface	
D.K. McMacken	23
A distributed spatial data library for the U.S. Geological Survey	
D.D. Nebert and Mark Negri	24
Plans for client-server computation in the general purpose computer center of the U.S. Geological Survey	
C.D. Nethaway, Jr.	25
Comparison of computer procurement trends for the Distributed Information System and other Federal agencies	
G.D. Pearsall	26
An interactive computer program (Zee) to plot and manipulate three-dimensional surfaces	
P.M. Rael	27
Educational opportunities available from the U.S. Geological Survey technology information centers in support of the Distributed Information System-II program	
N.J. Sage and Judy Ferrier	28
A procedure for transferring ground-water data from INFO to the National Water Information System	
K.M. Schurr	29
A geographic information system data-base-management system for pesticide-application data	
K.M. Schurr and S.E. Cox	30
Data model for the National Water Information System-II	
S.F. Siwec, C.M. Bostwick, R.P. Mayer, and K.W. Laurent	31
Demonstration of the National Water Information System-II	
D.W. Stewart, B.P. Sargent, S.J. Cauller, and T.E. McKallip	32
Analysis of hardware and software costs for distributed computing, A case study: U.S. Geological Survey, Water Resources Division, 1982-92	
G.J. Stiltner and J.C. Scott	33
Implementing software configuration management in the National Water Information System	
R.E. Thornberg and C.F. Merk	34
An assessment of the development methods of a national software system	
S.M. Trapanese, S.E. Hammond, R.P. Mayer, and C.R. Baxter	35
Source and authority for National Water Information System-II support files	
L.C. Trotta, W.R. Roddy, M.C. Rowan, and E.J. Wilson	36

	Page
The Laboratory Information Management System	
S.L. Turner, O.J. Feist, and J.A. Lewis	37
A computer program (TEK_SOFTKEYS) for efficient programming of selected terminal softkeys	
J.C. Watson and K.D. Cartier	38
Time synchronization methods for the Distributed Information System-II	
C.B. Wierda	39
Development of the National Water Information System-II	
O.O. Williams, T.H. Yorke, and C.F. Merk	40
Author index	41

PROGRAM

National Computer Technology Meeting

*Omni International Hotel
Norfolk, Virginia
May 17-22, 1992*

Sunday, May 17, 1992

- 1:00 p.m. - 5:00 p.m. Registration — Grand Promenade
7:00 p.m. - 9:00 p.m. Welcome Gathering

Monday, May 18, 1992

- 8:00 a.m. - 5:00 p.m. Registration
8:30 a.m. - 5:00 p.m. *USGS Scientific Visualization Workshop, sponsored by the
Advance Computer Technology Subcommittee of the Information
System Council*

Training — Stratford Hall

- 9:00 a.m. - 11:30 a.m. DG/UX 5.4 Differences, Moderators — Gail E. Kalen, WRD, Reston,
Virginia, and Richard A. Hollway, WRD, Portland, Oregon
11:30 a.m. - 1:00 p.m. Lunch
1:00 p.m. - 4:00 p.m. Computer Security for System Administrators, Moderators — Don
Watson, ISD, Reston, Virginia and Gail Kalen
4:00 p.m. - 5:00 p.m. Telecommunications Contingency Planning, Carol Lawson, ISD,
Menlo Park, California

Concurrent Training

- 9:00 a.m. - 5:00 p.m. Concurrent Training Schedule TBA

Evening Activities

- 5:30 p.m. - 7:00 p.m. Hospitality — Merrimac Room
8:00 p.m. - 10:00 p.m. Birds of a Feather

Tuesday, May 19, 1992

- 8:00 a.m. - 5:00 p.m. Registration — Grand Promenade
8:00 a.m. - 5:00 p.m. Visualization Workshop
8:00 a.m. - 5:00 p.m. Concurrent Training — Schedule TBA

Exhibits — York and Stratford Halls

- 1:00 p.m. - 5:00 p.m. WRD Sponsored Exhibit Opens, including vendor displays,
demonstrations of national software systems and poster presentations
by U.S. Geological Survey personnel

Meetings — Greenway Room

4:00 p.m. - 6:00 p.m. Northeast Region Computer Meeting, Moderator, Gregory E. Senko, WRD, Lemoyne, Pennsylvania

Evening Activities

5:00 p.m. - 7:00 p.m. Reception and Review of Poster and Vendor Exhibits — Grand Promenade

8:00 p.m. - 10:00 p.m. Birds of a Feather

Wednesday Morning, May 20, 1992

General Session

8:00 a.m. - 5:00 p.m. Registration — Grand Promenade

Keynote Session, Moderator — James Daniel, Water Resources Division

8:30 a.m. - 8:45 a.m. Introduction of Meeting — Gloria Stiltner

8:45 a.m. - 9:00 a.m. Dallas Peck, Director, U.S. Geological Survey

9:00 a.m. - 9:20 a.m. Philip Cohen, Chief Hydrologist, Water Resources Division

9:20 a.m. - 9:30 a.m. Introduction of Keynote Speaker — Gary Cobb

9:30 a.m. - 10:00 a.m. Keynote Speech — Ronald Skates, CEO, Data General Corporation

10:00 a.m. - 10:30 a.m. Break

10:30 a.m. - 10:50 a.m. James Biesecker, Assistant Director, Information Systems Division

10:50 a.m. - 11:10 a.m. Allen Watkins, Chief, National Mapping Division

11:10 a.m. - 11:30 a.m. Benjamin Morgan, Chief Geologist, Geologic Division

11:30 a.m. - 1:00 p.m. Lunch

Wednesday Afternoon, May 20, 1992

Concurrent Sessions

Concurrent Session — Providence Hall

Geographic Information System Applications, Moderator — Nick VanDriel, National Mapping Division

1:00 p.m. - 1:20 p.m. Macros for Editing Geographic Information System Spatial Data Bases, Kenn D. Cartier, WRD, Carson City, Nevada

1:20 p.m. - 1:40 p.m. Interactive Vectorization of Scanned Data, W.R. Barron, Jr., WRD, Nashville, Tennessee

1:40 p.m. - 2:00 p.m. A Computer Program (TEK_SOFTKEYS) for Efficient Programming of Selected Terminal Softkeys, John C. Watson and Kenn D. Cartier, WRD, Carson City, Nevada

2:00 p.m. - 2:20 p.m. Checking for Coding Errors in the Master Water Data Index Using a Geographic Information System, Howard E. Harrison, Michael E. Darling, and Bruce J. Fisher, WRD, Portland, Oregon

2:20 p.m. - 2:40 p.m. A Distributed Spatial Data Library for the U.S. Geological Survey, Douglas D. Nebert and Mark Negri, WRD, Reston, Virginia

- 2:40 p.m. - 3:00 p.m. Multiscale Characterization of Topographic Complexity in Colorado, Lee De Cola, NMD, Reston, Virginia
- 3:00 p.m. - 3:20 p.m. Measuring the Benefits of Geographic Information System in the Water Resources Division of the U.S. Geological Survey, Stephen Gillespie, NMD, Reston, Virginia

Concurrent Session — Poplar Hall

Using the AViiONs in the U.S. Geological Survey, Moderator — Ron Walton, Geologic Division

- 1:00 p.m. - 1:20 p.m. An Object-Oriented Graphic Kernel System Interpreter, James Fulton, WRD, Reston, Virginia
- 1:20 p.m. - 1:40 p.m. Time Synchronization Methods for the Distributed Information System-II, Clark B. Wierda, WRD, Little Rock, Arkansas
- 1:40 p.m. - 2:00 p.m. Moving from a Command Line User Interface to a Graphical User Interface, Dennis K. McMacken, ISD, Flagstaff, Arizona
- 2:00 p.m. - 2:20 p.m. Public Domain Software for UNIX Systems, Robert G. Clark, ISD, Reston, Virginia
- 2:20 p.m. - 2:40 p.m. An Interactive Computer Program (Zee) to Plot and Manipulate Three-Dimensional Surfaces, Patrick M. Rael, WRD, Little Rock, Arkansas
- 2:40 p.m. - 3:00 p.m. An Interactive Scientific Data Visualization Environment within the X Window System, Gary J. Granger, WRD, Reston, Virginia; and Margaret F. Johnson, ISD, Reston, Virginia
- 3:00 p.m. - 3:20 p.m. Using Multidimensional Diagrams as a System Analysis Tool, Leslie Patrick, WRD, Anchorage, Alaska

Exhibits — York and Stratford Halls

- 1:00 p.m. - 5:00 p.m. WRD Sponsored Exhibits, including vendor displays, demonstrations of national software systems and poster presentations by U.S. Geological Survey personnel

Evening Activities

- 5:30 p.m. - 7:30 p.m. Hospitality — Merrimac Room

Thursday Morning, May 21, 1992

Concurrent Sessions

- 8:00 a.m. - 5:00 p.m. Registration — Grand Promenade

Concurrent Session — Providence Hall, Networking Activities in the U.S. Geological Survey, Moderator — Wendy Budd, Information System Division

- 8:30 a.m. - 8:50 a.m. An Economical Solution for Computer Connectivity over Short Distances, Douglas Wellington, WRD, Tucson, Arizona
- 8:50 a.m. - 9:10 a.m. Local Area Network/Wide Area Network Telecommunications, R.D. Heilbron, ISD, Reston, Virginia
- 9:10 a.m. - 9:30 a.m. The Design and Implementation of a 10Base-T Network, Mark R. Werley, WRD, Tucson, Arizona

- 9:30 a.m. - 9:50 a.m. Metamorphosis—From Personal Computers to Distributed Information Systems-II, John P. Crisci, William S. Sockriter, III, and Marti J. Vaught, WRD, Arvada, Colorado
- 9:50 a.m. - 10:10 a.m. Plans for Client-Server Computation in the General Purpose Computer Center of the U.S. Geological Survey, Charles D. Nethaway, Jr., ISD, Reston, Virginia

