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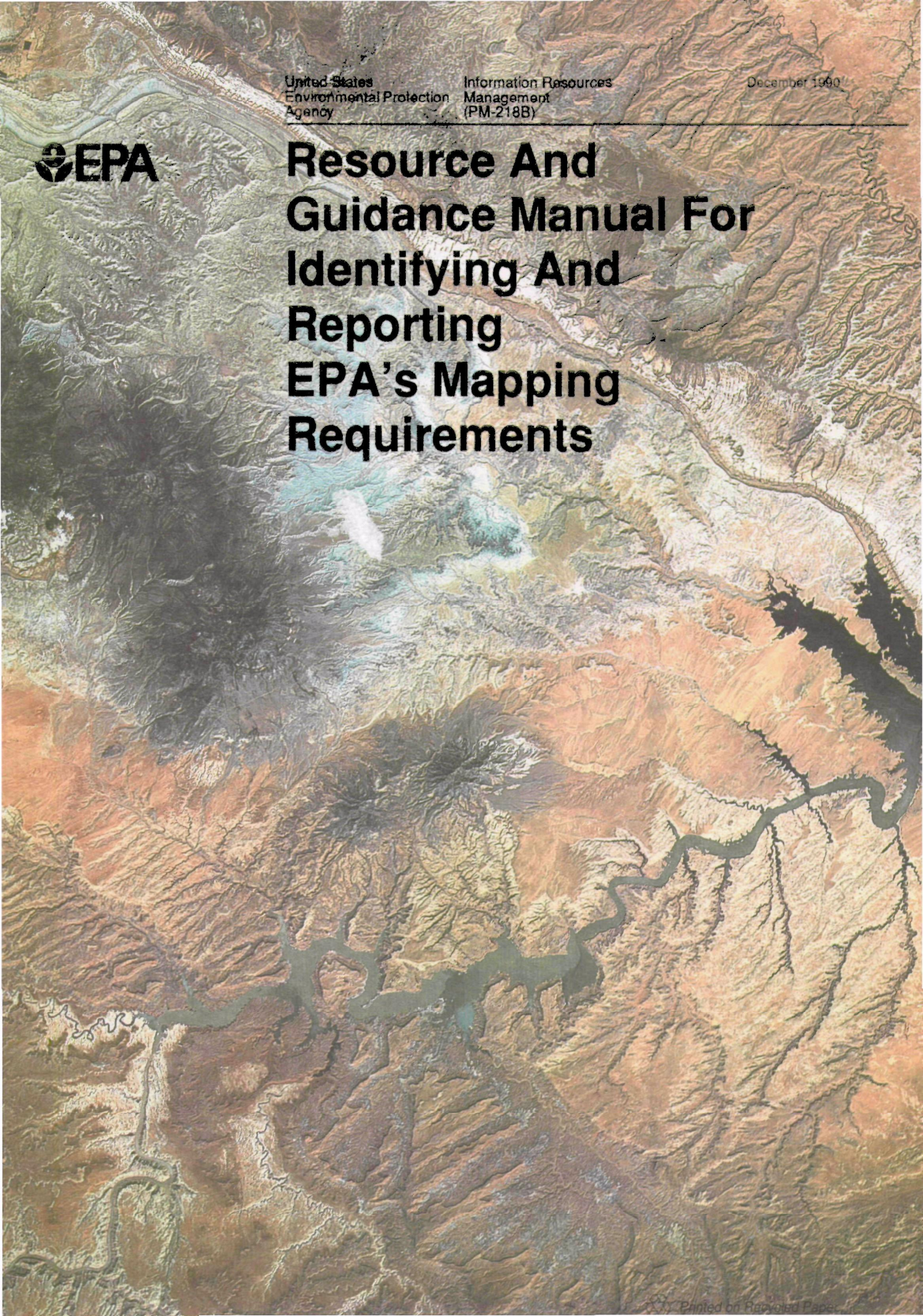

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National Mapping Requirements Program:

Resources and Guidance Manual for Identifying and Reporting EPA's Mapping Requirements

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NATIONAL MAPPING REQUIREMENTS PROGRAM

EXECUTIVE SUMMARY

The Office of Information Resources Management (OIRM) has initiated a National Mapping Requirements Program (NMRP) for EPA. The purpose of the NMRP is to provide EPA personnel the mechanism to identify, communicate, and acquire the geographic information necessary to meet program office goals.

OIRM established the NMRP in response to the U.S. Geological Survey's (USGS) request for EPA requirements for planning USGS national mapping programs. The focus of the NMRP was on the USGS map products and services as they pertain to EPA needs, as well as the Agency's own internal mapping capabilities provided by the Office of Research and Development. OIRM, through the NMRP, is responsible for coordinating the Agency's mapping requirements and its response to the USGS and other Federal agencies which provide mapping services.

The NMRP was designed to be a continuing program to identify EPA's present and long-term mapping requirements, communicate those needs to the appropriate agency, and provide the mechanism(s) for acquiring the geographic information. This goal was accomplished by establishing the following:

- *Mapping Requirements User's Group (MRUG)—comprised of representatives from the Program Offices, Regions, and Laboratories, to communicate the goals and requirements of the NMRP.*

- *National Mapping Seminar Series—conducted by EPA and the USGS to inform EPA personnel of the mapping products and services available to them.*

- *Resource and Guidance Manual—produced to serve as a product-oriented, reference document to assist EPA personnel in identifying and submitting their mapping requirements.*

- *NMRP Video Series—produced to highlight the National Seminar Series and to accompany the Resource and Guidance Manual for further review or Program summary.*

- *National Mapping Requirements Program Response—a consolidated, Agency-wide compilation of mapping requests from EPA staff which was summarized, ranked, and submitted to the USGS for consideration in its national mapping programs' production schedules.*

- *Information Identification and Acquisition Process—provided to assist EPA personnel in determining what geographic information is available, where it is available, and how to acquire it.*

The current focus of the NMRP is on USGS map products, data, technical and cartographic services. The USGS, as the premier mapping agency, has national programs designed to identify Federal agency mapping needs.

The USGS looks within and without its organization to identify map needs and to set priorities for future map production. The USGS mapping programs are conducted by three separate divisions, which rely on a coordinated approach to map production. The National Mapping Division (NMD) of USGS conducts the National Mapping Program (NMP), as directed by the Office of Management and Budget (OMB) Circular A-16. The NMP involves solicitation of Federal agencies for their cartographic and geographic mapping needs on an annual basis. The Geologic Division's (GD) National Geologic Mapping Program (NGMP) also identifies the mapping requirements of Federal agencies to identify areas in need of geologic mapping. There is no formal national program counterpart in Water Resources Division (WRD). Their review of hydrologic mapping requests from

Federal agencies are conducted on an as-received basis. However WRD has numerous programs that result in the production of various types of map products.

The goal of EPA's National Mapping Requirements Program is to foster information exchange. Through the NMRP, OIRM will assist EPA personnel in identifying and prioritizing geographic information needs and will coordinate Agency responses to the USGS. The NMRP will also result in an increased awareness of available geographic information and services, both within EPA and the USGS, as well as other Federal agencies. OIRM intends to increase options for EPA personnel to obtain information necessary for environmental protection. In addition, OIRM will assist in identifying the most cost-effective methods for obtaining the needed geographic information.

Chapter 1
Introduction

Chapter 1
INTRODUCTION

SUMMARY

Chapter 1 reviews the products, services, and responsibilities of the National Mapping Requirements Program (NMRP), the Office of Information Resources Management's (OIRM) involvement, and the cooperative roles of the EPA and the U.S. Geological Survey (USGS) which led to this EPA National Mapping Requirements Program.

1.1 The National Mapping Requirements Program (NMRP)

The purpose of the NMRP is to establish a mechanism for identifying and prioritizing EPA's current and long-term geographic information requirements. The NMRP is initially concentrating on U.S. Geological Survey's (USGS) map products and services and will respond to the USGS concerning agency requirements on a continuing basis. The reporting process to USGS is in direct response to requests from the Geological Survey for EPA involvement in two national mapping programs: (1) the USGS's National Mapping Program, which produces a variety of cartographic and image products and (2) the USGS's National Geologic Mapping Program, which produces a variety of geologic map products. The National Mapping Division annually canvasses Federal agencies as part of the USGS responsibility outlined in the Office of Management and Budget (OMB) Circular A-16. As the designated lead Federal agency for mapping, USGS has an important role in coordinating and producing the Federal government's primary geographic information. This mandate has been broadened to include geologic mapping under the National Geologic Mapping Program, which was initiated in FY 1988 to accelerate compilation and interpretation of data for the production of geologic maps.

The USGS's National Mapping Division, the Geologic Division, and the Water Resources Division jointly solicited EPA's participation to aid in the identification of mapping requirements. The Office of Information Resources Management (OIRM) responded by establishing the National Mapping Requirements Program (NMRP) and the process by which EPA will report their geographic information needs to the USGS.

The NMRP mechanisms currently consist of the following products and services:

- Mapping Requirements User's Group (MRUG);
- National Mapping Seminar Series;
- Resource and Guidance Manual;
- NMRP Video Series;
- Agency Response to the USGS; and
- Information Identification and Acquisition Process.

1.2 Office of Information Resources Management (OIRM)

The NMRP is being developed, conducted, and maintained within the Office of Information Resources Management (OIRM) by the Program Systems Division (PSD) in the Information, Technology and Integration Branch (ITIB). OIRM established the NMRP and the position of the NMRP Manager to lead the Agency-wide effort to identify mapping needs, prioritize those needs, and respond to the USGS. OIRM's mission is to ensure that the necessary information and information tools are available to EPA Program and Regional offices, which includes the planning, development, and operation of information systems and services in support of the Agency's administrative, programmatic, and research functions. Through the NMRP, OIRM will attempt to increase Agency awareness of available geographic information, assist in identifying mapping needs, and facilitate the acquisition of the requested geographic information. OIRM has the responsibility for developing a coordinated response to the USGS's national mapping programs.

Initial steps in the EPA coordination process were to discuss interagency communications with the EPA Office of Federal Activities, contact USGS staff for details on their national programs, and determine the optimum methods for OIRM to respond to the USGS requests for EPA participation. OIRM desires to communicate to the entire Agency that the selection and evaluation of future mapping need is necessary for

maintaining and expanding a comprehensive scientific information base to address environmental concerns properly. Key contacts are listed in Appendix A.

To obtain Agency-wide participation in the NMRP, OIRM desired to communicate with each EPA Program Office, Region, and Laboratory concerning the availability of geographic information within the USGS's national mapping programs and within EPA. The communications process involved letters to Senior Information Management Officers and other parties to announce and solicit interest in the NMRP, and to establish a core of active members for a Mapping Requirements User's Group (MRUG).

1.3 Mapping Requirements User's Group (MRUG)

The Mapping Requirements User's Group (MRUG) consists of EPA representatives from the Headquarters Program Offices, Regions, and Laboratories. MRUG's function is to communicate the goals and requirements of the NMRP to EPA staff and to facilitate information exchange within the Agency. Information exchange is accomplished through periodic national teleconferences, status reports, and NMRP product reviews (manual, mapping request submittal form, evaluation criteria selection) by MRUG representatives. All phases of the NMRP process were evaluated to provide a consolidated Agency-wide perspective. MRUG members are expected to take an active role in expressing Agency requirements and in informing other EPA personnel of the NMRP process to ensure the success of the program. MRUG participation is open to all EPA personnel and is encouraged for a more comprehensive and informed Program response. Anyone wishing to participate in MRUG and the NMRP should contact the Program Manager directly. See Appendix B for MRUG Representatives.

1.4 National Mapping Seminar Series

A National Mapping Seminar Series was conducted by OIRM and the USGS to educate and inform EPA personnel of the NMRP, mapping products, and services available and the process by which to identify and request geographic information. Ten seminars were conducted nationwide at Regional Offices, Headquarters, and Laboratories during the summer and fall of 1988. The first hour of the seminar was designed as an executive overview of the NMRP, its goals, objectives, and benefits, as well as a programmatic summary of the USGS and its three divisions which provide mapping services. The remainder of the seminar was a technical review of the divisions (National Mapping, Geologic, and Water Resources), their capabilities, products, and services as they pertain to EPA needs.

1.5 Resource and Guidance Manual

This document was prepared as a companion to the OIRM seminar series for the Agency-wide mapping program and to assist EPA personnel in assessing their geographic information needs. This first edition of the manual is intended to provide a summary of EPA and USGS mapping products, capabilities, sources, and contacts for further geographic information identification. As part of this document, a process is illustrated which will assist in determining and submitting future EPA mapping requirements. Revisions to this manual are presently scheduled to include pertinent mapping capabilities information from other Federal agencies.

1.6 National Mapping Requirements Video Series

NMRP Video is available for review and study by EPA personnel. The first two videos are a studio production of the seminar series which parallels its informational content and format. An executive overview is available for viewing separately from the technical presentations. The videos were produced for those EPA personnel who were unable to attend the national seminar series or who merely wish to review the information presented on the mapping capabilities and products of the USGS. Additional videos are also available describing the technical expertise of EPA's Office of Research and Development (ORD). These videos describe procedures and practical applications in the areas of Geographic Information Systems, Remote Sensing, and Environmental Photographic Interpretation.

1.7 National Mapping Requirements Program Response

It is the desire of OIRM to foster the exchange and acquisition of geographic information within the Agency. Mapping needs may range from individual maps for specific locations, to a broad acknowledgment that EPA will need national coverages for diverse environmental concerns.

The NMRP is intended to aid the EPA Program Offices, Regions, and Laboratories in identifying their future mapping needs for response to the USGS. As a result of the efforts of the MRUG members and the National Mapping Seminar Series, OIRM receives mapping requests from EPA staff for the products and services provided by USGS, EPA, and other Federal agencies. A mapping needs summary report will be compiled by OIRM, reviewed by MRUG members, and organized by Agency priority. This consolidated, Agency-wide response will include the summarized, ranked, and prioritized mapping requests for submittal to USGS for incorporation into its three-divisional budget requirements analyses for the following fiscal year.

When the USGS evaluations are complete, EPA will receive notification of the results of their requests within the overall responsibilities of the USGS Divisions. This notification will indicate how USGS intends to incorporate EPA's requests into their program planning and production schedule, and when the requests are scheduled for completion. This long-term planning process makes responding to immediate mapping needs difficult, especially when USGS will be incorporating EPA requests, and other Federal agency requests, into its following fiscal year planning.

USGS may not be able to respond to all of the EPA requests in a manner that meets the Agency's needs. High priority EPA cartographic and geographic information needs, which the Agency recognizes as requiring special attention from USGS, can be given greater emphasis in view of several options: demonstration projects; work-share; and cost-share agreements. However, prior to any interagency agreements for future map production, EPA's internal capabilities and resources should be reviewed. Many of EPA's mapping requirements can be accomplished through the expertise of the Office of Research and Development (ORD) and is the focus of Chapter 2. OIRM suggests that EPA staff contact the NMRP Manager for assistance in determining geographic information requirements and the options available for their acquisition.

1.8 Information Identification and Acquisition Process

Geographic information identification and acquisition is a planning process that requires a predetermined project design and methodology—both of which include interdisciplinary consultation and support. The following section is designed to assist EPA staff in identifying and acquiring the necessary geographic information *after* a project has been designed and a methodology for project implementation has been established. OIRM recognizes the importance of preproject design including consultation, project scoping, and technical support to identify the appropriate knowledge base for successful project implementation and completion. OIRM encourages EPA staff to contact the NMRP Manager for assistance in identifying the appropriate technical support for designing a geographically based application for environmental concern.

1.8.1 Identification of General Map Categories and Digital Cartographic Data

Background information on distinctions between maps and what types of maps are available is briefly summarized below. Greater detail is presented in Chapter 2 and Chapter 3 on the EPA capabilities and USGS programs, respectively, that produce maps and cartographic information relative to the development of a mapping needs request.

1.8.2 Printed Maps

The general categories of maps are planimetric, topographic, thematic, plots of digital data, and photometric. Each of these categories is discussed below.

Planimetric maps are those that contain only two-dimensional data (no relief). Base maps are included in this group since they are used as a beginning for the compilation of data for more specialized maps. Property maps, line-route maps, and national outline maps are examples of planimetric maps.

Topographic maps are further developments of a planimetric map with terrain and elevation details added. The most familiar topographic maps are the quadrangle map series, although there are also engineering,

flood control, landscape, and bathymetric topographic maps. In addition, terrain information is provided on shaded-relief topographic maps which simulate shadows to highlight terrain details, and on slope maps which portray elevation changes as a function of degree of slope.

Maps devoted to portraying a special theme are referred to as thematic maps. Examples are geologic, climatologic, historical, population, hydrologic, and land use thematic maps.

The plots of computerized data containing spatial components are referred to as digital maps. There are three types of digital map data: point, line, and areal (polygon). Data for a digital map are stored by coordinates, so that a consistent measurement scale is needed for those data. The major benefit of digital maps, for the user, is that the original data can be accessed automatically, analyzed, and layers of data accurately compared. Revisions and corrections to maps are also easier with digital data.

Photometric maps are used for rapid production of a map and are compiled from satellite, radar, sonar, or photographic systems data. Such maps are usually supplements to other map series and are considered to be interim maps. Orthophotoquads are photographic images (usually black and white) in the format of a quadrangle map and contain little additional cartographic information. Orthophotomaps are cartographically enhanced orthophotoquads. Both of these images have been adjusted to remove distortion effects.

1.8.3 Digital Cartographic Data

USGS is increasingly using digital data to produce maps. One of the goals of the NMP is to provide national coverage of primary cartographic data in digital form through the National Digital Cartographic Data Base (NDCDB) (USGS 1987). Data sharing and coordination with other agencies is being used to build and expand this national data base. The NMD will be transforming cartographic information, which had been presented in graphic form on its maps, into digital data for computerization. The GD is using digital data in the production of some of its maps, especially those in the Mineral Assessment Programs. Several data bases have been digitized by WRD (e.g., hydrologic units) and these data bases are also used to produce maps.

1.8.4 Federal Interagency Coordinating Committee on Digital Cartography (FICCDC)

In 1983 the FICCDC was created to (1) facilitate coordination and exchange of digital cartographic data by Federal agencies; (2) provide advice to USGS on digital data needs for the NDCDB; and (3) develop Federal standards for the NDCDB (USGS, 1987). The FICCDC has been chartered through 1991 by the Office of Management and Budget, is chaired by USGS, and contains representatives from 12 Federal agencies. The FICCDC is undergoing a rechartering review with EPA representation on that panel. EPA is also represented on several of the FICCDC working groups.

1.8.5 Map Scale, Accuracy, and Projections

A map is a symbolic visual representation of a location. The scale of a map is the ratio between distances in the area being mapped and the corresponding distance on the map. Therefore, the terms "small" scale and "large" scale refer to the relative magnitude of the ratio: the larger the scale, the smaller the area being mapped. When great areas of land are to be covered, the number of large-scale maps required may be cumbersome. Therefore, to maintain general content accuracy and reduce the number of maps needed, a user may select an intermediate scale map for a region of interest. It should be noted that when changing map scales, the content accuracy does alter. Highest accuracy and greatest detail are found in large-scale maps.

LARGE SCALE	1:24,000 (7.5-minute quadrangles)
INTERMEDIATE SCALE	1:50,000 1:62,500 (15-minute quadrangles) 1:100,000
SMALL SCALE	1:250,000 1:500,000 1:1,000,000 and above.

Mapping the curved, three-dimensional surface of the earth in two dimensions results in projection distortions, which vary with the type of projection. There are two major types of projections: equal area or conformal. Some projections are capable of equal-area mapping where constant scale is maintained, but shapes

and angles are distorted. This type of projection would be appropriate when it is of primary importance to measure or compare areas. When scale and shapes are of primary importance a conformal projection is used, but constant scale cannot be maintained. The most frequently used projection is the conformal. There are several familiar examples: (1) Lambert conformal conic projection which is used for State base maps at 1:500,000 scale and some of the 7.5-minute quadrangles; (2) Mercator conformal cylindrical projection which is used for nautical charts; and (3) Universal Transverse Mercator projection which is used for large-scale mapping, including some of the 7.5-minute quadrangles.

1.8.6 Information Acquisition Process

The acquisition of geographic information requires a systematic and thorough approach if the process is to be successful. A flow chart diagram (Figure 1-1) has been included to assist EPA personnel in understanding the procedures involved in acquiring the geographic information. This process is intended as a general guide to data acquisition, and therefore does not go into specific detail regarding issues of scale, quality assurance/quality control, data entry, documentation, verification, etc. OIRM encourages all EPA staff to contact the NMRP Manager and ORD staff for further clarification concerning these and other important issues. The NMRP Manager is available to answer specific questions at each phase of the acquisition process.

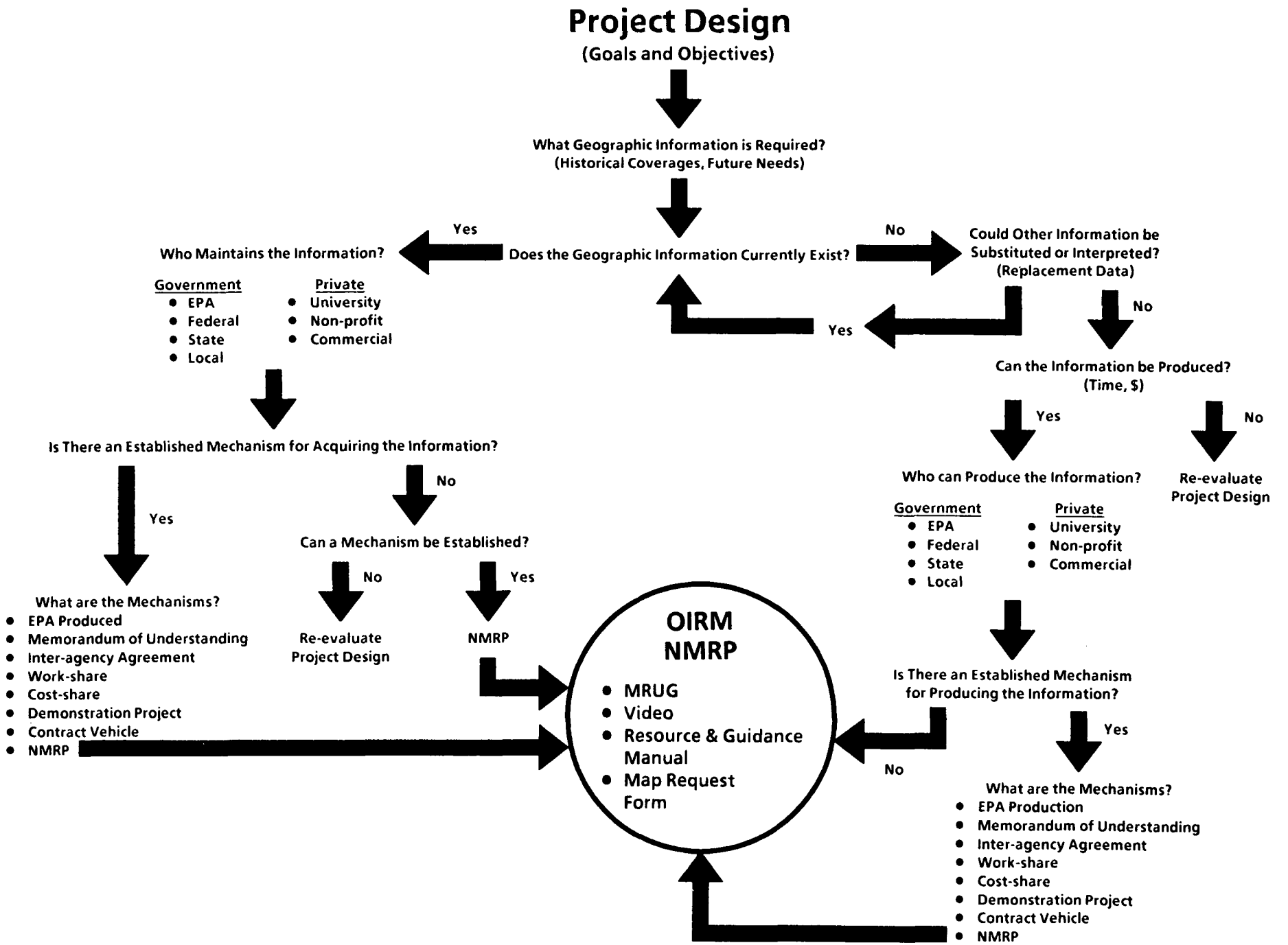


Figure 1-1. This flow chart illustrates the overall Information Acquisition Process and its interrogatory steps.

Chapter 2

EPA MAPPING CAPABILITIES IN THE OFFICE OF RESEARCH AND DEVELOPMENT

SUMMARY

The EPA Office of Research and Development (ORD)/Environmental Monitoring Systems Laboratory (EMSL-LV) in Las Vegas, Nevada, provides geographic information system (GIS) and remote sensing support (image processing, aerial imagery acquisition, and interpretation) for hazardous waste site investigations, assessments, and removal and remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended, under the revised National Contingency Plan (NCP), and under the Resource Conservation and Recovery Act of 1976 (RCRA). Support is provided through the Advanced Monitoring Systems Division (AMD) and its branches in Las Vegas, Nevada, and Warrenton, Virginia. The Remote and Air Monitoring Branch (AMS) provides multispectral image processing and GIS support to EPA programs. The Environmental Photographic Interpretation Center (EPIC) is a second branch of AMD and provides operational aerial photo interpretation and topographic mapping support. The EMSL-LV organization is illustrated in Figure 2-1.

2.1 Environmental Monitoring Systems Laboratory—Las Vegas, Nevada

The Spatial Analysis Laboratory (SAL), which is under EPA's Environmental Monitoring Systems Laboratory's (EMSL-LV) Remote and Air Monitoring Branch, is EPA's Center of Excellence for GIS and remote sensing research. SAL's primary purpose is to investigate, develop, and integrate spatial information systems in support of the Agency's mission.

EMSL-LV's mission includes the following objectives:

- Advance GIS and remote sensing research to meet EPA's needs;
- Facilitate transfer of GIS and remote sensing technology to EPA Regions and Program Offices; and
- Provide technical and policy support on GIS and remote sensing to all EPA programs and Regional offices.

To introduce the agency initially to the potential of remote sensing and GIS technologies, demonstration projects were conducted by EMSL-LV in each of the regions and across a broad spectrum of agency programs. Much of EMSL's work to date has been through these demonstration projects. As more of the Regional offices develop their own GIS implementation teams, the emphasis of EMSL-LV work on demonstration projects will diminish and greater emphasis will be placed on research programs, technology transfer, and support roles described below:

- Technical support to the regions;
- New technology evaluation;
- GIS technical memoranda series; and
- GIS training.

Because the demonstration projects conducted by EMSL-LV are numerous, three projects have been selected as case studies to be described in detail here. The case studies describe how a GIS has been used as a platform for other forms of data analysis including passive remote sensing imagery, active remote sensing (such as LIDAR), and modeling of flow systems.

2.1.1 GIS and Remote Sensing Research

As EPA's GIS Center of Excellence, EMSL-LV has undertaken a research program aimed toward the refinement of GIS and remote sensing technology and tools for the development of a broad range of applications specific to agency needs.

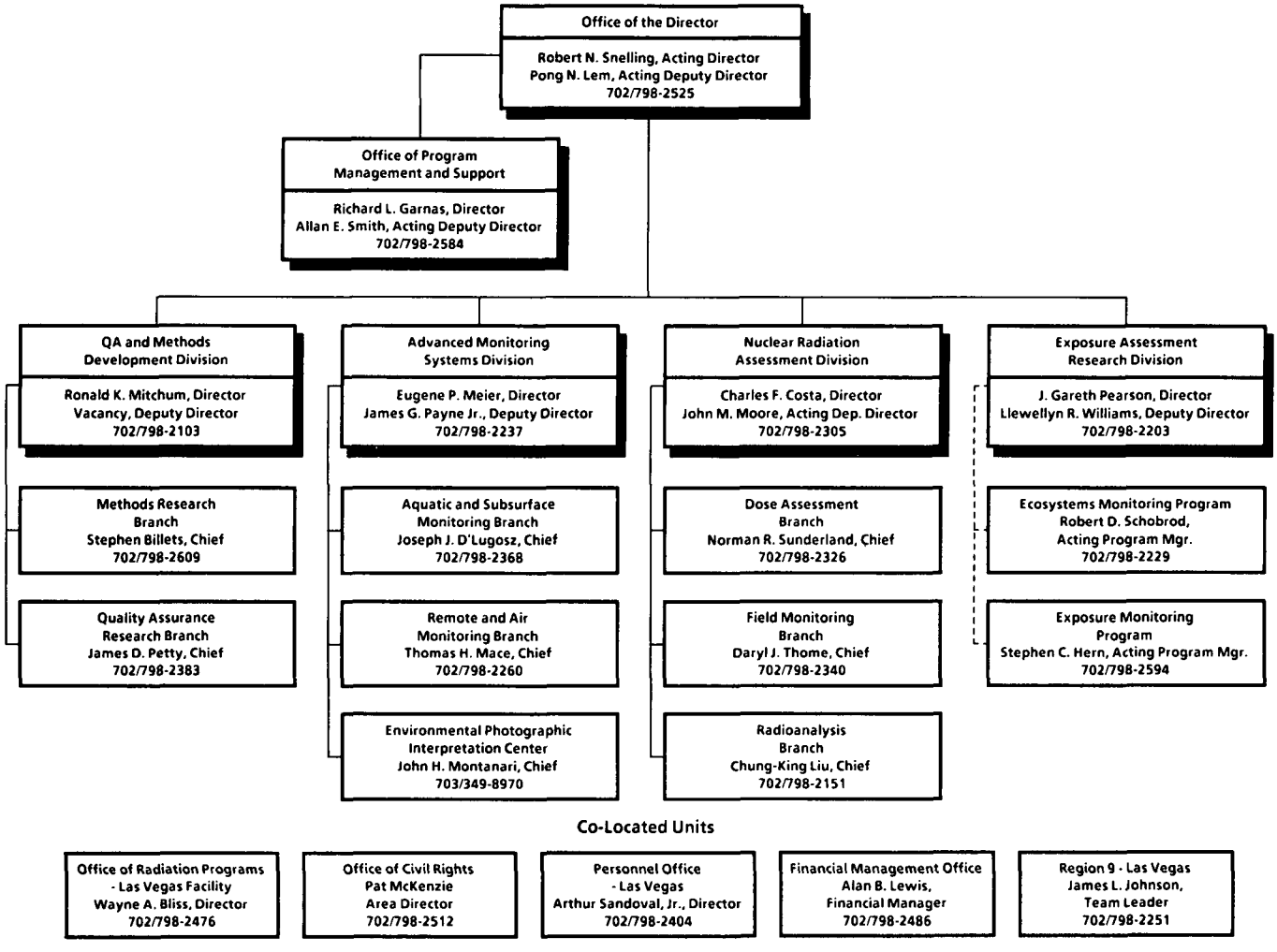


Figure 2-1. This figure presents the Office of Research and Development (ORD) Environmental Monitoring Systems Laboratory organizational structure.

GIS Research. EMSL-LV has initiated a cooperative agreement with the National Science Foundation to help establish the National Center for Geographic Information Analysis at the University of California at Santa Barbara, the University of Maine at Orono, and the State University of New York at Buffalo. Through this agreement, EMSL-LV will be coordinating its research efforts with other GIS researchers to examine design criteria for large spatial data bases, GIS data standards, quality assurance/control for spatial data, and the spatial representation of data uncertainty.

Other areas of GIS research being explored by EMSL-LV investigators include the following:

- Menu-driven user interface systems which allow less experienced users to access GIS data bases;
- ARC Macro Language (AML) programs to speed data processing and map product generation;
- Integration of external software programs to supplement ARC/INFO capabilities for data display and analysis;
- Specific tools and standard methodologies for CERCLA site assessment which serve to decrease the cost for using GIS for site-specific analysis;

- Three-dimensional modeling of data for scientific visualization;
- Incorporation of expert systems into GIS to broaden the decision-making capabilities of these support systems;
- Techniques to optimize data processing and sorting in GIS;
- Use of GIS as a platform to support environmental transport model development;
- Spatial data quality measurement and statistical analysis; and
- Development of EPA program-specific data base design standards and standards for data capture, data quality, documentation, and display.

