UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

ABSTRACTS OF PAPERS PRESENTED AT THE GEOGRAPHIC INFORMATION SYSTEMS SYMPOSIUM

JUNE 2–4, 1987
RESTON, VIRGINIA

Open-File Report 87-314

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FOREWORD

The U.S. Geological Survey held a bureauwide Geographic Information System (GIS) Symposium on June 2–4, 1987, in Reston, Virginia. This 3–day event provided Survey hydrologists, geologists, cartographers, computer scientists, and geographers an opportunity to meet colleagues and examine a comprehensive overview of current and future Survey GIS activities. For many, the symposium offered a glimpse of interdivisional cooperative efforts and projects. For others, it offered a forum to discuss bureau GIS goals, issues, and policy. Hopefully, it offered all a chance to discuss and exchange ideas.

This open–file report contains the final program and abstracts of symposium presentations, technical presentations, and poster sessions.

James T. O'Kelley, Jr., Chairman,
GIS Symposium Organizing Committee

John E. Findley,
GIS Symposium Coordinator

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BUREAU GIS SYMPOSIUM
DIVISIONAL COOPERATIVE EFFORTS FOR ACHIEVING BUREAU GIS GOALS

June 2-4, 1987

U.S. Geological Survey
Reston, Virginia
Auditorium

PROGRAM

PROGRAM

Tuesday, June 2
USGS Auditorium

8:00–8:45 **Registration**

8:55–9:00 **Welcoming remarks and review of agenda,** *Joel Morrison, NMD*

9:00–9:15 **Welcome,** *Dallas Peck, Director, USGS*

9:15–10:15 **TOPIC: Current GIS Technological Trends**

Keynote Speaker – *Dr. John E. Estes, Professor of Geography, University of California, Santa Barbara*

10:15–10:30 **Break**

10:30–12:00 **GIS Joint Cooperative Application Projects**
Moderator – *Joel Morrison, NMD*

- **CUSMAP Tonopah Pilot Study,** *Thomas Nash, GD & John Dwyer, NMD*
- **San Juan GIS RASA,** *Michael Kernodle, WRD*
- **Resource Assessment and Monitoring in Africa,** *Don Moore, Thomas Loveland, Norman Bliss, & Donald Lauer, NMD*

12:00–1:00 **Lunch**

1:00–2:30 **GIS Joint Cooperative Application Projects** *(continued)*
Moderator – *James Daniel, WRD*

- **National GIS Data Bases for Water Resources Studies,** *Kenneth Lanfear, WRD*
- **Continental Margin Maps,** *Edward Escowitz, GD*
- **GIS Environmental Management – Georgia,** *Jack Alhadeff, WRD*
- **Earthquake Hazards Assessment – Utah,** *Robert Alexander, NMD*

2:30–2:45 **Break**

2:30–5:30 **Concurrent Technical Presentations and Demonstrations**

Technical Presentations
USGS Auditorium

David Greenlee, NMD, Moderator

- **Modifying ARC/INFO Software,** *Kenneth Lanfear, WRD*
- **ARC/INFO Macros/Custom Procedures,** *Todd Augenstein, WRD*
- **Prolog for an AI User Interface,** *Stuart Doescher, NMD*

Tuesday, June 2
continued

- o AI Applications Using Prospector, *Walter Bawieck, GD*
- o An Improved Label Placement Algorithm, *Jan Van Roessel, NMD*
- o Converting Raster Land Cover to Vector Files for the Interim Land Cover Mapping Program, *Mark Shasby, NMD*
- o INFO for Large Tabular Data Bases, *Norman Bliss, NMD*

Demonstrations
Room 2P148

- o Micro/PC Session

2:30 – Earth Resources Data Analysis System, *Robert Clark, ISD, Richard Sanchez, NMD*
3:15 – pcARC/INFO, *David Stewart, WRD*
4:00 – AutoCad, *William Tolar, NMD*

USGS GIS Research Lab

- o GIS Projects Session

2:30 – San Juan GIS RASA, *Michael Kernodle, WRD*
3:00 – Continental Margin Maps, *Edward Escowitz, GD*
3:30 – Hazardous Waste Management – Georgia, *Jack Alhadeff, WRD*
4:00 – National GIS Data Bases for Water Resources, *Kerie Hitt, WRD*
4:30 – Wasatch Earthquake Hazards, *Elden Jessen, NMD*

Wednesday, June 3
USGS Auditorium

9:00–10:00 **TOPIC: The National Science Foundation's National Geographic Information and Analysis Center**

Keynote Speaker – *Dr. Ronald Abler, Program Director, Geography & Regional Science Program, National Science Foundation*

10:00–10:15 **Break**

10:15–12:00 **TOPIC: USGS GIS Research Labs & Operational Issues**
Moderator – *Richard MacDonald, Chairman, GIS Policy Task Force Technical Advisory Group*

TOPIC: Review of Lab Research Activities

- **Denver,** *Harry Tourtelot/Tom DiNardo*
- **Menlo Park,** *Len Gaydos*
- **Sioux Falls,** *Don Lauer*
- **Reston,** *John Houghton*

12:00–1:00 **Lunch**

1:00–3:00 **GIS Joint Cooperative Projects Funded by Director, FY '86**
Moderator – *James Biesecker, ISD*

- **Elizabeth River Project, Virginia,** *Todd Augenstein, WRD*
- **San Mateo County Project, California,** *Earl Brabb, GD*
- **San Juan Basin Project, Arizona, New Mexico, Utah, Colorado,** *Mike Crane, NMD*
- **James River Project, North Dakota,** *Susan Jenson, EDC, & Greg J. Wiche, WRD*
- **John Day River Basin Project, Oregon,** *Douglas Nebert, WRD*
- **Watershed Modeling,** *Alan Lumb, WRD*

3:00–3:15 **Break**

3:15–5:30 **Concurrent Technical Presentations and Demonstrations**

Technical Presentations
USGS Auditorium

Stephen Guptill, NMD, Moderator

- o **Desirable Characteristics of Future Geographic Information Systems,** *Stephen Guptill, NMD*
- o **Requirements for Improved Polygon Overlay,** *Jan Van Roessel, NMD*
- o **Introduction to Triangulated Irregular Network (TIN),** *Bruce Wright, NMD and Douglas Nebert, WRD*
- o **Extraction of Hydrologic Information from DEM,** *Susan Jenson, EDC*
- o **Central Region Integrated Mapping Strategy Interface,** *Thomas DiNardo, NMD*
- o **ARC to Scitex Interface,** *Greg Allord, WRD*

Demonstrations
Room 2P148

- o **Micro/PC Session**

3:15 – **CD Rom,** *Edward McFaul, ISD*
4:00 – **GS Digital Line Graph Query System,** *John Koehmstedt, NMD*
4:45 – **GSmap/GSdraw,** *Gary Selner, Dick Taylor, GD*
5:00 – **Prolog for an AI User Interface,** *Stuart Doescher, NMD*

Wednesday, June 3
continued

USGS GIS Research Lab

- **GIS Projects Session**

3:15 – **James River**, *Susan Jenson, EDC*
3:45 – **Elizabeth River**, *David Wolf, NMD*
4:15 – **San Mateo**, *William Acevedo, NMD*
4:45 – **John Day**, *Douglas Nebert, WRD*

Thursday, June 4
USGS Auditorium

8:30–9:00 **TOPIC: FICCDC/IDCCC/USGS Efforts to Develop Federal, Departmental, and Bureau Standards for Data Format, Coding, Content, Quality, and Compatibility**

Richard Kleckner, Digital Cartography Program Technical Coordinator, NMD

9:00–10:00 **TOPIC: Bureau GIS Research Policy, Requirements, and Opportunities**
Moderator – *Bruce Doe, Assistant Director for Research*

Panel Discussion by GIS Policy Task Force

- *Joel Morrison, NMD*
- *James Biesecker, ISD*
- *James Daniel, WRD*
- *Nicholas Van Driel, GD*

10:00–10:15 **Break**

10:15–12:30 **GIS Joint Cooperative Projects Funded by Director, FY '87**
Moderator – *Nicholas Van Driel, GD*