Concurrent Session — Poplar Hall, Data Base Applications in the U.S. Geological Survey, Moderator — Phil McKinney, Administrative Division

- 8:30 a.m. - 8:50 a.m. Display and Query of a “Near Real-Time” Hydrologic Alert Network, Timothy D. Lierbermann, WRD, Carson City, Nevada; Janet C. Ciegler and Susan C. Lambert, WRD, Columbia, South Carolina
- 8:50 a.m. - 9:10 a.m. A Procedure for Transferring Ground-Water Data from INFO to the National Water Information System, Karen M. Schurr, WRD, Tacoma, Washington
- 9:10 a.m. - 9:30 a.m. Relational Data-Base-Management System for Nevada Water-Rights Information, Kenn D. Cartier, and John C. Watson, WRD, Carson City, Nevada
- 9:30 a.m. - 9:50 a.m. The Laboratory Information Management System, Sandra L. Turner, Oliver J. Feist, and James A. Lewis, WRD, Arvada, Colorado
- 9:50 a.m. - 10:10 a.m. Status of the Administrative Information System Development (AIS), Mindy Lanza, WRD, Reston, Virginia; and Steve Brady, WRD, Lawrence, Kansas

Concurrent Panel Discussions

Poplar Hall

- 10:30 a.m. - 12:00 p.m. Data-Base Management and Analysis in the NAWQA Projects, Moderator — Linda Geiger, WRD, Tallahassee, Florida

Providence Hall

- 10:30 a.m. - 12:00 p.m. Data General AViiON, PC, Macintosh Integration Using the Novel Local Area Network, Moderator — Paul Celluzzi, ISD, Reston, Virginia

Exhibits — York and Stratford Halls

- 8:30 a.m. - 12:00 p.m. WRD Sponsored Exhibits, including vendor displays, demonstrations of national software systems and poster presentations by U.S. Geological Survey personnel

Thursday Afternoon, May 21, 1992

General Session

National Water Information System, Moderator — Thomas Yorke, Water Resources Division

- 1:00 p.m. - 1:20 p.m. Development of the National Water Information System-II, Owen O. Williams, Thomas H. Yorke, and Charles F. Merk, WRD, Reston, Virginia

- 1:20 p.m. - 1:40 p.m. Implementing Software Configuration Management in the National Water Information System, Ruth E. Thornberg and Charles F. Merk, WRD, Reston, Virginia
- 1:40 p.m. - 2:00 p.m. Use of Computer-Aided Software Engineering Tools in the Design and Development of the National Water Information System-II, Jeffrey D. Christman, Steven F. Siwiec, Stephen E. Hammond, and Nelson E. Williams, WRD, Reston, Virginia
- 2:00 p.m. - 2:20 p.m. Comparison of the National Water Information System-I and the National Water Information System-II, Lari E. Lopp, James C. Schornick, Melanie L. Clark, and James L. Kiesler, WRD, Reston, Virginia
- 2:20 p.m. - 2:40 p.m. Plan for Evaluating the Transfer Process of the New National Water Information System, Ileana E. Arroyo and James R. Kirk, WRD, Reston, Virginia
- 2:40 p.m. - 3:00 p.m. A New Approach to Software Testing in the National Water Information System Program, Leslie W. Lenfest, John C. Briggs, and Robert L. Moffatt, WRD, Reston, Virginia
- 3:30 p.m. - 3:50 p.m. Prototyping the Transfer Process to the National Water Information System-II, Scott D. Bartholoma, WRD, Salt Lake City, Utah; and Carmen R. Baxter, WRD, Reston, Virginia
- 3:50 p.m. - 4:10 p.m. An Assessment of the Development Methods of a National Software System, Susan M. Trapanese, Stephen E. Hammond, Robert P. Mayer, and Carmen R. Baxter, WRD, Reston, Virginia
- 4:10 p.m. - 4:30 p.m. Design and Development of a Graphical User Interface for the National Water Information System-II, Stephen J. Cauller, David W. Stewart, Thomas E. McKallip, and Susan M. Trapanese, WRD, Reston, Virginia

Meetings

- 1:00 p.m. - 4:30 p.m. Information System Council Meeting

Friday Morning May 22, 1992

Concurrent Sessions

- 8:00 a.m. - 1:00 p.m. Information Booth open

Concurrent Session — Providence Hall, Computer Resource Management Issues in the U.S. Geological Survey, Moderator — Gloria Stiltner, Water Resources Division

Moderator — Gloria Stiltner, Water Resources Division

- 8:30 a.m. - 8:50 a.m. Property Accountability Restructure: Why, What and How It Affects Water Resources Division, Kim Rogers and Mindy Lanza, WRD, Reston, Virginia
- 8:50 a.m. - 9:10 a.m. Analysis of Hardware and Software Costs for Distributed Computing, A Case Study: U.S. Geological Survey, Water Resources Division, 1982-92, Gloria J. Stiltner, WRD, Reston, Virginia; and Jonathon C. Scott, WRD, Oklahoma City, Oklahoma

- 9:10 a.m. - 9:40 a.m. Building Hydrologic Software with Partnerships, Alan M. Lumb and
Merritt E. Blalock, WRD, Reston, Virginia
- 9:40 a.m. - 10:00 a.m. Concept of a System in the Distributed Information System-II Environ-
ment, Jeff Miller, WRD, Lakewood, Colorado

Concurrent Session, The National Mapping Division Overview of Programs and Activities,

Moderator — Joel Morrison, National Mapping Division

8:30 a.m. - 10:00 a.m.

National Mapping Division Overview, Joel Morrison
Federal Geographic Data Committee (FGDC) Activities, Gene Thorley
The GIS Research Laboratory Network, Nick VanDriel
Spatial Data Transfer Standard, Kathryn Neff
The USGS Earth Science Information Centers, Wendy Hassibe
Digital Orthophotoquads, George Lee

General Session

Moderator — Gary Cobb, Water Resources Division

10:30 a.m. - 12:00 p.m. Panel Discussion — Latest Developments with the DIS-II Systems
Presented by the Water Resources Divisions Technical Advisory
Committee, Moderator — Richard A. Hollway, WRD, Portland,
Oregon

12:00 p.m. - 12:30 p.m. Closing Statements — Gary Cobb

**POSTERS AND DEMONSTRATIONS FOR
NATIONAL COMPUTER TECHNOLOGY MEETING
MAY 17-22, 1992**

POSTERS

- An Interactive Environment for Hydrologic Applications, Kathleen M. Flynn and Michèle Y. Gozé, WRD, Reston, Virginia
- Manuscript Preparation and Distributed Information System-II—A State-of-the-Art Approach, Theresa J. Lane, WRD, Lakewood, Colorado
- Using a Geographic Information System to Describe the Environmental Setting of the Red River of the North Basin, David L. Lorenz, WRD, St. Paul, Minnesota
- Comparison of Computer Procurement Trends for the Distributed Information System and Other Federal Agencies, Glenda D. Pearsall, ISD, Reston, Virginia
- Educational Opportunities Available from the U.S. Geological Survey Technology Information Centers in Support of the Distributed Information System-II Program, Nancy J. Sage and Judy Ferrier, ISD, Reston, Virginia
- A Geographic Information System Data-Base-Management System for Pesticide-Application Data, Karen M. Schurr and Stephen E. Cox, WRD, Tacoma, Washington
- Data Model for the National Water Information System-II, Steven F. Siwiec, Candice M. Bostwick, Robert P. Mayer, and Kevin W. Laurent, WRD, Reston, Virginia
- Source and Authority for National Water Information System-II Support Files, Lee C. Trotta, William R. Roddy, Michael C. Rowan, and Erik J. Wilson, WRD, Reston, Virginia

DEMONSTRATIONS

- Demonstration of Administrative Information System Financial Management Prototype, Steven J. Brady, WRD, Lawrence, Kansas
- Relational Data-Base-Management System for Nevada Water-Rights Information, Kenn D. Cartier and John C. Watson, WRD, Carson City, Nevada
- Computer Equipment and Software Tracking System, Edward L. Ford, WRD, Stennis Space Center, Mississippi; Gerald E. Gasser, and Rhonda L. Pierce, Sverdrup Technology, Stennis Space Center, Mississippi
- Using Wide Area Information Servers to Locate Earth Science and Global Change Data, Timothy L. Gauslin, ISD, Reston, Virginia
- Checking for Coding Errors in the Master Water Data Index Using a Geographic Information System, Howard E. Harrison, Michael E. Darling, and Bruce J. Fisher, WRD, Portland, Oregon
- Display and Query of a "Near Real-Time" Hydrologic Alert Network, Timothy D. Lieberman, WRD, Carson City, Nevada; Janet C. Ciegler and Susan C. Lambert, WRD, Columbia, South Carolina
- A Distributed Spatial Data Library for the U.S. Geological Survey, Douglas D. Nebert and Mark Negri, WRD, Reston, Virginia
- Demonstration of the National Water Information System-II, David W. Stewart, B. Pierre Sargent, Stephen J. Cauller, and Thomas E. McKallip, WRD, Reston, Virginia
- The Laboratory Information Management System, Sandra L. Turner, Oliver J. Feist, and James A. Lewis, WRD, Arvada, Colorado

PLAN FOR EVALUATING THE TRANSFER PROCESS OF THE NEW NATIONAL WATER INFORMATION SYSTEM

ARROYO, Ileana E., and **KIRK**, James R., USGS, WRD, 12201 Sunrise Valley Drive, Reston, VA 22092

In 1988, the U.S. Geological Survey began to develop a new National Water Information System (NWIS-II). This new system will integrate the data from the National Water Data Storage and Retrieval System (WATSTORE), the National Water Data Exchange, and the National Water Information System (NWIS-I) to a single system in a relational data base with expanded capability for data processing. The NWIS-I data base is the primary source of hydrological data to be transferred to NWIS-II. Software will be developed for use throughout the transfer process to assure the equivalent and complete movement of data into NWIS-II. Counts of lines, characters, number of records, and sizes of files in bytes on NWIS-I text files will be logged in transfer reports during the file movement from the NWIS-I minicomputers to NWIS-II 32-bit microcomputers. The data transfer software also will perform counts on critical data elements with one-to-one correspondence from NWIS-I to NWIS-II. Reports will be generated for any data that are assigned default values, or are rejected by the transfer software. A verification application will be written to compare data before and after the transfer to the NWIS-II data base. The verification applications considered are publication tables for annual reports of hydrologic data, cards-formats used in NWIS-I and WATSTORE, simple columns of data elements as a table format, and a type of statistical summary or graphical plot for ranges of values.