Remote Sensing Research. The intent of EMSL-LV's remote sensing research agenda is to continue the development of tools and techniques that will assist the agency in the monitoring and modeling of environmental conditions. EMSL-LV's research initiatives focus on experimentation with new active and passive sensor systems for enhancing data analysis, handling, and storage techniques. These research activities include the following:

- Evaluation of new, high-spectral-resolution sensor systems such as AVIRIS which provides 224 spectral channels of information;
- Evaluation of new spatial data processing and analysis techniques;
- Development of quality assurance and control methods to quantify the quality of output products;
- Use of remote sensing in conjunction with GIS technology to perform ecological risk assessment analysis in support of EPA's programs;
- Development of standardized data integration techniques particularly for the conversion of data from raster (grid) to vector (line) format;
- Definition of specifications for new sensor systems that will meet EPA's diverse applications and monitoring needs;
- Continued development of enhancements to existing sensor system, such as navigational data integration, data recording, and decommutation enhancements; and
- Continued development of active remote sensing systems such as the UVDIAL for sensing concentrations of airborne ozone, SO_2, and NO_2 and LIDAR (Light Detection and Ranging) for sensing concentration of airborne particulates at varied elevations.

EMSL-LV research in remote sensing has enabled the agency to map many different environmental media, including national air quality. The succeeding paragraph is included as an example of how remote sensing tools provide critical support for the implementation of the Federal environmental statutes.

Visibility Monitoring and Assessment. In support of the Clean Air Act of 1977 (CAA), EMSL-LV has been the Agency's center of technical expertise on monitoring and assessment for visibility-protected Class I areas, required by CAA Section 169A. Activities include design, deployment, management, operations, and interpretative analysis of data from routine and research monitoring programs. EMSL-LV staff maintain a high level of involvement in nearly every major multiparticipant visibility program including SCENES, WHITEX, and RESOLVE (research monitoring in the southwest United States); IMPROVE (a nationwide routine monitoring program); and the visibility assessment for the National Acid Precipitation Assessment Program. In addition, staff act in an advisory role in a number of programs including NESCAUM (a consortium of eight northeastern states), and, in California, for the Tahoe Regional Planning Agency visibility monitoring programs. These activities allow EMSL-LV to provide up-to-date technical assistance concerning availability of existing data, monitoring approaches, network design, and data interpretation.

2.1.2 Technical Support to the Regions

EMSL-LV provides technical support for regional project development involving GIS and remote sensing. The GIS assistance has included support for Regions in the development of custom system tools (e.g., tape management libraries, command libraries, symbol tables), review of documents on pilot projects, assistance in designing GIS data bases, and consultation on hardware and software problems associated with the use of GIS. Additionally, EMSL-LV maintains a GIS HOTLINE (FTS: 545-2179) to provide direct access to support staff for questions concerning GIS, remote sensing, and computer operations. Help with data conversion is the most often requested item on the hotline. Through this work, EMSL-LV assists in the integration of GIS technology throughout EPA, as well as supporting specific regional projects.

Remotely sensed images are available upon request to the regions. EMSL-LV is experienced in all aspects of imagery collection, spectral data processing, and classification. EMSL-LV also has the tools and expertise to ground truth the image classification correctly and georeference the image to the field location. Landsat, thematic mapper, and AVHRR satellite data can be purchased for anywhere in the country. In addition, low altitude multispectral scanner data can be collected using EMSL-LV's own plane and scanner. Remote sensing can be used to delineate land cover, stressed vegetation, wildlife habitats, and has been used very successfully for mapping wetlands (Figure 2-2).

Technical Evaluations

EMSL-LV has been called upon to review new and emerging technologies and assess whether these new technologies have an appropriate role in assisting EPA to further its mission. Currently, EMSL-LV is conducting technical evaluations for the Office of Information Resources Management (OIRM) in the following areas:

- PC GIS: EMSL-LV is evaluating the usefulness of PC GIS, its utility in the Regions, and interfaces with other computer platforms.
- Workstations: EMSL-LV is evaluating workstations and network systems that would run between the workstations and mini-computer-based GIS.
- GIS/Remote Sensing: EMSL-LV is investigating data transfer algorithms between these two technologies, which would involve the combination of vector and raster data.
- Global Positioning Systems: Topics pertinent to GPS survey planning, reconnaissance, and post-processing are being explored through the use of GPS in project work at EMSL-LV.

Further technical evaluations and cooperative efforts are planned in support of the program goals of the Office of Information Resources Management.

2.1.3 GIS Technical Memoranda

To disseminate the knowledge and experience that it gains through demonstration projects, support programs, and other technical research, EMSL-LV publishes a series of technical memoranda. To date, the topics of published and draft memoranda are as follows:

- "GIS Project Planning and Data Set Selection," published as GIS Technical Memorandum 1-88;
- "Processing Digital Line Graphs using ARC/INFO";
- "One-to-Many Relationships in ARC/INFO";
- "Methods for Population Enumeration Using a GIS";
- "Nationwide TIC Reference System"; and
- "Global Positioning Systems: A Primer."

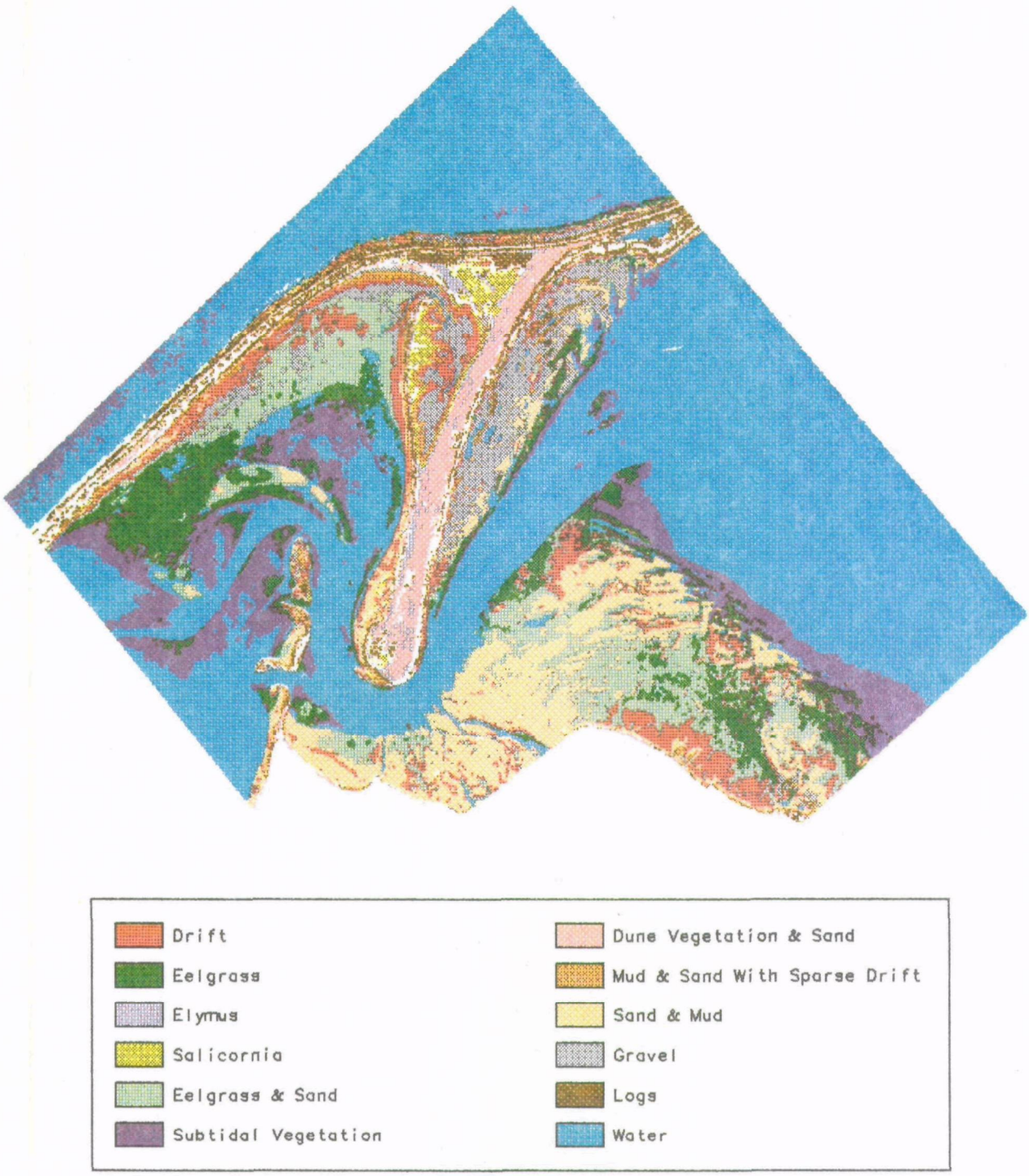


Figure 2-2. In this aircraft multispectral scanner imagery, collected over Dungeness Bay, Washington, the raw data records the amounts of energy reflected by the earth's surface in several channels or bands of wavelength. Computer-assisted analysis and comparison with known reflective patterns allows a grid cell classification of the type of surface cover. In this example, the data are classified in terms of vegetation habitats occurring within the intertidal zone of a portion of Puget Sound.

2.1.4 GIS Training

EPA will begin its own training program to instruct agency personnel in GIS and in the development and use of specific EPA GIS applications. Reliance upon vendor training classes will be substituted with classes explicitly tailored to meet EPA's GIS training needs. EMSL-LV will support OIRM on the content and structure of the GIS training program. EMSL-LV will be calling upon the University of California Santa Barbara (UCSB) to assist with the refinement of curriculum and will provide instructions for those individuals who will become EPA's GIS trainers. In addition, EMSL-LV will develop and present workshops on advanced topics in GIS.

2.1.5 Remote Sensing and GIS Case Studies

Three projects have been chosen for presentation in this Resource and Guidance Manual that are representative of the breadth of EMSL-LV's technical capabilities and expertise.

The Commencement Bay GIS is a project designed to support the execution of the National Contingency Plan process for hazardous waste site cleanup. The Pearl River Advanced Wetlands Identification GIS was built to compare different methods of wetland delineation and to serve as a platform for wetlands extent monitoring. The Denver Brown Cloud Project was developed using GIS as a tool to display and visualize the spatial distribution of LIDAR data and, eventually, to show the correlation of air quality with land use.

Commencement Bay NPL Site. EMSL-LV's work with the Commencement Bay NPL Site is an example of a demonstration project that has become a useful tool for environmental analysis in a Superfund site assessment. The project has given the Superfund remedial project manager the ability to browse, view, sort, and analyze data in ways previously unavailable because of the tremendous volume of data available. EMSL-LV's work demonstrated the power of combining a relational data base with a GIS, providing analytical processing capabilities and the ability to produce high-quality maps and summaries.

With the assistance of the Region 10 Superfund site manager, EMSL-LV obtained the Knowledgeman data base from the Superfund site contractor, and also acquired data on potential sources of contamination, including fish and water samples. EMSL-LV used this data, in addition to data purchased and digitized at the SAL, to build a comprehensive GIS data base.

Using ARC/INFO's NETWORK module, the segments of the drainage network contributing to outfalls in the bay were identified by simulating flow throughout the system. A map of outfalls and the associated drainage network was produced (Figure 2-3).

A digital parcel data set was obtained from the City of Tacoma and was incorporated into the GIS data base. By examining concentrations of contaminants at outfalls and the associated drainage network, parcels that may have contributed to the drainage could be identified. The data for these parcels could in turn be used to identify potential contributors of contaminants.

Pearl River Advanced Wetlands Identification. This project was initiated through a joint venture by EMSL-LV and Region 6 to promote GIS technology within the region. The region's Environmental Services Division believed that GIS could provide the tools necessary for the environmental analysis required for the Advanced Identification Process (ADID). Approximately 131,000 acres in size, the Pearl River wetlands contains one of four bottomland hardwood forests in the United States and is being adversely impacted by surrounding urbanization, channelization, and planned flood control projects.

ADID is a mechanism where wetland sites are identified based upon their suitability for future disposal of dredged or fill materials. Wetlands sites are assessed according to functional values, wetland trends, developmental pressures, and environmental analysis. GIS is being used to organize, integrate, analyze, and display environmental, geographic, and anthropogenic data associated with the ADID process. GIS objectives have focused on the development of analytical methods for delineation of wetlands, correlation to National Wetlands Inventory data, and technical transfer of these methods for analysis of other wetland association.

Wetlands delineation was based on comparisons of hydrologic extent, vegetation analysis, and soil types. GIS was used to perform watershed modeling and integrate remote sensing analyses with various base map and digital data from the U.S. Geological Survey and Soil Conservation Service (Figure 2-4). Remote sensing played a significant role in the compilation of land use data, using Thematic Mapper imagery for classification of land use types. A Theoretical Distribution of Wetlands module (TDW) has been developed at EMSL-LV to allow access, display, and analysis among the various spatial data bases compiled during the life of the Pearl River ADID Project. Using a menu-driven user interface, users can easily perform sophisticated data base queries related to wetlands delineation; initiate multiple-criteria comparisons, including the National Wetlands Inventory; and produce graphic displays and hard-copy maps of various analyses.

Denver Brown Cloud Project. EMSL-LV and Region VIII initiated the Denver Brown Cloud project to examine the feasibility of integrating Light Detection and Ranging (LIDAR) data with GIS. LIDAR is a laser technology which records, as a digital signal, the back scatter from particles or other substances reflecting the laser

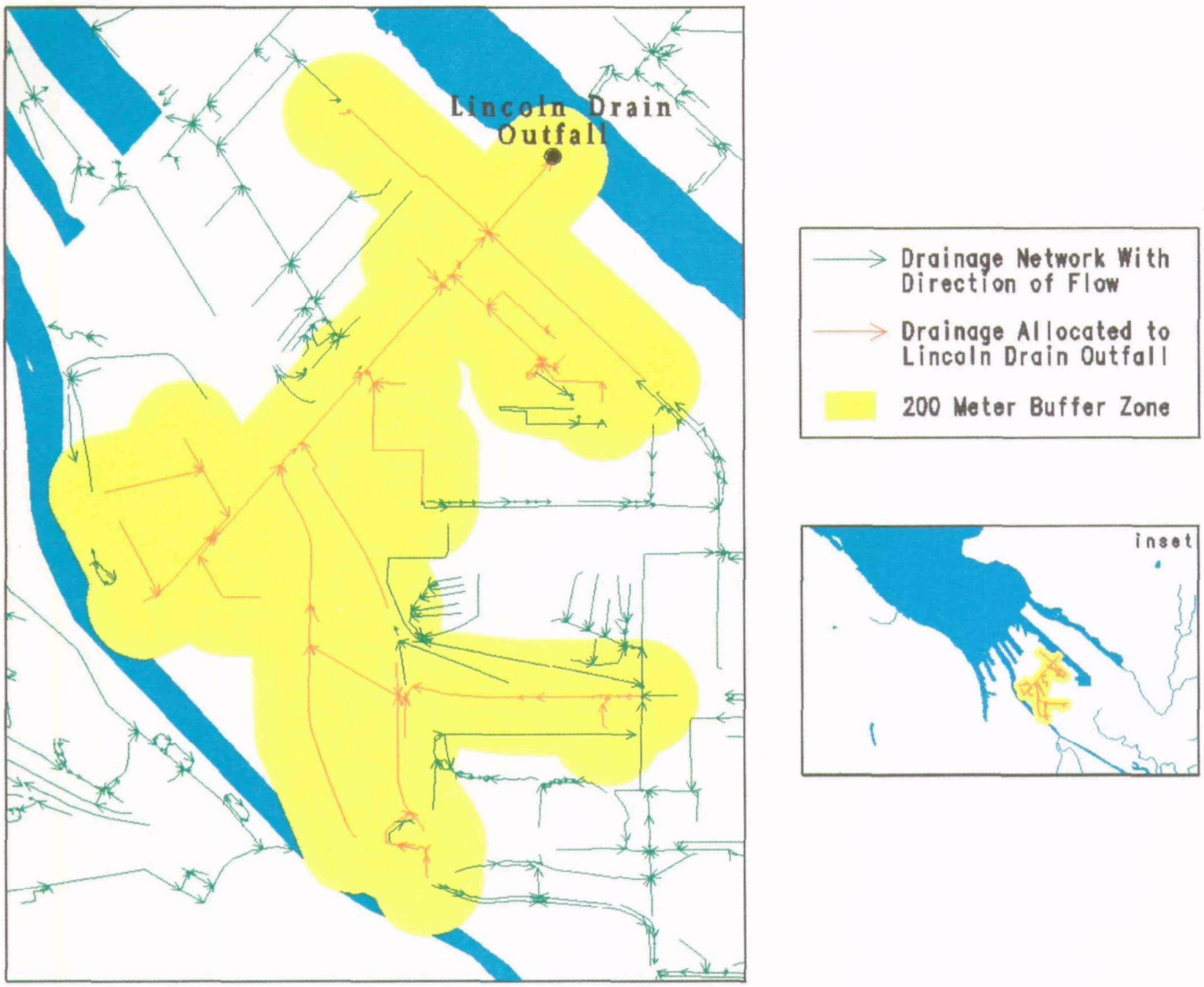


Figure 2-3. Intensive site analyses often include mapping of drainage patterns, such as this buffered drainage area in the Commencement Bay GIS Demonstration project.

beam. Because the back scatter from LIDAR may be due to factors other than particulates in the air, the Denver Brown Cloud project attempted to correlate LIDAR values with particulate values as measured by ground-monitoring stations. For the correlations, the particulate measurements from the ground-monitoring stations will be regarded as "truth." If the correlations indicate that the LIDAR values are highly correlated with the ground monitoring station values, then the LIDAR and GIS may be used as a technique to model atmospheric particulate (Figure 2-5). Initial results of the correlation tests between LIDAR and the ground-station data have proven inconclusive.

A second major effort of the Denver Brown Cloud project involved the development of a methodology for air pollutant exposure assessment. As part of an initial effort, LIDAR values from 30 meters elevation over Denver were grouped into nine ranges. The spatial distribution of these ranges was then mapped. Census tracts were digitized from 1:24,000-scale maps and population data by census tract and age/sex categories were obtained. The number of persons for specific age/sex categories were then overlaid with the ranges of LIDAR data as a preliminary assessment of populations at risk from particulate pollution. If LIDAR is validated as being an accurate measure of particulate pollution, LIDAR readings taken at various elevations could be overlaid with a variety of population and health statistics to assess health risks from particulate pollution.

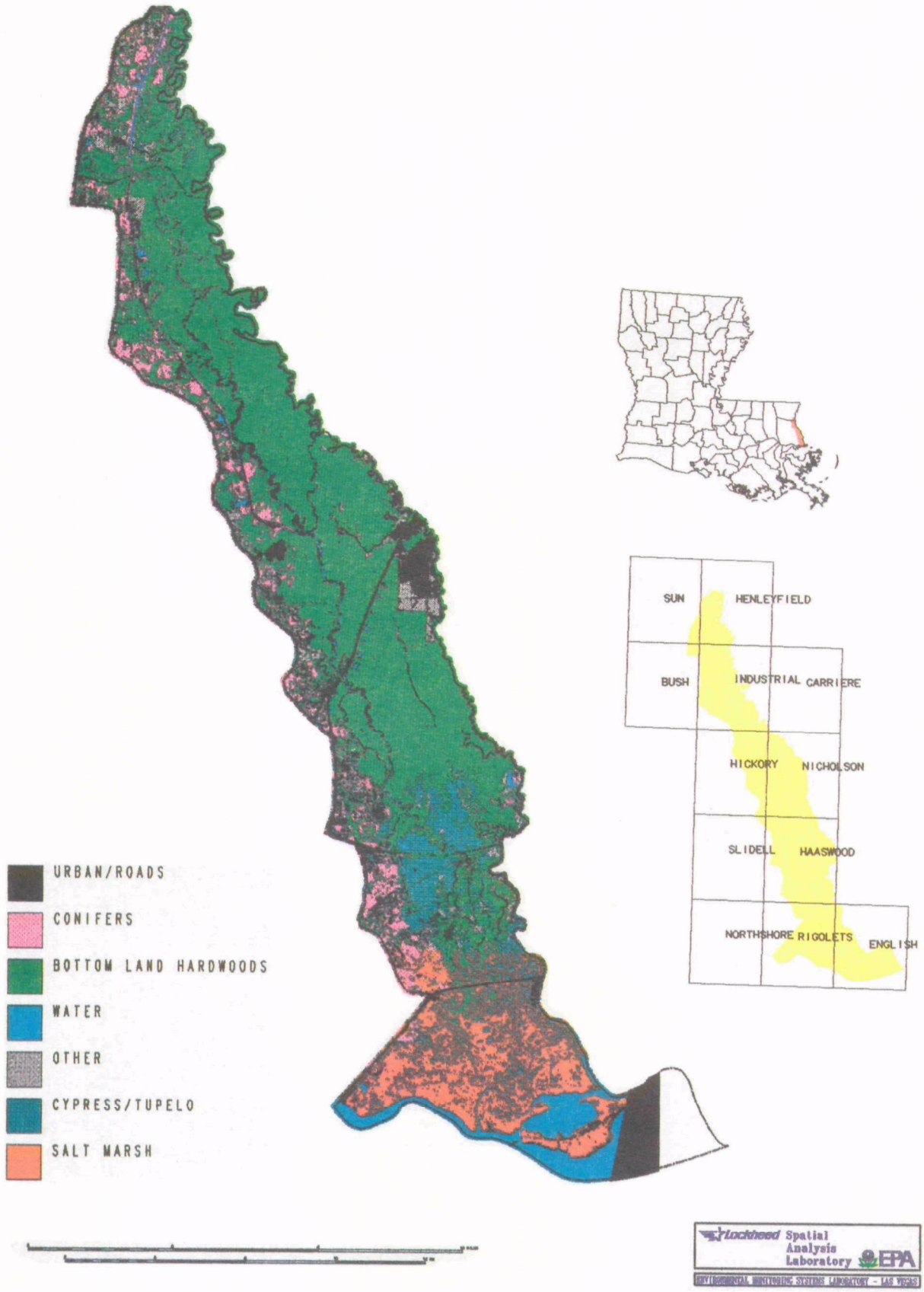


Figure 2-4. Wetlands analyses typically rely on aerial photographs for vegetation identification, such as in this Pearl River Wetlands ADID project.

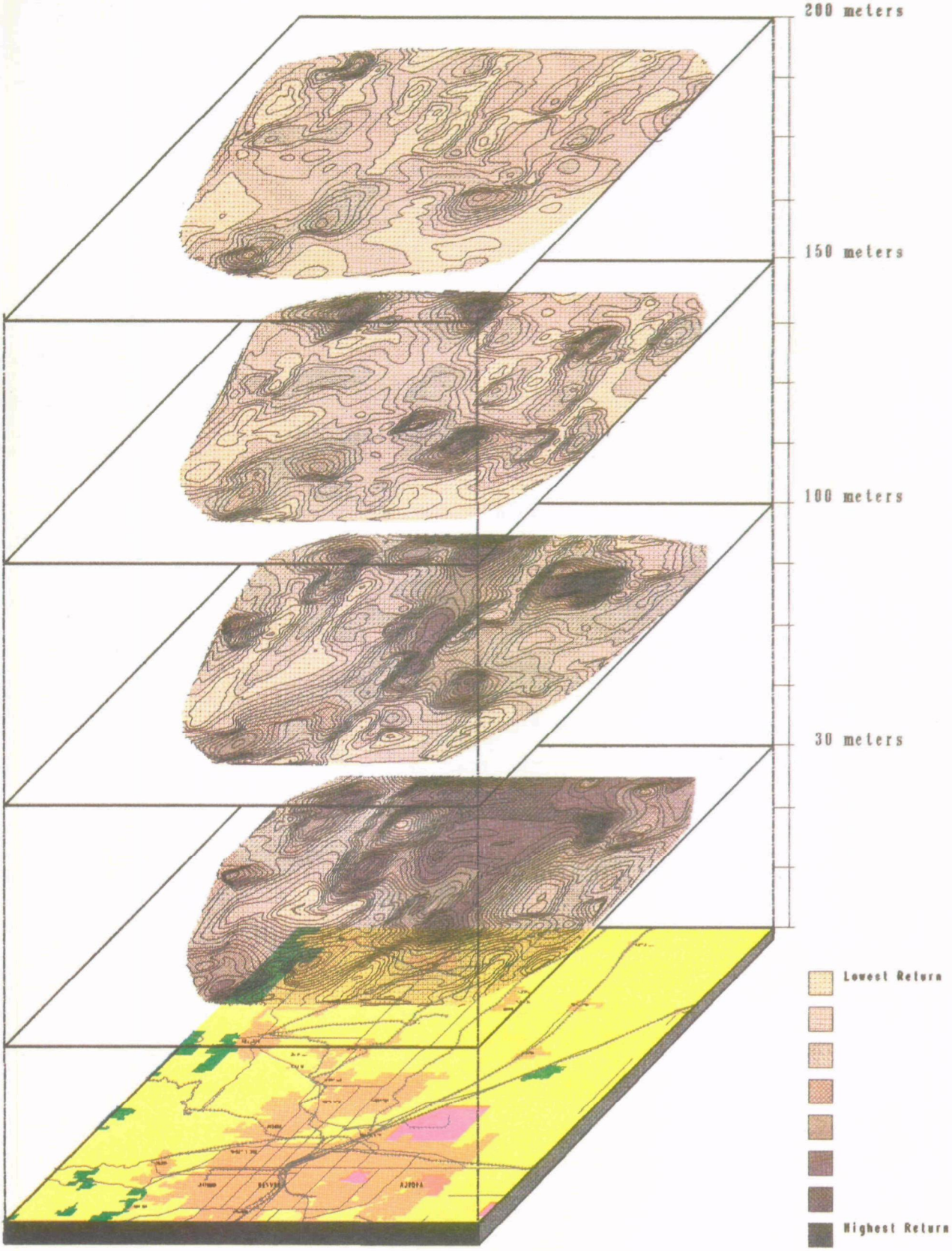


Figure 2-5. The Denver Brown Cloud project used Light Detection and Ranging (LIDAR) data to model atmosphere particulate levels at specific elevations. *These data are from the January 20, 1988 event.*

2.2 The Environmental Photographic Interpretation Center

The Environmental Photographic Interpretation Center (EPIC) provides operational remote sensing support to EPA Offices and Regions nationwide. EPIC is staffed by professionals skilled in applying photo interpretation methods and techniques to analyses of a variety of natural and cultural resources and impacts to these resources by man or natural processes.

EPIC has two separate facilities, each supported by private contractors who perform the majority of the aerial photo acquisition, photographic processing, and analysis work. EPIC operations are located at the EMSL in Las Vegas and at EPIC branch headquarters in Warrenton, Virginia.

Aerial photography is the most common remote sensing technique for supporting the Spill Prevention Control and Countermeasures (SPCC), CERCLA, and Resource Conservation and Recovery Act (RCRA) programs and investigations. The principal aerial photographic system used is the 9" x 9" mapping camera. Color and black and white film is most frequently used for photo analysis, black and white is often used for mapping, and color infrared films are often used to enhance such features as surface water turbidity, soil moisture, and vegetation stress. Various types of aircraft are used at flight altitudes ranging from 1,000 to 25,000 feet above the ground to obtain imagery at scales appropriate for the different types of information being sought. A number of special purpose products are produced from photographic data which are based on advanced technologies. Such products include topographic and flood plain mapping using photogrammetry.

Most historical photography is black and white. Little color or color infrared photography is available for the years prior to 1970. A major reference source for historical photography is the Earth Science Information Center of the U.S. Geological Survey, which maintains an index of the imagery holdings of the Earth Resources Observations Satellite (EROS) Data Center of the Department of the Interior and of the Aerial Photography Field Office of the Department of Agriculture. The earliest photography is available from the National Archives.

Archival aerial photography provides a valuable source of information for the historical analysis of sites and is routinely used. EPIC often uses the Sanborn Fire Insurance Maps which provide information about a site between approximately 1860 and the advent of regularly acquired aerial photography circa 1920. For more than a century, the Sanborn Map Company of Pelham, New York, has published maps and atlases of more than 12,000 U.S. cities and towns. These large-scale, highly detailed maps of commercial, industrial, and residential buildings are designed to provide accurate, current, and detailed information to fire insurance companies about the buildings they insure. The Sanborn maps furnish information about ownership, occupancy, building layouts, and materials used in chemical and other manufacturing processes.

2.2.1 Products and Services

EPIC offers a wide range of aerial products and services including the following:

- Aerial Photo Overflight Planning and Data Acquisition;
- Aerial Film Processing;
- Historical Aerial Photo Search and Acquisition; and
- Aerial Photo Analyses.

Image analysts are fully qualified to provide expert witness testimony on the analysis findings. In addition, EPIC has interagency agreements with the U.S. Army Corps of Engineers and the U.S. Geological Survey for preparation of the following:

- Topographic and Planimetric Maps;
- Orthophotos;
- Analog and Digital Map Products;
- Photogrammetric Mensuration;
- Aerotriangulation;
- Digital Elevation Models (DEMs);
- Digital Line Graphs (DLGs); and
- Custom Map Perspectives (e.g., 3-D modeling).

EPIC produces fully annotated maps and photos and descriptive reports as specified in requests for its services. Descriptions of seven project types are summarized below and presented in Table 2-1:

- Emergency Response Documentation;
- Single-Date Analyses;
- Intensive Site Analyses;
- Waste Site Inventories;
- Wetlands Analyses;
- Fracture Trace Analyses; and
- Photogrammetric Mapping.

The first four of these—Emergency Response, Single Data Analyses, Intensive Site Analyses, and Waste Site Inventories—are basic types of remote sensing projects under the CERCLA, RCRA, and other EPA programs. The highest priority projects are emergency responses to hazardous material release situations requiring rapid assessment of conditions at a site. When current information on a site is required, new photography is acquired. Single-date analysis may be conducted on this new imagery or on historical imagery taken during a particularly significant period in the history of a site. Intensive site analysis projects are performed on selected sites to document changing conditions over a period of time and include analysis of both current and historical photography. Finally, waste site inventories are surveys over large areas and are used to establish a baseline reference of possible sites.

Emergency Response. Emergency requests are given top priority and emphasis is directed toward quick response. Emergency requests are usually in response to a hazardous materials release and require information on current conditions at a site. Extent and location of visible spillage, vegetation damage, and threats to natural drainage and human welfare are examples of information gathered from emergency response activities. Typical products for an emergency response project include an immediate telephone report followed by photographic prints or positive film transparencies with interpretation results annotated on overlays to the photos, annotated topographic maps, and a short letter report describing analysis results. Scales for emergency photo coverage vary with condition and area coverage requirements. A response time of 1 to 5 days is typical, depending on weather conditions and type of coverage required.

Single-Date Analyses. Projects in this category are conducted on a routine basis to acquire current information on a site or sites. These projects usually require acquisition of new aerial photography, although recent photographic coverage of a site may suffice. Analysis generally focuses on surface drainage conditions, evidence of leachate, vegetation damage, adequacy of containment features, and threats to sensitive habitats. Final output products include reports documenting the analysis results containing photographs and maps with interpretation annotated on clear overlays to pinpoint the site locations and conditions. These projects can normally be completed in 6 to 36 weeks after data collection, depending on the number, size, and complexity of the sites and on the detail of information required.

Intensive Site Analyses. These projects are performed for an analysis of changing conditions at a site over time (Figure 2-6). These projects rely heavily on the availability of historical aerial photography (available from the 1930s for many areas). Photographic coverage of a site prior to the existence of any hazardous waste processing and disposal activities is obtained when available, as is coverage at several points in time afterwards.

Intensive studies performed by EPIC have characterized changes in surface drainage conditions; identified the location of landfills, waste treatment ponds/lagoons, and their subsequent burial and abandonment; detected and identified the burial of waste drums, and their horizontal extent in burial pits; and recommended drilling sites for sampling and identification of the sources of spillage and discharge of wastes.

Generally, an intensive site investigation requires 4 to 6 months to complete. However, the time required to complete any project will depend on the number of available data sets that must be acquired, processed, and analyzed. Acquisition of imagery alone takes approximately 2 months. Output products for intensive site investigations include a detailed report documenting the photo analysis results for each data set, and a summary of the analysis with specific reference to the purpose and requirements of the requester. The reports usually include photographs and maps with major observations annotated on clear overlays. Annotated photographic enlargements for field or legal purposes can be provided.