- **Yellowstone National Park Project, Wyoming**, *James Wilson, WRD*
- **Garrison Diversion Project, North Dakota**, *Robert Houghton, WRD*
- **Geologic Transect, Northeastern U.S. & Canada**, *David Stewart, GD*
- **Carson River Basin Project, Nevada & California**, *Elizabeth Frick, WRD*
- **Paducah Project**, *Walden Pratt, GD*
- **Interactive Ground Water/Surface Water Model, Washington & Oregon**, *Mike Darling, WRD*
- **Artificial Intelligence Project**, *Lynn Usery, NMD*

12:30–1:30 **Lunch**

Thursday, June 4
continued

1:30–1:45 **National GIS Symposium,** *James Biesecker, ISD*

1:45–2:00 **Summary and Wrap-up,** *Joel Morrison, NMD*

2:30–4:00 **Concurrent Technical Presentations and Demonstrations**

Technical Demonstrations
USGS Auditorium

Robin Fegeas, NMD, Moderator

- **Federal Geographic Exchange Format,** *Robin Fegeas, NMD*
- **Spatial Data Exchange Standard,** *Jan Van Roessel, NMD*
- **Raster to Vector Conversion of Nominal Polygons & Lines,** *Eugene Fosnight, NMD*
- **Improved DLG to ARC Conversion,** *Carl Rich, NMD*
- **GIS Interface Software,** *Stewart Gott, NMD*

Demonstrations
USGS GIS Research Lab

- **GIS Projects**

2:00 – **Geologic Transect,** *Bruce Wright, NMD*
2:30 – **Carson River Basin Project,** *Elizabeth Frick, WRD*
3:00 – **Interactive Ground Water/Surface Water Model,** *Michael Darling, WRD*
3:30 – **Federal Land Information System,** *Ray Arndt, Thomas Johnson, NMD*

ABSTRACTS

CURRENT GEOGRAPHIC INFORMATION SYSTEMS TECHNOLOGY TRENDS

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ABSTRACT

Geographic information systems (GIS's) evolved as a way to assemble and analyze diverse data relating to specific geographical areas with location of the data serving as a basis of the information system. From the Canadian GIS's through the present, GIS's have undergone changes as computer hardware and software improved. In addition, our understanding of those problems that can be addressed with GIS technology has also matured. Today systematic efforts continue to improve GIS's. Researchers and commercial firms are employing techniques from subfields of computer science to the design and implementation of new systems. Techniques from computer vision and image processing are also being more effectively incorporated into GIS's. Important here are the development of data structures and computational procedures for efficient storage, retrieval, and analysis of spatially indexed data, and our improved understanding of the use of GIS technology for mapping, monitoring, and modeling a wide variety of environmental issues.

SPATIAL ANALYSIS OF GEOCHEMICAL AND GEOLOGIC INFORMATION FROM THE TONOPAH, NEVADA, CUSMAP PROJECT

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ABSTRACT

Topical investigations of geographic information system (GIS) techniques for manipulating and interpreting geochemical and geologic information for resource assessment of the Tonopah 1° x 2° quadrangle, Nevada, demonstrate that they are powerful analytical tools but not a panacea. The Tonopah data base includes geochemical results for stream sediments and concentrates at 1,118 sites and digitized maps of drainage basins, geology, mineral occurrences, limonitic alteration interpreted from remotely sensed data, and digital elevation model data. This informal cooperative project has focused chiefly on spatial analysis of regional geochemistry data, refinement of geochemical backgrounds and anomaly thresholds for map units, and spatial mineral deposit models.

The digital maps of sampled drainage basins and geology permitted analysis of units that contribute sediment to the geochemical samples and better estimates of geochemical backgrounds according to geologic criteria. This spatial analysis of data is more realistic and precise than traditional methods that treat geochemical results as discrete data that are referenced to localities downstream from sources. Techniques that interpolate and smooth geochemical surfaces are indifferent to hydrologic domains. Extrapolation of data without proper geomorphic constraints is particularly inappropriate in areas with large Quaternary intermontane basins, such as in Nevada.

Map–based mineral deposit models for resource assessment are effectively supported by a spatial data base using GIS techniques. Tungsten–copper skarn deposits, a simple example, can be modeled as a series of spatial relations among favorable host units and plutonic sources, structure, and geochemistry; quantification of the model is accomplished by interactive processing and video display. More complex problems, such as the recognition of epithermal volcano–genic deposits with subtle geochemical signatures among pluton–associated deposits with strong anomalies, are conveniently handled within the GIS by integration of geologic and geochemical variables and evaluation of their spatial associations.

These topical studies demonstrate many useful applications of GIS techniques to problems of regional geochemistry and resource analysis. The GIS expedites scientific inquiry and analysis of complex multivariate data sets. Once the data base has been complied, spatial manipulation and preparation of graphic displays and map output become much faster than by manual techniques. The substantial time and cost of data base preparation must be anticipated; however, short–term studies that do not require integration of multiple data bases or many cartographic products are done at lower cost by conventional methods. Advanced capabilities for input and output and for manipulation of tabular, vector, and

raster data bases are required for projects with the complexity of a CUSMAP study. Data bases have been transferred on tape between the VAX system at the EROS Data Center in Sioux Falls, South Dakota, and the Data General system in Denver, Colorado. Although current GIS graphics capabilities are excellent, further work is needed to facilitate rapid publication of color map products.

USING A GEOGRAPHIC INFORMATION SYSTEM TO ASSIST IN NUMERICAL ANALYSIS AND TO PREPARE CARTOGRAPHIC PRODUCTS FOR THE SAN JUAN BASIN REGIONAL AQUIFER SYSTEM ANALYSIS, NEW MEXICO AND COLORADO

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ABSTRACT

A geographic information system (GIS) provides the capability to digitally process areal thematic data while maintaining correct topology and accurate attributes of the features. GIS technology is being used in the San Juan Basin Regional Aquifer-System Analysis (RASA) to generate and manage input for a numerical three-dimensional ground-water flow model. A direct product of this effort is the concurrent preparation of maps for a series of map reports describing the geohydrology for each of the eight major hydrologic units being investigated.

Using a GIS to generate and manage data for a numerical ground-water flow model offers at least four advantages.

1. Both the hydrologic information being processed and the spatial discretization used in the numerical model are identically fitted to any chosen map projection, allowing accurate overlay of information in geographic coordinates.

2. Objective (purely mathematical) assignment of cell values is performed, yet the data on which the assignments are based are conveniently evaluated, interpreted, and revised by the investigator to describe the geohydrologic framework.

3. The spatial discretization used in the model may be easily revised without concern for resultant changes in subjective representation of the geohydrologic framework.

4. Model simulation and quality map products are virtually a single directed effort.

Three major problems were anticipated and eventually resolved: (1) An automated method was needed to assign cell identifiers to a rectilinear grid of nonuniform dimension and rotated orientation; (2) a method had to be devised to generate a continuous surface with local discontinuities from point and other data, and then portray that surface in the GIS; and (3) the technology had to be developed to generate camera-ready map products, which meet Survey publication standards, directly from the GIS.

RESOURCE ASSESSMENT AND MONITORING IN AFRICA

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ABSTRACT

International development and assistance agencies need timely and accurate information describing the location, condition, and extent of resource assets, so that problems such as the recent food shortages can be rapidly assessed, remedial actions better managed, and development programs defined. The Earth Resources Observation Systems (EROS) Data Center of the U.S. Geological Survey is assisting the U.S. Agency for International Development (AID) in the development of remote sensing and geographic information systems (GIS) for resource assessment and monitoring in Africa. Remote sensing contributes to baseline resource surveys and is instrumental in monitoring both short- and long-term changes in resource conditions. GIS technology is needed to assimilate the vast amounts of resource and socioeconomic data, and to analyze and format results for use by decision makers.

The AID Famine Early Warning System (FEWS) uses information systems to assess the location and extent of populations at risk to famine in eight African nations. EROS is working with FEWS to use vegetation index data calculated from Advanced Very High Resolution Radiometer (AVHRR) imagery for near real-time vegetation condition monitoring. These data are combined with agricultural, statistical, weather, health, and nutrition information to assess the current food conditions and to assist in defining remedial actions necessary to reduce human suffering and starvation. Summary statistics are calculated by census district and compared to baseline data to determine the relative status of vegetation.