INTERACTIVE VECTORIZATION OF SCANNED DATA

BARRON, William R., Jr., USGS, WRD, 810 Broadway, Suite 500, Nashville, TN 37203

Certain line types are difficult to transform into vector format from raster data using a batch processor. Broken or dashed lines that are located close to each other are an example. Converting scanned, raster lines such as these to a vector format compatible with most geographic information systems results in numerous short line segments and in line segments that cross each other creating a "spiderweb" affect. Interactive processing, rather than batch processing of such difficult line types, is more efficient and more accurate.

The Tennessee District office of the U.S. Geological Survey recently procured a scanner and two software packages to facilitate the interactive conversion of difficult raster lines to vector format. Interactive conversion of data has substantially reduced the amount of time needed to convert scanned, raster data into digital data. Other advantages of the interactive system in use in Tennessee are as follows:

- Several scanning resolutions are available: 400, 300, 200, 150, or 75 dots per inch.
- Maps or illustrations as wide as 36 inches can be scanned. The only limit on the length of a map or illustration is the amount of disk space available.
- Scanning software options can be adjusted to pick up light lines.
- Scanning areas can be adjusted so that the size of the raster file will be smaller.
- Lines can be automatically traced (converted into vector format) using a variety of options.
- Automatic tracing stops when a parameter is outside the criteria in the software option and the user is able to interactively guide the tracing.
- ARC/INFO generate files can be created.

The equipment and software required for interactive vectorization was acquired at a cost of about \$19,500. The cost of the two major components of the procurement were:

scanner, including software -----	\$14,845
personal computer - 386/25, 130 megabyte hard drive,	
8 megabytes of RAM, 5.25" and 3.5" floppy drives,	
32K cache, VGA color monitor, mouse, DOS 4.01 -----	\$4,600

The accuracy of the data has been excellent. The vectorized linework is generally accurate to within 1/100 of an inch.

PROTOTYPING THE TRANSFER PROCESS TO THE NATIONAL WATER INFORMATION SYSTEM-II

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The U.S. Geological Survey is developing plans for the transfer of data from the current National Water Information System (NWIS-I) and the Water Data Storage and Retrieval System (WATSTORE) to the National Water Information System-II (NWIS-II). A major part of the conversion from NWIS-I to NWIS-II is the transfer of the existing data from the NWIS-I Indexed Sequential Access Method files to the new INGRES relational data-base-management system files.

Prototype INGRES data bases have been used to test different transfer approaches. The data bases were either designed to duplicate the NWIS-I file system or were based on a subset of the NWIS-II logical design. The text files taken from the NWIS-I files were moved from the current system's minicomputer to a 32-bit microcomputer using a file transfer program. The file transfer program processing times depended on the operating load of the computer system: the number of other processes on the system and the size of the text file being transferred. After the files were transferred to the microcomputer, the data were either moved using INGRES commands or computer programs from the text files into duplicate NWIS-I INGRES files; from the text files into NWIS-I INGRES files and then into NWIS-II INGRES files; or from the text files into NWIS-II INGRES files.

The processing times in moving text files into INGRES files depended on the size of the text files, the amount of disk space on the microcomputer, the INGRES storage structures, and the approach used to move the data. Space requirements for a NWIS-II data base and data-base growth rates may require districts to have more than five times the amount of space for a NWIS-II data base than was required for NWIS-I data. INGRES storage structure was another factor that affected processing times. Loads into indexed files were slower than into nonindexed files. Computer programs that generated keys, checked integrity, and converted data produced even slower processing times. As a result of the transfer tests, one or a combination of several transfer approaches will be used to move the data the fastest and most complete way possible.

MACROS FOR EDITING GEOGRAPHIC INFORMATION SYSTEM SPATIAL DATA BASES

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The Nevada District office of the U.S. Geological Survey (USGS) has developed a set of computer macros for editing spatial features on vector-based spatial data bases for a geographic information system (GIS). The macros were written in the Arc Macro Language (AML) for the ARCEDIT subsystem of ARC/INFO and were designed to decrease processing times and increase efficiency of cleaning large GIS coverages that were created using electronic scanners. Four of the macros were particularly successful in achieving these goals. The macros are named ADDTIC.AML, REVEAL.AML, TIPTOE.AML, and OVIEW.AML.

The ADDTIC.AML macro provides an automated and efficient method for placement of registration ticks on a coverage. The macro initially prompts the user to specify approximate locations for ticks on an overview of the coverage. The macro then sequentially redraws the coverage with a narrow map extent around each specified area and allows the computer user to indicate a more precise location for the registration ticks.

The REVEAL.AML macro allows the user to interactively select arcs from a GIS coverage based on topological characteristics and redraw the selected arcs with a specified line symbol. The macro isolates coverage arcs that might otherwise be difficult or time-consuming to locate and select. The computer user may then delete or modify the selected arcs. The macro is particularly effective for selecting arcs that correspond to unwanted text labels from a scanned map.

The TIPTOE.AML macro provides an efficient means for systematically examining features by sequentially establishing viewing areas around a selected set of elements of a coverage. The macro steps through the elements one at a time and allows the computer user to delete or modify the selected elements.

The OVIEW.AML macro draws a diagrammatic representation of an ARC/INFO coverage while the coverage is being edited in an ARCEDIT session. The diagram represents the default map extent of the coverage, the current map extent, and the current viewing window. The OVIEW diagram also can be used for resetting the current map extent and redrawing the coverage. The user might specify either a new map extent relative to two points on the diagram itself, or a new map extent relative to a grid overlay on the diagram.

The four AML macros have been applied to several projects in the Nevada District, USGS, thereby decreasing computer processing time for editing GIS coverages. Application of the macros has increased productivity and decreased user fatigue and frustration.

RELATIONAL DATA-BASE-MANAGEMENT SYSTEM FOR NEVADA WATER-RIGHTS INFORMATION

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The Nevada District office of the U.S. Geological Survey (USGS) has developed a data-base system for managing water-rights information for the State of Nevada using the INGRES software package. The data base presently (1992) contains approximately 60,000 water-rights records, including information on water-rights ownership, location, diversion rates, well logs, and water use. The State government uses the data base for administration of water-rights and computation of water-use within the State; the USGS uses the water-rights information for water-inventory and water-use studies.

The system is written in the INGRES 4GL language using the forms-based applications system Application-By-Forms (ABF). Control is primarily through screen menus. Privileged users have access to the data base through the interactive Structured-Query-Language (SQL). The menu-driven system contains four major components: applications for entering data and updating the data base, applications for making single record queries, applications for compiling and producing reports, and utility applications for managing the data base.

Data entry and query applications use a set of five screen-display forms containing both single-line entry fields and scrollable multiple-line entry fields. The system performs validation checking on data using both forms-based validation routines and routines written in the 4GL code. The reports application routes data to either the user's monitor or to a specified printer. The reports application includes routines for producing both simple data listings and complex reports. Complex retrievals, for example, can identify adjacent and potentially conflicting water-rights applications and lists of sequential water-rights modifications in a tree diagram. The utility application allows the data-base administrator to grant access rights to system users and to specify the characteristics of output devices.

DESIGN AND DEVELOPMENT OF A GRAPHICAL USER INTERFACE FOR THE NATIONAL WATER INFORMATION SYSTEM-II

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The U.S. Geological Survey is designing a new integrated National Water Information System, NWIS-II. The design and development of NWIS-II is a comprehensive effort to integrate both data and software functional requirements for several hydrologic disciplines including ground water, water quality, surface water, sediment, biology, and water use. The design of NWIS-II incorporates a graphical user interface (GUI) to a multidiscipline data base. A prototype of the GUI was developed, using an interactive design tool, to operate on a distributed network of UNIX workstations using the X Window System (a network-based graphical windowing system) and the Motif window manager. The GUI prototype models typical user interaction with the system. It contains interactive screens that are linked through the software. The theme and layout of multiple screens incorporates a division of the system by functional process. Each screen contains menu choices and options to guide users from one task to another, providing a path through various subfunctions within the system. The GUI prototype contains limited program functions, but provides a framework for users to evaluate a high-level system design. Evaluations of the GUI by user group representatives from each hydrologic discipline early in the design phase of NWIS-II has resulted in modifications to the GUI without affecting the underlying design of the system.

The development of a consistent, intelligible user interface in a multideveloper environment required the establishment of standards and guidelines for screen design. Principles were established to control the color, size, placement, and purpose of objects on each screen, and to ensure consistent and meaningful terminology for menu choices. Adherence to screen design and content standards has enabled numerous design and development personnel to produce a uniform product to benefit the end user.

USE OF COMPUTER-AIDED SOFTWARE ENGINEERING TOOLS IN THE DESIGN AND DEVELOPMENT OF THE NATIONAL WATER INFORMATION SYSTEM-II

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The U.S. Geological Survey is developing a new National Water Information System (NWIS-II) to replace its existing water-data and information systems (National Water Data Storage and Retrieval System, National Water Information System-I, National Water Data Exchange, and National Water-Use Information System) with a single, integrated system. The new system will be developed using INGRES, a commercial relational data-base-management system, and will be distributed on a national network of UNIX workstations. User access to the system will be provided through a windows-based graphical user interface, and system program modules will combine third- and forth-generation programming languages and structured query language.