Waste Site Inventories. EMSL-LV conducts general inventories over relatively large areas to detect and locate hazardous waste sites. The inventories are conducted by using archival, recent, and/or newly acquired aerial photography and may be single-date or multi-date in nature. Site locations are annotated on map sheets or on overlays to maps and photographs. No detailed site analyses are performed, but data sheets are provided with a brief description of each site. The interpreter will frequently flag those sites that appear to be particularly hazardous or threatening.

Hooker S-Area Site September 25, 1938 Approx. Scale 1:3,100

Figure 2-6. This figure shows a time sequence for the Hooker S area site in Niagara Falls, New York, from 1938 to 1958. Vertical and oblique (shot at an angle to the ground), black and white, and color aerial photographs were analyzed for this sequence which clearly illustrates substantial change and development of the site.

Hooker S-Area Site August 9, 1958 Scale Variable

Figure 2-6. (Continued)

Table 2-1. Remote Sensing Projects and Products

Project Type	Application	Product	Turn-Around	Approximate Cost/Site
Emergency Response	Hazardous Materials Release	Prints and Overlays, Annotated Maps, Interpretative Description	24 hours	$3.1K
Single Date Analysis	Current Information	Report with Prints, Maps, Overlays, and Interpretative Description—Single Date	6 to 36 weeks	$3.8K (Single sites) $2.1K (Multi-sites)
Intensive Analysis	Change Analysis	Report with Prints, Maps, Overlays, and Interpretative Description Using Historical and Current Data	4 to 6 months	$6.2K
Area Inventory	Regional Survey	Report with Prints, Maps, Overlays, and Interpretative Description	2 to 12 months	$70/sq mile
Wetlands Analyses	Mapping and Change Analysis	Report with Prints, Maps, Overlays, and Interpretative Description	3 to 8 months	*
Photo-geology and Fracture Trace Analysis	Mapping and Quantitative Analysis	Report with Prints, Maps, Overlays, and Interpretative Description	1 to 5 months	*
Photogrammetry	Mapping and Quantitative Analysis	Topographic Maps, Area and Volume Calculation	3 to 6 months	**

*We have insufficient data at present to provide accurate cost. Call for cost estimate on specific sites. Cost varies with site size and data density.

**Cost depends on contour intervals, size of site, population density, and on whether or not ground survey teams are required to wear protective gear while surveying the site. The larger sites will average out to lower cost per acre than the small sites. The costs have ranged from $10.00 to $1,300.00 per acre depending on the mapping requirement of each site. It is more cost-effective to conduct the ground survey around the hazardous waste site and not require the survey team to suit up into protective gear.

The use of archival photography offers the most economical and accurate method of compiling these inventories. The time required to complete an inventory will vary with the total square miles involved, the number of sites, the chronological range, number of dates of photography, and the analysis requirements.

Superfund Site Atlas. Uncontrolled hazardous waste sites listed by the EPA as being eligible for remedial response actions under Superfund are documented in photographic volumes for each EPA region. The atlas, intended as a reference document and planning guide for hazardous waste site cleanup under CERCLA contains site location, maps, and color aerial photographs with photo overlays showing the boundaries of the sites and surrounding areas. The atlas covers those sites designated as eligible on the National Priorities List (NPL) of September 1984. EMSL-LV maintains an index to available aerial photographic data for these priority sites.

Removal and Remedial Action Documentation. Aerial photography is collected before, during, and following removal and remedial actions at selected sites. Such documentation provides a useful record of the effectiveness of the cleanup efforts.

Wetlands Analyses. Executive Order 11990, "Protection of Wetlands," requires Federal agencies conducting certain activities to avoid the adverse impacts associated with the destruction or loss of wetlands. EPA's "Statement of Procedures on Floodplain Management and Wetlands Protection" requires programs to (1) determine if proposed actions will be in or will affect wetlands and (2) to avoid or minimize adverse impacts of those actions. Besides indicating actual impacts such as vegetation damage or habitat loss, aerial photographs can delineate areas that may be impacted if remedial action does not address certain problems. Aerial photographs can provide information as to vegetation type, wetland-upland boundaries, and draining patterns (Figure 2-7).

Photogeology and Fracture Trace Analyses. Photogeologic analysis services from EPIC entails the interpretation of the geology of an area from an analysis of landforms, drainages, tones, and vegetation distribution visible on aerial photographs. Information derived from photogeology has proven to be useful to hydrologists working at those hazardous waste sites having ground-water contamination problems.

Fracture trace analysis involves the use of aerial photographs and other types of imagery to identify linear features on the earth's surface. Linear features have several origins: geological (fractures, faults, dikes); vegetational (row crops, orchards); and man-made (roads, railways). Fracture trace analysis is often used for the placement of monitoring/remedial wells around CERCLA and RCRA hazardous waste sites. Fracture traces are naturally occurring and are defined as surface manifestations of subsurface fracture zones in the bedrock. Fracture traces are of environmental concern because contaminants are likely to move more easily through zones of fractured bedrock than through more consolidated bedrock.

Photogrammetric Mapping. EMSL-LV produces topographic and feature maps, generally at small contour intervals, using precision photogrammetry where control points have been established. This technique requires specialized equipment, complex computations, aerial photography, and field surveys. These maps are produced using the National Map Accuracy Standards and EPA Photogrammetric Mapping Specifications. Map scales, contour intervals, and planimetric details can be varied to suit specific requirements. A typical output from a photogrammetric project might include an orthogonally correct black-and-white, enlarged photograph of a site and reproducible Mylar map sheet(s) containing highly accurate, detailed topographic and planimetric features. At a very large scale (e.g., 1 inch equals 50 feet) the map may show buildings, roads, railroads, drainage features, bridges, culverts, fences, driveways, poles, sidewalks, individual trees, fire hydrants, manholes, catch basins, and other features of similar size.

There are several useful applications of photogrammetry in support of hazardous waste site assessments and removal or remedial actions. Highly accurate topographic and planimetric details may be recorded without setting foot on the site. This capability can be significant in overcoming problems related to gaining access to private lands and related to protecting field personnel from hazardous conditions. Maps may be useful in measuring the area, volume, and locations of the hazardous material to be handled (such as contaminated soil); defining drainage patterns; determining the height and placement of containment berms, dikes, and impoundments; and determining the depth of waste pits. Photogrammetric techniques are also useful in support of geophysical monitoring or well monitoring in terms of establishing precise location and orientation data. In addition, changes in size, shape, and other physical characteristics of a waste site can be documented through sequential photogrammetric mapping.

Date of Photography: July 18, 1987 Approx. Scale 1:5,900

Figure 2-7. Shown here is a Marathon Development Corporation site in Seekonk, Massachusetts. Black and white, natural color, and color infrared aerial photography are all used to map a broad range of impacts on wetlands environments. Black and white aerial photography is a valuable tool for illustrating changes over time. Natural color photography allows mapping of submerged aquatic vascular vegetation and delineation of emergent plant species. Color infrared photography is often valuable for enhancing the recognition of wetland plant species, illustrating the vegetation that may be stressed, and emphasizing the land/water interface in wetland areas.

2.2.2 Summary of Products and Services from EPIC

Examples of EPIC products and services include aerial photo overflight planning, data acquisition, and analyses; aerial film processing; historical aerial photo search and acquisition; topographic and planimetric maps; orthophotos; analog/digital map products; digital elevation models (DEMs) and line graphs (DLGs); and custom map perspectives (e.g., 3-D modeling). EPIC projects are facilitated through EPA Regional Office staff designated as Remote Sensing Coordinators.

2.2.3 EPIC Automated Report Information Retrieval System (Report Locator)

EPIC has developed its new report information data base which will provide all EPA Regional and Program offices with both hard copy of, and interactive computer access to, summaries of all aerial photographic analyses project reports ever completed by EMSL, Las Vegas. Information in the data base includes the following:

- site name;
- EPIC project number;
- report date;
- site size;
- funding source;
- project officer;
- image analyst;
- NPL number;
- report name;
- 7-1/2' quad name;
- latitude/longitude;
- EPA Region;
- State;
- county;
- city; and
- SSID number.

In addition, the data base lists the dates, types, and scales of aerial photographs analyzed as well as the types of information obtained from the analysis. A user's guide, manual, and computer disks/tapes will be available for distribution to Regional and Program offices.

Chapter 3
USGS MAPPING CAPABILITIES

SUMMARY

Chapter 3 identifies the mission of the United States Geological Survey (USGS) and describes in detail the mission, organization, and capabilities of the three USGS program divisions:

- *National Mapping Division (NMD)*
- *Geologic Division (GD)*
- *Water Resources Division (WRD).*

The current programs of each division are described, as well as planimetric, topographic, thematic, photo-image, and digital mapping activities, products, and services available to EPA. Selected research and development efforts are identified for each division along with specialized capabilities that may be tailored to meet special mapping needs.

Major programs that are identified in this chapter include:

- *NMD National Mapping Program (Section 3.2)*
- *GD National Geologic Mapping Program (Section 3.3.2.1)*
- *GD Environmental Geochemistry and Geophysics Program (Section 3.3.2.2)*
- *GD Offshore Mapping Program (Section 3.3.2.4)*
- *WRD Federal Program (Section 3.4.3)*
- *WRD Federal-State Cooperative Program (Section 3.4.4)*
- *WRD Other Federal Agency Program (Section 3.4.3).*

Essential information required to develop a statement of mapping requirements to be conveyed from EPA to USGS is presented. As part of the Agency NMRP, these requirements will be compiled, reviewed, prioritized, and presented to USGS. Table 3-1 (see page 3-17) lists the USGS program status maps from the NMD for illustration of map coverage. Contacts from either EPA or USGS can assist EPA staff in the development of mapping requirements which may be satisfied by existing products or require a special mapping request. Exhibit A at the end of this document contains the form for use in communicating your mapping needs to OIRM.

3.1 Geological Survey

The United States Geological Survey (USGS), a bureau of the United States Department of the Interior, was established in 1879 to conduct a systematic and scientific classification and examination of the public lands, geological structure, and mineral resources of the Nation. Soon after its establishment, the USGS began topographic surveys to prepare reliable base maps of the Nation, and in 1888 began irrigation surveys to measure the flow of the Nation's streams. These tasks were expanded in 1962 when the USGS began to examine the ocean floor and certain areas outside the United States, and in 1983 when the USGS began to evaluate resources in the newly created U.S. Exclusive Economic Zone (EEZ) which stretches 200 nautical miles seaward from the Nation's coastline.

3.1.1 USGS Mission

The mission of the USGS is to collect, interpret, and publish information about the Nation's energy, mineral, water, and land resources; to determine the geologic structure of the United States; and to develop an understanding of earth processes and hydrologic principles. To accomplish its mission, the USGS performs the following functions:

- Conducts and sponsors research in geology, hydrology, cartography, geography, and related sciences and provides scientific support for legislative, regulatory, and management decisions.

- Produces and updates geographic, cartographic, and remotely sensed information in graphic and digital formats.
- Collects and analyzes data on the quantity and quality of surface water, ground water, precipitation, and water use.
- Assesses water resources and develops an understanding of the impact of human activities and natural phenomena on hydrologic systems.
- Describes the onshore and offshore geologic framework of the Nation and develops an understanding of its formation and evolution.
- Describes the aquifer framework of the Nation and develops an understanding of ground-water flow systems and water quality.
- Assesses energy and mineral resources, determines their origin and manner of occurrence, and develops techniques for their discovery.
- Evaluates hazards associated with earthquakes; volcanoes; floods; droughts; toxic materials; landslides; subsidence, and other ground failures; and develops methods for hazards prediction.
- Publishes reports and maps, establishes and maintains earth science data bases, and disseminates earth science data and information.
- Coordinates topographic, geologic, and land-use mapping; digital cartography; aerial photography; and water-data activities with Federal, State, and local agencies as well as with academia and industry.

3.1.2 Organizational Structure

The USGS is organized into five divisions (Figure 3-1). Its scientific studies are conducted in the National Mapping, Geologic, and Water Resources Divisions. The Information Systems and Administrative Divisions provide support for these studies. The *National Mapping Division* produces topographic maps and updates and revises these maps periodically, conducts research to improve map production and techniques to develop new map products, and develops national digital cartographic and geographic data bases. The *Geologic Division* conducts geologic, geochemical, and geophysical investigations to determine the geologic structure and processes affecting the Nation, to assess the energy and mineral resources of the Nation, and to establish geologic factors that bear on land use, environmental quality, and geologic hazards. The *Water Resources Division* conducts investigations on the amount and quality of the Nation's surface and ground water, studies hydrologic flow and transport processes to better understand, evaluate, develop, and manage the Nation's water resources, coordinates water data acquisition activities of other Federal agencies, and works with other Federal agencies to investigate specific water-resource problems.

3.2 National Mapping Division

The primary mission of the National Mapping Division (NMD) is to conduct the National Mapping Program. This program provides cartographic and geographic products for the United States and outlying areas of sovereignty and jurisdiction. The products include several series of topographic maps in both graphic and digital form, photo and other image maps, land use and land cover maps and associated data, geographic names information, geodetic control data, and remotely sensed data.

The NMD conducts several activities to accomplish its mission:

- Collects, compiles, and analyzes information about natural and man-made features on the Earth's surface, and documents changes as appropriate.
- Produces and maintains a series of accurate and up-to-date, general purpose base maps and thematic maps.

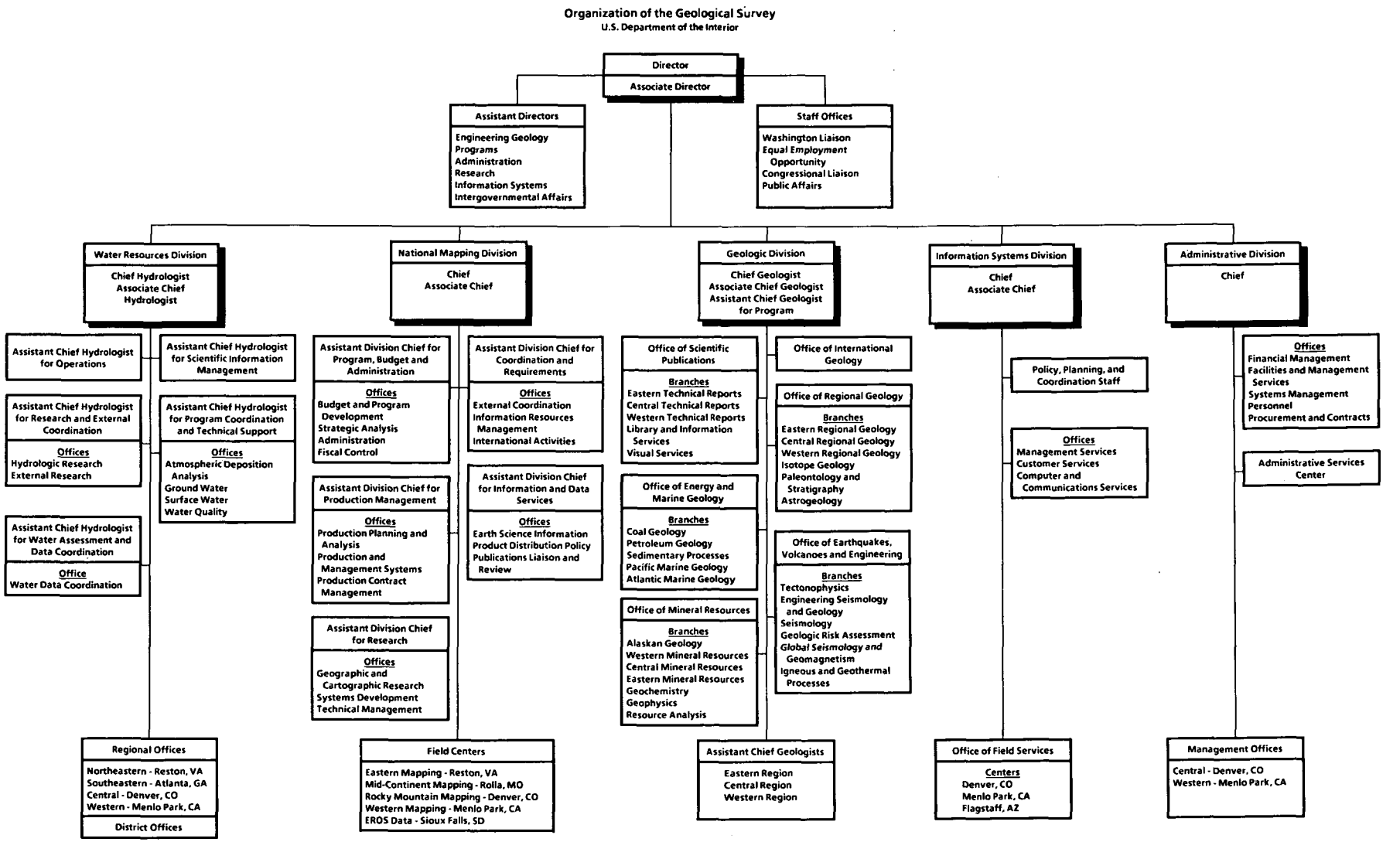


Figure 3-1. The U.S. Geological Survey is composed of five divisions.

- Develops technology for remote sensing applications and produces image maps from remotely sensed data to satisfy user requirements.
- Develops and maintains a digital cartographic and geographic data base for multipurpose needs.
- Conducts research in mapping, geography, remote sensing, and lithography.
- Provides information and technical assistance through established centers and offices which gather, index, analyze, archive, and disseminate cartographic, geographic, and remote sensing products and information.
- Coordinates Federal mapping, digital cartographic, and remote sensing activities as designated by the Office of Management and Budget Circular A-16 and other documents.
- Represents the national interest through participation in international mapping and training activities.

The Geological Survey is responsible for all functions, including staff support to the interdepartmental Board on Geographic Names (BGN), that relate to domestic geographic names under P.L. 80-242. The Geological Survey compiles, publishes, and maintains the National Gazetteer of the United States of America and has developed and manages the National Geographic Names Data Base.

3.2.1 Organizational Structure

The National Mapping Division, headquartered in Reston, Virginia, is organized into five primary offices: Program, Budget and Administration; Coordination and Requirements; Production Management; Research; and Information and Data Services (Figure 3-2). The cartographic products are generated by five regional mapping centers in Reston, Virginia; Rolla, Missouri; Sioux Falls, South Dakota; Denver, Colorado; and Menlo Park, California. The Division also operates Earth Science Information Centers (ESIC) throughout the country. Appendices E and F provide more information on USGS offices, information sources, and publications. Information on map products and services of the NMD can be obtained by calling 1-800-USA-MAPS (for the Washington, D.C. metropolitan area, call 703-648-6045 or FTS:959-6045).

3.2.2 Programs and Activities

NMD is involved in five major activities: map production, digital cartographic data production, mapping research, dissemination of map products and cartographic information, and coordination of Federal mapping requirements. Through the National Mapping Program (NMP), the NMD provides the graphic, image, and digital cartographic maps and their associated data. These products include several series of topographic maps (graphic and digital), photo image maps, land use and land cover maps and data, geographic names data, geodetic control data, and remotely sensed data. The USGS conducts the Federal agency canvass of mapping needs in response to the OMB Circular A-16.

The National Mapping Program is dedicated to the production and revision of the 7.5-minute (1:24,000 scale) topographic maps for the conterminous United States and Hawaii, plus the 15-minute (1:63,360 scale) topographic maps for Alaska. At the present, not all States have been completely mapped. However, a schedule has been formalized to complete the effort by 1991.

The intermediate and small-scale mapping activities include the preparation of 1:50,000, 1:100,000, and 1:250,000 series maps. Of these maps, the small-scale map series at 1:250,000 has been completed and has begun a cycle of revision. Completion of the 1:100,000 scale map series is scheduled for Fiscal Year 1995. The 1:50:000 scale map series is produced on an as-needed basis with the majority of requests originating from the Defense Mapping Agency. The 1:50,000 and 1:100,000 scale maps series are also produced on a cost-share basis in a county map format.

Base map production of digital data is in progress. Production is controlled to yield maps produced at standard scales, accuracies, and with standard computer formats. The categories of data currently being digitized at the 1:24,000 and 1:100,000 scales are the Public Land Survey System, boundaries, transportation, elevation data, and hydrography. Digitization at the 1:250,000 scale is being conducted for the following

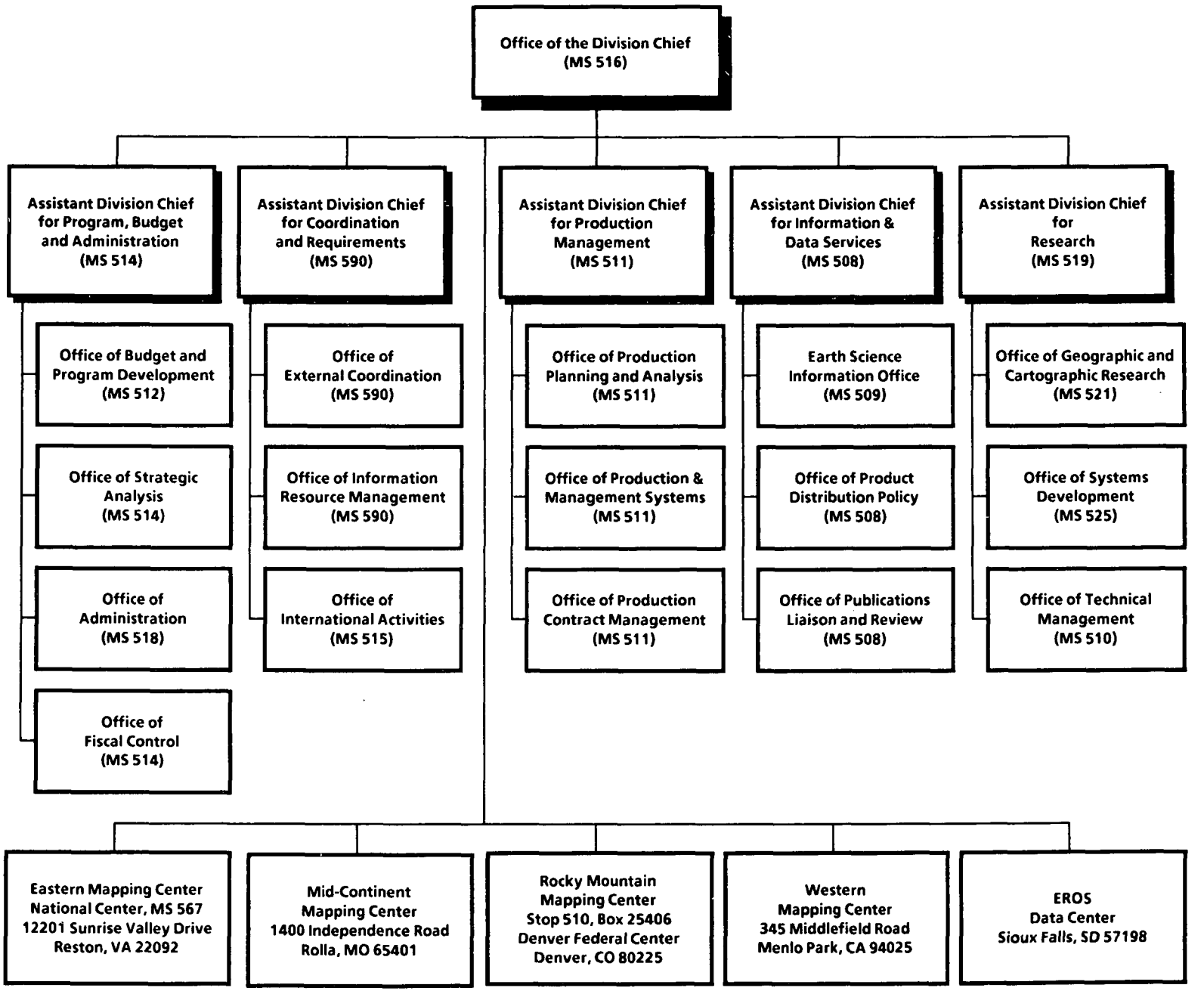


Figure 3-2. This organizational chart shows the various offices within the National Mapping Division of the U.S. Geological Survey. See Appendix C for USGS contacts.

data categories: census tracts, land use and land cover, political boundaries, hydrologic units, and Federal land ownership. Digital data are available from the National Digital Cartographic Data Base which contains digital line graphs (DLGs) and digital elevation models (DEMs).

Photoimage maps are prepared by NMD from satellite sensors, radar, sonar, or other remote-sensing image systems. Photoimage maps from NMD are primarily in the form of Landsat imagery or orthophotoquads.

Cartographic research is focused on the application of various technologies for the generation of mapping data and graphics to reproduce the geographic information. The NMD is currently working with other Federal agencies for geographic information systems (GIS) technology development and applications.

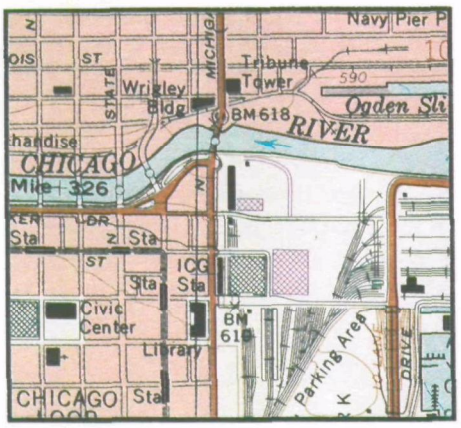
3.2.3 Map Production

The production of maps is a primary function of NMD. During the last few decades there has been a dramatic increase in the Nation's need and uses for maps. This has increased the demand for more efficient mapping operations. In response to this demand, the Department of the Interior, in 1975, modified, extended, and restructured its National Topographic Program to better serve the basic cartographic data needs of the country. This new program, the National Mapping Program, includes those activities necessary to make available basic map data and a family of general purpose maps.

Multipurpose map-data categories, such as roads, buildings, topography, streams, lakes, boundaries, and shorelines, are identified as base categories. Other map data of public value may also be incorporated into the National Mapping Program as non-base categories. The non-base categories are developed and maintained by agencies and are made available under cooperative agreements through the National Mapping Program's coordination and dissemination arrangements.

There is a wide variety of map products routinely generated by NMD (Figure 3-3). The best known are the conventional topographic line maps of the 1:24,000-scale primary map series (in Alaska 1:63,360), the intermediate-scale map series (1:50,000- and 1:100,000-scale maps), the 1:250,000-scale map series, the 1:500,000-scale State map series, and the 1:1,000,000-scale map series. The features shown on all of these topographic maps are essentially the same. However, as the scale of the map decreases, for example from a 1:24,000 to 1:100,000, it is necessary to omit or generalize some information. The following is a list of some common features found on topographic maps:

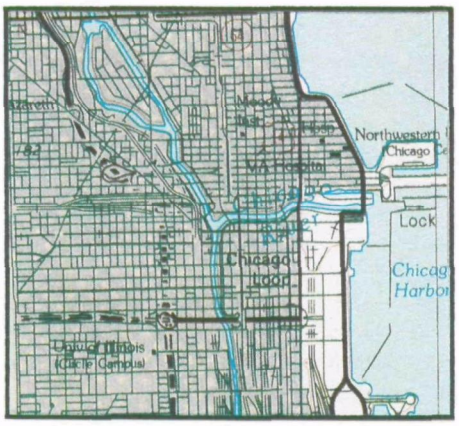
- Boundaries—Includes political and administrative subdivisions;
- Hydrography—Includes streams, rivers, springs, lakes, ponds, marshes, and swamps;
- Public Land Survey System (PLSS)—Describes the rectangular township and range system of land surveys that form the framework for property boundaries in many States;
- Transportation—Includes major transportation systems, such as roads, railroads, transmission lines, and canals;
- Other Significant Man-made Structures—Includes buildings, water tanks, concrete dams, and airports;
- Hypsography—Contours and elevations that describe topographic relief;
- Surface Cover—Describes vegetative surface cover, such as woods, scrub, orchards, and vineyards;
- Non-Vegetative Surface Features—Includes lava, playas, sand, and gravel features;
- Geographic Reference Systems—Information about the points of established horizontal position and elevations that are used as fixed references in positioning and correlating map features; and
- Geographic Names—Place names such as villages, towns, and cities, as well as other features including streams, schools, hospitals, cemeteries, mountains, and other landmarks.



MORE DETAIL

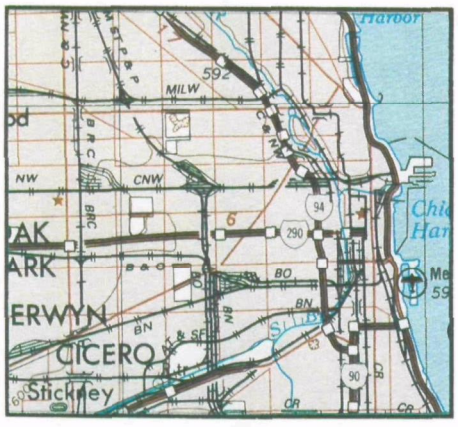
1:24,000-Scale (1 inch = 2,000 feet)
Area Shown = 0.6 square mile

Covers approximately 57 square miles and are used where detailed land surface information is required. Used for energy and mineral exploration, for natural resource and water management, for agricultural and census area statistics, for outdoor recreation activities, and for many engineering studies and surveys. Approximately 54,000 maps are required to cover the conterminous U.S.



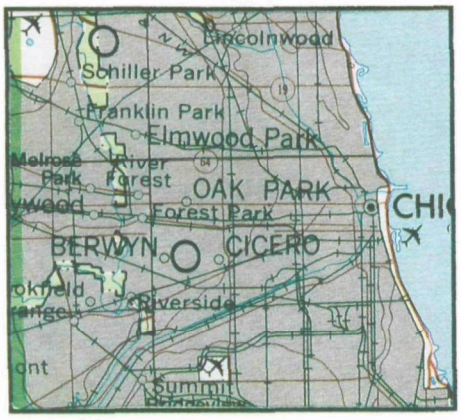
1:100,000-Scale (1 inch ~ 1.5 miles)
Area Shown = 10 square miles

Covers an area equal to 32 of the 1:24,000-scale maps from which the content is derived. Maps are used for countywide studies where less extensive detail is required. Used as a multi-purpose base for displaying important farmlands, wetlands, Federal land ownership and subsurface mineral rights, and for State and county management planning. Approximately 1,800 maps are required to cover the conterminous U.S.



1:250,000-Scale (1 inch ~ 4 miles)
Area Shown = 72 square miles

Covers an area equal to 128 of the 1:24,000-scale maps. Maps are used for regional planning, water resource studies, for civil defense and disaster relief coordination, and as bases for air pollution, aeronautical charts, land-use, and weather records. Approximately 450 maps are required to cover the conterminous U.S.



1:500,000-Scale (1 inch ~ 8 miles)
Area Shown = 290 square miles

These maps generally cover a State and are used to plan general studies, inventories and management activities; to help in locating interstate utilities; to delineate drainage basin boundaries and as a base to prepare State Highway and other maps. They are available as a planimetric, topographic, or shaded-relief edition.

LESS DETAIL

Figure 3-3. A wide variety of maps are available through the National Mapping Division. Scales of the maps differ depending on the amount of detail needed.

1:24,000-Scale Maps. The best known topographic maps produced by the USGS are the conventional line maps of the 7.5-minute, 1:24,000-scale topographic quadrangle series (Figure 3-4). National coverage of this primary series is scheduled for the end of Fiscal Year 1990. A systematic effort is underway to revise this map series. There are approximately 57,000 individual 7.5-minute quadrangle maps that cover the conterminous United States, Hawaii, Alaska, and the territories. [Maps of Alaska in this primary series are published at 1:63,360 scale (1″ = 1 mile).]

Intermediate-Scale Maps. The intermediate-scale map series includes topographic base maps at scales of 1:50,000 and 1:100,000 in quadrangle and county format (Figure 3-5). The National Mapping Division plans to make available national coverage of 1:100,000-scale topographic editions by Fiscal Year 1995. Planimetric editions are now available. All other map products in this series are produced under jointly funded arrangements.

1:250,000-Scale Maps. The 1:250,000-scale series has been designated by the Board on Geographic Names as the standard reference for geographic nomenclature in Government publications (Figure 3-6). Elevation data, digitized from the contours on the 1:250,000-scale maps, are available on magnetic tape from the National Earth Science Information Center (Section 3.2.6).

This map series was originally prepared as military editions by the U.S. Army Map Service [now Defense Mapping Agency Hydrographic/Topographic Center (HTC)] during the 1950s; the series is now maintained by the USGS. These topographic maps are published in quadrangles having dimensions of 1 degree latitude by 2 degrees longitude.