AVHRR data are also being used for large-area monitoring in Senegal, Gambia, and Mauritania to support grasshopper and locust control efforts. EROS is involved in an AID-sponsored pilot test to determine if daily acquisitions of AVHRR imagery that are transformed into a normalized difference (ND) vegetation index can provide a means for monitoring grasshopper breeding habitat and outbreak susceptibility conditions. Sequential comparisons of ND provides a means to monitor changes in agricultural vegetation that may be attributed to consumption by large swarms of locusts.

NATIONAL GEOGRAPHIC INFORMATION SYSTEM DATA BASES FOR WATER-RESOURCES STUDIES

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ABSTRACT

National water-resources studies require a data management system capable of efficiently handling large amounts of geographic data. The U.S. Geological Survey's National Water Summary Program has compiled an extensive and increasing data base that includes not only traditional water-resources data but also related data on such issues as population and economics. By using a "workbench" analogy that integrates a variety of tools, efficient techniques have been developed for capturing, reaggregating, analyzing, and graphically displaying national data sets.

A comprehensive set of digital base maps is the key to handling spatial data. The base maps not only provide a background on which data can be displayed, but also can be used for classifying the data. On-line digital data for base maps for the National Water Summary, most at the 1:2,000,000 scale, include State and county boundaries, streams, water bodies, and drainage basins. A number of reduced-resolution base maps also allow rapid graphical displays of preliminary data and the design of attractive output formats.

The base maps have provided the foundation for national studies of a number of water-resource issues. One issue under study is the relation between point and nonpoint sources of pollution. The data base includes a list of all known major point-source discharges, coded by hydrologic cataloging unit and county, along with estimates of nonpoint discharges by county. The geographic information system (GIS) is being used to identify those parts of the country where tradeoffs might be possible between point and nonpoint pollution control strategies.

The GIS contributes to our knowledge of pesticide application practices. Estimates of application rates of 184 pesticides, by crop and by county, are stored in a relational data base. An automated procedure extracts the data for a particular pesticide, performs the necessary aggregation, and graphically displays the pesticide's usage on a national basis. The ability to see the spatial distribution is a major advantage over previous tabular displays.

A linear programming technique is being used in combination with the GIS to optimize the selection of data for study areas in the Survey's National Water Quality Assessment Program. Drawing upon the data base for the National Water Summary, the GIS is used to extract and aggregate data on population, water use, pollution sources, and economic activity within candidate study areas. The GIS assembles input for the linear programming solution, which, given the constraints, selects an optimum set of study areas for investigation. The data for selected study areas are returned to the GIS for immediate graphical display and analysis.

Newly developed procedures, such as a binary search on a key file, now give the GIS the capability to quickly access massive data files. In one experiment, a GIS data base was constructed that included all 72,000 surface-water gaging stations where records are

maintained by the Survey. This data base could be searched interactively, and the stations within a particular State, county, or hydrologic unit displayed on the base maps in a matter of seconds. Such experiments clearly demonstrate the potential of the GIS as a graphical interface to future data bases.

The powerful display and analysis capabilities of the GIS permit new opportunities for national water–resources studies. As the data base continues to increase, each addition provides new insights on water resources.

U.S. GEOLOGICAL SURVEY'S CONTINENTAL MARGIN MAPPING (CONMAP) PROJECT

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ABSTRACT

The U.S. Geological Survey has established the Continental Margin Mapping (CONMAP) Project as part of its overall research program focused on the nation's Exclusive Economic Zone (EEZ). The project was commenced in response to the need for a systematic means to reference and disseminate geographically oriented data and information.

Primary goal of this project is the preparation of a series of maps that will provide coverage of the EEZ at a map scale of 1:1,000,000. The series will consist of more than 20 map panels prepared on an Albers conic equal-area projection. A second phase of the CONMAP Project, to prepare more detailed thematic maps of coastal areas, is also underway. These maps are being prepared at a scale of 1:100,000 and will allow exposition of topics where more detailed data and information are available. All information on the maps will be derived from digital data bases. The all-digital foundation allows the CONMAP series to remain dynamic because new information can be easily appended to the data bases and revised maps can be redrawn by computer.

Thematic data for each panel of the series are maintained as separate digital cartographic overlays and are similar to the concept of registered overlays used in more conventional mapping work. A software system for map generation (MAPGEN) was developed at the U.S. Geological Survey for implementation on UNIX-based operating system computers. MAPGEN software is used to process digital data bases into registered map overlays, which can be displayed on graphic computer terminals or plotted on a variety of hard-copy output devices. The maps and overlays are organized in a simple hierarchical structure that is equivalent to a set of map cabinets and map drawers, an electronic map library for EEZ cartographic data.

DEVELOPMENT OF STATEWIDE GEOGRAPHIC INFORMATION SYSTEM TO SUPPORT ENVIRONMENTAL MANAGEMENT ACTIVITIES IN GEORGIA

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ABSTRACT

Throughout Georgia there are approximately several hundred known waste landfills and an even greater number of facilities that generate, transport, or store hazardous wastes. Each location represents a potential contamination source of public and private water supplies as well as a contamination source of nearby land and atmospheric resources. To correlate and assess information from these facilities and other sources, a geographic information system (GIS) data and analysis technique was selected. The objectives were to create resources planning and areal analysis tools for use by those responsible for resources management in Georgia and to demonstrate GIS applications for State water management agencies. The data base that was developed consisted of both a broad statewide GIS model and a detailed three-county model to evaluate ground-water vulnerability. Data gathered on a statewide basis, in addition to base data (transportation and hydrography), included hazardous and Resource Conservation Recovery Act sites, municipal water-supply intakes and waste-water discharge sites, surficial geology and soils, extent and depth of aquifers, pesticide application, recharge and outcrop areas, ground-water and streamflow monitoring sites, and population density. In addition, data collected on a three-county scale included detailed soils data (soil classification and slope, land use, and soil erosion characteristics) and aquifer data.

Three specific applications of GIS technology were identified for use on a three-county study area in south Georgia. These included siting a potential landfill, assisting in making hazardous-waste-site management decisions, and delineating areas of nonpoint source pollution. Siting a landfill involved compositing several data layers to locate a potential site of several hundred acres where (1) few wetlands exist, (2) few urban or densely populated areas exist, (3) few municipal weils are located, (4) low permeability soils exist, and (5) the direction of ground-water flow is away from the site. Hazardous-waste-site management decisions, which included assessment of contamination potential and prioritization of cleanup funding, were made by compositing several data layers to locate Resource Conservation and Recovery Act sites where (1) urban or densely populated areas exist, and (2) the direction of ground-water flow is toward nearby municipal water-supply intakes. Delineating areas of higher nonpoint source pollution from agricultural chemicals and herbicides involved compositing several data layers to identify municipal weils that have the highest potential for contamination by nonpoint sources. These weils were related to (1) shallow depth of the aquifer, (2) proximity to prime farmland, and (3) proximity to wetlands, streams, and water bodies.

INFORMATION SYSTEMS APPLICATIONS TO EARTHQUAKE HAZARDS ASSESSMENTS IN UTAH

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ABSTRACT

Demonstrations of potential applications of geographic information systems (GIS) in the U.S. Geological Survey's Regional Earthquake Hazards Assessments (REHA) Program were carried out using test data from the area of the Sugar House Quadrangle, Salt Lake City and County, Utah. The test area lies within the Wasatch Front earthquake hazard zone which, according to recent studies, is likely to experience earthquakes up to a magnitude of 7.5 that could cause human casualties ranging from hundreds to thousands and economic losses in excess of a billion dollars.

Data bases representing both the geophysical aspects of the hazards (e.g., surficial geology, liquefaction potential, land stability) and the facilities and populations at risk (e.g., land use, schools, gas mains, census geographic units) were compiled, analyzed, and assembled into demonstration materials that include reports, slides, computer terminal displays, and a portable atlas containing 30 selected examples of digital data bases and GIS manipulations that demonstrate earthquake hazard applications.

Project team members made 20 major presentations to potential users in the scientific community and in national, State, and local level organizations having responsibilities for some aspects of earthquake hazards mitigation. Digital data bases and associated GIS capability are seen as having major potential roles in earthquake hazard reduction, including earth science research, loss estimation, land use planning, disaster response and recovery, and more effectively communicating implications of earthquake-related research to nonscientist officials and the general public.