Computer-Aided Software Engineering (CASE) tools were used in the design to support selected analysis and design methods, control of the analysis and design process, and documentation of the analysis and design products. The primary CASE tool selected for use in the design and development of NWIS-II is Cadre's *Teamwork*, a UNIX-based product that supports multiple users. The analysis and design methods supported by *Teamwork*'s various modules are consistent with those selected for use for NWIS-II. The NWIS-II logical process model was developed according to an industry standard method of structured analysis, using the *Teamwork/SA* (System Analysis) module. The *Teamwork/IM* (Information Modeling) module was used in the development of the NWIS-II logical data model using the entity-relationship diagram method. The physical design of NWIS-II was done according to an industry standard method of structured design in which software structure charts and module specifications required for coding and implementation of NWIS-II were developed with the *Teamwork/SD* (Structured Design) module. Each of these *Teamwork* modules share a common data dictionary, or repository of information about various model objects. Additional tools developed in-house, such as a data dictionary within INGRES and documentation tools, were added to the NWIS-II CASE environment to expand on the capabilities provided by the *Teamwork* product.

The efficient and effective use of CASE tools within the NWIS-II design and development process required establishing guidelines and standards for their implementation in a multi-user environment. Guidelines were developed for information modeling, structured analysis, and structured design methodologies, including diagramming standards and naming conventions for all types of model objects. These guidelines enabled a team of many developers to work on various parts of the NWIS-II models and design specifications concurrently, while ensuring consistency and integrity in the analysis and design process and products.

PUBLIC DOMAIN SOFTWARE FOR UNIX SYSTEMS

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In the face of decreasing government and University funding, many researchers are turning to public domain software in lieu of spending limited funds on commercial software. Established methods using existing network software are used to locate and acquire such software as image processing systems, visualization software, data-base-management systems, and computer languages. Electronically published lists specify the locations for this software. A standard UNIX file transfer program with the login name of "anonymous" is used to acquire a listing of available software and the software itself. Typically, this software has compile procedures for specific platforms. On occasion, a version of the software does not exist for a desired platform. To replicate the software for different computing environments, an understanding of UNIX compile procedures, the C programming language, and UNIX system files are frequently required. Although system security and software reliability are not addressed, these issues are left to policy statements and systems administrators. Possibly, with appropriate use of this free software, more U.S. Geological Survey funding could be used on additional earth science research issues.

METAMORPHOSIS—FROM PERSONAL COMPUTERS TO DISTRIBUTED INFORMATION SYSTEMS-II

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The U.S. Geological Survey has a major investment in a large number of personal computers (PC's) with a pool of experienced users. Ease of use, many off-the-shelf programs, versatility, and independence from the idiosyncrasies of a centrally located computer have fostered allegiance to the PC. Many PC users do not need the power of large desktop workstations. These users need to begin the shift from single-user platforms to the more versatile multi-user platforms, to be consistent with the commitment to the Distributed Information Systems-II (DIS-II). They do not need to change overnight; thus they can benefit from the experience obtained by the transition of earlier DIS-II users.

The metamorphoses of the PC through the use of X Window emulators might ease the transition. X Window emulators are software packages that are easy to install and maintain, and present the look and feel of the UNIX platforms to a target population that requests simplicity of transition. Research shows that transfer of knowledge is greatest when the individual can build on existing skills.

The purpose of this project was to develop an X Window environment in a PC local area network (LAN) using two LAN networks. The function and use of a PC X Window package in a complex network (Novell) and a simpler network (Lantastic) were evaluated. The major problems centered on implementing the X Window software in a system using PC clones with unknown third-party components. Costs to individual projects and vendor commitment also are addressed.

MULTISCALE CHARACTERIZATION OF TOPOGRAPHIC COMPLEXITY IN COLORADO

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Modeling and analysis of environmental processes require the analysis of data at a range of scales. As part of the U.S. Global Change Research Program, a multiscale raster analysis system was developed that first creates aggregated images by averaging 2×2-cell windows and then reports on both the distribution of cell values and the differences between the values of adjacent cells. The system can analyze either a complete raster or regular partitions of the raster, reporting: (1) mean, (2) variance, (3) spatial autocorrelation based on multiscale analysis of variance, and (4) a monofractal scaling parameter based on the analysis of isoline lengths.

The first test of the system analyzes 1-kilometer digital elevation model data for a square region, 1,024 kilometers on a side, that includes Colorado. The system illustrates several characteristics of topographic complexity in the region. First, spatial autocorrelation varies with elevation and variance, being greater in the eastern (High Plains) part of the raster. Second, topography is a multifractal field in which fractal dimension is highest along a northwest-southeast ridge. Third, topographic aspect is sensitive to changes in resolution—aggregation results in the domination of the raster by a dominant aspect, particularly at lower resolutions. This last finding will be of particular interest to hydrological modelers.

This research is preliminary to the multiscale investigation of correlations among topography, climate, and vegetation in the region. The system can be used for such tasks as selecting imagery for the revision of maps, measuring the complexity of a geophysical field, and integrating heterodimensional data (point observations, imagery, or geographic information system entities). A goal of this research is to establish protocols for judging when and how aggregation can justifiably provide resolution requirements for U.S. Geological Survey environmental data bases.

AN INTERACTIVE ENVIRONMENT FOR HYDROLOGIC APPLICATIONS

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The Hydrologic Analysis Support Section of the Geological Survey Program Coordination and Technical Support is supporting a number of libraries that might be useful in developing hydrologic applications. These include the ANNIE Interactive Development Environment (AIDE), the Watershed Data Management (WDM), and graphics libraries. In addition to these basic libraries, higher level utilities that use these libraries also are available. These libraries are currently being used in a number of applications.

Major goals in the development of these libraries have been code re-usability and machine portability and independence. The libraries are written in standard Fortran77. In addition to the Data General AViiON workstations, the libraries run on PRIME minicomputers, IBM PC's and compatibles, and VAX computers.

AIDE is a character-based, full-screen interactive environment. AIDE supports the use of macros, allowing frequently used procedures to be automated. Using the macro features of AIDE, the application developer can design tutorials to facilitate introducing new users to a program, or experienced users to new features in a program. An application using AIDE includes a sequential American Standard Code for Information Interchange (ASCII) file that describes screens and valid user responses, a Fortran program that calls the AIDE library, and a window for the user interaction.

COMPUTER EQUIPMENT AND SOFTWARE TRACKING SYSTEM

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The Computer Equipment and Software Tracking System (CEAST) was developed to provide a mechanism for tracking hardware and software located at the U.S. Geological Survey Hydrologic Instrumentation Facility (HIF) at the Stennis Space Center. CEAST was developed in INGRES and Windows4GL for use on the Data General AViiON workstation. The tracking system consists of four major components or modules: employee, hardware, software, and maintenance.

The employee module allows users to register employees and generate reports of employee hardware and software assignments. Employee reports identify ownership and custodianship for elements registered in the system. The reports can be generated for a single employee, all employees within a section, or all registered employees in the system.

Registration of hardware, assignment of hardware to employees, and generation of hardware data reports are performed using the hardware module. In hardware registration, the user defines a hardware unit, the components of the unit, any peripheral equipment attached to the unit, and the custodian of the equipment. The hardware assignment function is used to assign registered hardware to the employee possessing the equipment. The flexibility of the system allows users access to hardware information for the entire facility, a section, an individual, or a single hardware unit. Reports generated using the hardware module include hardware unit descriptions, communication port addresses, and assignment and custodianship details.

Software tracking functions provided by the system include software registration, assignment of software to employees, and software reports. Software registration allows the user to register software packages and enter detailed information—custodian, license number, version, documentation list, and other related information—for each copy of the package. Each registered copy of a software package is associated with a hardware unit and employee by means of software assignment. The user can generate reports for unlicensed and duplicate-licensed software packages, all copies of the specified software package(s), or all software packages in the system. The reports list the software package data, the hardware unit on which the package is located, and the owner and custodian of the package.

The maintenance module of the tracking system provides the user with the capability of establishing system validation tables or lookup tables to make the system easier to use and to help ensure system data integrity. Validation table data are used by the system to build selection lists for user data entry. Validation tables in the current version of the tracking system include section names, hardware base-unit types, hardware component types, communication types, and media types.

AN INTERACTIVE SCIENTIFIC DATA VISUALIZATION ENVIRONMENT WITHIN THE X WINDOW SYSTEM

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Visualization of scientific data often must be accomplished using several different plotting utilities and computer systems. Problems arise because of incompatibility of data and graphical formats, and because excessive amounts of time and money are spent by scientists who must learn, operate, and maintain each of these utilities and systems. Also, general plotting tools frequently are not flexible enough to provide both simple visualization plots and report-quality figures meeting rigid publication standards. U.S. Geological Survey scientists are solving these problems by developing a single, integrated, data-visualization tool—the Scientific, Interactive, and Extensible Visualization Environment (SIEVE)—for UNIX-based workstation.