1:500,000-Scale. The 1:500,000-scale State map series is frequently published as planimetric and topographic base maps. The essential specifications for the State map series are: separate 1:500,000-scale maps for each State, except for some combinations of more than one small State. State maps are published in one sheet if possible. Alaska is the only State for which there is no 1:500,000-scale map. The Alaska topographic State maps are published at scales of 1:1,584,000 (2 sheets) and 1:2,500,000.

United States 1:1,000,000-Scale Maps. The 1:1,000,000-scale topographic maps are available in two series. The IMW series is the United States contribution to the International Map of the World (IMW). The other series is based on a series of 1:1,000,000-scale maps compiled by the Army Map Service. In both series published by the USGS, each map is numbered in accordance with the designation system adopted for the IMW series and is named for one of the principal localities or natural features within its area. The maps are derived from the latest 1:250,000-scale maps and other source material. Maps of the 1:1,000,000-scale series have quadrangle dimensions of 4 degrees latitude by 6 degrees longitude (12 degrees longitude for Alaska).

Special Maps. The USGS publishes a number of maps to meet special needs of Federal agencies and Congress:

- The National Park Series of topographic maps, at various scales, covers national parks, monuments, and historic sites. The scales range from 1:960 to 1:250,000 and are dependant on the size of the park.
- United States maps showing the entire Nation are published at various scales ranging from a letter-size page at 1:16,500,000 scale to large wall maps at a scale of 1:2,500,000.
- Separate sheets of selected thematic and general reference National Atlas maps are available from the USGS. The content ranges from physiographic information to environmental and economic trends. One set of maps covers the United States in 21 sections at 1:2,000,000 scale; another details the 25 largest urban areas at 1:500,000 scale. Selected outlying areas are covered by maps at scales of 1:1,000,000 and 1:250,000. Special-subject maps at scales of 1:7,500,000, 1:17,000,000, and 1:34,000,000 depict national characteristics such as relief, geology, climate, water resources, discovery, exploration, territorial growth, agriculture, minerals and mining, manufacturing, trade, transportation, population, income, education, counties, Standard Metropolitan Statistical Areas (SMSAs), judicial districts, and congressional districts.

Figure 3-4. This is a portion of a 1:24,000-scale map of the Stafford, Virginia, area. It was produced from a 7.5-minute quadrangle map and is typical of the topographic maps produced by the USGS.

- Antarctic maps are published at various scales ranging from 1:250,000 scale to 1:2,188,800 scale. Various types of maps are published such as topographic, topographic reconnaissance, geologic reconnaissance, sketch, and satellite maps.

Image Maps. Photoimage maps are available for some areas. These maps can be produced quickly, economically, and accurately by modern "orthophoto" techniques (refer to Glossary and see Figure 3-7). Image map products complement conventional line maps by providing an accurate base for interpreting and documenting vegetative, geologic, and other physiographic features.

Land Use/Land Cover Maps. The USGS land use and land cover classification system has been developed to meet the needs of Federal and State agencies for an overview of land use and land cover (Figure 3-8). The classification includes categories such as urban or built-up land, agricultural land, rangeland, forest land, water, wetland, barren land, tundra, and perennial snow or ice. The following land use and land cover products are available:

- Land use and land cover maps for use with the 1:250,000-scale base maps and with selected 1:100,000-scale base maps.
- Associated maps showing political units (counties and States), hydrologic units (drainage areas), and census county subdivisions including census tracts.
- Magnetic tapes containing digital data obtained by digitizing in polygon format the land use and land cover maps.
- Land use and land cover statistics by political units, hydrologic units, and census county subdivisions.

Knowledge about land use and land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use data are needed in the analysis of environmental processes and problems which must be understood if living conditions and standards are to be improved or maintained at current levels. Therefore, land use maps may have particular applicability to the EPA.

3.2.4 Digital Cartographic Data Production

The production of digital cartographic data is a second major activity of the NMD (Table 2-1). The average topographic map contains over 100 million separate bits of information.

As 1:24,000-scale map digital coverage of the United States becomes available, the USGS is shifting its emphasis to the maintenance of existing maps and to the development of automated capabilities for more efficient map production and revision. Remotely sensed data, in digital form, is now being used in the automation process (see cover). In digital form, cartographic information can be updated more easily from reliable sources, permitting current graphic production on a timely basis. Moreover, the data can be used with thematic data in geographic information systems to automate many spatial analyses.

In 1980, the National Digital Cartographic Data Base (NDCDB) was formally established with the objective of providing users with digital cartographic data from USGS topographic maps. Components have been added to the data base, including line and elevation data from other map series, land use and land cover maps, and geographic names data. An index and complete ordering information for digital data are available from the Earth Science Information Center (Appendix D). Two examples of available digital data are as follows:

- Digital Line Graphs (DLGs) are digital files consisting of planimetric or linear information about one class of map information, such as hydrography. The following categories of DLGs are being collected from 1:24,000- and 1:100,000-scale maps: Public Land Survey System, boundary, hydrography, contour, and transportation features. Transportation and hydrography DLGs are available

Figure 3-5. This is a portion of a 1:100,000-scale topographic map of Sonoma County, California. It is one of the first maps in a new USGS county series at scales of 1:100,000 or 1:50,000. The maps are formatted on county boundaries rather than parallels or meridians.

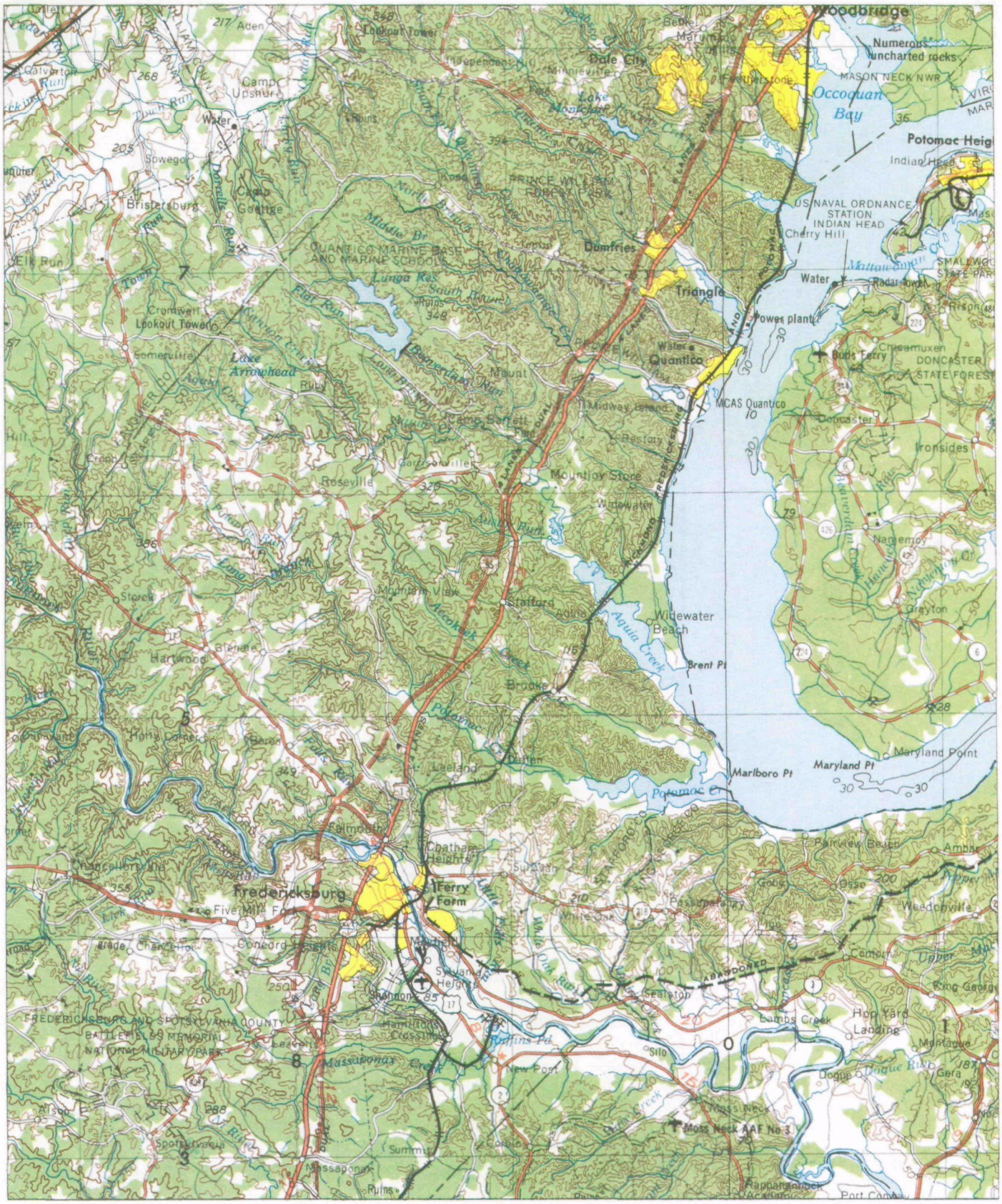
for the 1:100,000-scale map series. Boundary, hydrography, and transportation features from the 1:2,000,000-scale sectional maps of the National Atlas of the United States of America are also available in digital form for the entire United States.

Digital Elevation Models (DEMs) are digital files of terrain elevations for ground positions at regularly spaced horizontal intervals. Digital elevation data are available in blocks that correspond to 7.5-minute topographic quadrangle maps. The ground distance between each pair of digitized elevation points is 30 meters. The data base also includes digital elevation data of the United States from contour plates digitized from the 1-degree by 2-degree (1:250,000-scale) map series. Those data are collected at a ground distance interval of 3 arc-seconds (approximately 100 meters between each pair of digitized elevation points).

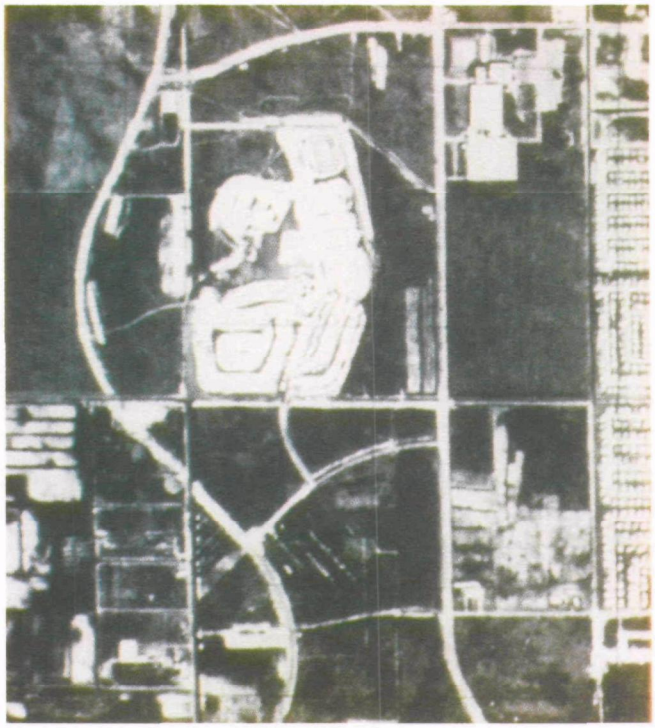
The National Digital Cartographic Data Base also contains digital data from land use and land cover as well as associated maps and information on U.S. geographic names. The land use and land cover data are derived from thematic overlays registered to 1:250,000- and 1:100,000-scale base maps. Land use and land cover maps provide information on urban or built-up land, agricultural land, rangeland, forest land, water, wetland, barren land, tundra, and perennial snow or ice. The associated maps display information on political units, hydrologic units, Federal land ownership, and census county subdivisions. The geographic names data are contained in a computerized file of more than two million place names in the United States—from towns, schools, reservoirs, and parks to streams, valleys, springs, and ridges.

In addition to the National Digital Cartographic Data Base, the USGS maintains spatial, earth science data at the Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, South Dakota. Two examples of data bases maintained at the EROS Data Center are as follow:

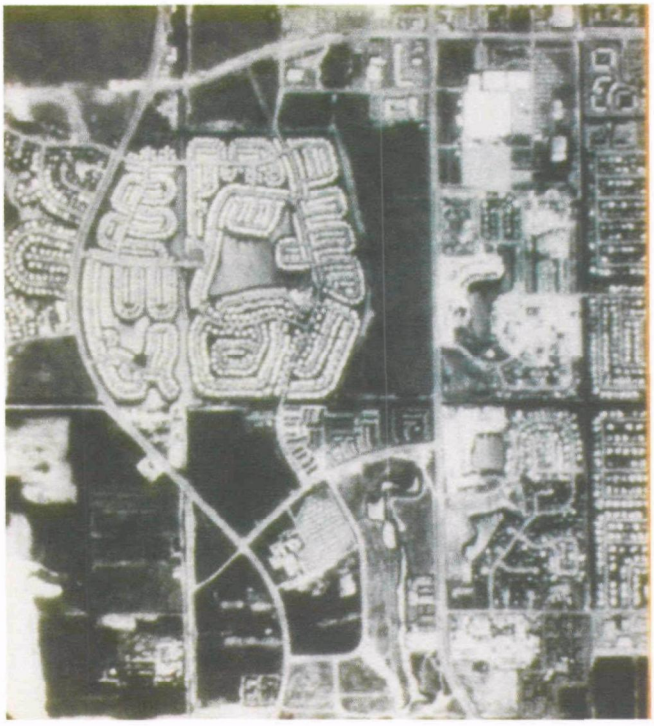
- Digital earth science data collected by the National Uranium Resources Evaluation (NURE) Program of the U.S. Department of Energy. Earth sciences research in the NURE Program included geochemical and stream-sediment reconnaissance sampling, coordinated rock sampling and analyses, airborne radiometric and magnetic surveys, geologic mapping and ore deposit studies, subsurface geologic investigations (borehole drilling), technology application studies, development of resource estimation methodologies, and uranium resource evaluations incorporating research results. Several years of data collection generated substantial geologic, geophysical, and geochemical data that can be used in other earth science research. Nearly all data from the NURE Program are organized and retrievable by reference to a rectangular grid system that corresponds to the 1:250,000-scale topographic quadrangle system used by the USGS.
- Advanced Very High Resolution Radiometer (AVHRR) satellite data. Limited quantities of geographically referenced AVHRR data for the conterminous United States, needed to support Federal earth science research and land management programs, are routinely available within 24 hours of a satellite overpass. A few obvious land science applications include image mapping, rainfall distribution monitoring, and vegetation monitoring.


Woodbridge
Numerous uncharted rocks
MASON NECK NWR
Occoquan Bay
Potomac Heig
Indian Head
US NAVAL ORDNANCE STATION INDIAN HEAD
Cherry Hill
Dale City
Dumfries
Triangle
Quantico
MCAS Quantico
Burns Ferry
Chesamuxen
DONCASTER STATE FOREST
Doncaster
Ironsides
Nanjemoy
Greyton
Widewater Beach
Brent Pt
Marlboro Pt
Maryland Pt
Maryland Point
Aquia Creek
Stafford
Mountjoy Store
Roseville
Garrisonville
Hartwood
Brooks
Leeland
Falmouth
Chatham Heights
Fredericksburg
Ferry Farm
Five Mile Fork
Concord Heights
Sylvania Heights
Shannon
Hamilton Crossing
FREDERICKSBURG AND SPOTSYLVANIA COUNTY BATTLEFIELDS MEMORIAL NATIONAL MILITARY PARK
Massaponax Creek
Massaponax
Spotsylvania
Summit
Sealston
Lambs Creek
Hop Yard Landing
Montague
Dogue
Dogue Run
Moss Neck
Moss Neck AAF No 3
Rappahannock
Port Conway
Camden
Parkview Beach
Weedonville
Bristersburg
Cromwell
Lookout Tower
Somerville
Lake Arrowhead
Lunga Res
Camp Upshur
Camp Goodtige
QUANTICO MARINE BASE AND MARINE SCHOOL
PRINCE WILLIAM FOREST PARK
Water
Power plant
Radar tower
Aden
Sowego
Elk Run
Storck
Mountain View
Widewater
Midway Island
Camp Barrett
Lake Monticello
Dale City
Minnieville
Beddoe
Marumsco Hills
Featherstone
Rippon
Lake Jackson
Occoquan Creek
Quantico Creek
Chopawamsic Creek
Aquia Creek
Potomac Cr
Rappahannock River
Mattaponi
Chesapeake Bay
Lake Anna
Lake Orange
Lake Barcroft
Lake Braddock
Lake Fairfax
Lake Manassas
Lake Ellen
Lake Frederick
Lake Caroline
Lake Cohoon
Lake Cubbage
Lake Gordon
Lake Lanier
Lake Lawrence
Lake Lee
Lake Lenwood
Lake Lillian
Lake Linden
Lake Lorraine
Lake Louise
Lake Lucy
Lake Luxmanor
Lake Manchester
Lake Marcella
Lake Marie
Lake Marion
Lake Martin
Lake Mary
Lake Matoaca
Lake Meade
Lake Merritt
Lake Michael
Lake Minnewanna
Lake Monticello
Lake Moore
Lake Nancy
Lake Nelson
Lake Nottoway
Lake Nottoway
Lake Nottoway

COOPER CITY, FLORIDA
ORTHOPHOTOQUAD

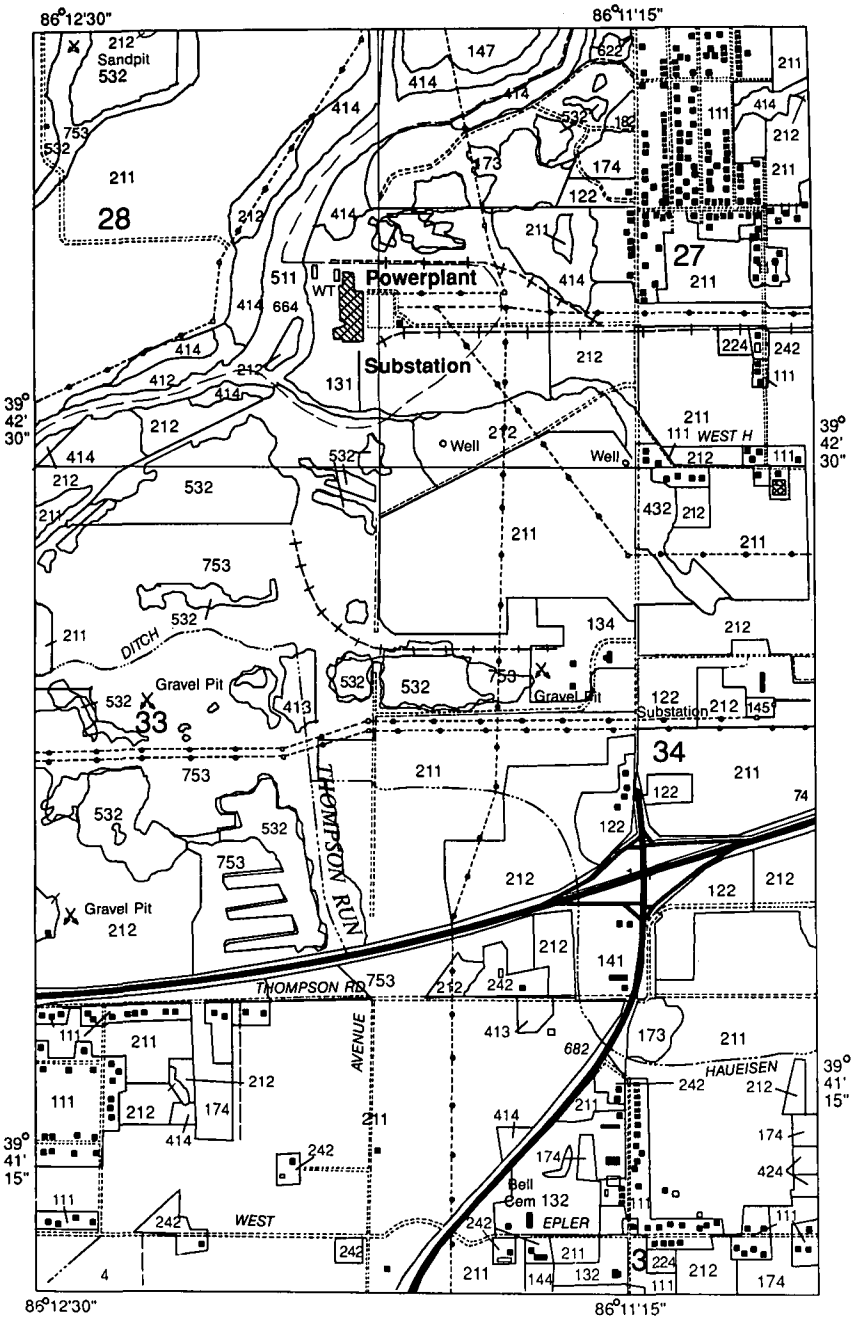


February 1973



July 1980

Figure 3-7. Image maps, such as these orthophotoquads of Cooper City, Florida, are useful in discerning land use changes over time.



PARTIAL CODE LISTING EXPLANATION

- 111 Single family
- 122 Retail trade
- 131 Primary processing
- 132 Fabrication
- 134 Extraction facilities
- 141 Highways
- 144 Airports
- 145 Communications
- 147 Utilities
- 173 Waste dumps
- 174 Urban undeveloped
- 211 Cropland
- 212 Pastureland
- 224 Nurseries and floriculture
- 242 Farmsteads
- 412 10–30 percent crown cover, deciduous
- 413 30–70 percent crown cover, deciduous
- 414 >70 percent crown cover, deciduous
- 424 >70 percent crown cover, evergreen
- 432 10–30 percent crown cover, mixed
- 511 Streams
- 521 Lakes
- 532 Water-filled quarries
- 622 Mudflats
- 753 Sand and gravel pits (active)

Figure 3-8. This prototype map shows a Level III land use and land cover in part of the Maywood, Indiana, 7.5-minute quadrangle base map.

3.2.5 Mapping Research

A third major activity of NMD is mapping research. Some of the innovative programs with which the Division is involved are the following:

- Development of automated methods to generate map products from data stored in the National Digital Cartographic Data Base discussed earlier (Section 3.2.4). The development of such methods will lead to more flexible, efficient, economical, and accurate mapping.
- Improving exchange of data among varying digital cartographic and thematic data bases, improving the capabilities of existing geographic information systems (GIS) to input, store, and analyze spatial data, and demonstrating new and improved applications of GIS technology.
- Adoption of a new geodetic surveying system that is expected to replace existing methods. The Global Positioning System (GPS) was designed by the U.S. Department of Defense to provide a continuous, worldwide navigation capability. The system will comprise 18 Earth-orbiting satellites, a network of ground-control stations to monitor and update the satellite orbits, and user equipment to determine the user's position in three dimensions. The Global Positioning System can be used for real-time navigation or for precise surveying.

3.2.6 Dissemination of Map Products and Cartographic Information

The Earth Science Information Center (ESIC), managed by NMD, provides a national information service to make cartographic data of the United States more easily accessible to the public and to various Federal, State, and local agencies. At present, more than 30 Federal agencies collect and prepare cartographic data (Appendix E). ESIC does not obtain cartographic data from present holders; rather it collects and organizes descriptive information about that data, provides location, ensures availability, and provides ordering assistance. ESIC services include the following:

- The ESIC Map and Chart Information System and Cartographic Catalog System are computer-based and microfilm-supported systems, which contain detailed information on all topographic map series of the National Mapping Program, as well as other major map series such as the Federal Highway Administration's County and Metropolitan Highway Series.
- The Aerial Photography Summary Record System (APSRS) was developed by NCIC to provide information on aerial photography. It catalogs the planned, in-progress, and completed aerial photographic missions in the United States so that informed decisions on photograph acquisition can be made. Moreover, it provides a reference for learning about the availability of aerial photographs, both current and historical.

ESIC provides different levels of service for the various types of cartographic data. For general purpose data (topographic maps and aerial photographs) the objective is to provide complete service, including the identification of specific products and assistance in ordering these products. On the other hand, only general information and referral service are provided for special purpose cartographic data. The types of cartographic data for which ESIC offers assistance are listed in Table 3-1.

Table 3-1. Summary of Cartographic Data and Map Information Available From Earth Science Information Center (ESIC)

Multiuse maps and charts including:

- Aeronautical charts
- Bathymetric maps
- City maps
- Extraterrestrial maps
- Flood-plain maps
- Forest maps
- Geologic maps
- Highway maps
- Land use and land cover maps
- Map and chart features
- Nautical charts
- Orthophotomaps and orthophotoquads
- River surveys and damsite maps
- Slope maps
- Soil maps
- Topographic maps
- U.S. maps
- World maps

Survey data including:

- First- and second-order control from any source
- Third-order control from any source that is useful
- Selected fourth-order control
- Photogrammetrically derived control
- Selected private control
- Land plats
- Census subdivisions

Aerial and space imagery from Federal, State, and private sources including:

- Photographs
- Satellite computer-compatible tapes
- Photomosaics
- Other remote-sensor data

Closely related data such as:

- Cartographic educational materials, atlases, gazetteers, and other related literature
- Digital data representing detail on maps and charts
- Geographic names

3.2.7 Coordination of Federal Mapping Requirements

OMB Circular A-16, originally issued by the Bureau of the Budget on January 16, 1953, and revised May 6, 1967, appoints the Department of the Interior (delegated to the U.S. Geological Survey) to exercise "government wide leadership in assuring coordinated planning and execution" of cartographic activities that are funded in whole or in part with Federal funds. This coordination activity is to be accomplished within the capacity and capabilities of the USGS National Mapping Program.

The primary purpose is to minimize duplication of effort and costly single-purpose mapping activities among Federal agencies. The A-16 process helps the NMD identify the geographic areas where specific types of maps and cartographic data are needed, and provides the NMD with a better understanding of other agencies' program needs. Through this process, NMD can more effectively plan its mapping programs to support other Federal agency needs.

In the second quarter of each fiscal year NMD solicits cartographic and geographic data requirements for the ensuing fiscal year from nearly 40 Federal agencies. The solicitation package contains general information about the National Mapping Program, instructions for submitting requirements, and program status indexes for mapping and digital data products.

Implementation of the A-16 process is between headquarters personnel at the participating Federal agency and the NMD. Regional Offices of each agency participate in the identification and ranking of their mapping

needs through their headquarters' offices. Regional offices are encouraged, however, to contact regional facilities of the NMD (Appendix D) to obtain existing map products.

OMB (on April 4, 1983) additionally assigns the Department of the Interior (delegated to the USGS) the chairmanship of the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC) "to improve the use of digital cartographic base data within the Federal Government and to provide a framework for its proper management...." This memorandum was renewed on March 18, 1986. Coordination of digital cartographic data is accepted as an integral part of the OMB Circular A-16 process.

EPA has formally responded to USGS through the A-16 process to request USGS mapping products for the first time in 1989. Materials prepared by OIRM were submitted to USGS.

3.3 Geologic Division

The Geologic Division (GD) conducts a broad spectrum of earth science investigations of onshore and offshore areas of the United States and its territories and Exclusive Economic Zone (U.S. Geological Survey, 1986b). These investigations are designed to (1) determine the geologic framework of the Nation and the geologic processes that shaped that framework; (2) assess the energy and mineral resources of the Nation; (3) establish the geologic factors that bear on the use and environmental quality of the land and offshore areas; and (4) understand the nature and impacts of geologic hazards such as earthquakes, volcanic eruptions, and landslides, and evaluate geologic constraints on hazard mitigation. GD carries out these responsibilities by activities that include the following:

- Geologic, geophysical, and geochemical mapping to determine the composition and structure of rocks at and beneath the Earth's surface;
- Investigations of geologic processes, including specialized research in many earth science disciplines, to provide a basic research foundation for GD's applied research missions;
- Development of new exploration and assessment techniques to aid in the increasingly difficult search for new sources of energy and mineral commodities;
- Collation and synthesis of geologic information on energy and mineral resources to develop a comprehensive background of knowledge upon which to base resource and resource-potential assessments; and
- Operation of seismological networks and geomagnetic and volcano observatories to monitor and aid in understanding geologic processes and events that have a potential for risk to life and property.

3.3.1 Organizational Structure

The headquarters office of GD is located in Reston, Virginia, and consists of the Office of the Chief Geologist and six subordinate offices (Figure 3-9):

- Earthquakes, Volcanoes, and Engineering;
- Regional Geology;
- Mineral Resources;
- Energy and Marine Geology;
- International Geology; and
- Scientific Publications.

Assistant Chief Geologists for the Eastern, Central, and Western Regions act for the Chief Geologist in carrying out general objectives, policies, and procedures for the Division within their region. Project operations are conducted by personnel located principally at regional centers in Reston, Virginia; Denver, Colorado; and Menlo Park, California; at field centers in Flagstaff and Tucson, Arizona; Albuquerque, New Mexico; Spokane, Washington; Reno, Nevada; Anchorage, Alaska; Woods Hole, Massachusetts and St. Petersburg, Florida; and at Volcano Observatories in Hawaiian Volcano National Park, Hawaii and Vancover, Washington (Appendix C).

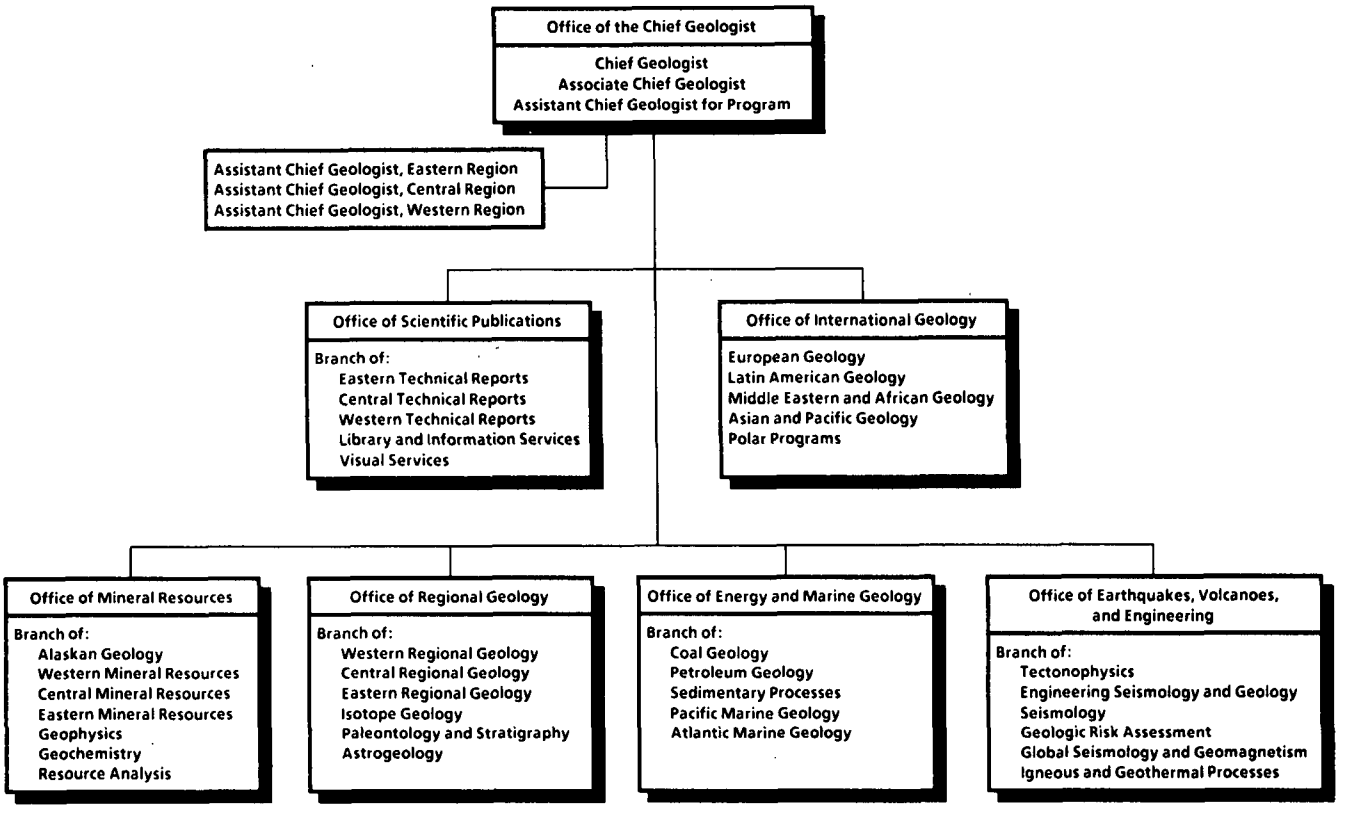


Figure 3-9. The U.S. Geological Survey's Geologic Division consists of the Office of the Chief Geologist and six subordinate offices.