Recommended follow-on actions include: (1) introduce GIS component in future REHA projects; (2) add multi-scale map linkages to future digital capability for earthquake studies, including scale ranges from 1:500,000 to 1:1,200; (3) add National Mapping Division and Water Resources Division research collaboration to REHA projects involving information systems and implementation; and (4) develop digital data exchange capability with census, emergency management, and local land parcel data bases to improve access to information needed for earthquake hazard applications.

THE NATIONAL SCIENCE FOUNDATION
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ABSTRACT

The Geography and Regional Science Program at the National Science Foundation will establish a National Center for Geographic Information and Analysis (NCGIA) in the summer, 1988. It will be funded at $1.25 million per year.

The Center will be devoted to basic research on geographic analysis utilizing geographic information systems. Its goals are to advance the theory, methods, and techniques of geographic analysis based on geographic information systems (GIS) in the disciplines involved in GIS research; augment the Nation's supply of experts in GIS and geographic analysis in participating disciplines; promote the diffusion of analysis based on GIS throughout the scientific community; and provide a central clearinghouse for information regarding research, teaching, and applications in GIS.

NCGIA research programs will address several of the following general problems: improved methods of spatial analysis and advances in spatial statistics; a general theory of spatial relations and data base structures; artificial intelligence and expert systems relevant to the development of geographic information systems; visualization research pertaining to the display and use of spatial data; and social, economic, and institutional issues arising from the use of GIS technology.

To accomplish those goals, the NCGIA will focus on problems that are more effectively addressed by teams composed of scientists from different disciplines than by individual investigators supported by separate research awards; develop programs for transferring knowledge to industrial users, government agencies, and other academic institutions; serve as an exchange point for data bases of common communities; involve both undergraduate and graduate students in Center research activities as a means of preparing them for careers in academic research or in practice; promote scholarly and technical communication among those engaged in GIS research and practice by sponsoring symposia, workshops, training programs, and postdoctoral research and by providing an attractive site for scholars and practitioners on sabbatical or other leaves; and give specific attention to programs for upgrading the quality of GIS instruction in academic institutions.

The NCGIA will be located at an academic institution with close links among research, education, and practice. Proposals from a consortium of two or more institutions are appropriate if a more effective Center will result from such cooperation.

Proposals are due January 29, 1988. The award will be announced in June 1988.

A PILOT GIS STUDY TO ASSIST ENVIRONMENTAL MANAGEMENT DECISIONS IN THE ELIZABETH RIVER BASIN, VIRGINIA

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ABSTRACT

The U.S. Geological Survey is currently engaged in a cooperative geographic information system (GIS) project with the U.S. Environmental Protection Agency. Input from about 15 other Federal, State, and local agencies will also be included. The impetus for this co–operation has been the effort to restore the Chesapeake Bay—the Nation's largest estuary--to its healthy and productive past. The Elizabeth River Basin, located in and around Norfolk, Va., drains approximately 205 square miles of some of the most heavily industrialized and developed area on the Bay watershed.

In order to assess the potential for contamination in the Elizabeth River Basin, a series of data layers covering location, movement, and impact are needed. By incorporating these spatial data layers from Geological Survey and other Federal, State, and local agencies into a centralized framework compatible with the GIS, specific analytical techniques can be carried out by local administrators, scientists, and managers in order to make more sound environmental management decisions within the basin and ultimately the Bay watershed.

ANALYZING AND PORTRAYING GEOLOGIC, CARTOGRAPHIC, AND HYDROLOGIC INFORMATION FOR LAND USE PLANNING, EMERGENCY RESPONSE, AND DECISIONMAKING IN SAN MATEO COUNTY, CALIFORNIA

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ABSTRACT

A total of 19 scientists, engineers, and computer specialists from the U.S. Geological Survey in Menlo Park, together with Planning and Emergency Services staff from San Mateo County and an information specialist from the Association of Bay Area Governments, are currently working to produce geologic-hazard maps of San Mateo County using geographic information systems (GIS) technology. Data bases in digital form include geology (strength of materials, direction and inclination of potential shear surfaces, and location of earthquake-generating faults), engineering properties of hillside materials, elevation data at 30-m grid spacing, real-time precipitation, landslide distribution, vegetation, land use, and census statistics. Maps produced in color from these digital data bases show liquefaction susceptibility, slope, aspect, predicted seismic intensities, potential for debris flows, potential for earthquake-generated landslides, and cumulative earthquake-damage potential for tilt-up concrete, steel-frame, and wood-frame buildings. The color-separation negatives for these maps have been prepared on a laser scanning and plotting system with a potential resolution of 72 lines/mm.

Work in progress includes representation of the shape of the Earth's surface by a triangulated irregular network (TIN), so that landslide habitats can be recognized and mapped automatically; preparation of a residential-development index providing information on the costs of hillside development in relation to geologic hazards; derivation of an aspect/slope map from digital elevation models that would contain more readily interpretable topographic information than contour maps or shaded-relief images; comparison of the reliability and information content of slope maps at 1:24,000, 1:62,500, 1:100,000, and 1:500,000 scales; development of a system for releasing San Mateo County GIS data to the public in digital form; and development of new or revised procedures for incorporating GIS data into the county's general plan, ordinances, policies, and emergency procedures.

Most of the maps produced or in progress are the first of their kind. Many of these exciting scientific products would not have been attempted without the availability of GIS technology and a sophisticated laser plotting system permitting the preparation of color-separation negatives quickly, inexpensively, and with correct registration.

SAN JUAN GIS PROJECT

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ABSTRACT

This research endeavor involves the National Mapping Division (NMD), Water Resources Division (WRD), and Geologic Division working to develop mutually beneficial techniques for using the ARC/INFO geographic information system to automate tasks that are common to earth science studies. NMD's role in this project is multidimensional. One objective has been to develop a procedure for the creation of both digital and graphic base maps to WRD publication standards using NMD digital data. Another objective concerns interfacing ARC/INFO to NMD's automated cartographic systems for the direct generation of publication–quality graphics.

The geographic focus of this investigation is the San Juan structural basin. Encompassing approximately 20,000 square miles, the basin is situated in the Four Corners region of Arizona, New Mexico, Colorado, and Utah.

Accomplishments of this research project include the development of an improved method for moving NMD digital data into ARC/INFO. Twenty–three 1:100,000–scale digital line graph files (hydrography, transportation) were utilized in the digital compilation of the project base map. Boundary information was also required on the base map which necessitated manual digitizing of the information using ARC/INFO. NMD standards for digital line graph data sets were applied during the digitization. However, several ARC/INFO deficiencies precluded incorporation of these files in the U.S. Geological Survey's National Digital Cartographic Data Base. The capabilities of ARC/INFO were also used to annotate the base map with appropriate text. To facilitate the direct generation of publication–quality map products, a program interface has been created to NMD's Kongsberg plotter. The photo–head plotting capability of the Kongsberg plotter was used to produce the final project base map graphic. Other interfaces are being developed between ARC/INFO and NMD's Gerber and Versatec plotters.

Work on this project is expected to be completed and a final project report produced by the end of FY 1987.

JAMESTOWN DRAINAGE REFINEMENT PROJECT

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ABSTRACT

National Mapping Division, Water Resources Division, and the Bureau of Reclamation (BOR) have completed cooperative work that analyzes the watershed of a BOR–administered dam on the James River at Jamestown, N.D. The hydrology of the area provided a particularly challenging problem because of flat slopes, the complex nested drainage of the potholes, and a poorly defined drainage network. A special problem of pothole terrain is the determination of contributing versus noncontributing areas, and this critically affects flood estimates. This problem was solved by development of a new technique for identifying noncontributing areas.

The project utilized raster, vector, and tabular geographic information system tools and required the development of several specialized algorithms. Hydrologic parameters, such as pothole volumes and areas, were extracted from specially derived, high–accuracy digital elevation models and used to drive runoff calculations that estimated flood magnitudes. The results of this study are being used by BOR to evaluate the existing dam for potential upgrades.