SIEVE provides a user-friendly, flexible, and portable environment within which a broad range of visualization-related functions can be performed. The X Window System and the Massachusetts Institute of Technology's Athena Widgets library serve as the foundation for SIEVE's graphical user interface. Unidata's netCDF, a machine-independent, self-descriptive, direct-access data file format, allows SIEVE to display the structure and attributes of data files conveniently and efficiently with an X window. SIEVE's visualization graphics are based on the Graphical Kernel System (GKS) American National Standards Institute/International Organization of Standards (ANSI/ISO) standard. Thus SIEVE can incorporate any GKS plotting routines—even specialized, user-defined routines—through Fortran and C-language interfaces provided within SIEVE. SIEVE uses XGKS, a Unidata-supported, public-domain implementation of GKS for the X Window System, to display plotting calls in an X window. The National Center for Atmospheric Research (NCAR) Graphics library, which is based on GKS, supplies many of SIEVE's built-in plotting capabilities. For output, SIEVE supports the ANSI Computer Graphics Metafile (CGM) standard and the PostScript format, among others. The X Toolkit Intrinsics research manager controls the attributes and plotting options within SIEVE; hence SIEVE can be adapted to the user's needs and desires—from generation of rough-draft plots to publication-quality figures. SIEVE reduces dependence on specific software or hardware systems by focusing on portable, well-maintained, quality, public-domain components: machine-independent netCDF data files, the GKS and CGM standards, the X Window System standard, and the UNIX platform. All of the software components used by SIEVE are supported by public institutions. NetCDF, XGKS, and the Athena Widgets are available at no cost, whereas NCAR Graphics is available at nominal cost—institutional site licenses are available.

SIEVE, by means of data windows and pull-down menus, permits users to select various types of data from netCDF files, such as time-domain data, three-dimensional data, and map-coverage data. For visualization, various routines are available for creating general plots, such as simple line graphs, contour plots, three-dimensional surface renderings, and gridded vector fields. Other routines can be more specialized, such as the routine which plots map boundaries derived from ARC/INFO, a geographic information system. Several plots can be combined in one plot window, and several plot and data windows can be viewed simultaneously; hence, immediate visual and numerical comparisons of data sets are possible. In addition, SIEVE can add and graphically edit labels, axes, fonts, legends, and other objects within the GKS window. SIEVE is being developed on a Sun SPARCstation and has been ported to the Data General AViiON series of workstations, as well.

CHECKING FOR CODING ERRORS IN THE MASTER WATER DATA INDEX USING A GEOGRAPHIC INFORMATION SYSTEM

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A geographic information system (GIS) has been linked to a full copy of the U.S. Geological Survey Master Water Data Index (MWDI) on both Prime and UNIX computer systems. The purpose is to demonstrate how such linked systems will assist users in selecting National Water Data Exchange (NAWDEX) sites. Once these systems are linked, maps of selected sites, along with summary data, as well as reports for any or all MWDI items can be produced.

This GIS-linked MWDI design required the preparation of spatial maps of NAWDEX sites using the longitude and latitude coordinate values stored in the MWDI. The remaining attributes from the MWDI, including hydrologic unit, state, and county (HSC) were stored as files within a data-base-management system (DBMS) and related to the sites in the digital maps. Spatial maps of hydrologic unit boundaries, state outlines, and county boundaries were acquired separately as the reference criteria. These maps also contained coded items for HSC.

The GIS was used to compare the NAWDEX site HSC codes against those in the reference maps. By use of the GIS's DBMS, validity checks were made for each NAWDEX site to determine if any site has been incorrectly coded. The occurrence of duplicate site entrees in the MWDI were also verified. Additional programs were written to check other MWDI items for inconsistencies and missing mandatory fields.

To update and remedy inconsistencies in the MWDI, programs have been written that produce standard form letters from the Office of NAWDEX. These letters have been sent to NAWDEX members identified to have sites with mismatches in code items. The letters state that a GIS was used to validate their water resources site codes in the MWDI, and that there may be potential errors in the latitude and longitude values, or in one or more of the HSC code items for the sites listed. Provided was a list of the sites by name and identification number, a comparison between the original coded HSC values and those obtained by GIS from the digital reference maps, and a request that the member check these sites, correct any identified errors, and get in touch with the nearest NAWDEX service center. The NAWDEX data-base administrator received a tabulated report of all NAWDEX sites which have HSC code mismatches. A statistical summary by state and by contributing member was also produced.

LOCAL AREA NETWORK/WIDE AREA NETWORK TELECOMMUNICATIONS
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In the U.S. Geological Survey (USGS) telecommunications environment, local area networks (LAN) are connected through a wide area network (WAN). The data transmission rates of the two networks vary widely. A LAN transmits data at 10 million bits per second, whereas the WAN may be limited to 56,000 bits per second or less. Users traversing the WAN will notice the speed difference but must adapt to the slower speed. The software packages used might not easily adapt to the slower speed. Improper coordination of the different transmission rates could result in unnecessary traffic being generated on the LAN. In one example, LAN traffic was more than 10 times the WAN traffic. With increased usage, the LAN performance could deteriorate.

The purposes of this paper are to illustrate how problems can occur in the LAN <-> WAN <-> LAN environment and to provide a method of detecting and resolving these problems. For example, problems can be detected by observing the transmit lights on transceivers or through network monitoring devices. Resolution might be as simple as revising key parameters in the software packages. A specific problem associated with using the Transmission Control Protocol / Internet Protocol (TCP/IP) File Transfer Protocol (FTP) will be thoroughly analyzed. In this problem two host computers residing on LAN's that were connected through a WAN failed to adjust to the different transmission speeds. Multiple data packets were transmitted at LAN speeds. Since buffering did not occur, data were lost and had to be retransmitted.

MANUSCRIPT PREPARATION AND DISTRIBUTED INFORMATION SYSTEM-II—A STATE-OF-THE-ART APPROACH

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Currently (1991), personnel of most offices of the U.S. Geological Survey (USGS) are using some type of word-processing software on personal computers, dedicated word processors, or through the PRIME to produce USGS manuscripts and supporting documentation. Implementation of the Distributed Information System-II (DIS-II) software and hardware offers the advantage of state-of-the-art electronic reports processing (ERP).

What is ERP and how does it differ from word processing? With ERP software, the user can designate a wide variety of fonts, point sizes, type styles, document formats, and character formats that can easily integrate graphics and text into one document. FrameMaker is one of few ERP software programs that has an equation builder within the same software. Electronic reports processing software programs have cross-referencing and indexing capabilities. Most ERP software programs permit the user to draw simple graphics. Comprehensive templates for reports, memorandums, journal articles, and other manuscripts can be created with ERP software so that the user needs only to type or import data in to the template and use paragraph formatting to change type style, font, and size of text. Electronic reports processing software is WYSIWYG ("What you see is what you get"), thus the user will see from the monitor exactly what will print. Although many word-processing programs have some of the above listed capabilities, most applications can be done easier and faster using ERP software.

The DIS-II ERP software program is FrameMaker by Frame Technology, Incorporated. FrameMaker uses the X window environment to its full potential and has its own equation builder, FrameMath, that permits the user to produce equations easily for logarithms, functions, calculus, relations, and other complicated math applications. FrameMaker permits the user to define formats for master pages, reference pages, and body pages so that when combined, these formats produce a neat, orderly manuscript. FrameMaker has indexing and cross-referencing options and enables the user to compile a table of contents in a separate document and then import the table of contents into the main document in any specified format. FrameMaker has a graphics feature that permits the user to draw rectangles, ovals, circles, squares, and other simple graphics. Various fill patterns and stroke thicknesses are additional graphics options.

The Paragraph Catalog in FrameMaker permits the user to indicate type style, font, font size, leading, tabs and indents, alignment, and so forth for a particular part of the document; for example, "Title," "1st Order" (first-order heading), "2d Order" (second-order heading), "Body Text" (text of the body of report), and "Body Tab" (body of a table). Global changes can be made to type styles, fonts, capitalization, leading, tabs, and indents with this Paragraph Catalog option. Text can be flowed around graphics using FrameMaker's Anchored Frame options. Footnote properties, as well as column formatting, can be specified for a particular page or for the entire document.

FrameMaker is a large set of software, uses about 8 megabytes (Mb) of memory (12 or 16 Mb can be used to increase performance), and is the type of software that can be used in a limited capacity for typing letters or memorandums or can be used to its full potential for preparing formal and informal USGS reports, symposia and conference papers, journal articles, abstracts, and supporting documentation.

A certain amount of training is essential to use any type of ERP software, and FrameMaker is no exception. The intensity of training depends on the user's software applications. Training an

employee who prepares manuscripts, such as an editorial assistant, goes beyond the use of ERP software; for example, basic typesetting concepts and terminology, such as leading, proofreading marks, point sizes, page-layout, and composition concepts also must be an integral part of the training for the manuscript-preparation personnel. Initially, a large amount of time may be spent in training personnel in the use of FrameMaker, but with time, quality and quantity production of manuscripts, which is a primary goal of the U.S. Geological Survey, will increase.

FrameMaker is a page-composition program that is very useful in text manipulation when operating in the UNIX X Windowing environment because more than one document can be displayed at a time. Productivity should increase because of the ease of preparing manuscripts and of integrating illustrations therein.

A NEW APPROACH TO SOFTWARE TESTING IN THE NATIONAL WATER INFORMATION SYSTEM PROGRAM

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“But I only changed one line of code!” is the anguished, but too often heard cry made by programmers following a major computer system failure. By adopting a software testing plan early in the development process this cry can be muted, software failures can be minimized, and software maintenance costs substantially reduced using a minimum of resources.

The U.S. Geological Survey National Water Information System Program has adopted a formal software test plan that consists of four types, or phases, of testing: System Acceptance, System, Integration, and Unit testing. Each phase of testing is formally documented by listing each test case, test data, and expected results so that they may be re-used throughout the operational life of the software. System Acceptance tests are developed by end users of the system to ensure that the delivered system meets users’ requirements and expectations, and that the system is ready for release. System testing includes tests to determine if requirements and performance criteria have been met, operational tests to demonstrate that the system can be operated in accordance with the instructions provided, and destructive tests to determine whether the system can be made to fail. Integration testing verifies that the system modules work together correctly as stated in the requirements and design specifications. Unit testing determines whether individual modules function as specified by the design.

The formal software test plan provides for evaluation during development and a structure for testing throughout the life of the system. Automation of testing processes allows developers or maintainers of the software to rerun all or selected procedures, a form of testing known as regression testing, to verify that a change made to one module affects only the target modules or programs.