3.3.2 Mapping and Research Programs and Products

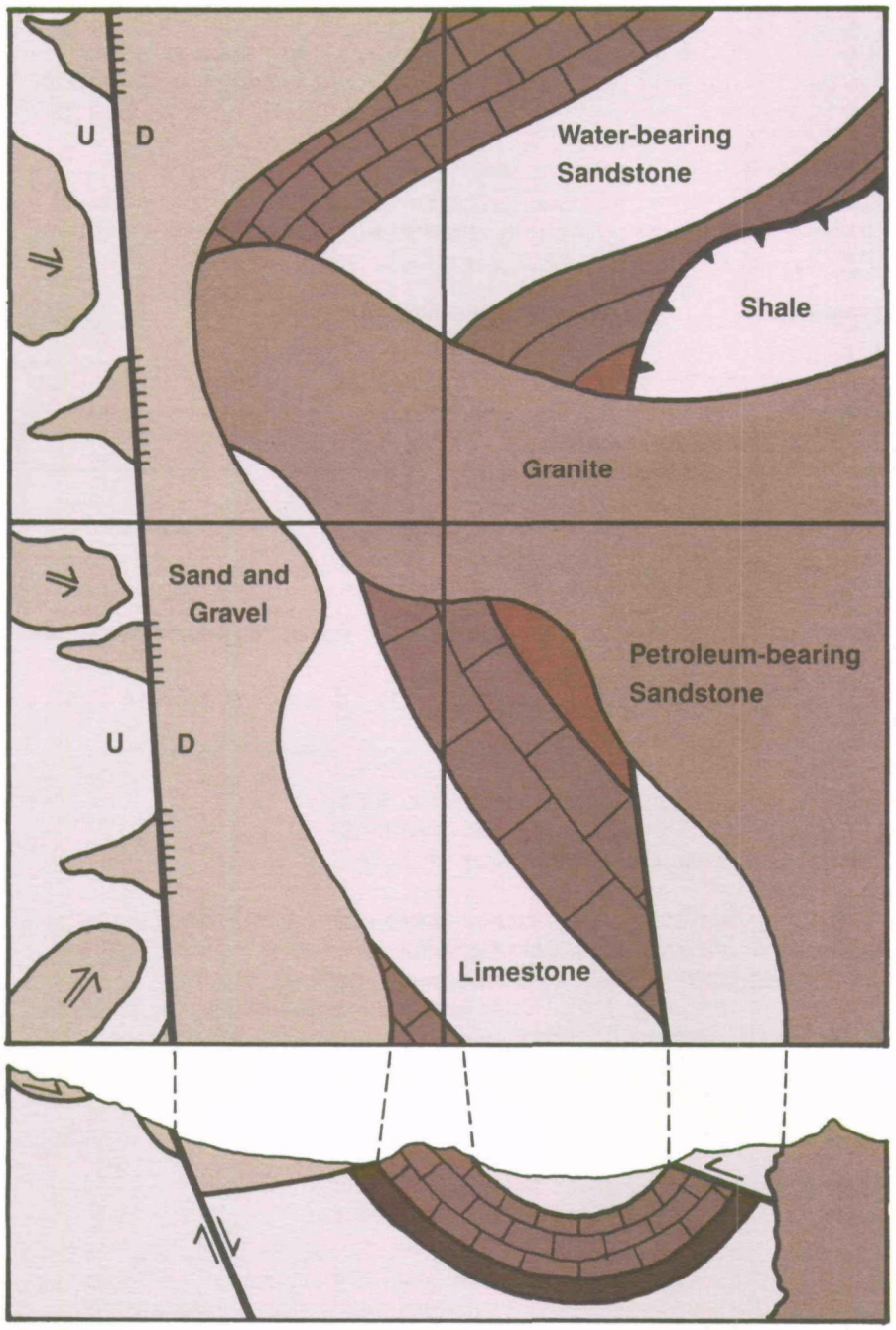
The GD conducts a variety of earth science mapping activities that identify the distribution, composition, and structure of geologic materials and geologic environments, and that provide a framework for interpretive investigations. The various activities can be grouped into four major categories: geologic mapping, geochemical mapping, geophysical mapping, and offshore mapping. Each of these mapping techniques provides a unique method of describing and interpreting earth materials. When used in combination, the mapping techniques provide a powerful analytical package for portraying the surface and subsurface geologic structure and composition of an area.

3.3.2.1 Geologic Mapping: National Geologic Mapping Program

Research Strategy. The long-term objective of the National Geologic Mapping (NGM) Program is to determine the geologic framework and composition of the Nation through expansion of the national geologic map data base. The Program achieves its objective through basic research investigations that combine general purpose geologic mapping with a variety of special purpose research studies. The map products and topical reports provide information about the distribution, age, structural and stratigraphic setting, isotopic signature, and geologic history of earth materials that occur in areas determined to be of critical importance to the economic, social, and scientific welfare of the Nation.

3.3.2.1.1 Product Description. A geologic map is a graphical information display that uses a combination of colors, lines, and symbols to depict the geologic setting of an area and to interpret the events which shaped that setting (Figure 3-10). The graphical display not only describes the bedrock and surficial units visible at the Earth's surface, but forms a three-dimensional model that predicts the configuration of rock

GEOLOGIC MAPS: PRIMARY DATA BASE FOR THE EARTH SCIENCES



SUPPORT RESEARCH AND DECISION BY:

- GOVERNMENT
- INDUSTRY
- ACADEMIA

IDENTIFY GEOLOGIC HAZARDS:

- EARTHQUAKE FAULTS
- LANDSLIDES
- LAND SUBSIDENCE
- RADON
- VOLCANOES

LOCATE NATURAL RESOURCES:

- WATER
- ENERGY
- MINERAL
- INDUSTRIAL

FACILITATE LAND-USE PLANNING:

- CRITICAL FACILITIES
- HAZARDOUS-WASTE REPOSITORIES
- URBAN DEVELOPMENT

Figure 3-10. To illustrate the diverse applications of mapping, this figure shows four schematic geologic quadrangle maps combined into a mosaic. The geologic cross section at the bottom of the mosaic shows subsurface relations along a transect parallel to the bottom of the map. A geologic map also serves as the base for geochemical and geophysical maps.

bodies and geologic structures in the subsurface. This combination of descriptive and predictive information makes a geologic map a powerful research tool for understanding the earth's composition and structure, internal and external processes, and history.

The standard geologic map is a general purpose product that is useful to a broad range of applications. This versatility stems from the requirements of a general purpose map: it must convey essential information about all aspects of the geologic setting, not just one or a few aspects. For a prescribed area, a general purpose map can identify many different bedrock formations such as granite, limestone, sandstone, or shale and their altered or mineralized equivalents (Figure 3-11); different kinds of surficial units such as soils, landslides, and sediment deposited by streams, wind, and glaciers (Figure 3-12); and different kinds of geologic structures such as folds, faults, and fractures. A general purpose geologic map thus provides a single comprehensive record of a diverse suite of geologic features.

3.3.2.1.2 Product Uses. Because of its versatility, a geologic map is the primary data base for derivative special purpose investigations that focus on specific geologic features, processes, or applications. The geologic map serves as a starting point for many different earth science specialists, including:

- Environmental specialists concerned with the distribution and origin of geologic materials known to host radon, selenium, asbestos, and other naturally occurring toxic substances that may pose a threat to human health.
- Environmental specialists concerned with inland, near-shore marine, and coastal wetlands.
- Engineers requiring information about the distribution and geologic relations of rock units targeted or utilized as host media for nuclear or toxic waste repositories.
- Seismic-safety specialists requiring information concerning active faults and geologic hazards caused by earthquake-induced ground shaking (Figure 3-13).
- Mineral-resource specialists concerned with the origin and distribution of geologic units known or suspected to host metallic and nonmetallic mineral resources.
- Land-use planners charged with the safe siting of public facilities and transportation and utilities corridors and the development of multiple-use lands that must accommodate recreational, agricultural, residential, industrial, and conservation needs.
- Engineers concerned with the geotechnical character of geologic materials where highways, tunnels, over- and under-crossings, subgrade utilities, and reservoirs are planned.
- Hydrologists concerned with the discovery, utilization, and protection of ground-water resources and their quality.
- Agronomists and soil scientists concerned with soil management research that bears on crop production and soil conservation.
- Energy-resource specialists concerned with the origin and distribution of geologic materials known to host energy resources.
- Slope-failure specialists concerned about landslides and hillslope creep (Figure 3-14).
- Earth scientists conducting basic research on the Earth's composition and structure, internal and external processes, and history.

3.3.2.1.3 Product Scales. Geologic mapping is conducted at scales that depend on the complexity of the geologic setting and the objectives of the mapping activity (Figure 3-15). The National Geologic Mapping Program produces geologic maps at three different scale categories:

Explanation of Symbols

Contact—Approximately located. Contacts of Pennsylvanian through Cretaceous formations are solid where exposed, dashed where not exposed, dotted where concealed by younger units

Boundary of block-glide landslide—Dashed where approximately located. Glide mass is stippled

78 70° B ? M **Fault or fracture zone**—Showing dip and bearing and plunge of slickensides where known. Dashed where approximately located; dotted where concealed; queried where uncertain. M, locality where fault zone contains mylonite; B, locality where fault zone contains breccia

Folds—Showing approximate trace of axial surface, and bearing of plunge of hinge lines where known. Dashed where inferred; dot-dashed where projected through younger pegmatite; dotted where concealed. Form of folds, which may change along trace, shown by following symbols

Anticline

Antiform

Description of Map Units

Knf **Fort Hays Limestone Member**—Light-gray, thick-bedded micrite. Abundant *Inoceramus* and *Pseudoperna congesta*. About 15 ft (5 m) thick

Kcgm **Carli Shale, Greenhorn Limestone, and Graneros Shale (Upper Cretaceous) and Mowry Shale (Lower Cretaceous)**—Total thickness about 495 ft (151 m). Units cannot be separately mapped due to poor exposure

Carlile Shale—Olive-gray silty claystone and sandy siltstone. About 75 ft (23 m) thick

Greenhorn Limestone—Interlayered dark-gray limestone and olive-gray calcareous silty claystone and siltstone. About 250 ft (76 m) thick

Graneros Shale—Dark-gray to grayish-black siltstone and claystone. About 150 ft (46 m) thick

Mowry Shale—Siliceous, white-weathering shale. About 20 ft (6 m) thick

Kd **Dakota Group (Lower Cretaceous)**—Subdivisions of the Dakota are those defined by Waagé (1955). Shown as group on cross sections only. Total thickness about 290 ft (88 m)

South Platte Formation—Consists of the following members:

Ksf **First sandstone member**—Gray to tan, well-sorted, fine- to medium-grained sandstone. Basal contact interpreted as an unconformity by Waagé (1955, p. 39). About 25 ft (8 m) thick

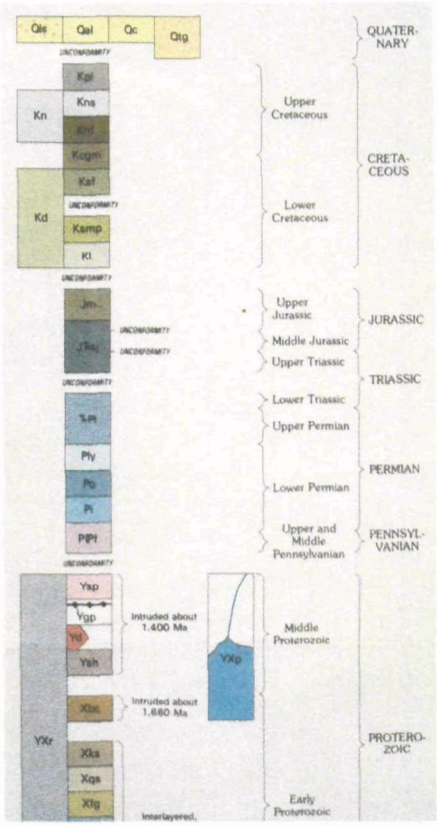
Ksmp **Middle shale member and Plainview Sandstone Member, undivided**—The middle shale is dark-gray carbonaceous shale, thin, bentonite, and thin gray siltstone and sandstone beds. The underlying Plainview is gray to tan, thin-bedded, fine-grained carbonaceous sandstone. Total thickness of combined unit is about 185 ft (56 m)

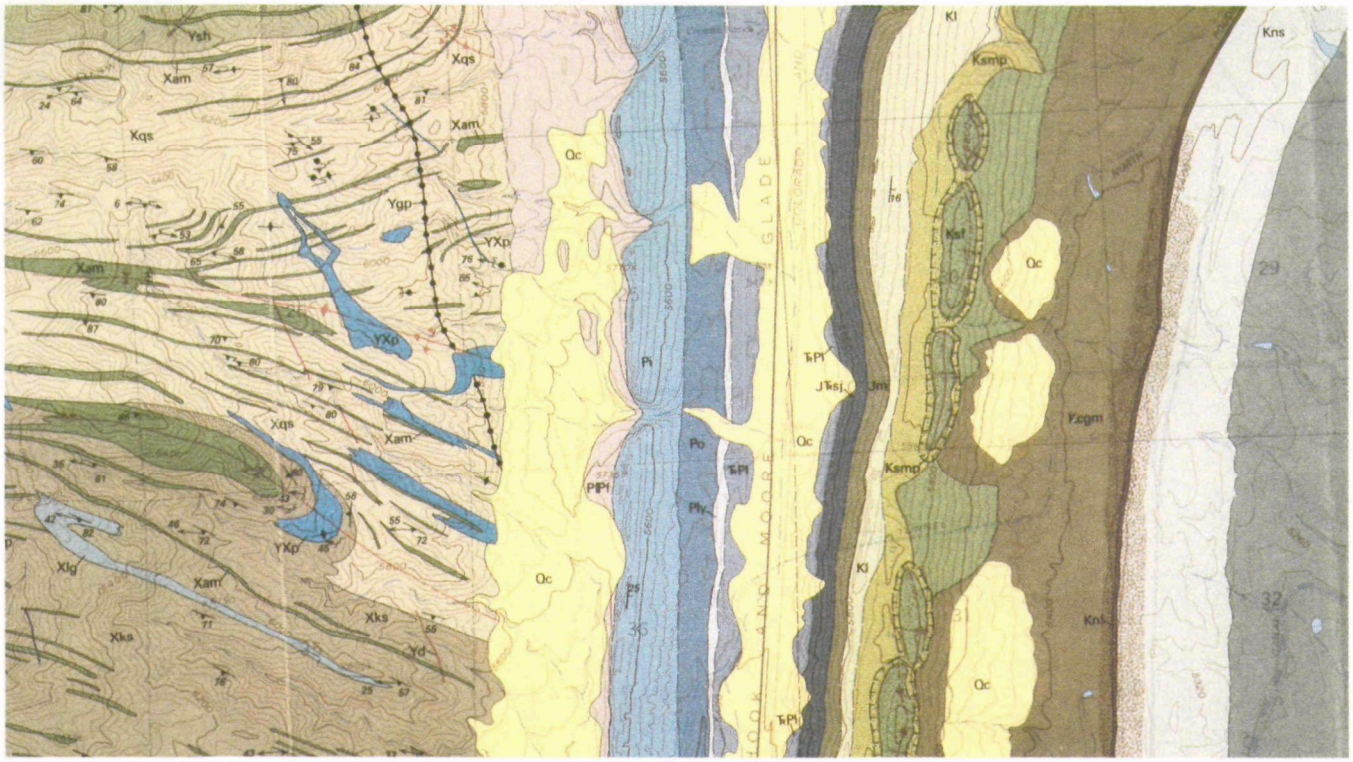
Kl **Lytle Formation**—Gray to tan, coarse-grained to conglomeratic sandstone and blocky-weathering, varicolored non-carbonaceous mudstone. About 80 ft (24 m) thick

Jm **Morrison Formation (Upper Jurassic)**—Green, red, yellow and white, blocky-weathering claystone and siltstone, and interbedded gray micrite and gray, fine- to medium-grained sandstone. About 320 ft 98 m) thick

JTsj **Sundance Formation (Upper and Middle Jurassic and Jelm Formation (Upper Triassic), undivided**—Mapped unit consists of the Sundance and Jelm Formations (Pipiringos and O'Sullivan, 1976), which have a combined thickness of 152 ft (46 m) at north edge of quadrangle and 197 ft (60 m) at south edge.

Correlation of Map Units



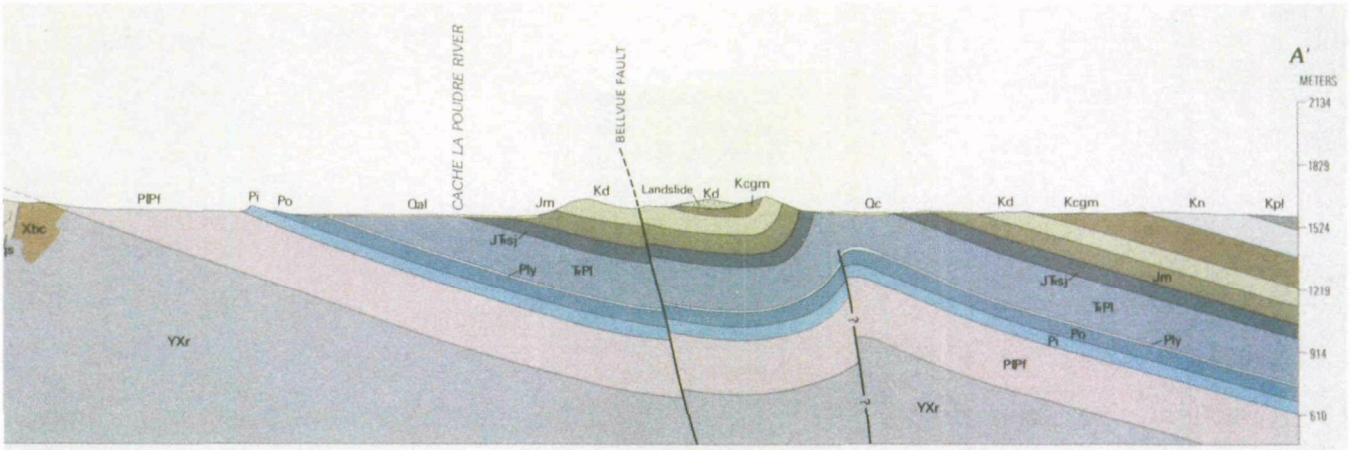


SCALE 1:24,000

1 ½ 0 1 Mile

Contour Interval 40 Feet
Dotted Lines Represent 20-Foot Contours
National Geodetic Vertical Datum of 1929

Bar Scale



Cross Section

Figure 3-11. This geologic map of Laporte Quadrangle, Larimer County, Colorado (Map GQ-1621, 1:24,000) is an example of a general purpose map that provides a detailed background framework. The subject area is underlain primarily by bedrock geologic materials, but with local deposits of surficial materials. The major geologic units are a sequence of north-south trending nonmarine and marine sedimentary rocks (units PPf through Kpl) that rest depositionally on an older terrane of granitic and metamorphic rocks (units Ysp through Yxr and units Xbc through Xcg). An east-west oriented geologic cross section interprets subsurface relations among these units and explanatory material identifies their physical characteristics and age as well as the meaning of lines, symbols, and colors.

Explanation of Symbols

Contact—Long dashes where approximately located; short dashes where inferred

Lineament—Axis of major linear feature on the Sandwich moraine. These features include push ridges where ice overrode the outwash plains, accumulations of drift marking former positions of the ice front, and ice-channel fillings

Area of small festoon-shaped parallel ridges—Possibly marking former positions of the ice front on the Sandwich moraine

Lineament formed by dune crests on Sandy Neck

—20— Contour showing the inferred pre-collapse and pre-erosion outwash plain surface—Datum is mean sea level

—500— Contour showing the altitude, in feet below sea level, of the buried bedrock surface—Datum is mean sea level

BH 247 Location of boreholes described in table 3

800 B.P. 1,800 B.P. 2,400 B.P. 2,700 B.P. X——X 3,300 B.P. Shoreline of Sandy Neck at various stages in its development—Numbers indicate years before present. From Redfield (1965, p. 53)

A Seismic station described in table 1

cl Exposure or auger hole

S-cg Pit—Extent of large pits; shown by hachures—Letter symbols on map and in table 3 show texture of deposits: *s*, sand; *vfs*, very fine sand; *fs*, fine sand; *ms*, medium sand; *cs*, coarse sand; *vcs*, very coarse sand; *g*, gravel; *pg*, pebble gravel; *cg*, cobble gravel; *bg*, boulder gravel; *p*, pebbles; *c*, cobbles; *b*, boulders; *sl*, silt; *cl*, clay, *t*, till. Superposition of symbols indicates section, comma reads "and", hyphen reads "to."

Description of Map Units

Qbs **STORM-BEACH DEPOSITS (HOLOCENE)**—Sand to small boulders (about 1 ft maximum dimension) in the bottom of storm sluices and as overwash fans. The storm sluice (Howard, 1939, p. 405), a flat-floored depression underlain by gravelly sand, near the east end of Sandy Neck was probably cut in the dunes during a major northeast storm. Planar, current, and deltaic bedding common. Beds generally an inch to several inches thick.

Qmd **MARINE DEPOSITS (HOLOCENE)**—Sand, gravel, silt, and clay deposited offshore by waves and currents. Shown only on cross section.

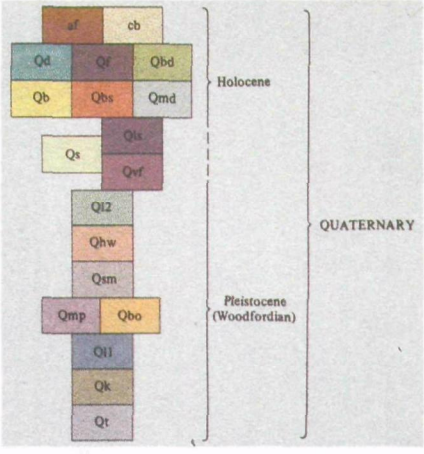
Qls **LAKE-SHORE DEPOSITS (HOLOCENE AND PLEISTOCENE)**—Formed along the shores of ponds and lakes, includes beaches and small spits composed of well-sorted sand and gravel, bag deposits composed mostly of pebble to cobble gravel as a result of wave winnowing of the glacial deposits, and levee-shaped ridges 1 to 2 ft high composed of poorly sorted sand and gravel pushed up by expanding lake ice

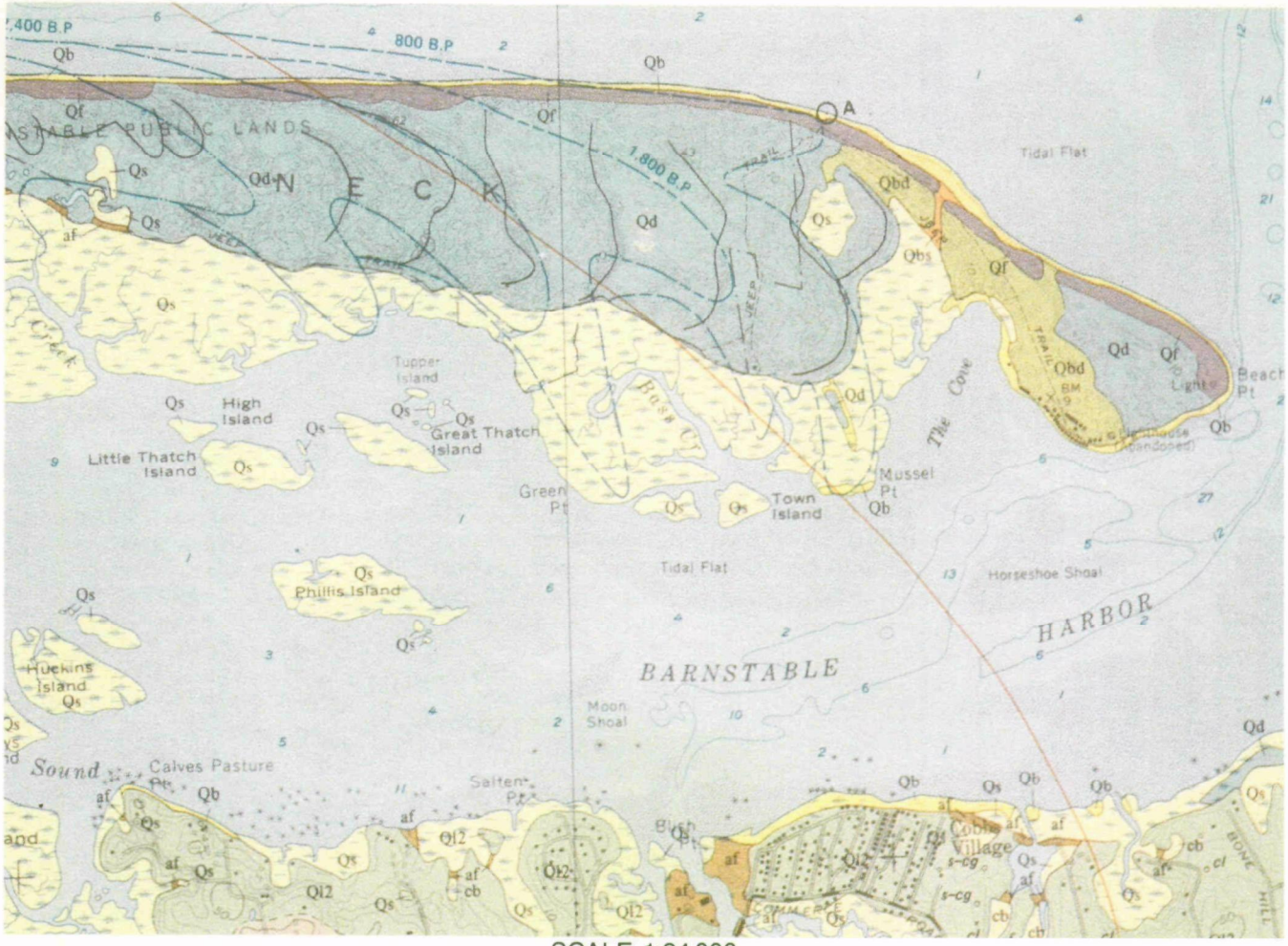
Qs **MARSH AND SWAMP DEPOSITS (HOLOCENE AND PLEISTOCENE)**—Mostly decaying marine-marsh plants mixed with varying amounts of sand, silt, and clay. Underlain by glacial deposits, by marine sand, silt, and clay, or by fresh-water pond and peat deposits; locally overlain by dune and beach deposits. Capped by live marine marsh plants. Includes lesser amounts of fresh-water swamp and marsh deposits

Qvf **VALLEY-FLOOR DEPOSITS (HOLOCENE AND PLEISTOCENE)**—Sediments deposited in the floors of valleys (furrows) cut into the outwash plains. Mostly gravelly sand and pebble to small-boulder gravel

Ql2 **YOUNGER GLACIAL-LAKE AND ICE-CONTACT DEPOSITS (PLEISTOCENE)**—Associated with a proglacial lake in Cape Cod Bay. Mostly a discontinuous veneer of clay and silt (Barnstable Series of Shaler, 1898) over ice-contact deposits composed of gravelly sand, gravel, till, and large boulders (a few tens of feet maximum dimension). Silt and clay massive to laminated, locally deformed. Sand and gravel planar and current bedded. Beds a foot to a few feet thick.

Correlation of Map Units



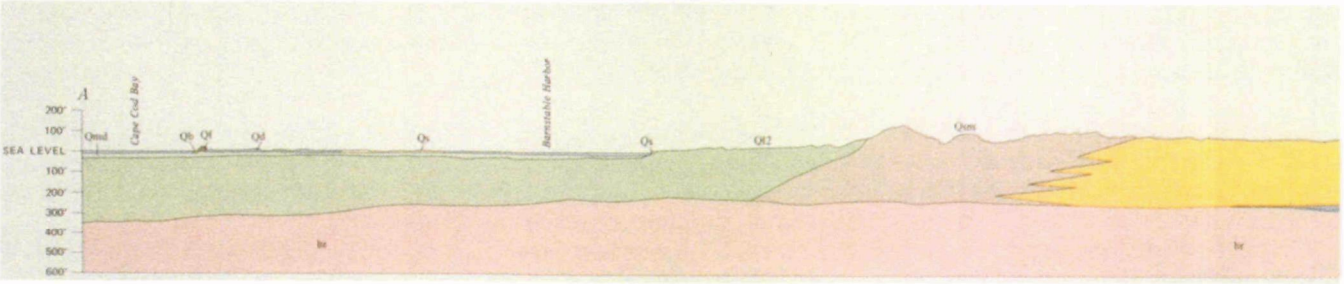


SCALE 1:24,000

1 ½ 0 1 Mile

Contour Interval 10 Feet
Datum is Mean Sea Level
Depth Curves and Soundings in Feet-Datum is Mean Low Water
Shoreline Shown Represents the Approximate Line of Mean High Water

Bar Scale



Cross Section

Figure 3-12. This thematic map presents a variety of information on the Hyannis Quadrangle, Barnstable County, Cape Cod, Massachusetts (Map GQ-1158, 1:24,000). As a general purpose map, it describes an area underlain primarily by surficial deposits of glacial origin but including materials formed in near-shore marine and coastal wetlands environments. A north-south geologic cross section interprets subsurface relations among these surficial materials; explanatory material identifies their physical characteristics and age as well as the meaning of lines, symbols, and colors.

- **Detailed scale (1:24,000 to 1:62,500).** Most of the geologic maps generated by the NGMP are produced at detailed scale because (1) this scale is appropriate for portraying the essential features of most geologic settings and (2) it is the scale of choice for most map users who require maps for land-use planning, environmental review, resource exploration and assessment, and geohazard evaluation (National Research Council, 1988). Detailed-scale maps are appropriate for most site-specific applications that require a background framework (Figure 3-15). The NGM Program generally does not produce geologic map products for areas smaller than the standard 7.5 minute quadrangle or at scales more detailed than 1:24,000.
- **Intermediate scale (1:100,000).** The NGM Program generates intermediate-scale maps in order (1) to synthesize the geologic framework of moderately large regions and (2) to display the geologic features of areas or regions whose relatively simple geologic architecture does not require a more detailed treatment. Intermediate-scale maps are useful to regional land-use planning or resource-assessment evaluations that require a relatively detailed but regionally comprehensive survey of the geologic setting.
- **Regional-scale (1:250,000 or smaller).** The NGM Program produces regional-scale maps in order to synthesize the geologic framework of very large regions. Regional-scale maps generally are not appropriate for the site-specific requirements of most geologic map users and the NGM Program does not emphasize this map product.

3.3.2.1.4 Production Requirements. The production time for a typical 1:24,000-scale geologic map generated by the NGM Program depends on the area's geologic complexity, but typically involves 1 to 1.5 years of field and laboratory effort culminating in preliminary release of the geologic map information. Production steps include (1) field acquisition of point, line, and polygon data; (2) acquisition of appropriate specialized data sets (geochronology, geochemistry, geophysics, paleontology, pedogenic-soil analysis, geomorphology) required to augment field data; (3) compilation of the geologic map data set and integrating it with specialized data sets; (4) scientific peer review and editorial review to ensure compliance with scientific and technical map standards; and (5) cartographic production and assembly of all the graphical elements that are combined to create the geologic map.

Final production of a colored map product released through the formal USGS thematic-map series can take several years. Therefore, many maps produced by the NGM Program are released as preliminary black-and-white maps distributed on demand through the USGS Open-File Services process. Even if digital map-production methods are employed, 1 to 1.5 years are to be expected for a production cycle that results in Open-file release of preliminary geologic map information.

3.3.2.1.5 Product Format. The USGS publishes geologic map information in a variety of paper-map series (Tables 3-2 and 3-3). These products are available for inspection in USGS public-inquiries offices or in earth science libraries in universities, State geological surveys, and the USGS regional centers. Map products can be purchased or otherwise obtained through the channels identified in Appendix D.

To date, all geologic maps produced by the USGS have been released in conventional paper form. The USGS presently does not have a formal publication mechanism for releasing geologic map information in digital form, although digital methods increasingly are being used to produce geologic maps. The NGM Program is developing digital map production methods that ultimately will generate digital geologic map data files for release to the user community. The goal of this activity is the creation and maintenance of a national digital geologic map data base comparable to National Mapping Division's National Digital Cartographic Data Base.