SPATIAL DATA BASE DEVELOPMENT FOR HYDROLOGIC SYSTEMS ANALYSIS, JOHN DAY RIVER BASIN, OREGON

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ABSTRACT

In 1984, the U.S. Geological Survey Water Resources and National Mapping Divisions conducted a pilot study with the State of Oregon to demonstrate the use of geographic information systems (GIS) in water resources data management and analysis. The John Day River Basin of northeastern Oregon was selected by the State agencies to be a pilot basin for strategic water planning using a GIS. Each agency contributed tabular and mapped data pertinent to the individual agency's management requirements. U.S. Geological Survey personnel acted as advisors to designated personnel from each State agency in the design of the data sets, the entry of the data into the GIS, and the coordination of similar and related data elements among agencies.

Phase I of the project utilized a raster-based GIS called IDIMS and a relational data management system, INFO. Management scenarios were prepared using these systems to show the utility of GIS in resolving resource management problems with which the participating agencies are familiar. A report and a presentation were prepared for the State describing all phases of data base development including documentation of the final data sets and the results of the management scenarios.

Phase II of the project, conducted in 1986, focused on the conversion of data from the predominantly raster format to a topologic, arc-node format, where appropriate. This was done (1) to facilitate the transfer of data sets between the U.S. Geological Survey and State agencies who were in the process of developing a GIS capability of their own, (2) to take full advantage of state-of-the-art GIS analysis tools available through arc-node systems coupled with a relational data manager, and (3) to complete analysis and write a final report. Hydrography at 1:100,000 scale was acquired and tagged with Oregon stream codes. Other data themes were converted using raster-to-vector or vector-to-arc-node conversion utilities written for the project.

The large number of data themes from different sources managed by this project presented an opportunity to implement automated data documentation and archiving techniques. Documentation of source data, positional accuracy, date of compilation, projection parameters, and other pertinent information is managed with the archived spatial data. These documentation and archiving techniques will greatly facilitate the future use of the data by Geological Survey and cooperator personnel.

INTEGRATION OF GEOGRAPHIC INFORMATION SYSTEMS AND RIVER BASIN MODELS

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ABSTRACT

Geographic information systems (GIS's) have great potential for applications in river basin modeling. First, a GIS can help compute various input parameters and physical dimensions required by the river basin models. Second, a GIS could be a major part of an expert advisor system for applications of the models. Third, a GIS has potential for disaggregating a river basin into source areas and channel segments of relatively homogeneous properties. Also, river basin models can be modified to take full advantage of GIS tools.

The goal of this project is to verify the utility of a GIS on the first and third potential applications stated above. For the GIS techniques that have proven utility, procedures manuals will be developed to help transfer the technology. Currently, GIS tools are not that easy for modelers to use. Unless the tools are better packaged with easier access to digital data, they will not significantly impact river basin modeling.

The first GIS application will be the development of input for models. Given a vector or raster coverage of vegetation, soils, and elevation, many model inputs can be developed. For each tributary area in a river basin, soil evaporation and transpiration parameters depend on vegetation, soils, and aspect; infiltration of rainfall depends on soils, slope, and vegetation. Estimation of precipitation on tributary areas from point values at gages depends on digital elevation data and storm directions. Data on the volume, surface area and depth of channels, lakes, and depressions depend on digital elevation data. River basin drainage networks, the upstream–downstream connection of channels, and the association of tributary areas to channels can be derived from digital elevation data and digital line data on hydrography.

The second potential application of GIS technology in river basin modeling is in an expert advisor system for the application of a calibrated and verified model. As an example, the assessment of best management practices for the control of nonpoint sources of pollution or the evaluation of a new pesticide could be made. Under an expert advisor system, a user would identify a river basin in an interactive computer session, input the name of the new pesticide and its properties, and select the crops that might need the pesticide. Next, a map of the river basin would be displayed highlighting the areas where the pesticide would be applied. Next, a summary of the mean and range of the soil permeability, percent clay content, and depth of ground water would be displayed. If there is a potential contamination of ground water, a root–zone, hydrologic model would be applied using the soils, crop, pesticide, and climatic data to provide summaries of the risk of ground–water contamination. If a risk of surface–water contamination exists, a surface–water model would be applied based on the properties of the pesticide and erodability of the soil. The user, on a map of the drainage basin, would then locate points in the basin for summaries of pesticide concentrations in the water and the associated risks.

The third potential application is a more complex use of GIS technology for disaggregating a drainage basin. Given (a) soils data, (b) digital elevation models or surfaces represented with triangles, (c) vegetation cover, and (d) a set of rules, GIS software could divide the river basin into land areas of relatively uniform hydrologic response. Rules might include maximum or minimum area, maximum elevation difference, and maximum variation in aspect or slope. Vegetation cover and soils could be ranked based on their effect on the hydrologic response. Flow-path distance from nearest identified channel also could be used in the rules. Development of the technology will require much research, development, and testing.

Full realization of the GIS potential in river basin modeling might involve modifying or restructuring current river basin models. An example would be the routing of surface runoff from tributary areas. Using the National Mapping Division software and digital elevation data, a time-area graph based on overland flow times would be developed for a tributary area. With the graph as input, algorithms then could be modified in the river basin models.

The utility of GIS procedures is being explored on four projects: the 600-square mile Patuxent River basin, Maryland, for simulation of nutrients from urban and agricultural land; the 20-square mile Four Mile Creek, Iowa, for flow and sediment; the 90-square mile Lower Willow Creek, Montana, for snowmelt; and the 300-square mile Skokomish River for impact of timber harvesting on flow and sediment.

In addition, National Mapping Division, U.S. Environmental Protection Agency (EPA), and Aqua-Terra Consultants are designing and implementing file structures and utility subprograms for better integration of a GIS and river basin models. Software being used in the project includes ARC/INFO, macros for ARC/INFO, National Mapping Division basin delineation software, and Water Resources Division/EPA software, ANNIE/WDM, for data management and user interaction related to river basin models.

STANDARDS--WHY BOTHER?

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ABSTRACT

I know what you are thinking, "Frankly, standards are a pain! For example, to meet data entry standards for production of DLG-3 base category data one must use high-resolution equipment, digitize from map separates on stable base material, use complex attribute coding, etc.--all of which translates into extra time, effort, and expense. Why bother?"

I agree. The adoption and adherence to standards is a difficult, time-consuming process and can initially increase the effort and expense of performing a project. But look around. We live in a world greatly assisted by standards; e.g., our system of measurement, the color and position of lights that regulate the flow of traffic, the characteristics of gasoline that allow interchangeability among cars and petroleum manufacturers, and on and on! I believe that the user community and the Nation would be greatly served by the early adoption of digital spatial data standards.

Let me give a simple illustration. The adoption of the 5 1/4" compact disk as the standard size and data format for the new laser technology by the recording industry. This "standard" enables any entreprenuer in the world to devise a process (device) to read the disk more efficiently, with higher fidelity, with less power, and with a smaller physical size--in effect, to optimize the use of the data presented in this standard format.

In contrast, consider the inefficiencies introduced by as few as two different standard formats, as are found in the video cassette industry (i.e., VHS and Beta). One has to decide which format to invest in when purchasing a video cassette recorder (what do my friends have?), and the companies that rent video cassettes have to maintain copies in both Beta and VHS. Finally, consider the difficulty of implementing a technology that has many hardware and software systems, with 10 or more data formats--the current situation in the dynamic evolution of GIS technology.

We have the opportunity to emulate the success of the recording industry: to adopt a standard exchange format, to reduce the variety of approaches to data structure and content, and to consider common classification schemes and terminology. We have the opportunity because the GIS technology is still evolving, with no apparent dominant vendor who can implement a "de facto" standard, and we are just beginning the huge task of developing and converting data to digital form.

The timely development of appropriate standards is one of the primary goals of the Federal Interagency Coordinating Committee on Digital Cartography and the Interior Digital Cartography Coordinating Committee. These two committees, chaired by the U.S. Geological Survey, have a number of activities underway that directly or indirectly affect GIS research, development, and use. For example, in September 1987 a draft digital cartographic data exchange standard is expected from a special Geological Survey-chaired task force; by early 1988, a Departmentwide digitizing services contract should be available, ensuring compatibility of any digital data produced under the contract. Also early next year, a document should be forthcoming that outlines a process for evaluating geographic information systems, including a checklist of the generic functional

components of applications software, hardware, and operating software; and in the next few years, additional data categories (e.g., soil and wetlands) should be established as standard national thematic base categories. Considerable effort is still needed, however, to establish mechanisms to provide compatibility and linkages between the variety of thematic digital data bases produced at the regional or project level.