DISPLAY AND QUERY OF A “NEAR REAL-TIME” HYDROLOGIC ALERT NETWORK

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An extensive hydrologic network has been established to record and transmit currently sensed data to the Automated Data Processing System (ADAPS) on Prime computers in District offices of the U.S. Geological Survey (USGS). For a given sampling site, data can be recorded by several hydrologic parameter codes for stage, streamflow, precipitation, specific conductance, or other characteristics. Data are transmitted by satellite, routed to the appropriate District office, and processed within ADAPS. Data that exceed predefined thresholds are flagged as “alert values.” Knowledge of the current alert status at sampling sites within a state is of critical importance during floods, hurricanes, and other extreme hydrologic events.

A system of computer programs called RTMAP (real-time mapping) was developed to provide interactive graphics display and query of those hydrologic data in a map-based, menu-driven environment. The programs were designed to be portable, require a minimum of installation effort, and are available to all District offices within the USGS. The RTMAP system is composed of two sets of computer programs, both of which reside on the two principal computer operating systems used by the USGS. One set of programs, written in Command Processing Language (CPL) and Fortran, retrieves data from ADAPS on the Prime computer. Unit-values data are retrieved for those sites and parameter codes for which alert thresholds have been set within ADAPS. Under default conditions, data are retrieved within 15 minutes to 4 hours after being recorded, resulting in a “near real-time” data base. The data are transferred to a UNIX-based computer for all further processing and display.

A second set of programs, written in Arc Macro Language (AML) and Fortran, processes site-header information and unit-values data into an ARC/INFO point coverage and related files. The macro RTMAP.AML controls the menu-driven display and query of the data. Hydrologic sites are displayed on a state map and flagged according to their alert status. If a site and associated parameter code are selected, a time-series graph of the current value, and values from the previous 5-day period, can be drawn to the graphics screen. Plot files of the current map, graph, or entire graphics screen can be sent directly to a Postscript printer. Extensive additional functions are incorporated into the RTMAP graphics system that give the user a wide range of options for investigating the available data.

COMPARISON OF THE NATIONAL WATER INFORMATION SYSTEM-I AND THE NATIONAL WATER INFORMATION SYSTEM-II

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The U. S. Geological Survey (USGS) is developing a new hydrologic data system, the National Water Information System-II (NWIS-II), based on a relational data-base-management system, to replace its existing hierarchical and indexed sequential access system (NWIS-I). NWIS-I includes four subsystems for ground water, surface water, water quality, and water-use information, which are logically and physically independent of each other with the exception of a common Site File. NWIS-II is an interdisciplinary system, designed around the hydrologic data-collection activities of the USGS, including establishing sites, making measurements, collecting and analyzing samples, and analyzing data.

The NWIS-I Site File contains a mixture of information about where data are collected. The site information includes a textual name, the hydrologic feature, and locators for the site. NWIS-II presents a view of this information in its logical components: a hydrologic feature name and type (for example, spring, stream, and aquifer), a structure name and type (for example, well and gaging station), and a reference location (for example, latitude, longitude, and altitude). In addition to storing the location of points on the earth's surface, NWIS-II will provide the ability to store cross sections, transects, and offsets from points where measurements are made, or samples are collected, or both.

The design of NWIS-II is based on the concept that values and their qualifiers are integrated in one system, regardless of the type of activity that produced the values. Files from the NWIS-I model, which predominantly contain activities and data values, include the Quality of Water File, Unit Values File, Daily Values File, Water-Levels File, and Water-Use Annual Measurements File. NWIS-I uses the U.S. Environmental Protection Agency parameter-code system or hard-coded data elements to identify the values being stored. The information embedded in the parameter name will be decomposed and distributed into its logical primitive components in NWIS-II, including statistical information, measurement units, measurement methods, and sample characteristics that will be linked through a series of data elements, or attributes, to fully characterize the value. NWIS-II also will provide the ability to store additional information, which is not part of the NWIS-I, including information about equipment and sample preparation.

USING A GEOGRAPHIC INFORMATION SYSTEM TO DESCRIBE THE ENVIRONMENTAL SETTING OF THE RED RIVER OF THE NORTH BASIN

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A geographic information system was used to describe the environmental setting of the Red River of the North Basin, one of 20 study units in the U.S. Geological Survey National Water Quality Assessment Program. Thematic data used to describe the environmental setting were mean annual precipitation, mean annual streamflow, surficial and buried aquifers, and ecological regions. A geographic information system was used to compile these data from various sources and from various spatial scales, to overlay the themes of data, and to create map products of the basin. Due to the long-term, in-depth nature of the regional water-quality assessment, an early description of the environmental setting of the study unit is critical for planning the study. The subsequent multiscale analyses for the water-quality assessment will be facilitated with the geographic information system.

BUILDING HYDROLOGIC SOFTWARE WITH PARTNERSHIPS

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Adequate resources are available within the U. S. Geological Survey (USGS) to develop and support quality software for hydrologic analysis. Yet, the end user often does not have the software, documentation, or support needed for hydrologic studies. Furthermore, inconsistencies in the user interface and data bases cause learning curves to be much longer than necessary.

In June 1991, the Hydrologic Analysis Support Section (HASS) was created within the USGS Office of the Assistant Chief Hydrologist for Program Coordination and Technical Support to provide a focal point and headquarters responsibility for hydrologic-applications software. The scope of the applications software has evolved from work groups and many discussions with the National Water Information System (NWIS-II) development teams. That scope is defined in the software functional requirements for NWIS-II and the hydrologic-applications-software requirements document of HASS.

To develop high quality hydrologic software, partnerships need to be developed between HASS and NWIS-II, HASS and Districts, and HASS and the National Research Program. This will take time, but much progress has already been made. High quality software also requires a software quality-assurance plan and quality-control procedures. A quality-assurance plan has been drafted. For software quality control, tools have been acquired or developed and standards and guidelines drafted.

To efficiently produce and support the required software and to minimize the costs to transfer the software to other computer systems, HASS has made the following decisions:

- maximize re-use of code with applications software libraries
- maximize use American National Standards Institute (ANSI) and Federal Information Processing Standards (FIPS) standard languages (Fortran, C)
- maximize use ANSI and (FIPS) standard graphics (Graphical Kernel System)
- minimize use of single-vendor software
- begin with a character-based (keyboard) user interface.

The latter and most controversial decision has been reviewed and accepted by the USGS Strategic Planning Group, Office of the Chief Hydrologist, and the Planning and Implementation Committee, Office of the Assistant Chief Hydrologist for Scientific Information Management.

MOVING FROM A COMMAND LINE USER INTERFACE TO A GRAPHICAL USER INTERFACE

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With the advent of inexpensive UNIX workstations, many users are requesting that their applications be moved to these platforms. The bitmapped graphics capabilities of the workstation displays tempt the application programmer to develop graphical user interfaces (GUI's) for application software programs. However, in many cases, users also must operate the application on simple American Standard Code for Information Interchange (ASCII) text terminals. The U.S. Geological Survey Image Processing Facility at Flagstaff, Arizona, has recently faced this problem in the conversion of the Planetary Image Cartography System (PICS) to run on UNIX workstations. The techniques considered as part of this study include GUI front ends for programs, GUI shell program environments, and GUI's built into programs. The conclusion is that GUI shell environments and GUI front ends for programs allow the greatest flexibility while maintaining ASCII terminal compatibility.

A DISTRIBUTED SPATIAL DATA LIBRARY FOR THE U.S. GEOLOGICAL SURVEY
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The U.S. Geological Survey (USGS) is undertaking the design and prototype implementation of a Distributed Spatial Data Library (DSDL) for use in water-resources investigations. Information stored in DSDL includes on-line digital spatial data, data-processing programs, and extended descriptions of standardized procedures to make commonly used spatial data usable—spatial data-automation guidelines. The DSDL uses a standard library format that facilitates data access and exchange among geographic information system (GIS) users in the USGS. The DSDL design includes a data dictionary of available data layers and their attributes, a standard directory structure and file nomenclature, an index of available data at various map scales, and data browsing software. The prototype implementation of DSDL is being developed through extensions to existing GIS tools and data structures to accommodate storage and access to vector, raster, image, and cartographic products meaningful to USGS applications. The initial definition of priority data layers and data-automation procedures is being conducted with assistance from the National Water Quality Assessment program study unit staff. The continued population of the DSDL with data, programs, and data-automation guidelines is accomplished through national programs and individual offices in a coordinated manner to support existing research and water-resources applications at the local, regional, and national level.

PLANS FOR CLIENT-SERVER COMPUTATION IN THE GENERAL PURPOSE COMPUTER CENTER OF THE U.S. GEOLOGICAL SURVEY

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This paper describes plans for incorporating scientific workstations and related file servers into the suite of computational platforms available through the U.S. Geological Survey (USGS) General Purpose Computer Center (GPCC). The USGS has adopted a policy of using a variety of appropriate technology for information processing. Scientific workstations and file servers connected in a client-server relationship are now a frequent model for computing resources in the scientific community, in general, and the USGS, in particular. In order to enhance accessibility of all systems, a method of connectivity is being developed.

Until recently, the GPCC has consisted of a mainframe computer and a minicomputer, along with significant telecommunications facilities. The mainframe, with over 200 gigabytes of disk storage and over 40,000 cartridge tapes in its library, is used for storing and manipulating very large data bases and for the processing of administrative and financial information from several Federal agencies. The minicomputer is used for telecommunications and a few scientific applications. The GPCC mainframe and minicomputer are regularly accessed from many desktop microcomputers, workstations, and large minicomputers from around the country.