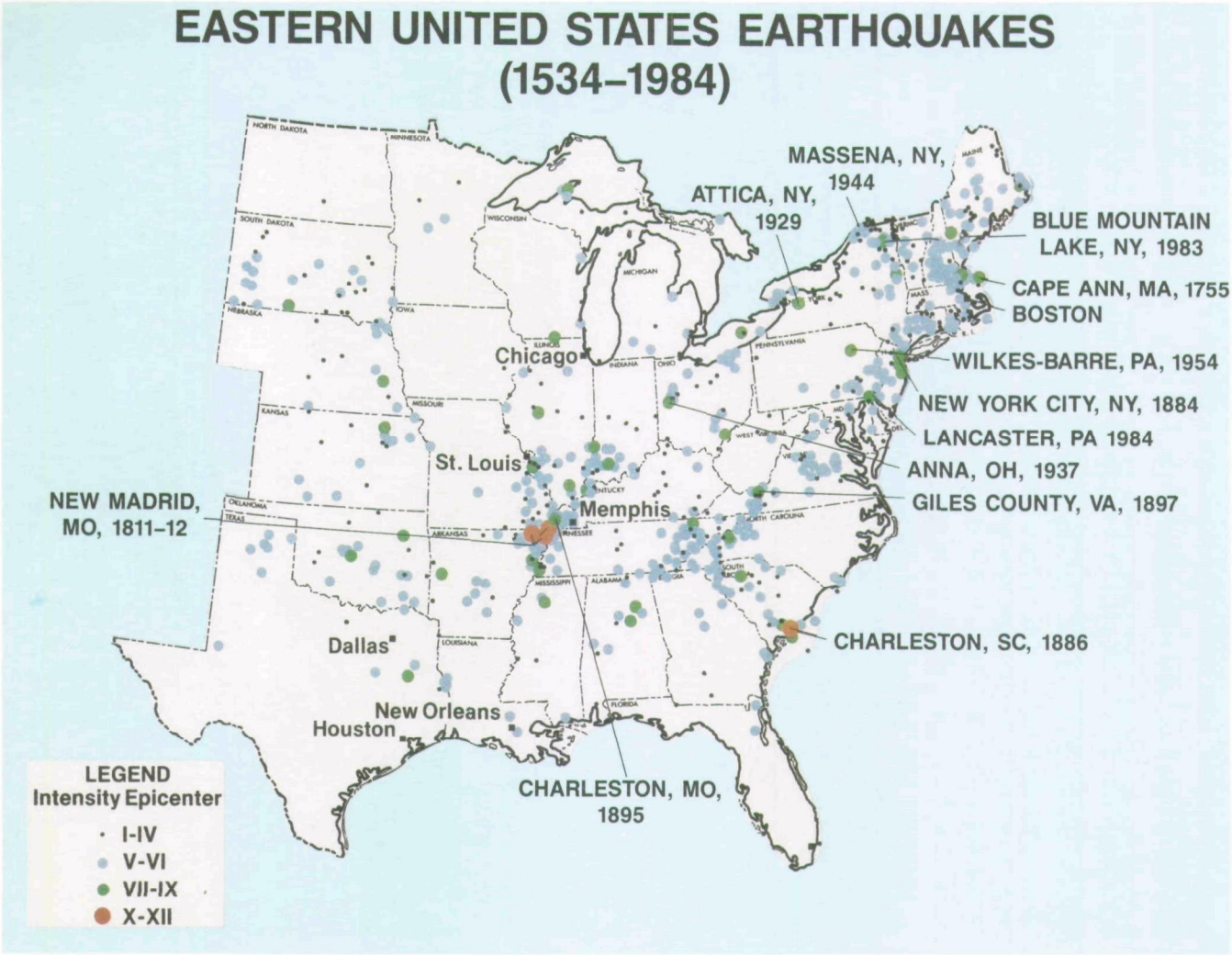


Figure 3-13. Identifying earthquakes that occurred in the eastern United States (1534–1984) is an example of data that can be used in combination with a general purpose geologic map to evaluate the potential for earthquakes and their recurrence.

A database of geologic maps, titled "GEOINDEX", is maintained by GD's Office of Scientific Publications. The GEOINDEX file comprises approximately 20,000 entries and identifies by title, author, latitude/longitude coordinates, and a number of other attributes all GQ, I, and MF maps produced by the USGS, as well as geologic maps published by State geological surveys and professional geoscience journals and societies (Table 3-2). The GEOINDEX file is complete through 1988 and an up-to-date nationwide summary is available in digital form. The GEOINDEX file has also been published on a State-by-State basis over the past 15 years as Geologic Map Indexes (GMIs). The GD's Office of Scientific Publications has released GEOINDEX with search and retrieval software available from Online Computer Library Center, Inc. (OCLC) in Dublin, Ohio, on a CD-ROM disk labeled "Earth Sciences."

3.3.2.1.6 Planning for Future Products. Long-term planning for the NGM Program is guided by two factors: (1) prioritized national need for geologic map information and (2) prioritized scientific problems that require geologic mapping. National need is determined by an examination of the user community (e.g., EPA); scientific need is determined by an inward look at the USGS mission and need for geologic mapping.

- **National need**. The NGM Program identifies national need as the prioritized geologic map requirements of the broad

LANDSLIDE POTENTIAL IN THE UNITED STATES

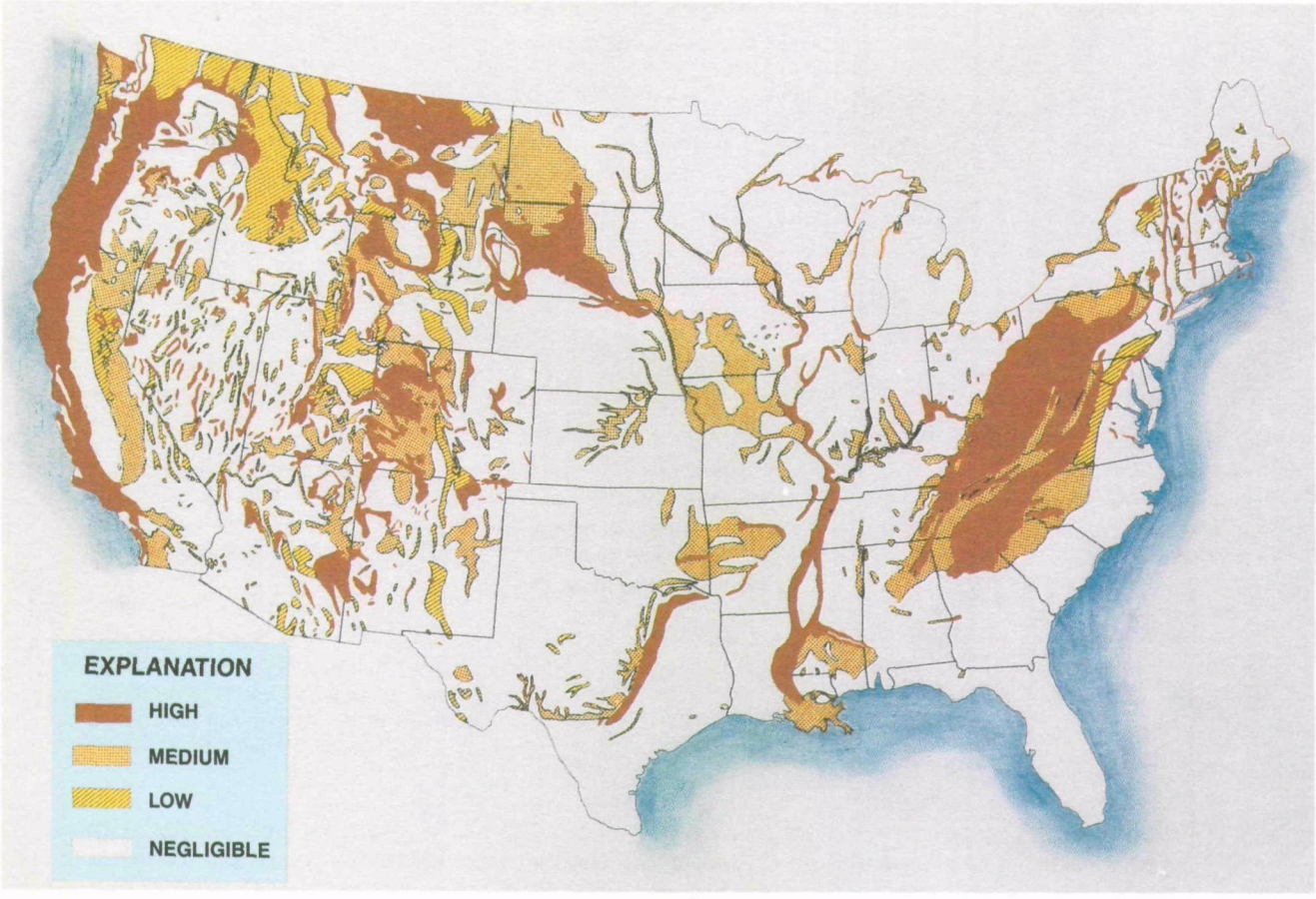


Figure 3-14. This view of the landslide potential in the United States is an example of a special purpose geologic map. It is based on information derived from general purpose geologic maps.

map-user community including information users in Federal and State agencies, academia, and the private sector. The need for basic geologic maps can be characterized as "national" in scope if (1) the maps will address multiple overlapping needs or (2) the maps address a single need that is compelling because of its impact on the economic, environmental, or resource requirements of the Nation. The NGM Program's outreach to EPA is part of a broader effort involving numerous Federal agencies. EPA's geologic map requirements will be considered together with those from the broad user community to determine the NGM Program's long-term national need.

- **Scientific need**. The NGMP identifies scientific need as critical earth science problems whose solutions transcend the boundaries of the local project area and thereby contribute to the understanding of rocks or processes elsewhere in the Nation thereby fulfilling GD mission goals.

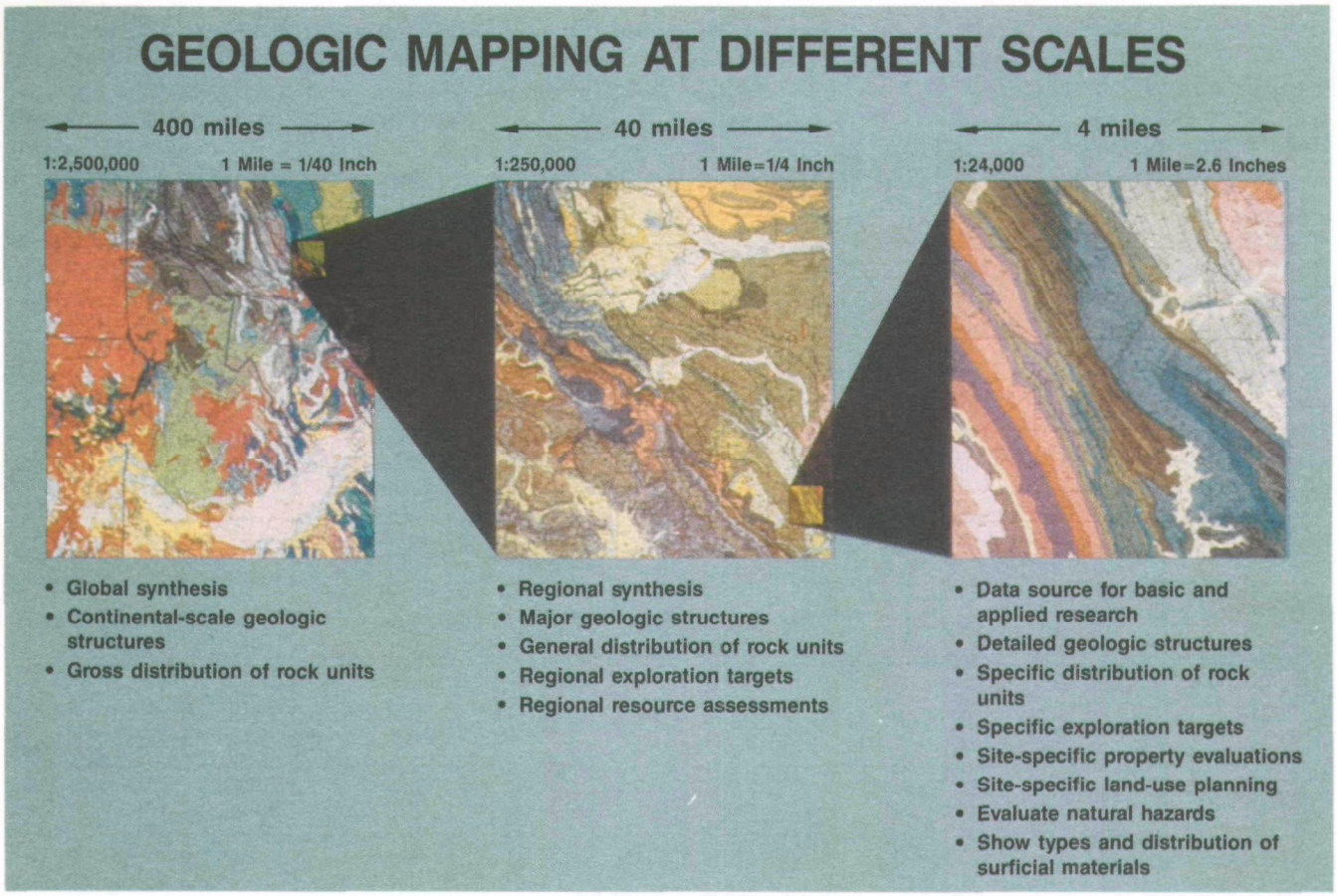


Figure 3-15. Geologic mapping is conducted at varying scales depending on the compexity of the geology and the intended use (site-specific evaluations versus regional planning). From left to right, the scale of each geologic map is more detailed, culminating in a 1:24,000-scale map that is typically produced by the National Geologic Mapping Program.

The level of scientific need can be measured by the benefit gained from transferring geoscience information from a local area throughout an entire region.

3.3.2.2 Geochemical Mapping

GD performs geochemical sampling and geochemical mapping in support of two programs: (1) mineral resource exploration and assessment and (2) environmental geochemistry. The purpose of geochemical maps for both mission requirements is

- To provide a statistically reliable geochemical baseline (background) against which potentially unusual samples may be judged, and against which future samples can be compared; and
- To provide stable geochemical maps.

Geochemical maps show trends so that predictions of unusual element concentrations may be made. Commonly the geochemical data are carefully examined and statistically manipulated, providing a basis for

making surficial geochemical maps that relate to geochemical processes. Geochemical maps for one purpose may be used for another since the surficial processes causing unusual geochemical values are often the same. For mineral assessments, the unusual values are often due to mineral occurrences (a natural, but rare event) and for environmental monitoring unusual values are often due to environmental contamination. The geochemical processes controlling the dissolution, transportation, and deposition of trace elements for both mineral formation and contamination are the same.

Environmental Geochemistry and Geophysics Program. The primary objective of the USGS Environmental Geochemistry and Geophysics program (EGG) is to understand (1) sources of elements; (2) how they are transported; (3) how they are deposited; and (4) the characterization of surficial and subsurface environments. Most of the geochemical and geophysical maps made within this program are funded through other Federal agency programs. Examples of USGS experience in assessing four general types of environmental contamination based on the work of contaminant distribution are shown below:

Distribution	Examples
1. Point Source, Natural	Mineral Occurrences
2. Point Source, Man-made	Lead, Mercury, Arsenic, Man-made Organic Compounds
3. Non-point Source, Natural	Radon, Selenium
4. Non-point Source, Man-made	Selenium, Agricultural Chemicals

Table 3-2. Geologic Information Products

	Series							
	GQ	GP	PP	B	I	MF	OFR	Digital
Geologic Maps and Data								
— General Purpose	X		X	X	X	X	X	X
— Special Purpose			X	X	X	X	X	X
Geochemical Maps and Data			X	X	X	X	X	X
Geophysical Maps and Data		X	X	X	X	X	X	
Marine Mapping and Data			X		X	X	X	X
— Exclusive Economic Zone (EEZ)					X	X	X	X
— Continental Margin Mapping Series					X	X	X	X
— Coastal Mapping Series					X	X	X	X
Assessment Maps								
— Mineral Resources			X	X	X	X	X	X
— Energy Resources			X	X	X	X	X	X
— Earthquake Hazard (seismic potential, ground shaking, ground response)			X	X	X	X	X	X
— Volcano Hazards			X	X	X	X	X	X
— Landslide and Subsidence			X	X	X	X	X	X

Series Legend:

GQ — Geologic Quadrangle Map Series (available in color and in 1:24,000 to 1:62,500 scales from earth science libraries and PIO).
GP — Geophysical Map Series (available in any scale from earth science libraries and PIO).
PP — Professional Paper Series.
B — Bulletin Series.
I — Miscellaneous Investigation Series (available in color and in any scale from earth science libraries and PIO).
MF — Miscellaneous Field Studies Series (available in black and white and in any scale from earth science libraries and PIO).
OFR — Open-File Reports (available in black and white and in any scale from USGS and Open-File Services).
Digital — Compact Disc/Read Only Memory (CD/ROM), floppy disks, tapes.

The approach used within the EGG Program to address environmental problems is based on the time available. When a rapid assessment is required, data are synthesized by integrating existing geologic, geochemical, and geophysical data bases. In the intermediate term, existing samples may be reanalyzed. The USGS sample archives includes almost two million rock, stream sediment, and soil samples that can be reanalyzed. Where the existing samples are not sufficient for the purpose of the study, additional field geochemical data is acquired. Additional geochemical data will be collected in cases where either examination of changes through time or comparison with a previous geochemical baseline is required.

3.3.2.2.1 Product Description. Geochemical maps are graphic displays of element concentrations in an area to emphasize locations of high and low concentrations, and provide a mechanism for making estimates between sample points. The geochemical maps may be made utilizing the total concentration of an element or the concentration of an element based on partial extractions. Stream sediments are the most commonly collected and analyzed surficial materials for making geochemical maps. Other surficial materials, including soils, rock, water, and plants, may be used as well, depending on the purpose of the map.

3.3.2.2.2 Product Uses. A geochemical map is most commonly used to show trends in element composition to locate areas of unusually high and, for some purposes, unusually low values. Geochemical maps may also identify the source of unusually high contaminant values (either natural or anthropogenic) and the areal distribution of surficial geochemical process (Figure 3-16).

Geochemical baselines are very important in situations of potential environmental contamination and are commonly prepared in the process of making a geochemical map. Geochemical maps of plant tissue generally reflect the bioavailability of an element, and are important in many environmental studies. Geochemical

Table 3-3. Scales of Geologic Maps Commonly Used by USGS

Map Scale	Type of Information	Purpose
1:2,500,000	Very general distribution of limited number of very large and heterogeneous rock units.	General planning and resource evaluation over very large regions (Federal regions, very large States).
1:500,000	General distribution of a larger number of somewhat less heterogeneous rock units. Little information on depth.	General planning, and resource evaluation over large regions (large States, river basins). Common scale for older State maps.
1:250,000	Semidetailed distribution of large numbers of fairly homogeneous rock units. Some information on depth. Often has topographic base.	More detailed planning and resource evaluation in medium-sized areas (small States, large counties, national forests, mineralized belts).
1:100,000 1:63,360 (Alaska) 1:62,500	Detailed distribution of large number of homogeneous rock and surficial units and considerable information on thickness and depth. Generally has topographic base.	Detailed planning, land-management, and resource studies (mining districts, urban areas, many counties).
1:24,000 1:20,000 (Puerto Rico)	Very detailed distribution of large number of quite homogeneous rock units. Surficial deposits may be shown on separate map. Much information on thickness and vertical extent of rock units. Has topographic base.	Detailed planning, zoning, site selection, resource planning, and exploration (cities and towns, subdivisions, mining districts, mine sites, large construction projects).

Source: Thompson (1988).

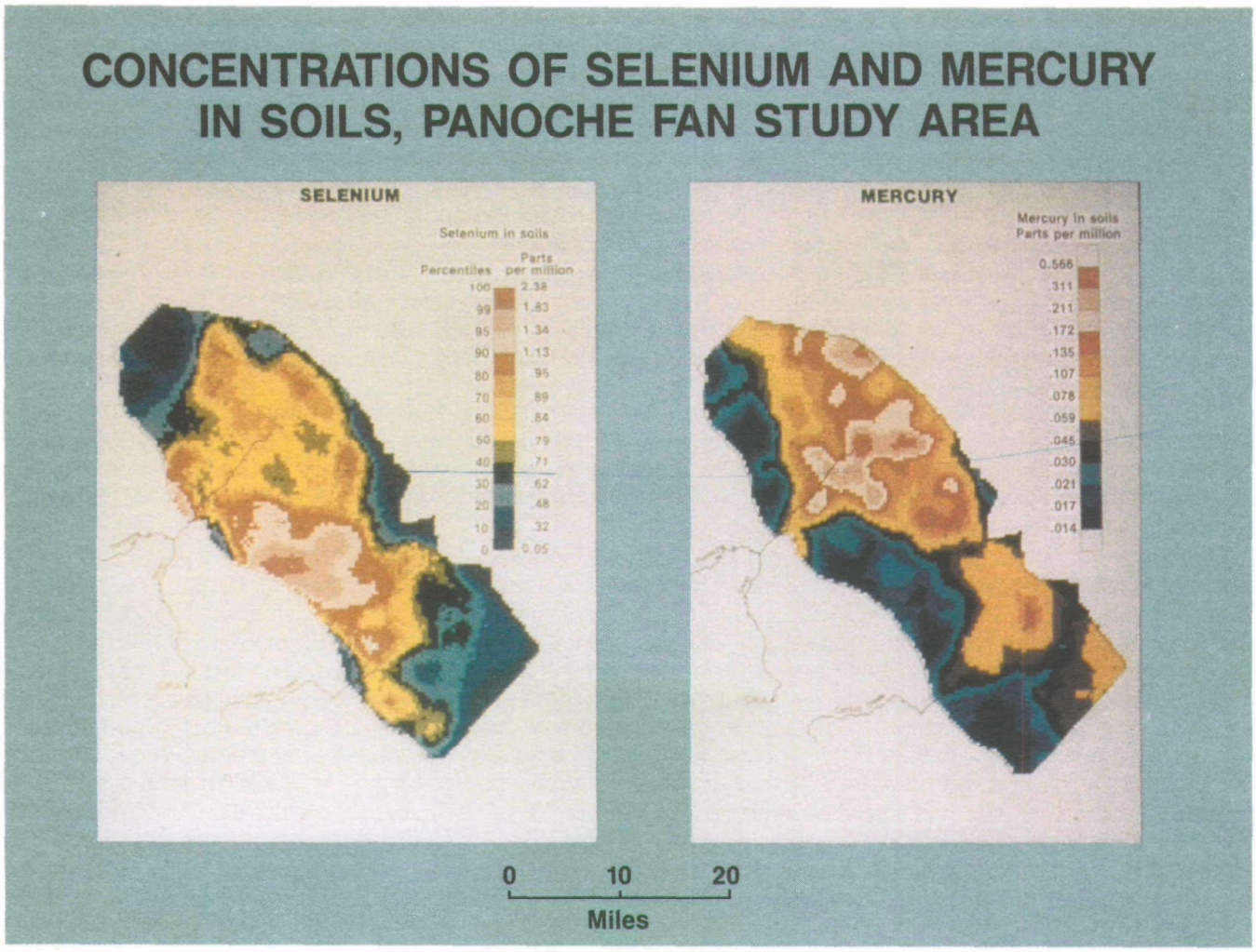


Figure 3-16. These geochemical maps reveal concentrations of selenium and mercury in soils at the Panoche Fan Study area.

maps generally reflect only surface information. Samples from drill core are required to produce geochemical maps that show variation with depth.

3.3.2.2.3 Product Scales. The scale of a geochemical map can vary greatly to include detailed sampling at local (large-scale, 1:1,000) scales, to very broad (small-scale, 1:250,000) scales, such as the whole of the United States. The broad-scale maps lose resolution and more detailed sampling may be required to achieve the objectives of a particular project. The resolution of a map depends on the sampling density and is independent of scale.

3.3.2.2.4 Production Requirements. Preparation of a statistically stable geochemical map is a two-part process. The variability due to sample spacing, sampling methods, and analytical protocols is determined first. Then, baseline estimates are determined and sample densities and locations calculated. The production time of geochemical maps may vary from a few days when data already exists in the geochemical data base, to about 2 years when samples need to be collected and analyzed in the two-stage process. Reanalysis of archived samples for constituents not previously determined requires an intermediate timeframe as no field work is necessary. While formal publication production of a geochemical map may take several years due to peer review and the publication process, interim data can commonly be made available more rapidly in a less formal format.

3.3.2.2.5 Access to Available Products. Geochemical maps are typically part of a broader program objective and are available within reports and Open-File Reports. Geochemical maps are also published in scientific journals, and in many cases are available in both paper and digital format. The Office of Scientific Publications within the Geologic Division provides the mechanism for release of most published geochemical maps. Two existing data bases that contain large numbers of archived samples are the National Uranium Resource Evaluation (NURE) samples and the USGS Rock Analysis Storage System (RASS). The NURE data base contains geochemical information for stream sediments, ground and surface water. The NURE sample archive consists of stream-sediment samples. The RASS data base and sample archive includes geochemical information for rock, soil, sediment and plant samples.

All of the data in the USGS RASS and NURE data bases are available in digital format. A CD/ROM disk containing all of the NURE data is being prepared; the RASS data will be added later. The CD-ROM disks will be available for general distribution. Additional information is available in USGS Circular 817 "Scientific and technical, spatial, and bibliographic data bases and systems of the U.S. Geological Survey, 1983."

3.3.2.2.6 Planning for Future Products. Because of the need to assess the availability of existing data and determine whether the data are sufficient for the intended study, geochemical mapping requirements need to be planned on a case-by-case basis. Additional consideration should also be given to the complications that can be introduced in areas where the means of element transport and deposition are not well understood.

3.3.2.3 Geophysical Mapping

Geophysical maps are produced in support of energy, mineral resource, and environmental analysis and assessments. They are commonly integrated with geochemical and geologic maps. Geophysical maps are used to determine the stratigraphy of the subsurface of the earth. A large number of geophysical techniques are commonly employed (Table 3-4) depending on the nature of the area and the problem being addressed. Figures 3-17 and 3-18 present examples of two geophysical mapping techniques. Covering each geophysical technique is beyond the scope of this manual, but can be obtained either from the USGS or from the EPA Environmental Monitoring Systems Laboratory (EMSL) at Las Vegas, Nevada (Appendix B). Geophysical techniques are generally non-invasive and can give real time information. These attributes are often very important in assessing environmental problems.

3.3.2.3.1 Product Description. Geophysical maps show either aerial data (profiles) or vertical data (soundings). Data may be gathered by satellite, airplanes, or on the ground. Geophysical maps show the variation of a variety of subsurface earth material attributes, depending on the technique, for the area of interest. The data are interpreted in combination with other available geoscience information such as geology and geochemistry. Products include geophysical maps, interpretive maps and reports, and digital data.

3.3.2.3.2 Product Uses. Geophysical techniques sense electrical, physical, and chemical differences in the earth using electromagnetic, magnetic, radiometric, density, and seismic techniques. The information can be used to examine the stratigraphy of the subsurface and may include depth to bedrock, the subsurface stratigraphy, the depth to ground water, chemical composition of the ground water (including organics and dissolved elements), clay-organic interactions, and other attributes.

Each geophysical technique gives varying, commonly complementary, information. Through funding from EPA (EMSL), an "expert" system was written by the USGS to aid selection of geophysical techniques to address environmental questions. The system was designed to lead nongeophysicists through a series of questions relating to the setting of interest and focus attention on the information needed to assess the situation properly. These questions are important to determine the relative strengths and weaknesses of geophysical techniques for the problem at hand. The system should be tested as a guide to appropriate geophysical techniques and supplemented by experience.

3.3.2.3.3 Product Scales. The scale at which a geophysical map is produced depends on the purpose of the investigation. General geophysical maps are produced at small scales, while detailed geophysical maps from soundings are made at much larger scales. The scales of geophysical maps vary greatly from about 1:10,000,000 for gravity and magnetic maps of North America to detailed maps of small areas at large scales of about 1:1,000 for maps compiled using ground-penetrating radar, electromagnetic, and other techniques. It is also possible to make detailed gravity and magnetic maps.

Equally important to scale in geophysical maps is the concept of resolution. For example, aeromagnetic maps may be made at the same scale, but could be based on flight lines as much as 6 miles apart or as

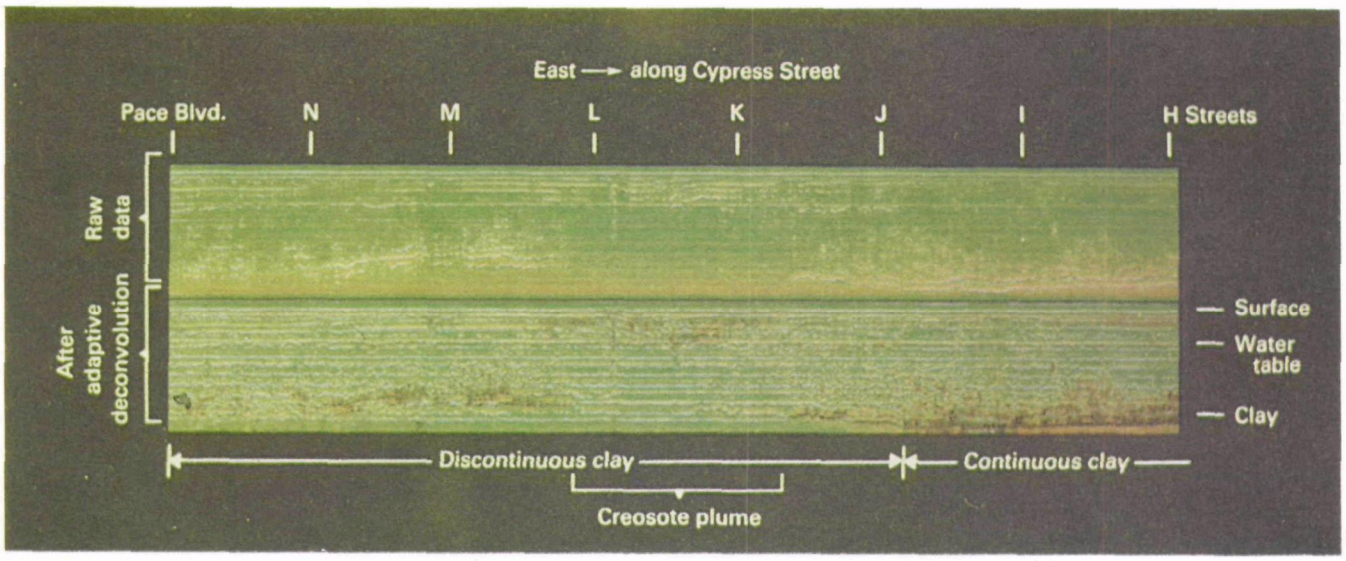


Figure 3-17. The use of ground-penetrating radar allows the mapping of subsurfaces and is a valuable technique for examining localized environmental problems, such as the extent of a creosote plume.