Instituting standards is tough business; most everyone is for them, as long as they affect someone else! Why bother? I believe that digital spatial data standards are the critical ingredient to ensure that the Nation's investment in digital data base development for use in GIS is of maximum benefit in the long term. In addition, focusing management attention on data compatibility and standardization will allow the evolution of the development and use of GIS technology to proceed with minimum constraints--a la the compact disk example.

BUREAU GIS RESEARCH POLICY, REQUIREMENTS, AND OPPORTUNITIES

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ABSTRACT

The Bureau GIS Policy Task Force prepared a policy statement for GIS that was endorsed by the Director in a memorandum dated November 6, 1985, "Geographic Information Systems (GIS) Policy and Approach."

The GIS policy statement highlights six major areas:

1. Application of GIS to the accomplishment of the Survey's traditional missions.
2. Identification of new and related missions.
3. Expansion of interdisciplinary research.
4. Improvement of GIS technology through research and application.
5. Development of data organization techniques.
6. Coordination of Federal Government GIS activity.

The U.S. Geological Survey strategy will be to build a sound GIS research base, conduct application projects, exchange data bases, and provide a mechanism for encouraging Survey scientists to use this powerful tool in their investigations.

To accelerate progress in achieving GIS goals, the Director established a bureau–level GIS fund of at least $500,000 to be applied with matching resources from project participants to support approved projects.

There are those that question the research value of GIS even though they know that diverse kinds of information are needed to solve most earth–science research problems. These researchers are uncomfortable with using more information than they can retain in their heads, perhaps supplemented by one or more file–cabinet folders of information. Not only do such researchers often ignore or are ignorant of much information necessary to their investigations, but their limited approach ignores the important scientific research findings of pioneers in the use of automated data banks. The advances in geophysics, for one example, brought on by computerized data banks are nothing short of astounding, from the modeling of the internal structure of the Earth in the 1950's; through body waves, surface waves, and Love waves in the 1960's; to seismic tomography today. In the post World War II period, we have gone through an information explosion in which most data only have been used to try to solve restricted problems. The vast amount of available data looked at in limited ways forms a research frontier of inestimable proportions for looking at complex problems that are closer to the realities of nature. GIS forms the gateway to this frontier for those pioneers willing to set forth into the unknown.

USE OF EARTH-RESOURCES INFORMATION FOR MANAGEMENT OF NATURAL RESOURCES IN THE GREATER YELLOWSTONE AREA; WYOMING, MONTANA, AND IDAHO

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ABSTRACT

A geographic information system (GIS) potentially is a powerful tool for the coordinated management of natural resources within large, complex ecosystems such as the Greater Yellowstone Area. The purpose of this project is to apply GIS techniques to selected resource-management problems by combining earth-resources information with biologic, land use, and other spatially distributed information. The Greater Yellowstone Area is well suited for such a study. This area of more than 12 million acres, widely recognized for its scenery and wildlife, includes (1) parts of three States and seven national forests; (2) two national parks and three national wildlife areas; and (3) wilderness areas, grazing lands, and many smaller areas of State, county, and private land. The area is used for outdoor recreation, timber harvesting, livestock grazing, water development, and energy and mineral resources development. Competing with human use of the land and water are such diverse wildlife as bear, elk, bison, eagles, cranes, and trout.

The project is designed to demonstrate the feasibility of an interactive GIS for natural-resources management in the Greater Yellowstone Area. Four specific issues are being addressed: (1) geologic hazards in Yellowstone National Park; (2) effects of conflicting use of land and other resources in the Mount Leidy highlands area of the Bridger-Teton National Forest and adjacent parts of Grand Teton National Park; (3) sources of sediment in streams in the Lamar River basin, Yellowstone National Park; and (4) the relation of recreational uses of the Snake River to riparian habitat used by eagles and other wildlife in Grand Teton National Park. Many different thematic coverages will be created for GIS analyses related to these issues.

A digital cartographic data base is being assembled from 17 quadrangles at 1:100,000 scale. The National Mapping Division is providing training and guidance to assure that digitizing of selected map features, such as boundaries, meets the standards for entry into the U.S. Geological Survey's National Digital Cartographic Data Base. Geologic Division personnel are assembling selected earthquake, geothermal, uplift, and other data related to geologic hazards. Some coverages for Yellowstone National Park, including bedrock geology, slope/aspect polygons, and vegetation type, are available from the National Park Service GIS Unit in Denver, Colo.; these coverages will be converted from the SAGIS (Spatial Areal GIS) format to ARC/INFO. New coverages to be automated for the same area, such as surficial geology and faults of Quaternary age, will be converted to standard DLG (Digital Line Graph) format for use by the Park Service in its GIS. Water-quality, fishery, and other data for the Lamar River basin will be provided by the Park Service and the U.S. Fish and Wildlife Service. For the Mount Leidy/Snake River area, with the exception of DLG data, all earth-resources, ecologic, and land use information remains to be digitized. The U.S. Forest Service has offered data and other assistance for the Mount Leidy part of the GIS. Source material at a scale of 1:24,000 will be used for that area.

APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM ANALYSIS TO ASSESSMENT OF IRRIGATION-DRAINAGE QUALITY, NORTH DAKOTA

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ABSTRACT

The Garrison Diversion Unit will irrigate approximately 130,940 acres of North Dakota farmland that has elevated arsenic and selenium contents. To assess the quality of probable irrigation return flows, a single 23,660-acre irrigation area near Dakes, North Dakota, was selected for evaluation. Samples of each soil horizon from borings made on quarter-mile spacings were analyzed for phase-specific and total trace-element contents. Although arsenic and selenium were found to occur principally in certain mineral phases, their absolute content in soil did not appear to be predictable from mineralogic abundances or other soil properties known on a more dense geographic basis. A weak north-south trend in trace-element content suggested evaluation using a geographic information system (GIS) might establish a statistical correlation.

Accordingly, data on soil trace-element content, elevation, land use, soil classification series, soil texture and particle-size, depth to water table, ground-water quality, soil mineralogy and organic content, soil oxygen concentrations, and soil hydraulic properties on quarter-mile or smaller spacing were stored in ARC/INFO GIS data bases. Data will be related topologically to attempt to establish correlations that will permit geographic distribution of the trace-element contents. These results will be compared to distributions generated using two-dimensional and three-dimensional kriging routines interfaced with ARC/INFO.

Once a geographic distribution of the trace-element data is obtained, equilibrium-speciation and reaction models will be used to predict the solubility of mineral species bearing the trace elements under the altered environmental conditions anticipated to occur during irrigation. A mass-balance water budget then will be used to predict drainage quality for the entire irrigation area.

THE QUEBEC–MAINE–GULF OF MAINE GLOBAL GEOSCIENCE TRANSECT

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ABSTRACT

This transect, a component of Global Geosciences Transects Project CC–7 of the International Lithosphere Program, will incorporate and integrate all available geological and geophysical data for the crust along a corridor 100–km wide and about 850–km long from southwest of Quebec City, Quebec, to the East Coast Magnetic Anomaly on oceanic crust southeast of Georges Bank. The transect crosses all major crustal features of the northern Appalachian orogen and is one of the first transects in the world for which the geophysical data sets were generated specifically to describe the entire crust in as much detail as possible. A newly added principal goal is to be one of the first to use current and developing geographic information system (GIS) technology to create three–dimensional representations of the Earth's crust to depths of ~50 km.

The project involves simultaneous manipulations of numerous large digital data sets that were acquired since 1983 on land and at sea by United States and Canadian government scientists and university collaborators. Many of the operational problems, such as selecting standard projections, finding compatible formats, and identifying necessary communication links between computers, mostly have been resolved, and large segments of the data are now or soon will be ready for manipulation.

High priority is being placed on assembling all available data sets for a test area measuring approximately 50 by 70 km so that the ARC/INFO GIS software and three–dimensional software packages such as Interactive Surface Modeling and UNIRAS can be evaluated using these data. Availability of digitized geologic, magnetic, and gravity data has already enabled evaluation of gridding intervals and the preparation of advanced derivative maps that demonstrate new geologic relations within the upper 10 km of the crust that can be verified with seismic reflection and refraction data. Examples of these derivative products will be shown.