Plans are being made to enhance and create a "Distributed GPCC" by adding and integrating powerful scientific workstations and file servers in Reston, Virginia; Lakewood, Colorado; Menlo Park, California; and Flagstaff, Arizona. All of these systems will be connected to one another using Layers 1-4 of the International Standards Organization open systems interconnect (OSI) model. Beyond relatively simple connectivity issues, it is planned that many integrated applications across networks will be accomplished in conformance to OSI Layers 5-7. Wide-ranging applications may include, among others, large, mainframe-based information systems; numerically intensive tasks on high-speed workstations; and the use of small data sets on individual desktops.

The long-range goal, perhaps difficult to achieve, is to provide integrated applications and resource sharing on as many computers as possible, for as many applications as practical. After user interfaces are written, the client (end user) will be able to use distributed applications without needing to know, or be concerned with, where given applications and data reside and execute. One should then be able to select the most appropriate technology, data bases, and application programs to increase one's effectiveness and productivity.

COMPARISON OF COMPUTER PROCUREMENT TRENDS FOR THE DISTRIBUTED INFORMATION SYSTEM AND OTHER FEDERAL AGENCIES

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Distributed Information Systems-II was the largest requirement ever approved within the U.S. Geological Survey and Department of the Interior. A \$127,000,000 contract was awarded to Data General providing all the Department of the Interior Bureaus access to UNIX workstations and servers over the next 7 years.

More than 1,400 workstations and 120 servers have been installed within the Department of the Interior, with 96 percent of these systems located at U.S. Geological Survey locations. A variety of software is being procured or developed for use with this Data General hardware. In addition, a variety of hardware is also being procured for compatibility with the Data General hardware. Displays detailing the variety and value of hardware and commercial software within the bureau as compared to other Federal agencies will be described.

AN INTERACTIVE COMPUTER PROGRAM (ZEE) TO PLOT AND MANIPULATE THREE-DIMENSIONAL SURFACES

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A computer program called Zee has been developed by the Arkansas District office of the U.S. Geological Survey to interactively display and manipulate three-dimensional data points on the Distributed Information System-II (DIS-II) workstations. Zee is an X Window System and Motif graphics program written in the C language. Although proprietary software packages performing similar tasks are available, this program is designed to specifically view data points arranged in row-column format in an ASCII file. This arrangement simplifies the input to the program. The data image can be rotated interactively by moving the workstation mouse. The image moves as the mouse moves giving maximum control of the display process. The mouse can also be used to change the image scale, either larger or smaller. Automatic clipping as the image scales larger, gives the impression of getting inside the image. Perspective projection, where closer means larger and farther away means smaller, has been added to further enhance the realism. Zee should have many useful applications in modeling studies and is simple to use.

EDUCATIONAL OPPORTUNITIES AVAILABLE FROM THE U.S. GEOLOGICAL SURVEY TECHNOLOGY INFORMATION CENTERS IN SUPPORT OF THE DISTRIBUTED INFORMATION SYSTEM-II PROGRAM

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The U.S. Geological Survey (USGS) operates Technology Information Centers in Denver, Colo.; Flagstaff, Ariz.; Menlo Park, Calif.; and Reston, Va. The Centers provide educational opportunities and technical assistance to the USGS user community as well as to other Federal agencies. In support of the Distributed Information System-II Program, the Centers provide UNIX and C Language courses on interactive video, videotape, and other computer-based media and a reference area containing texts, periodicals, and other publications of interest to those working in the UNIX environment. A network of Data General AViiON workstations is available for USGS personnel to demonstrate and use applications software. The Centers also sponsor and coordinate computer training, technical seminars and demonstrations, and computer trade shows featuring technological advances in UNIX-platform products and applications.

Each of the four Technology Information Centers provides a variety of resources dedicated to the Distributed Information System-II Program. Self-paced training courses, an important means of supplementing classroom training, will be described and demonstrated. Displays detailing the specific resources of each Center will describe the clientele and activities used during 1991.

A PROCEDURE FOR TRANSFERRING GROUND-WATER DATA FROM INFO TO THE NATIONAL WATER INFORMATION SYSTEM

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INFO software was used to manage the primary data base of the Pasco Basin ground-water project in Washington. In order to transfer the data into the National Water Information System (NWIS), a set of programs was written that translates an INFO ground-water data base to the format required for entry into the NWIS Ground-Water Site Inventory System. The requirements for such a procedure need to be taken into consideration before designing an INFO data base for ground-water projects.

With ARC software, the INFO files were manipulated to create data-field groupings that are comparable with the sections on the NWIS site inventory form. Names for the project data files and data fields were paired in an INFO data-dictionary file with their equivalent NWIS codes. The programs then wrote the formatted file for entry to NWIS and the file was edited by NWIS.

Some of the INFO records for this ground-water project were created from the NWIS system. Subsequent updates and additions were made only to the INFO files. In this procedure, all records are initially identified as additions to the NWIS system. A program reads the error messages from an NWIS edit. If the message from the NWIS edit system indicates that certain records cannot be added because they already exist in NWIS, the program changes the input file, instructing NWIS that the existing records are to be modified by the new data. If there are other error messages, the records are set aside in a separate data file for later study. A new input file is written, checked by an NWIS edit, and, if error-free, entered into NWIS.

A GEOGRAPHIC INFORMATION SYSTEM DATA-BASE-MANAGEMENT SYSTEM FOR PESTICIDE-APPLICATION DATA

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A geographic information system (GIS) data-base-management system was designed to store and spatially display pesticide-application data. This system also could accommodate application data for other agricultural chemicals. On request, the pesticide data are submitted by farmers and applicators to the Washington State Department of Agriculture. A statewide data-base system was required; the degree of data resolution had to be balanced against available data-management and computer resources. The Public Land Survey System grid was used as the spatial framework for the pesticide-application data, and the data were located to the nearest quarter-quarter section. ARC/INFO programs were adapted to subdivide section coverages into 16 quarter-quarter sections, regardless of the section size or shape, for plotting purposes. For data entry, a transparent quarter-quarter section grid was placed over the farmer's or applicator's sketch map and the affected quarter-quarter sections were recorded.

Numerous other agencies are interested in accessing the data base and using the data with various GIS layers. The system includes a menu-retrieval program that can be used by someone with little or no ARC/INFO experience. The user is prompted to enter a few basic requirements for the retrieval; then the system creates a plot and automatically displays it on the screen. The system also creates data listings and plot files. In order to save computer space and computer resources, the system does not routinely create coverages for retrievals, but the user can easily create them with one of the system programs. The system was quality-checked with actual data from a small geographic area consisting chiefly of large farms; soon it will be tested for an area consisting chiefly of small farms. Future enhancements, such as a map library, might be required as the data base is expanded.

DATA MODEL FOR THE NATIONAL WATER INFORMATION SYSTEM-II

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The U.S. Geological Survey (USGS) is developing a new National Water Information System (NWIS-II) to replace several of its existing autonomous water-data and information systems with a single integrated system. One of the goals of the NWIS-II development effort is to provide users with a high-quality, highly flexible, hydrologic data system that is easily maintained in a rapidly expanding and changing technological environment. In support of this goal, NWIS-II will utilize INGRES, a commercial relational data-base-management system. The system will be implemented as a distributed data base, and operate on UNIX workstations located in USGS offices nationwide connected through a wide area network.

In designing the NWIS-II data base, a rigorous data analysis was conducted, resulting in the Logical Data Model (LDM) of the system. During this iterative process, the data requirements of the system, as put forth by eight USGS User Groups representing various scientific or data disciplines, were analyzed and decomposed to their most primitive level. Analysis also involved the identification of similarities, differences, and relationships among these primitive data elements or attributes. Logical groupings of attributes, called entities, were identified and each attribute was assigned to the appropriate entity that it characterizes. An entity is a person, place, thing, event, or concept about which information is to be stored in the NWIS-II data base. Each entity may be thought of as an NWIS-II data-base table, with its attributes representing the columns of data within the table. Each row in a table is a unique occurrence of the entity it represents. Data-base tables are physically linked by a common attribute, called a key.

The NWIS-II LDM provides the basis on which the physical data base is built, in that the data base is a physical representation of the LDM. However, the actual NWIS-II data base differs somewhat from the LDM. Some entities have been combined into a single data-base table, while others have been partitioned into several tables. These deviations from the LDM were made to the NWIS-II data base to optimize the system's performance and allow for efficient use of computing resources. Additional departures from the LDM were required due to constraints and limitations imposed by external physical agents, such as hardware, software, and network configuration. Finally, many additional support tables not shown in the LDM were required in the physical data base. These tables include lists of valid attribute domains, information required for system access and security, and physical information required for the system to operate, such as hardware specifications.

DEMONSTRATION OF THE NATIONAL WATER INFORMATION SYSTEM-II

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The U.S. Geological Survey (USGS) is designing and developing a new National Water Information System (NWIS-II) to replace the current water-data information systems. NWIS-II will be used by the USGS to store, retrieve, process, analyze, and manage hydrologic data. A prototype or working model of the NWIS-II is demonstrated on a UNIX workstation, utilizing the INGRES relational data-base-management system. The prototype highlights the high-level menu structure and a subset of the functional specifications contained in the first release of the software. The prototype demonstrates the graphical user interface, which utilizes a mouse pointing device; user interface objects or widgets, such as pull-down menus, pop-up selection boxes, and push buttons; and how users of varied hydrologic background will navigate through the integrated system to perform various tasks.

**ANALYSIS OF HARDWARE AND SOFTWARE COSTS FOR DISTRIBUTED
COMPUTING, A CASE STUDY: U.S. GEOLOGICAL SURVEY, WATER RESOURCES
DIVISION, 1982-92**

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In 1982, the U.S. Geological Survey (USGS) began distributing their computer hardware and software resources from a centralized mainframe computer to a network of minicomputers. In 1990, USGS began a second phase of distributing the computer resources by using a combination of UNIX-based file servers and workstations placed on users desktops.

Distribution of computer resources to the desktop has been less costly and more efficient than the minicomputers when measured on a per-user basis. Results of comparison of hardware and software costs during the period 1982-92 for the minicomputers and the server/workstation combination shows the cost savings. Comparison of the capabilities of the minicomputers and the workstations shows that significantly greater computational resources have been made available.