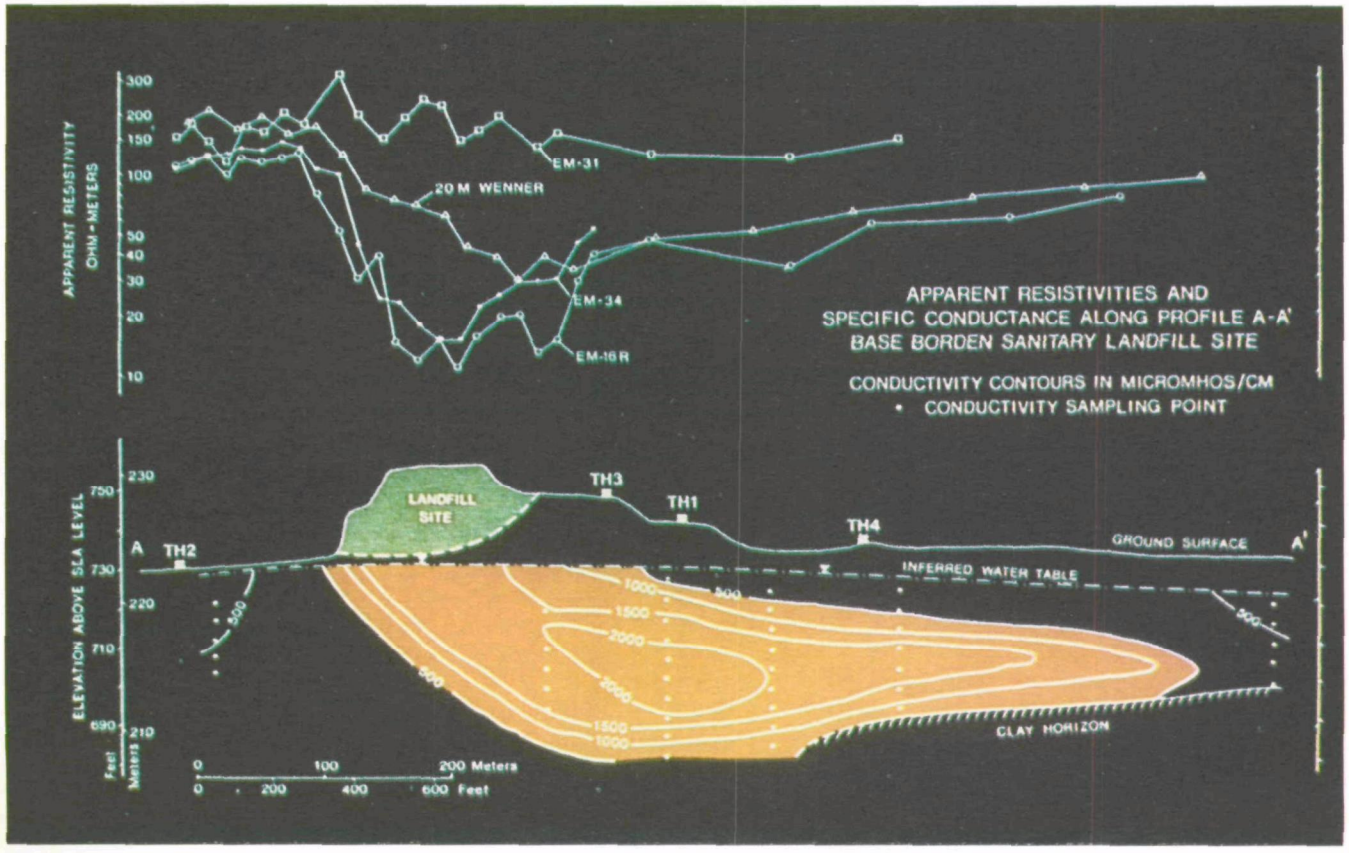


Figure 3-18. Electromagnetic induction, another geochemical mapping technique, provides data on the interaction of inorganic and organic compounds with clay minerals.

Table 3-4. Geophysical Mapping Techniques

Technique	Description
Remote Sensing	Applications, either airborne or satellite, include determining the regional distribution and character of exposed surficial materials (rocks, soils, man-made features), determining the surficial distribution of some minerals, including clays, mapping fractures and fracture zones at the surface detecting and characterizing thermal sources, both natural and anthropogenic.
Magnetic	Applications include locating magnetic objects such as drums, barrels, pipes, casings, and some geologic materials.
Ground-Penetrating Radar	Applications include mapping the subsurfaces showing the water table, depth to bedrock, stratigraphy of soils and sediments, containers and organic contaminants. This is one of the most valuable techniques for many localized environmental problems (Figure 3-17).
Electromagnetic Induction	Can detect bedrock, water tables, clay lenses, buried metallic objects, and inorganic plumes (Figure 3-18).
Complex Resistivity	May detect buried metallic objects, plumes of inorganic, clay lenses, and organic compounds reacted with clay minerals.
Seismic	Procedures are used to determine the stratigraphy of the subsurface. Depth of survey depends on the procedure used.
Radiometric	Procedures measure radioactivity. Measurements may be made from the air where natural radiation from elements such as uranium, thorium, and potassium may be determined. On the ground variety of elements may be determined, such as radon.
Gravity	Procedures measure differences in density of subsurface materials for geologic framework surveys. Other gravity techniques may be useful in locating voids, trenches, and potential subsidence problems.
Well Logging	Techniques are used to determine several different characteristics of rock in a drill hole.
Borehole	Geophysical techniques are used to determine the structure of the subsurface between two drill holes.

close as ¼ mile. The spacing of the flight lines is dependent upon the resolution required. Analogous spacing concerns apply to geophysical measurements made on the ground as well.

3.3.2.3.4 Production Requirements. The variety of geophysical techniques necessarily dictates a wide range of time frames for the production of a new geophysical map. Some ground-based techniques may give real time information, while several months to years may be necessary when flying many flight lines. Commonly a large amount of computer time is necessary to reduce the data to produce a map.

3.3.2.3.5 Access to Available Products. Geophysical maps are produced as paper products; however, the data are commonly available in a digital format. Generally the geophysical maps are published as Open-File reports, in the MF series, in the Geophysical Investigations (GP) series, and in scientific journals (Table 3-2). Most published geophysical maps also include data and interpretations.

3.3.2.3.6 Planning for Future Products. Ongoing mission work, mineral, and environmental assessments utilize a large proportion of the resources available for producing geophysical maps. However there may be overlap in some areas of interest to EPA, so that the needs for geophysical maps should be made known to the USGS through OIRM.

For long-term projects requiring geophysical maps, it would be useful for the USGS to be contacted at the planning stage so that the long-term goals of both agencies can be met with existing resources.

3.3.2.4 Offshore Mapping

The Presidential proclamation of March 10, 1983, declared an Exclusive Economic Zone (EEZ) and the USGS began a program to map the seafloor. The EEZ encompasses the seafloor extending from the coast seaward to 200 nautical miles (over 3-million square nautical miles). The wide-swath, sonar-mapping system known as Geologic Long-Range Inclined Asdic (GLORIA), developed and operated by the Institute of Oceanographic Sciences (IOS), United Kingdom, was selected by the USGS as the EEZ mapping system. Between 250,000 and 300,000 square nautical miles of seafloor are mapped annually as part of a scientific cooperative agreement with IOS. At the start of Fiscal Year 1988, over one-third of the EEZ (1,000,000 square nautical miles of seafloor) had been mapped using GLORIA, which encompasses the EEZ around the conterminous United States, the Commonwealth of Puerto Rico and the U.S. Virgin Islands, from the island of Maui south in the Hawaiian Islands and in the Bering Sea. By 1991, the reconnaissance-scale mapping of the deep-water EEZ around the 50 states will be complete.

The digital sidescan-sonar GLORIA data are image-processed, enhanced, and mosaiced into image maps of the seafloor. These maps are published as atlases of each region. The data and maps are also being distributed on CD-ROM disks available to a broad PC-based user community. The atlases of GLORIA sidescan sonar data contain image maps at a scale of 1:500,000, covering the seafloor from the edge of the continental shelf (approximately 200 m water depth) to the seaward edge of the EEZ. It takes approximately 18 months from completion of data collection to publication of image map atlases. Atlases and CD-ROM disks are available as USGS publications. Using these data and maps, regions of the seafloor can be identified for detailed study to assess resource potential (both energy and mineral), evaluate dynamic seafloor processes, and predict engineering and environmental conditions that will affect resource development.

Continental Margin Mapping Project (CONMAP). The Continental Margin Map Series is a digital compilation of information on the EEZ. Digital cartographic techniques are used to capture and display the data. The CONMAP Series will provide continuous coverage at a scale of 1:1,000,000 of the 20 overlapping map areas. A base map of topographic (onshore) and bathymetric (offshore) data as well as up to 10 thematic maps for each area are planned. Thematic maps include distribution of sediment types, sediment thickness, tectonic features, and sediment geochemistry. In addition to printed maps, the digital data base used to construct the maps will also be available.

Coastal Map Series (COASTMAP). A Coastal Map Series is also under development for displaying near-shore data at a scale of 1:100,000. A base map of topography (onshore) and bathymetry (offshore) is prepared in conjunction with thematic maps such as sediment grain size distribution. These maps also are produced by computer from a digital data base (Figure 3-19). This map series is useful in addressing coastal issues such as erosion and near-shore resources. As data are collected they can be used to build, expand, and update existing data bases.

Coastal Geology Program. The Coastal Geology Program consists of three main areas of research: coastal erosion, coastal resources, and coastal pollution.

- Coastal Erosion: The overall objective of the coastal erosion component is to better determine the processes causing erosion. By better understanding processes, the ability to predict future erosion and better assess the utility of attempts to mitigate erosion should improve. At present, the USGS has ongoing studies of barrier island erosion and wetland loss processes in Louisiana (Figure 3-20), and shoreline erosion in southern Lake Michigan. Each study includes acquiring marine geophysical and remote-sensing data to determine the shallow geologic framework within which the erosion is taking place, understanding the detailed processes leading to erosion such as sea-level rise and sediment supply, and displaying the results on maps and in reports.
- Coastal Resources: The overall objective of the coastal resources component is to better determine the processes leading to concentration of hard mineral resources in coastal areas. By better understanding how concentrations of resources develop, USGS should be better able to predict their locations. Hard mineral resources in the

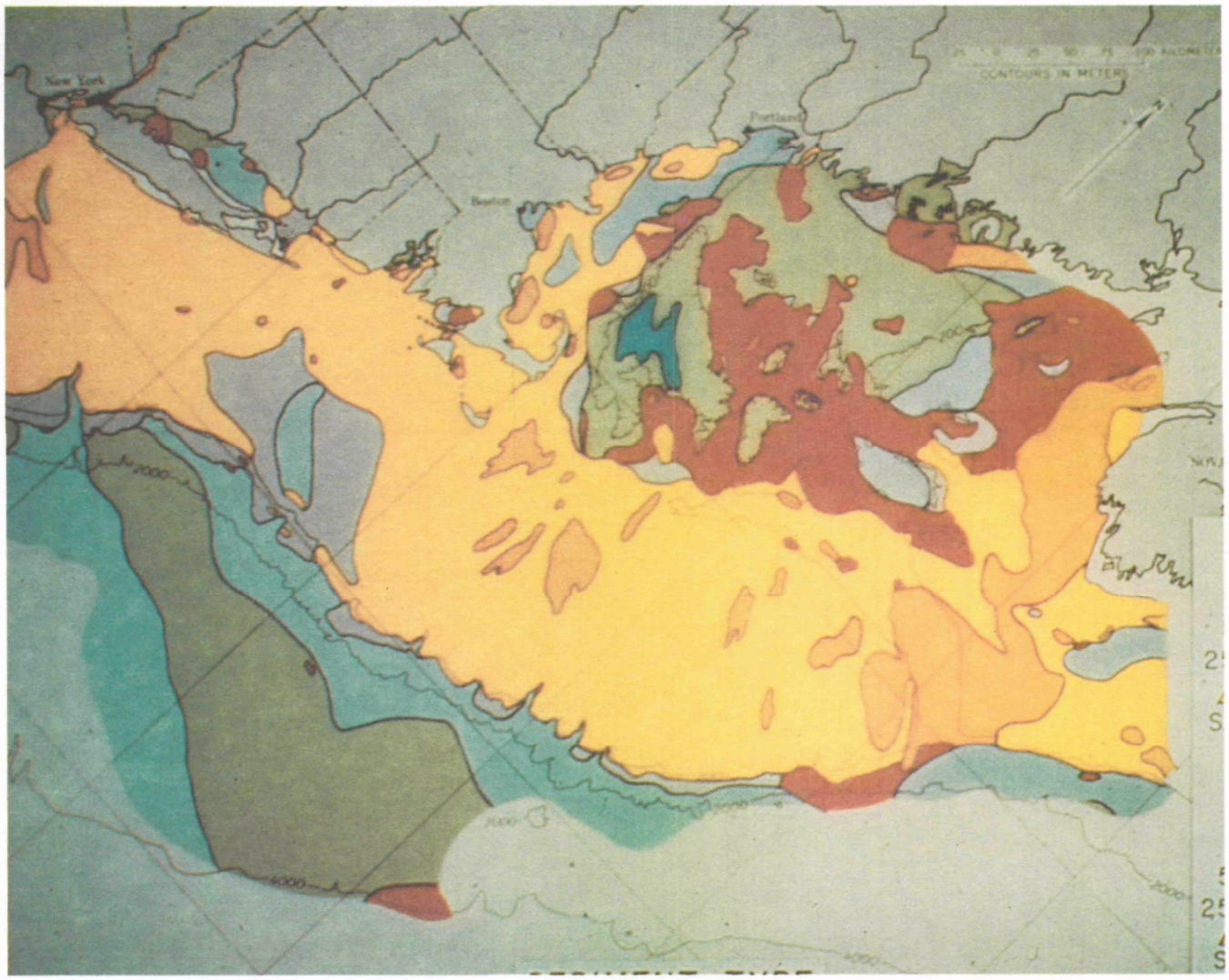


Figure 3-19. A Coastal Map Series is being produced that will combine topography (onshore) and bathymetry (offshore) maps with thematic maps, such as sediment grain size distribution, to provide detailed information on various coastal areas. This COASTMAP series will be helpful in addressing coastal problems such as erosion.

coastal zone include heavy minerals such as ilmenite (a source of titanium) and sand and gravel used for construction purposes and beach nourishment.

- Coastal Pollution: The overall objective of the coastal pollution component is to determine how pollutants are disbursed and concentrated in coastal and estuarine waters. The emphasis is on pollutants that adhere to fine sediment particles and which may be deposited into sedimentary deposits in quiescent waters or remobilized during storms. At present, USGS has completed a reconnaissance study of Boston Harbor where it measured currents, sediment transport, and dispersal of pollutants through the stormy winter season as well as conducted detailed mapping of the seafloor using sidescan sonar and other high-resolution geophysical equipment.

Products. The results from investigations in all three components of the Coastal Geology Program are published and made available to the scientific community and the general public in the form of written reports and abstracts summarizing oral presentations as well as in thematic maps (Figure 3-12). These are available through a variety of media, including USGS report series, scientific and technical journals, and as proceedings from domestic and international meetings of professional societies. Any of the products may be obtained from either the USGS sales offices or other central libraries (see Appendices C and D).

3.3.2.5 Access to Geologic Division Products

Geoscience products of GD are accessible to any EPA organization or individual having a need for the services and facilities. The general categories of information and service include (1) publications, (2) libraries, (3) data bases and data systems, and (4) geologic information services. The GD is an active publisher of geologic maps, thematic maps, written reports, and abstracts. These reports are published through a variety of media, including the USGS professional paper, bulletin, circular, and Open-File report series, as well as scientific and technical journals of non-USGS societies. Thematic maps are published under one of several USGS map series. After review, the material is published by the Office of Scientific Publications, with the exception of map products. Final preparation and printing of USGS map series products is the responsibility of the NMD.

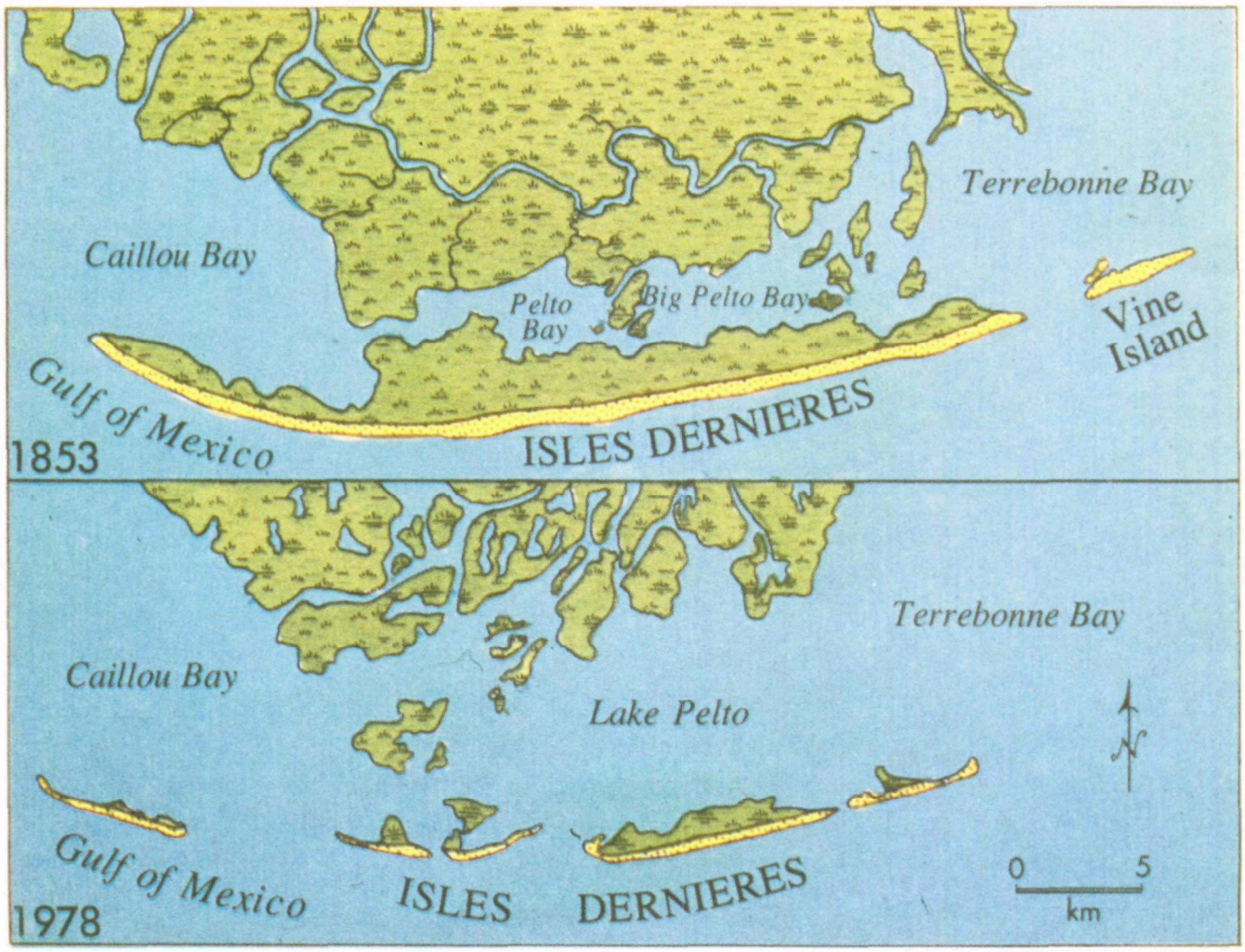


Figure 3-20. The mapping of coastal erosion allows us to predict future erosion and better assess the effectiveness of mitigation efforts. These maps show the effects of erosion over a 125-year period (1853 to 1978). Maps such as these are frequently developed in cooperation with State geological surveys.

ıD is responsible for maintaining the USGS Library System. This system, administered by the Office of ɜntific Publications, contains more than one million holdings in the main library in Reston, as well as e holdings at the Denver, Menlo Park, and Flagstaff locations. The library system can be utilized by Fed- and State agencies, universities, industry, and the general public. The library holds both a standard col- ion of publications, as well as field records, notebooks, manuscripts, and other background materials n projects undertaken by any USGS personnel. The Photographic Library, located in Golden, contains ıe 200,000 photographs taken during field studies which date back to the year 1869. Please refer to ɔendices E and F for further information on how to obtain library services and to use library facilities.
ıD maintains a series of data bases and data systems. The data bases are usually accessible for retrieval 'esearchers and other parties, and cover a multitude of subjects including earthquakes, energy and eral resources, rock analyses, and geologic maps. A comprehensive listing of USGS data bases and sys- s can be found in USGS Circular 817, "Scientific and technical, spatial, and bibliographic data bases systems of the U.S. Geological Survey, 1983."
ıD also maintains Geologic Information Services (GIS). There are three groups in the GIS: the Geologic nes Unit, the Geologic Inquiries Group, and the Visual Information Services Group. Of the three, the up most useful to the EPA staff is likely to be the Geologic Inquiries Group, which is responsible for ɔonding to inquiries on all aspects of geology, geologic maps, and mapping directed to the USGS by ɜr Federal, State, and local agencies as well as from the general public (see Appendix C).

3.4 Water Resources Division

'he Water Resources Division (WRD) conducts a wide variety of earth science investigations to carry out Division's mission to appraise the Nation's water resources and to provide the hydrologic information ɜded for managing these resources as described in USGS Circular 1005 (USGS, 1986b). To accomplish mission WRD, in cooperation with State and local governments and other Federal agencies, performs the ɔwing functions:

- Collects data on a systematic basis to determine the quantity, quality, and use of surface and ground water, and the quality of precipitation.
- Conducts water resources investigations and assessments at national, State, and local scales, characterizes water resources conditions, and provides the capability to predict the impact on the resource of managerial plans or actions, and the effects of natural phenomena.
- Conducts basic and problem-oriented hydrologic and related research to produce knowledge that is useful in resolving water resources problems.
- Acquires information that is useful in predicting and describing water-related natural hazards that may result from the occurrence of flooding, volcanic eruptions, mudflows, land slides and land subsidence.
- Coordinates the activities of all Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground waters.
- Disseminates data and the results of investigations through reports, maps, computerized information services, and other forms of public release, and operates water information centers.
- Provides scientific and technical assistance in hydrology to other Federal agencies, to State and local agencies, to licensees of the Federal Energy Regulatory Commission, Nuclear Regulatory Commission, and, on behalf of the U.S. Department of State, to international agencies.
- Administers provisions of the Water Resources Research Act of 1984, including the State Water Resources Research Institute Program and the National Water Resources Research Grant Program.

3.4.1 Organizational Structure

The Water Resources Division functions are carried out at two levels—Headquarters and field (Figure 3-21). The Headquarters level is responsible for the overall direction of the Division, and consists of the Chief Hydrologist, the Associate Chief Hydrologist, and five Assistant Chief Hydrologists one each for Operations, Scientific Information Management, Program Coordination and Technical Support, Research and External Coordination, and Water Assessment and Data Coordination.

General direction of the Division's field program is through four Regional Hydrologists, each of whom is located at a regional center: Reston, Virginia (Northeastern Region); Atlanta, Georgia (Southeastern Region); Lakewood/Denver, Colorado (Central Region); and Menlo Park, California (Western Region). These Regional Hydrologists represent the Chief Hydrologist and the Director of the U.S. Geological Survey in negotiations and dealing with other organizations and committees. They also oversee the programs of the 43 WRD District offices, which carry out the water resources investigations and data collection programs of the Division. The Division's hydrologic research effort is directed to determining new methods for hydrologic data collection and analysis, and providing new concepts in the understanding of hydrologic processes.

Each District office is under the guidance of a District Chief who is responsible for planning, programming, and implementing the data collection activities and hydrologic studies within the District. Many District activities are supported by a jointly funded program, whereby the USGS matches funds with State and local agencies on a 50-50 basis. Each District typically has one or more subdistricts and field offices that report to the District Chief. Three multi-State Districts also have offices that coordinate programs within each State and report to the District office.

The Division's field organization enables the Geological Survey to have close contact with State and local agencies, allows the accumulation of detailed experience and knowledge of regional and local hydrologic conditions, provides an early-warning system for the detection of emerging water problems, and reduces costs for conducting investigations and operating data collection networks.

3.4.2 Programs and Activities

Program development in WRD is an evolving activity. Existing programs are reviewed regularly and future needs for water data and hydrologic investigations are projected. Water problems and data needs frequently are brought to the attention of the Division by State and local agencies and the public; thus, program development is a grass-roots effort. As data needs and water-related problems change, the programs are modified accordingly.

The programs of are of three major types: (1) data collection and dissemination; (2) problem-oriented water resources investigations; and (3) research. Budgetary documents classify the WRD's activities according to source of funds: direct congressional appropriations (Federal Program); joint or shared funds (Federal-State Cooperative Program); and funds from other Federal agencies (Other Federal Agencies Program). Although this classification is helpful, most of the programs are so interrelated that they are difficult to explain exclusively by source of funds or type of activity. For example, theories arising from research are the foundation of data collection and problem-oriented water resources investigations, and data collection is a major component of all water resources appraisals and most of the research studies.

Since the early 1900s, WRD has been conducting areal and research water resources investigations, many of which are related to surface- and ground-water contamination. The number of investigations related to water resources contamination and water resources appraisal has increased each year. Many of the WRD programs have mapping components associated with particular needs of the program.

During the past few years, water-resources contamination has received highest priority consideration and various investigations and research efforts are ongoing to obtain an improved understanding of the Nation's water quality and the factors affecting it. Some of the USGS research into the regional hydrologic framework of aquifers and fate and transport of chemicals, in which hydrologic mapping is conducted as part of the analyses of the systems, include the Regional Aquifer Systems Analysis (RASA), the Toxic Substances Hydrology Program, the Central Valley of California selenium study, and the National Water Quality Assessment (NAWQA) program. The RASA studies are of particular interest as they provide definition and mapping of regional aquifer systems.

Hydrologic maps produced by WRD are part of interpretive investigations and cover such topics as acid rain, surface-water hydrologic units, quality and flow conditions, aquifer characteristics and boundaries, ground-water flow systems, geochemistry, contaminant plumes, geophysics, soils, water use, and well locations. Much of the basic information used to prepare these maps is available in computer data bases located at District or WRD Headquarters' Offices. Some of the information is available in GIS ARC/INFO format.

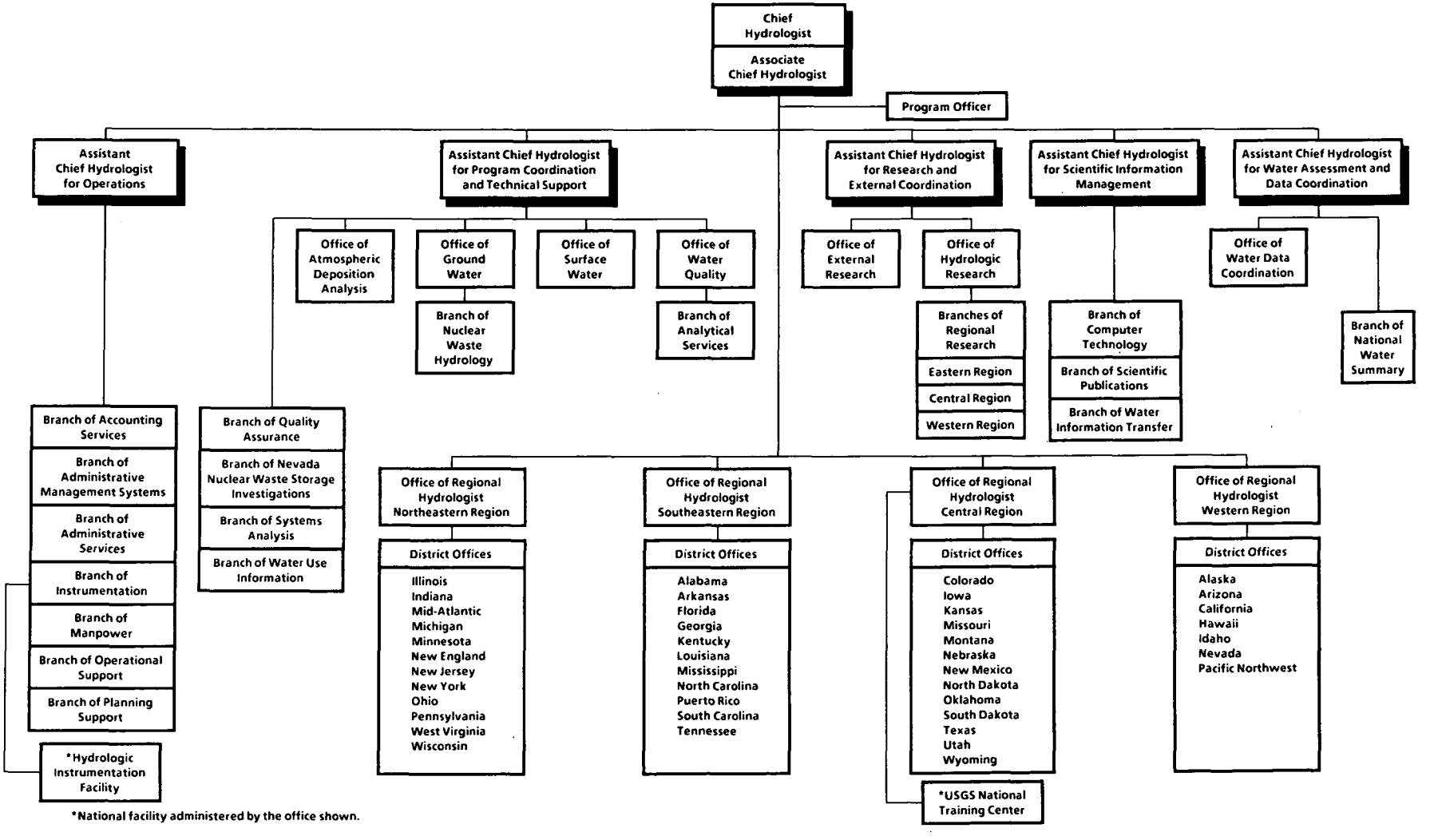


Figure 3-21. The Water Resources Division has numerous functions which are carried out at two levels. The headquarters level consists of the Chief Hydrologist, Associate Chief Hydrologist, and five Assistant Chief Hydrologists. At the field level are four Regional Hydrologists, each of whom is located at a regional center.

These hydrologic data bases provide the data for the understanding of hydrologic systems and facilitate the application of surface-water, ground-water, and solute transport models. As part of the process of evaluating aquifer systems, hydrologists begin the evaluation by depicting the resulting maps' characteristics such as tops and bottoms of aquifers and confining units; recharge/discharge areas; lithology, structure, and thickness of hydrologic units; saturated thickness; depth to water; potentiometric surface; transmissivity and hydraulic conductivity; porosity; yields; water quality; and source and movement of contaminants using geologic maps as a preliminary description of the earth. This information is combined with data from aquifer tests, drill-stem tests, geophysics—both surface and borehole as described in Table 3-4—drillers' logs, water-quality data, and other information to provide an understanding of the aquifer systems.

Hydrologic investigations in WRD are conducted through the three major Programs—Federal, Federal-State Cooperative, and Other Federal Agency Programs. Hydrologic map products are an integral part of the ongoing interpretive and basic data collection activities in these programs. Mapping scales are selected according to the analytical and presentation needs of the various programs, but generally are one of the scales in the existing topographic series. However, the final publication scale may be reduced from that of the compilation scale. Other maps are published in map series, such as in the Hydrologic Investigations Atlases described later in this chapter. Selected WRD programs that produce maps or provide computer-based data pertinent to mapping are described in the following sections on the Federal (other Federal Agencies) and Federal-State Cooperative Programs.

3.4.3 Federal Program

The Federal program is specifically identified in annual Congressional appropriations and provides for the collection of water resources data, investigations of resources, and resources activities in areas where the Federal interest is paramount. These interests include water resources in the public domain, river basins and aquifers that cross State boundaries, and other areas of international or interstate concern.

Regional Aquifer-System Analysis Program. The Regional Aquifer-System Analysis (RASA) Program is a systematic effort to study a number of regional ground-water systems that represent a significant part of the Nation's water supply. A regional aquifer system, as the term is used here, may be of two general types: (1) aquifers that are of regional extent, such as those underlying the Great Plains and the Atlantic Coastal Plain (Figure 3-22); and (2) groups of aquifers that share so many characteristics that investigation of a few of these aquifers can establish common principles and hydrologic factors controlling the occurrence, movement, and quality of ground water throughout similar aquifer systems.

The purpose of the RASA program is to provide the basic information and knowledge needed to manage ground-water development from a regional perspective. Its activities include the following:

- Determine availability and chemical quality of water stored in and being transmitted through each aquifer system.
- Evaluate discharge/recharge characteristics of each aquifer system.
- Evaluate geologic, hydrologic, and chemical controls that govern the responses of the aquifer systems to stresses.
- Develop computer-based flow-simulation models to assist in understanding the aquifer systems and their responses to such human activities as pumping or irrigation.

Ground-Water Atlas of the United States. The Atlas will assimilate the vast amount of information on ground water that the Survey has accumulated for many years in hundreds of reports of wide-ranging scope and scale (Figure 3-23). The Atlas would provide both State and national perspectives by discussing ground-water information that applies to individual states and by showing how each state's resources fit into the regional and national picture. The Atlas will bring together and summarize past and current ground-water information for the Nation to provide an educational document that summarizes the Nation's ground-water resources for a broad audience. The Atlas is intended to document aquifer nomenclature used by Federal, State, and local agencies.