Problems that must be resolved soon include development of a widely applicable and expandable Digital Line Graph code for digitized geologic maps, selection of three–dimensional software, and specification of format and content of initial published products. Longer term goals include (1) digitizing and blending the different geologic maps for Quebec, Maine, and the Gulf of Maine, and also the regional gravity and magnetic maps and (2) developing interactive display software that has the capability to rapidly evaluate and edit alternative crustal models and to produce derivative data sets.

GEOGRAPHIC INFORMATION SYSTEM FOR INTERPRETING AND DISPLAYING GEOCHEMISTRY OF SOIL, SHALLOW AQUIFER MATERIAL, AND GROUND WATER IN THE CARSON RIVER BASIN, NEVADA AND CALIFORNIA--PROJECT OBJECTIVES AND PLANS

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ABSTRACT

A geographic information system (GIS) is being developed to integrate physical and chemical data for surface soil, shallow aquifer material, and ground water in the Carson River basin of western Nevada and eastern California. The primarily semiarid closed basin covers 3,980 square miles and consists of a headwaters area and six major alluvial and lacustrine valleys that are interconnected by the Carson River.

The general objective of the project is to examine whether relations found between solid-phase geochemistry and water chemistry can aid in the regional description of ground-water quality. Specific objectives of this study are to (1) develop procedures to relate inorganic soil chemistry to trace inorganic ground-water chemistry on a regional scale; (2) determine if relationships exist between soil chemistry, shallow aquifer-material chemistry, and shallow ground-water chemistry on a local scale in the Carson River basin; and (3) contribute to the characterization of regional ground-water quality in the Carson River basin as part of the U.S. Geological Survey National Water Quality Assessment (NAWQA) Program.

Water-quality data that will be included in the GIS are information being collected for an assessment of ground-water quality in the basin, as part of the NAWQA project; and existing data from files of the U.S. Geological Survey and State and local agencies. Solid-phase chemistry data will include analyses of 360 soil samples being collected as part of a Geological Survey appraisal of soil chemistry in the Carson River basin; samples of soil and shallow aquifer material to be collected at 40 wells being drilled as part of the NAWQA project; 16 bottom-material samples collected as part of an irrigation-drainage project in the lower part of the basin; and limited existing rock- and sediment-chemistry data.

Determination of 25 inorganic constituents will be common to the soil, shallow aquifer material, and water-quality samples collected. Of these constituents, arsenic, boron, lithium, mercury, molybdenum, selenium, and uranium are known to occur within the study area in concentrations that affect human, livestock, or crop health.

Additional information such as geology, land use, soil characteristics, water use, hydrography, ground-water levels, and topography will be included in the GIS to aid analysis of the relationship between the geochemistry of surface soil, shallow aquifer material, and ground water in the Carson River basin.

The GIS for the basin will efficiently integrate text, numerical, and spatial information into one data base. The GIS provides analytic and manipulative capabilities that are difficult or impossible with conventionally structured data bases. Analysing and displaying these data in the context of a GIS is expected to enable relationships to be found among two or more physical or chemical properties that otherwise might be overlooked.

THE PADUCAH PROJECT: A DIGITAL CUSMAP

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ABSTRACT

The Paducah 1° x 2° quadrangle in southern Illinois and adjacent parts of Missouri, Indiana, and Kentucky was selected for resource assessment under the Conterminous U.S. Mineral Assessment Program (CUSMAP) because it contains significant known deposits and potential areas favorable for undiscovered resources of metallic and industrial minerals, coal, oil, and gas. The general objectives of the CUSMAP project are to develop an improved understanding of the geology, geochemistry, and geophysics of the quadrangle; to develop geologic models for the types of undiscovered mineral deposits that may be expected to occur; and to systematically apply the results of the modeling studies. The geologic data developed by the project will be used to evaluate the resource potential of the quadrangle and identify areas favorable for occurrence of undiscovered resources.

Specific geographic information system (GIS) objectives of the Paducah project study are (1) to develop GIS techniques for input of a variety of geoscience data from many different cooperating investigators from several Divisions of the U.S. Geological Survey and four State geological surveys with differing GIS technical capabilities; (2) to develop standardized methods for transfer of the data among the various contributors, so that all parties will have access to the data; and (3) to develop systematic methods of manipulating and combining the data utilizing the geologic models to make resource assessments.

Planned applications of GIS techniques for the project, new to CUSMAP, include the following: (1) digitization of geologic mapping at an intermediate scale (1:100,000), so that the final geologic map at 1:250,000 scale can be edited and produced digitally; (2) digital generation of subsurface geologic maps (isopach, lithofacies, and structure contour maps) directly from digitized data from hundreds of drill holes; (3) digital generation of subsurface geochemical maps from a complex digitized analytical data base; (4) comparison, synthesis, and experimentation with all the digital data sets, at each of the participating stations (Geological Survey–Denver and the State geological surveys); and (5) production of a variety of final maps for publication directly from the digital data bases.

Evaluation of ARC/INFO as a GIS system to geographically coordinate the large amounts and varieties of data required for a digital CUSMAP project began in January 1987. Digital line graph (DLG) vector data; geophysical data; point and watershed geochemical data; drill hole data; and structural, bedrock, and surficial geologic maps must be imported to the GIS coordinating system. Much of these data can be loaded directly into ARC/INFO, but data conversion and transfer techniques must be devised or improved to import subsurface, geochemical, and geophysical data from a variety of data bases. Because ARC/INFO works only in two dimensions, Interactive Surface Modeling software will be used to construct all contour, lithologic, and subsurface maps and cross-sections. This derivative information must be moved back into the GIS system.

The feasibility of the project is being tested with data for a pilot area of four representative adjoining 7.5-minute quadrangles. Planimetric and topographic bases, bedrock geology, surficial geology, mines and mineral occurrences, and aeromagnetic and gravity maps are in digital form. Input of subsurface stratigraphic data for drill holes in the area is in progress. Trial runs are expected to begin in May 1987. The main problem encountered has been the development of uniform methods of data transfer, both to and from the various cooperating agencies.

A GEOGRAPHIC INFORMATION SYSTEM DEMONSTRATION; INTERFACE TO A GROUND-WATER FLOW MODEL, WALLA WALLA RIVER BASIN, OREGON-WASHINGTON

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ABSTRACT

During the past decade, computerized geographic information systems (GIS) have become viable and valuable tools for managing, analyzing, and displaying water resources information. The Oregon office of U.S. Geological Survey, Water Resources Division, is evaluating the application of GIS technology to manage ground-water data associated with a three-dimensional, finite-difference ground-water flow model.

This project had the following objectives:

1. Apply GIS techniques to regrid the data arrays of an existing large-area, low-resolution ground-water model to a smaller, high-resolution grid.
2. Demonstrate GIS techniques for assembling data input arrays for the ground-water model.
3. Demonstrate use of GIS to (a) rapidly display different kinds of ground-water model output and (b) create customized maps from the ground-water model for use in reports.

The Walla Walla River basin, a 1,330-square-mile area of eastern Oregon and Washington, was selected as the study area. The Columbia Plateau RASA (Regional Aquifer-System Analysis) project was the source of the initial ground-water data used for this project.

Data for each of the five aquifer layers were transferred from the RASA grid of 80 rows by 130 columns (8,000- by 15,000-foot cell size) to a new grid of 83 rows by 83 columns (4,000- by 4,000-foot cell size). An area-weighted smoothing method was developed to transfer aquifer characteristics such a lateral hydraulic conductivity, vertical conductance, and top and bottom elevations of each aquifer from the larger RASA data arrays to the smaller grid.

GIS has been utilized to produce such displays of these data as contour plots of the aquifer surfaces and cross-sections of the basin showing the aquifer thickness. Information on the rivers, drains, recharge, and head boundaries also was transferred from RASA data arrays into GIS. The results have shown that a GIS can successfully be used to redefine an existing grid system and its related characteristics. GIS enhancements include interactive updating of model characteristics and displays of ground-water model output features.

A GEOLOGICAL ENGINEERING APPLICATION OF A KNOWLEDGE-BASED GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

The objective of this research, being conducted by the U.S. Geological Survey and the University of Missouri-Rolla, is to create a knowledge-based geographic information system (KBGIS) that can aid in the production of geological engineering maps and tables for a prototype study area. Expert system techniques are being investigated to implement a set of rules for geological engineering map production that can handle a variety of input data sources and output classification schemes.