IMPLEMENTATING SOFTWARE CONFIGURATION MANAGEMENT IN THE NATIONAL WATER INFORMATION SYSTEM

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The U.S. Geological Survey is developing a National Water Information System-II (NWIS-II) that will integrate and replace the existing water information systems. The National Water Information System (NWIS) Program established a Quality Assurance and Configuration Management Unit in 1989 to establish and manage the NWIS life cycle development. Software quality assurance plays an important role throughout this development process to ensure that the users' needs are met. Software configuration management provides control of software throughout the software life cycle. As the integration and development progresses, the volume and complexity of the project increases, and controlling software and its changes generated by this effort become difficult. During the life cycle of NWIS-II, automated software configuration management will report problems and change requests, and will assist the NWIS Program managers, analysts, programmers, and testers in managing the new software and control subsequent software changes.

AN ASSESSMENT OF THE DEVELOPMENT METHODS OF A NATIONAL SOFTWARE SYSTEM

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The U.S. Geological Survey (USGS) is developing a second-generation National Water Information System (NWIS-II) that involves the use of new hardware and software technology and software design methods. A pilot study was initiated to assess the affects that new technology and methods will have on the NWIS-II development processes. The pilot study used a subset of the NWIS-II functional and data requirements to create a software model. The model was developed following and utilizing the proposed NWIS-II software development methods and tools incorporated throughout the development life-cycle phases. More specifically, the pilot study investigated the methods for software design specification, communication with the District offices of the USGS assigned to code the software, software configuration management, testing, and quality assurance. The assessment concentrated on the methods and tools used in the design process of the pilot study and included an assessment of the level of detail necessary to specify a software system to decentralized coding shops. During the pilot study, metrics on complexity and the amount and level of effort were documented to gain better understanding of the NWIS-II development process. The results of the pilot study are intended to provide developers and managers an increased knowledge and confidence of the software development process, improve estimates of time needed for development, and identify where other alternatives need to be evaluated.

SOURCE AND AUTHORITY FOR NATIONAL WATER INFORMATION SYSTEM-II SUPPORT FILES

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The new U.S. Geological Survey (USGS) National Water Information System (NWIS-II) will depend on a variety of support files. These support files consist of reference lists and lookup tables. A reference list is a group of related information explaining the syntax and usage options of particular types of data. A lookup table relates one value to another. These values and domains are central to a hydrologist's day-to-day work.

User groups formed from each hydrologic discipline were the source of many reference lists in NWIS-II. In addition, existing files maintained by authorities both inside and outside the USGS have been incorporated.

The authority for updating most of the reference lists will be the NWIS Program, the discipline offices of the Assistant Chief Hydrologist for Program Coordination and Technical Support, or the originating agency.

THE LABORATORY INFORMATION MANAGEMENT SYSTEM

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The U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) is implementing a new Laboratory Information Management System (LIMS-II) in coordination with the National Water Information System (NWIS-II) and the Administrative Information System (AIS).

LIMS-II consists of the Laboratory Analytical Data System (LADS) to handle analytical functions of the NWQL and the Laboratory Administrative System (LADM) to handle the administrative functions that are unique to the NWQL. NWIS-II incorporates the requirements developed for LADS in the logical design of the data base. Several functions developed by LADS will be shared by NWIS, including the following: (1) on-line Analytical Services Catalog, (2) on-line publication of the Techniques of Water-Resources Investigations manuals, (3) interactive sample login and sample tracking, (4) quality-control review of analyses in the laboratory using the same techniques as used in the District offices of the USGS, (5) processing of "alert" conditions at the NWQL and at the District offices, and (6) timely data transmission of reports from the NWQL to the District offices. Several functions developed for LADM will be shared by AIS, including (1) project planning to budget projected analytical requirements, (2) workload planning at the NWQL based on the projected requirements, (3) current, accurate, and convenient electronic billing, and (4) electronic purchasing of necessary NWQL supplies.

A COMPUTER PROGRAM (TEK_SOFTKEYS) FOR EFFICIENT PROGRAMMING OF SELECTED TERMINAL SOFTKEYS

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TEK_SOFTKEYS is a Fortran program that creates macros in the Prime Command Processor Language (CPL). The macros issue host commands for programming the softkeys on Tektronix-style terminals (4100, 4200, and 4300 series). For many applications, such as digitizing or editing of geographic information system coverages, programmed softkeys can increase user efficiency and productivity. Programmed softkeys can be used as a means for issuing commands in PRIMOS or in specific software packages such as ESRI ARC/INFO. TEK_SOFTKEYS has the capacity to assign up to 32 programmable softkeys: unshifted F1-F8, shifted F1-F8, control F1-F8, and control-shifted F1-F8. The TEK_SOFTKEYS program can either interactively prompt for data or read data from a command-log file. The user has the option of saving the commands in either volatile (not saved on logout) or nonvolatile status. An option also is provided to allow deletion of nonvolatile commands. The softkey commands are limited to 40 characters each and may include multiple commands, separated by semicolons. Upon execution, the macro selects the proper command/operating mode for the host terminal and writes the macro for programming the softkeys. The user-defined commands are written to a command-log file which can be edited, used for building other CPL's, or resubmitted to the TEK_SOFTKEYS program.

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TIME SYNCHRONIZATION METHODS FOR THE DISTRIBUTED INFORMATION SYSTEM-II

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The U.S. Geological Survey (USGS) Distributed Information System-II makes more efficient use of distributed file systems but has potential problems with time synchronization of the local systems that make up the national network. The first Distributed Information System, a national network of minicomputers, had one clock for the entire set of file systems at a site. The Distributed Information System-II, a national network of locally networked workstations, allows a file system to be distributed over multiple platforms, each with its own clock. A potential problem exists because of differences in time of as much as 4 minutes between platform clocks. A method is needed to synchronize these clocks. This method must be compatible with multiple platforms, have minimal impact on system or network performance, and provide close association with National Institute of Standards and Technology standard time. Two software packages have been implemented by the Arkansas District office of the USGS that meet these conditions. The first consists of two parts, a server and a client running on a local area network. The second supports the Network Time Protocol for access to Internet resources. The first package can stand alone to synchronize any network and is portable to any platform that can connect to the local area network. It does not require any connection beyond the local area network. The Network Time Protocol compliant package allows synchronization of the local clocks to the National Institute of Standards and Technology standard clock across the Internet for those sites with such access.

DEVELOPMENT OF THE NATIONAL WATER INFORMATION SYSTEM-II

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The development of the National Water Information System-II (NWIS-II) has involved coordination and information exchange among more than 150 individuals at all levels of the Water Resources Division of the U.S. Geological Survey. The 5-year development effort, which began in August 1988, has included an initiation phase by the senior staff of the Division and the NWIS Program, definition of requirements by users, integration of requirements and system design by user/developers on the design and development team, coding by user/programmers, and testing by programmers, developers, and users. The key to the development process has been a software quality-assurance plan that has involved end users at each phase of the software life cycle. Fifty users were assigned to eight user groups, each representing different scientific disciplines or interests, and were charged with defining the requirements of the system. Other users were trained in the techniques of system analysis and design and assigned as developers to the design and development team. Another group of users was designated as a review team to evaluate the work completed by the design and development team and assess whether the user's requirements would be met. The users also will be instrumental in testing the system before it is released. They will provide test cases and test data that will be used by programmers for unit testing, by developers for integration testing, and by the review team and other users during system acceptance testing.

AUTHOR INDEX

Arroyo, I.E.	1	Lopp, L.E.	20
Barron, W.R., Jr.	2	Lorenz, D.L.	21
Bartholoma, S.D.	3	Lumb, A.M.	22
Baxter, C.R.	3, 35	Mayer, R.P.	31, 35
Blalock, M.E.	22	McKallip, T.E.	6, 32
Bostwick, C.M.	31	McMacken, D.K.	23
Briggs, J.C.	18	Merk, C.F.	34, 40
Cartier, K.D.	4, 5, 38	Moffatt, R.L.	18
Cauler, S.J.	6, 32	Nebert, D.D.	24
Christman, J.D.	7	Negri, Mark	24
Ciegler, J.C.	19	Nethaway, C.D., Jr.	25
Clark, M.L.	20	Pearsall, G.D.	26
Clark, R.G.	8	Pierce, R.L.	12
Cox, S.E.	30	Rael, P.M.	27
Crisci, J.P.	9	Roddy, W.R.	36
Darling, M.E.	14	Rowan, M.C.	36
De Cola, Lee	10	Sage, N.J.	28
Feist, O.J.	37	Sargent, B.P.	32
Ferrier, Judy	28	Schornick, J.C.	20
Fisher, B.J.	14	Schurr, K.M.	29, 30
Flynn, K.M.	11	Scott, J.C.	33
Ford, E.L.	12	Siwiec, S.F.	7, 31
Gasser, G.E.	12	Sockriter, W.S., III,	9
Gozé, M.Y.	11	Stewart, D.W.	6, 32
Granger, G.J.	13	Stiltner, G.J.	33
Hammond, S.E.	7, 35	Thornberg, R.E.	34
Harrison, H.E.	14	Trapanese, S.M.	6, 35
Heilbron, R.D.	15	Trotta, L.C.	36
Johnson, M.F.	13	Turner, S.L.	37
Kiesler, J.L.	20	Vaught, M.J.	9
Kirk, J.R.	1	Watson, J.C.	5, 38
Lambert, S.C.	19	Wierda, C.B.	39
Lane, T.J.	16	Williams, N.E.	7
Laurent, K.W.	31	Williams, O.O.	40
Lenfest, L.W.	18	Wilson, E.J.	36
Lewis, J.A.	37	Yorke, T.H.	40
Liebermann, T.D.	19		