The project uses the Earth Resources Data Analysis system (ERDAS) software to process earth resource information. Currently, rules for geological engineering map preparation are being entered into an IBM PC-based expert system called First Class. These rules will later be converted to Goldworks, an artificial-intelligence development environment for the IBM PC/AT, which includes an expert system shell, LISP programming, and interfaces to other languages.

The design requires the expert system to compare available data sources to desired output products, including maps, classification schemes, and tables. The system will account for missing data through a set of programmed rules and will select the optimum path for processing the basic earth resource information through the ERDAS software to achieve the desired output. The expert system will also generate ERDAS batch files to accomplish the processing and provide the user with a set of initial results. The user will then interact with the initial products to generate the final set of results. Map generation will be accomplished by converting the ERDAS raster files to a vector format and then entering these files into the ARC/INFO system. Final graphic products will be generated by the ARCPLOT software and plotted on a high-resolution cartographic plotter.

An initial examination of the KBGIS II software, delivered by the University of California-Santa Barbara to the Geological Survey under contract, was performed. This software system has potential application to the project; however, because of a lack of on-site hardware on which to install this software and a lack of training, KBGIS II is not being used. In later project stages, hardware may be available and KBGIS II will be reexamined at that time. Current project status is as follows:

- ERDAS is under procurement for the Geological Survey.
- Goldworks is under procurement.
- Rules for preparation of several maps have been assembled. This task is approximately 50 percent complete.
- The software design is complete.
- Data sets for the Rosiclare, Ill.-Ky., 7.5-minute quadrangle test site are available, including transportation, land net, boundaries, hydrography, hypsography, surficial geology, bedrock geology, and soils. Additional data sets, including remotely sensed imagery, depth to bedrock, borehole, and other geologic information, are being acquired.

GIS TECHNOLOGY FOR A MAP OF THE GLACIATED UNITED STATES EAST OF THE ROCKY MOUNTAINS

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ABSTRACT

A map has been prepared that shows for the first time a three-dimensional perspective of the Quaternary deposits in the glaciated United States east of the Rocky Mountains, at a scale of 1:1,000,000. When printed, the full-color map will show the textural character of surface sediments, the total thickness of Quaternary sediments, well-known buried units, and a variety of related point data. Cartographic preparation by conventional peelcoat methods is not practical because of the intricacies of the map areas, the complexities inherent in combining multiple polygonal data sets onto a single map, the need for scratch boundaries, and the large size of the map sheets. Digital map preparation is being researched by National Mapping Division and Geologic Division to provide an efficient means of publishing the map, and to create a digital version of the map data.

To develop the technology necessary to digitize and print this map, a small part of the map near Chicago, Ill., was selected as a test area. Linework for surface geology and sediment thickness was scanned by Scitex, and the polygons were tagged. The data sets were then converted to the ARC/INFO environment where they were merged, the resultant polygons were tagged, and spurious sliver polygons were eliminated. The data then were reconverted to Scitex format for preparation of positives or negatives to create press plates for map printing. All of these steps have resulted in a newly acquired technical capability for National Mapping Division's eastern region that is applicable to thematic maps in general. In addition, an interactive routine that enables the map author to tag and fill polygons is being developed by the GIS laboratory for use on this project.

This surficial geologic digital data base will be a principal part of a regional GIS that includes other geologic, hydrologic, environmental, and land use data. Cooperative studies that employ other data formats for the generation of derivative maps are being sought. For example, the locations of public supply well fields or landfills could be compared on a derivative map with areas of surface or buried sand and gravel and subsurface groundwater drainage divides. GIS technology will enable calculation of the total volume of sediment moved by various ice lobes during multiple continental glaciations and changes in sediment volume transport during the Late Wisconsinan. Further analysis, including a synthetic bedrock-surface topography map derived from the thickness contours and DEM data, may lead to a new understanding of the changing topography of the northern U.S. during the Pleistocene and residence time for glacial sediment on land.

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT EASTERN POWDER RIVER BASIN, WYOMING

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ABSTRACT

The U.S. Geological Survey, in cooperation with the Wyoming Department of Environmental Quality, is conducting a study to assess the cumulative hydrologic impacts resulting from surface coal mining in the eastern Powder River Basin of Wyoming. There are 16 producing surface coal mines in the study areas. Six additional surface coal mines either are being constructed or have applied for permits. Projected mine areas range from about 1,000 to 13,000 acres. Mining at the Wyodak mine began in 1922. The remainder of the mining operations were started in the 1970's and 1980's. Production from existing surface coal mines is projected to end between 1996 and 2026. Additional areas suitable for surface coal mines have been identified and are being considered for leasing in the future. A geographic information system is being used in the study as both a method of data compilation and management, and as a tool in the analysis of the data.

Considerable data have been compiled from a variety of sources. Boundaries of lease areas and of potential disturbed areas were obtained from maps on file with the Wyoming Department of Environmental Quality. Boundaries for Preference Right Lease Areas and Selected Coal Tracts were obtained from the U.S. Bureau of Land management. Drainage-basin divides were interpreted from topographic maps. Coal-outcrop and overburden-thickness maps were obtained from the Wyoming Geological Survey. Maps showing the predicted areal extent of water-level decline in the coal aquifer, due to dewatering of the mine pits, were obtained from the Wyoming Department of Environmental Quality. Ground-water rights and well-completion data were obtained from the Wyoming State Engineer's Office. The location and description of surface-water monitoring sites were obtained from Wyoming Department of Environmental Quality and U.S. Geological Survey records.

To the extent possible, the geographic information system will be used as an analytical tool in the study. A composite map of leased areas, Preference Right Lease Areas, Selected Coal Tracts, and overburden thickness has been made. From this map, an interpretation can be made regarding the relative size and distribution of leased areas, areas that are being considered for leasing, and areas that may be considered for surface coal mining in the future. Drainage-basin boundaries were overlain on the map with potential disturbed areas to determine the percentage of the area in each drainage basin that may be disturbed by surface coal-mining activities. These data will be used to assess the effects of surface coal mining on quantity and quality of surface runoff. The predicted extent of water-level decline in the coal aquifer was combined with the coal outcrops to define areas of potential ground-water decline. Well-completion data in the areas of potential ground-water decline will be used to identify water wells that may be affected by surface coal-mining activities and to assess the effects on individual wells.

ARTIFICIAL INTELLIGENCE APPLICATIONS USING PROSPECTOR

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ABSTRACT

The PROSPECTOR mineral consultant system is a computer hardware and software system designed to assist geologists in evaluating the potential mineral resources within a geographic area. Artificial intelligence (AI) techniques are emerging as the major problem-solving tools for knowledge-based systems. The use of AI technology has the potential for revolutionizing the way the U.S. Geological Survey, State, and other Federal agencies carry out regional mineral resource investigations and the way in which resource assessments are made. Advanced AI technologies have the potential to enhance the Survey's ability to perform a wide variety of its traditional missions.

The current version of PROSPECTOR resides on Xerox Artificial Intelligence Workstations located in the Geologic Division in Reston, Va., and the Water Resources Division in Denver, Colo. Presently 88 mineral deposit models constitute the knowledge base. The models have both procedural and data aspects, so that the geologist can either access values of variables or invoke methods for searching the knowledge base. A normal consultation with PROSPECTOR involves the geologist volunteering information about the general geology of an area and the program responding with the types of deposits most likely to occur within the area. An advantage is that the dialog between the geologist and the program is conducted using terminology familiar to the geologist.

There are a number of directions that the future development of PROSPECTOR can take. First, more deposit models need to be added to the existing knowledge base. A total of 200 models may be required to adequately represent the range of possible types of deposits to be found within an area. Second, handling of spatial data is needed in evaluating the potential mineral resources of an area; such evaluation requires the capability to handle map data in a manner similar to that already developed in geographic information systems (GIS's). Finally, quantitative resource assessments are needed in terms of the expected number, size, and grade of undiscovered deposits. These developments can take place only with the mutual cooperation of those engaged in regional mineral resource studies, those who are building GIS systems, and those developing quantitative methods for resource assessment.

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