Toxic Substances Hydrology. The Toxic Substances Hydrology Program (TSHP) of the U.S. Geological Survey was established in 1985, in response to rising national concern about contamination of the Nation's ground water and surface water. The purpose of the TSHP is to provide the Nation with earth science information to improve waste disposal practices, and mitigate or prevent further contamination of water resources by toxic substances (Figure 3-24).

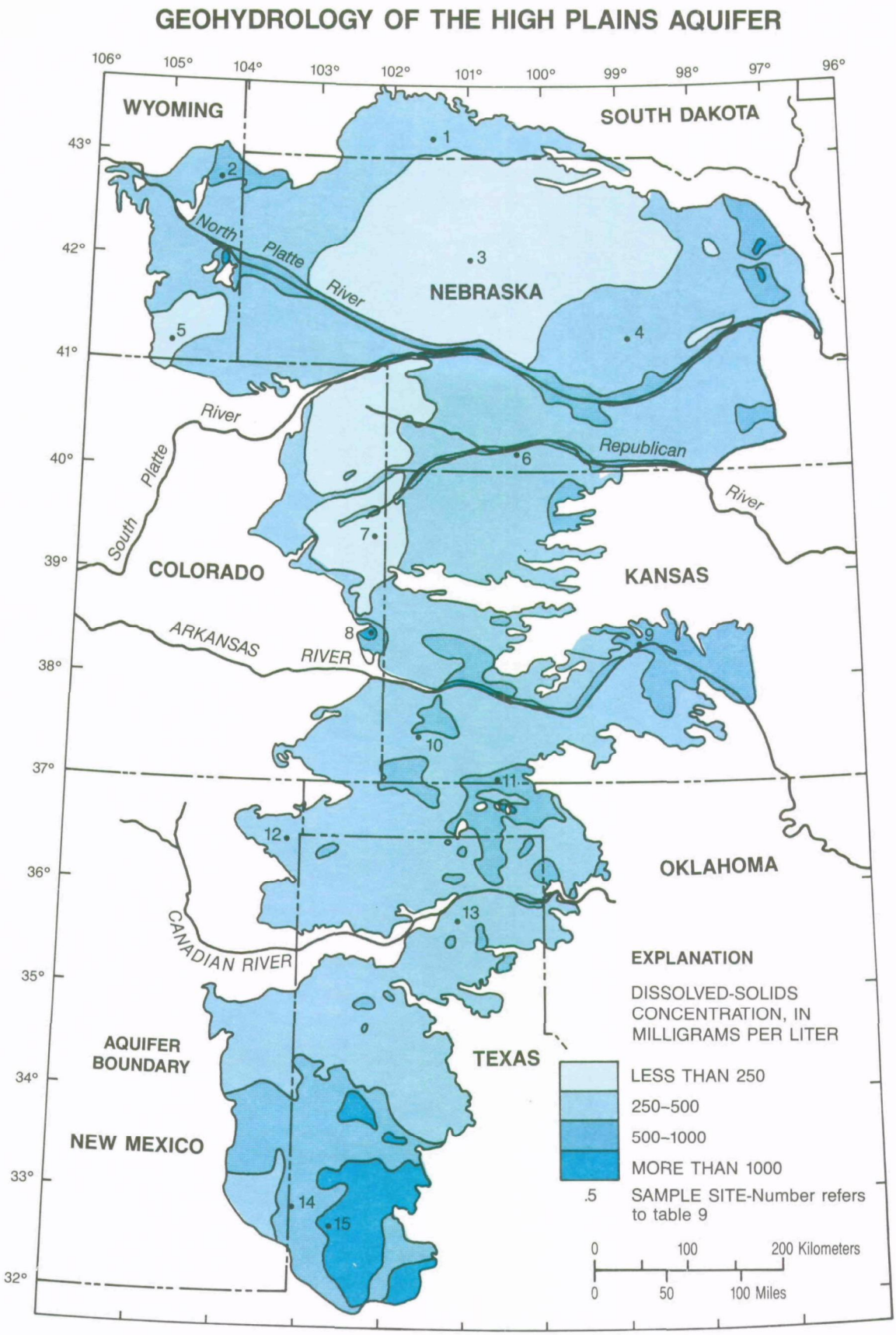
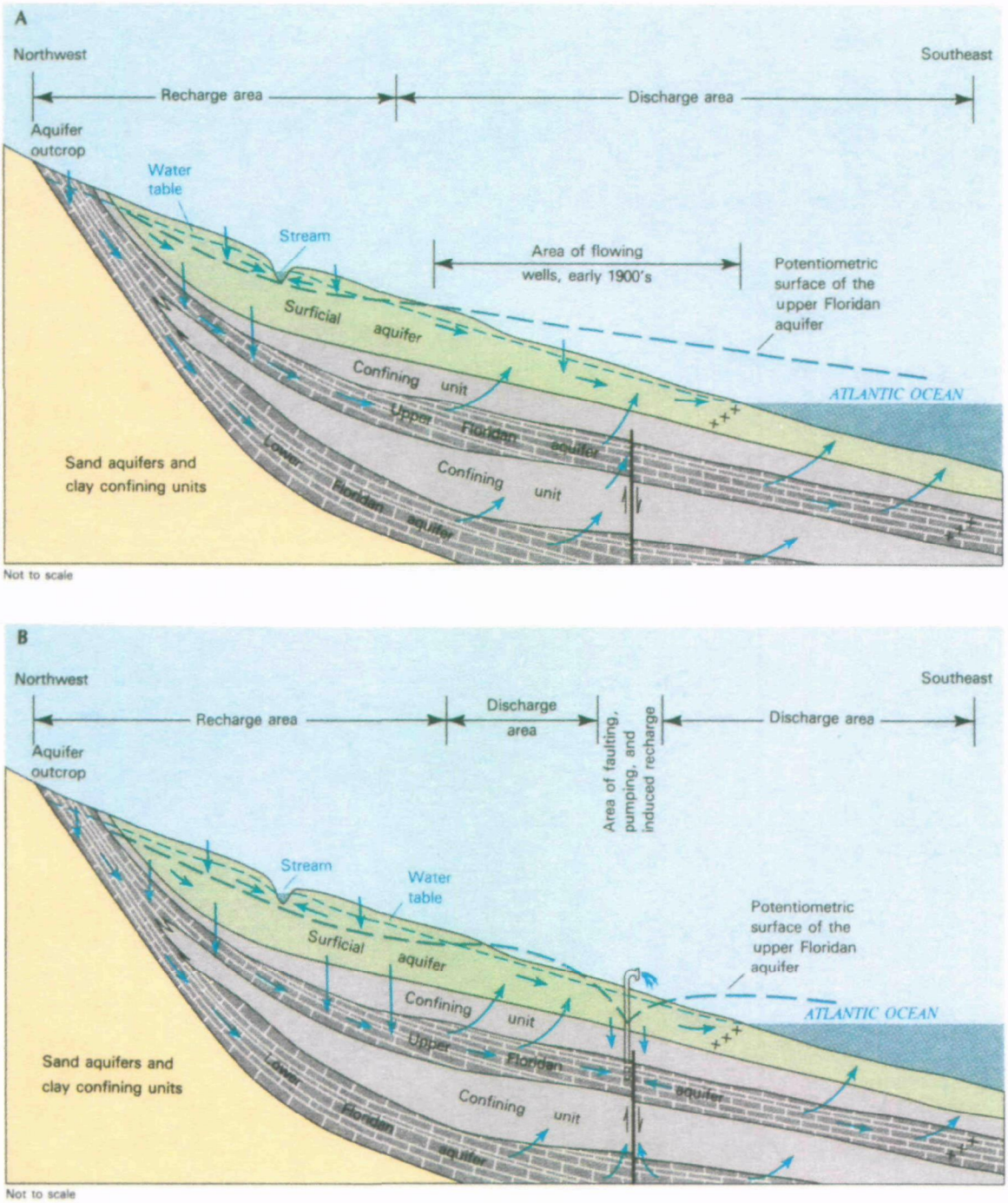


Figure 3-22. This figure shows the geohydrology and dissolved-solids concentration in water from the High Plains Aquifer. Source: Krothe et al., 1982.



EXPLANATION

Fault - Arrows indicate relative vertical movement

Freshwater-saltwater interface

Direction of groundwater flow

Figure 3-23. Comparison of ground-water flow conditions before and after development in the Floridian aquifer system, southeastern Georgia. A = Before development, pre-1900. B = After development, early 1980s. Source: Krause and Randoph, 1987.

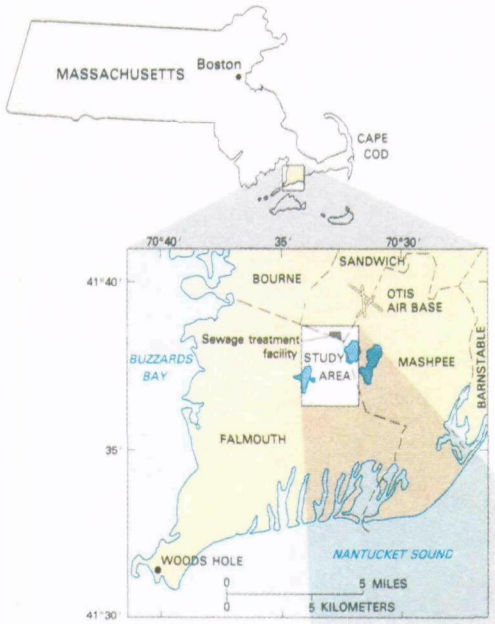
The TSHP requires extensive research in ground-water hydrology, erosion and sediment transport, geochemistry, and ecology. The TSHP is directed to improve knowledge about the occurrence, movement, and fate of contaminants in ground-water and surface-water systems. Ongoing efforts include the following:

- Developing and evaluating methods to assess the distribution and magnitude of ground-water contamination;
- Characterizing the process by which contaminants move through the subsurface; and
- Conducting intensive field investigations of ground-water contamination, and thereby
  - — Apply theoretical and analytical methods in real-world situations.
  - — Improve monitoring and sampling procedures.
  - — Develop new ways to mitigate ground-water contamination.
  - — Evaluate the reliability and value of predictive models for characterizing and predicting the course of ground-water contamination.
- Conducting investigations of the six most common and persistent groups of ground-water contaminants: petroleum products (gasoline and diesel fuels), volatile chlorinated organic solvents (trichloroethylene, for example), wood treatment and related products (such as creosote and pentachlorophenol), sewage, other selected organic compounds, and selected trace metals (lead, mercury and cadmium, for example); and
- Conducting detailed field investigations of 3 to 4 years duration into surface-water contamination in selected river basins, to
  - — Determine the occurrence, distribution, and movement of organic substances and trace metals under different conditions.
  - — Improve knowledge of the processes and factors that govern the movement and fate of different classes of toxic substances in different hydrologic settings.
  - — Develop improved study approaches and sampling methods for evaluating the magnitude, distribution, and movement of toxic substances in water, sediment, and biota.

National Water-Quality Assessment Program. Beginning in 1986, the Congress has annually appropriated funds for the U.S. Geological Survey to test and refine concepts for a National Water-Quality Assessment Program (Hirsch et al., 1988). The goals of a full-scale program would be as follows:

- To provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources;
- To define long-term trends (or lack of trends) in water quality; and
- To identify, describe, and explain the major factors that affect observed water-quality conditions and trends.

As presently envisioned, the proposed program would be accomplished through investigations of about 120 study areas—aquifer systems and river basins—that are distributed throughout the Nation and that incorporate about 80 percent of the Nation's water use. Organization into these discrete study units would enable examination of the causes of observed water-quality conditions, which is vital if the program is to be useful to managers and policy makers at Federal, State, and local levels.



EXPLANATION

–32– **Water-table contour**—Shows altitude of water table. Arrows show direction of ground-water movement. Contour interval 4 feet. Datum is sea level.

Line of equal concentration— Dashed where inferred

–100– **Boron**—Interval 100 micrograms per liter

–1.0– **Detergents (MBAS)**—Interval, in milligrams per liter, is variable

–100– **Volatile organic compounds**— Interval 100 micrograms per liter

• **Water well**—Single well or cluster of wells.

A—A′ **Trace of section**

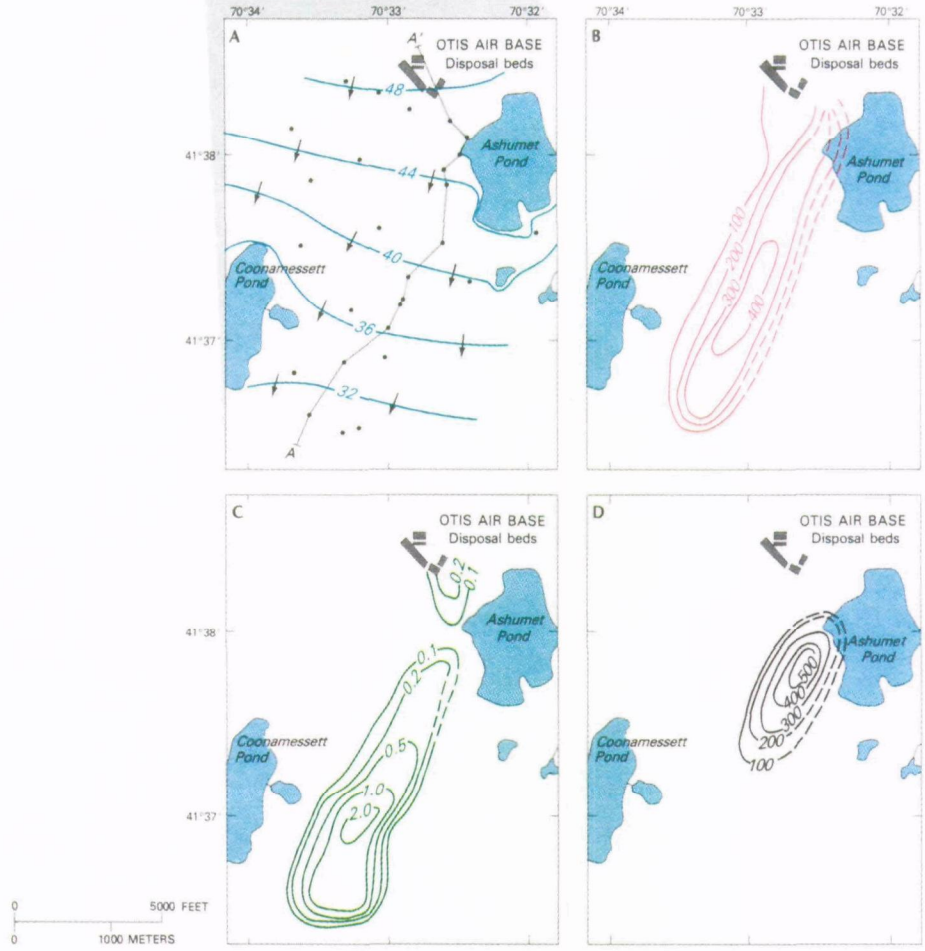


Figure 3-24. This multipanel figure presents a sewage plume in ground water downgradient from Otis Air Base, Cape Cod, Massachusetts (1983). A = Water table configuration. B-D = Areal distribution of boron (B) in micrograms per liter. C = Detergents (methylene-blue-active substances) in milligrams per liter. D = Volatile organic compounds in micrograms per liter. Source: Modified from LeBlanc, 1984, and Thurman et al., 1984.

The study units will be linked together in several ways to form a national program:

- A prescribed set of study approaches and protocols for sample collection, sample handling, laboratory analysis, and quality assurance will be followed;
- Data will be collected and interpreted on a nationally consistent set of water-quality constituents;
- Consistent records of ancillary information will be recorded on streamflow and basin characteristics, well and aquifer characteristics, and land use and other measures of human activity;
- Written reports will contain similar information for each study unit; and
- Data will be stored in national data files, where they will be available to the user community upon request.

Assessment activities in each of the study units will be done on a rotational rather than continuous basis. Only a subset of the study units will be studied in detail at a given time. For each study unit, 3- to 5-year periods of intensive data collection and analysis will be alternated with longer periods during which the assessment activities will be less intensive.

Several types of maps will be produced at the study-unit scale for the NAWQA Program. Depending on the spatial distribution of the constituents of interest, the maps will take several forms including (1) maps showing locations of sampling sites and results of water-quality analyses (Figure 3-25); (2) maps that distinguish river reaches or aquifer zones that differ in their average values or in their frequencies of exceedance of given concentrations of water-quality constituents; (3) maps of the locations of water-quality anomalies that cover large areas (tens of river miles or tens of square miles in an aquifer system); and (4) maps of factors that affect the vulnerability of aquifer systems to contamination.

At present, the program is in a pilot phase. Seven pilot projects, representing a diversity of hydrologic environments, were selected to test and further refine the assessment concepts; four projects focus primarily on surface water and three projects focus primarily on ground water.

A decision about proceeding to full-scale implementation will be made in 1990. The decision will be influenced by an ongoing evaluation of the design and the potential utility of the program by a committee of the National Academy of Sciences.

Hydrologic Research. WRD conducts research in six major fields of study: surface-water hydrology, geochemistry, ground-water hydrology, sediment transport (Figure 3-26) and geomorphology, water chemistry, and ecology.

Studies are conducted in fate and transport of hazardous substances in surface water and ground water (Figure 3-27), geophysics, geochemical modeling, effects of acid precipitation on watershed chemistry, and numerous other areas.

Recent accomplishments that are relevant to EPA interests include the following:

- Developed sophisticated ground-water flow models to better understand ground-water systems and to provide insight into the effects of the application of various ground-water management schemes.
- Initiated a new program of research and investigations regarding hazardous-substances contamination of surface water and sediments.
- Increased understanding of the role of lakes in the hydrologic system with respect to ground-water recharge and discharge by defining ground-water flow systems relative to lakes.
- Developed and demonstrated the usefulness of complex computer models to simulate movement of radionuclides in ground water.
- Demonstrated the importance of flow through gravel zones in river bottoms to the sorption and transport of pollutants in streams.
- Developed new borehole geophysical methods in characterizing fractured rock zones.

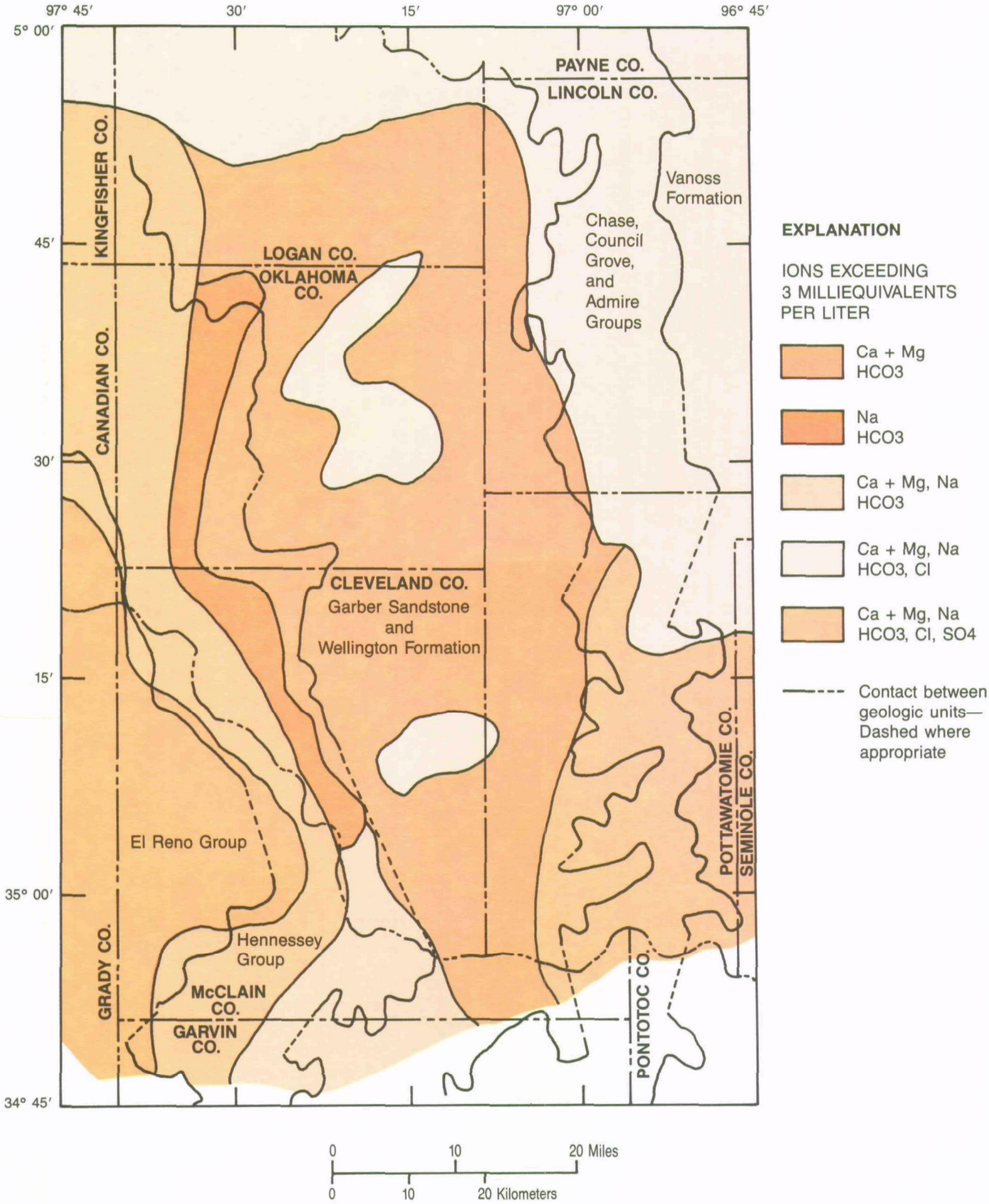
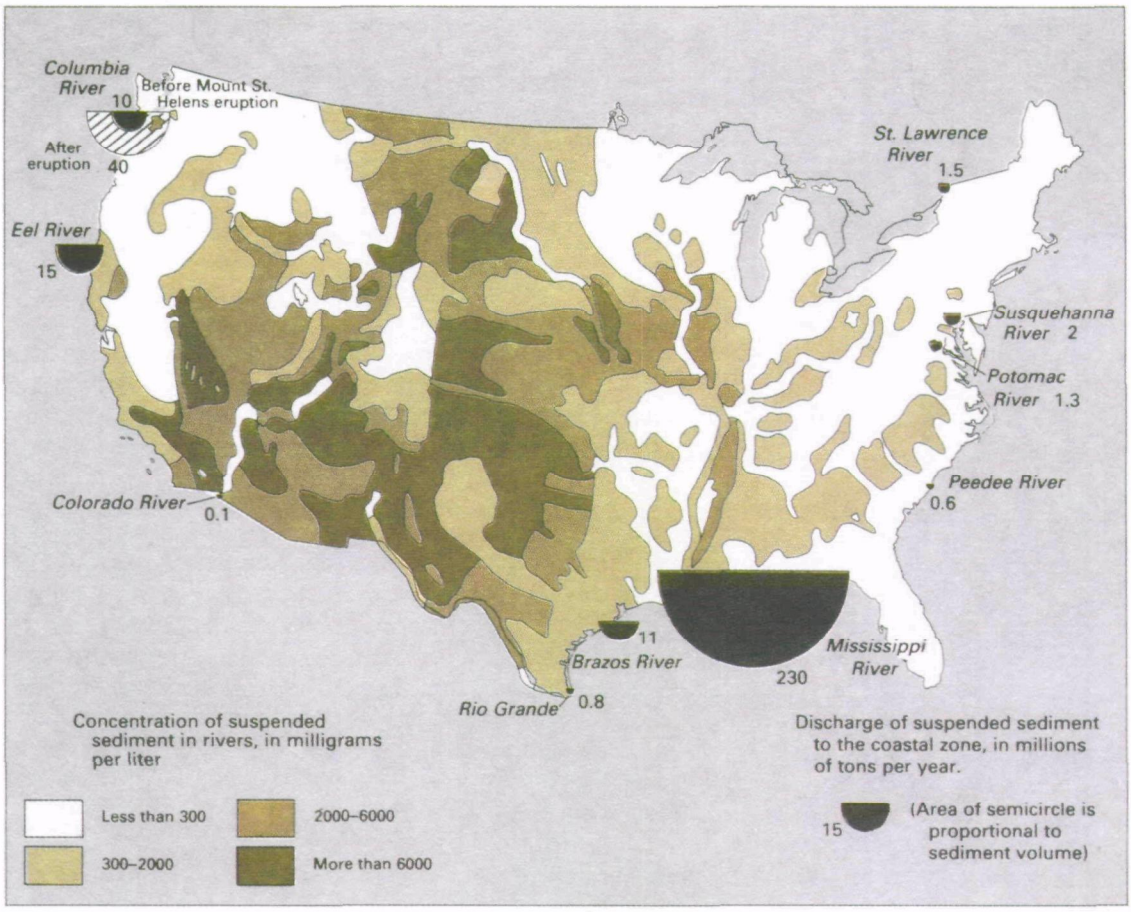


Figure 3-25. This map, a sample of those produced under the National Water-Quality Assessment Program, shows the major ion chemistry in the shallow zone of a study unit.



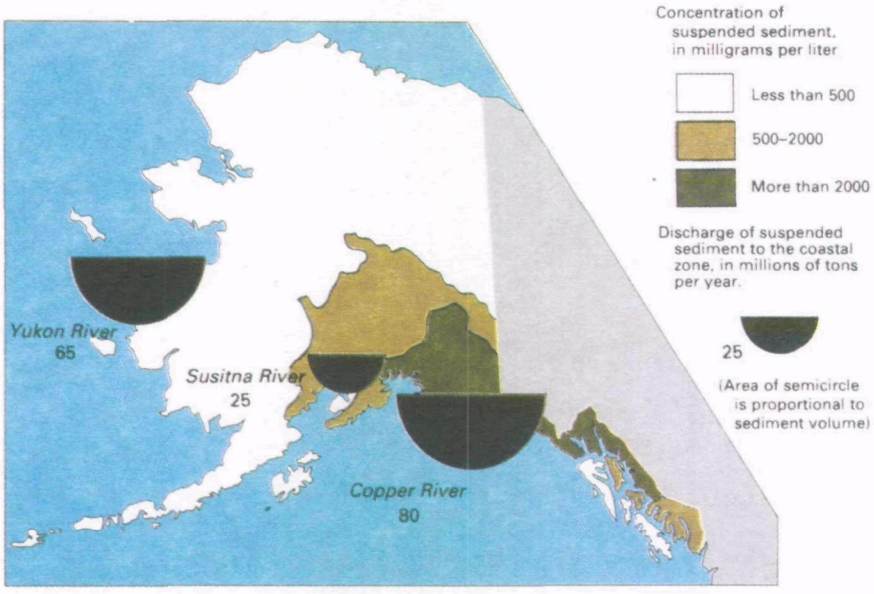
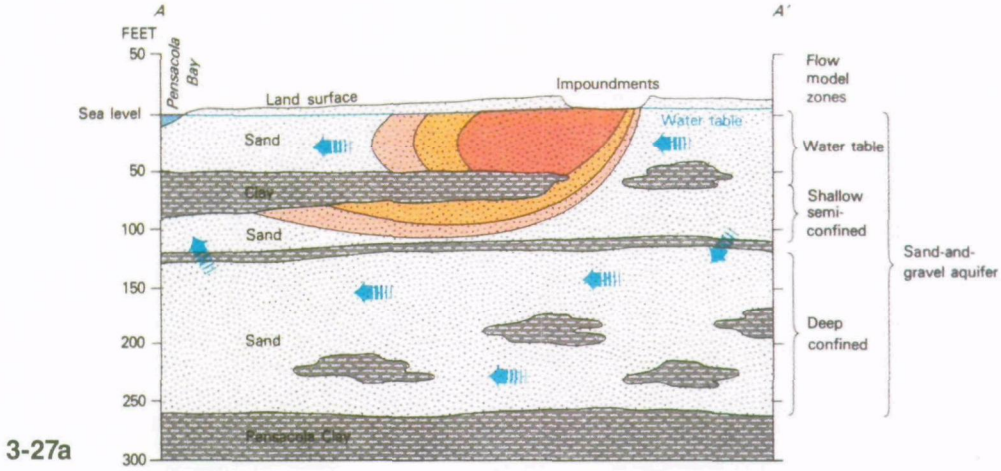
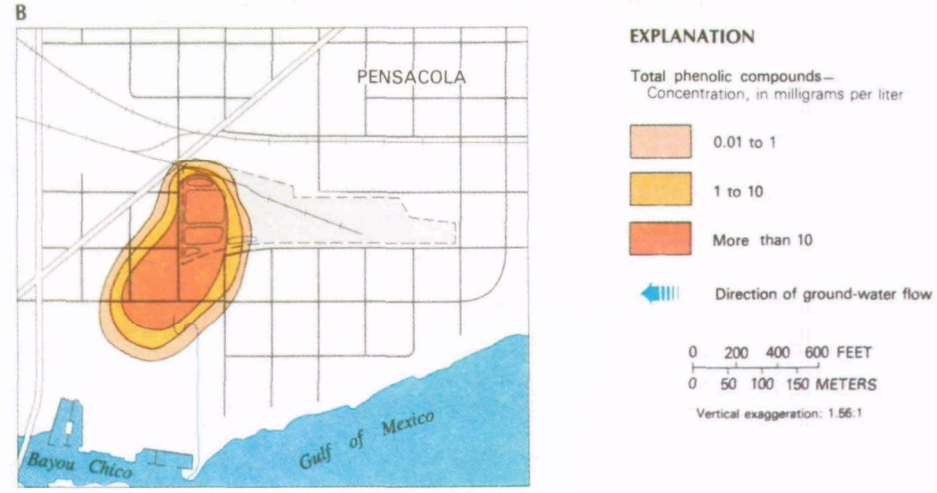


Figure 3-26. This map, showing the sediment transport of selected rivers in the United States, reflects one of six major areas of study by the Water Resources Division. Source: Concentration map modified from Rainwater, 1962; sediment discharge data compiled by R.S. Parker and R.H. Meade from files of the U.S. Geological Survey, U.S. Army Corps of Engineers, and the International Boundary and Water Commission.



3-27a



3-27b

Figure 3-27. This multipanel figure examines the fate and transport of hazardous substances at a designated study area.

Figure 3-27a shows the vertical distribution of phenolic-compound contamination in a surficial aquifer, Pensacola, Florida (1985).

Figure 3-27b presents an areal distribution of total phenolic-compound contamination in a surficial aquifer at a wood-preserving plant, Pensacola, Florida, (1985). A = Location of plant site. B-C = Extent of contamination in the water-table zone (B) and the shallow, semiconfined zone (C). Source: Modified from Franks et al., 1986.

Assistance to Other Federal Agencies. WRD is often called upon by other Federal agencies to provide specific hydrologic information. WRD also provides assistance in interpreting and complying with environmental laws and regulations as required by the National Environmental Policy Act of 1969.

Circular 1005 cites examples of the types of activities that WRD engages in as part of requests by other Federal agencies. These activities include providing data on energy research and development, siting and investigating municipal waste-disposal sites, studying ground water/lake relationships, collecting water-quality information, and providing hydrologic assistance for toxic waste cleanup actions.

Accomplishments relevant to EPA interests include studies describing hydrology of eastern and western coal mining areas; a study of the hydrochemistry, pertaining to concentrations of selenium and other trace elements, in water of the San Joaquin Valley, San Luis Drain Service Area, and the Kesterson National Wildlife Refuge; coordinating data and information transfer to EPA groups; collaborating with EPA in developing ground-water protection strategy; and assisting EPA in remediating toxic waste disposal sites. Many of these

accomplishments result in mapping activities and map production for the ultimate use of the EPA and other agencies.

National Water Summary Program. The National Water Summary Program was established in 1981 to synthesize information about the availability, quantity, quality, and use of water resources and to organize it in ways that portray the condition of the Nation's water resources. "National Water Summary" reports have been published annually since 1984. The National Water Summary is a periodic publication by WRD which focuses upon a water-related theme and results from selected projects. Each Summary contains information on a national basis for the theme plus State summaries. The program also prepared maps, reports, and statistics to assist other Federal agencies in their water-resources assessment activities. Information about this program may be obtained from the *Branch of National Water Summary* (USGS, 1988).

Hydrologic Data-Collection Program. The Hydrologic Data-Collection Program is the WRD's basic program for collecting, compiling, and analyzing surface and ground-water data. Table 3-5 presents the types of data that are collected and the number of stations per fund type.

National Water-Data Storage and Retrieval System (WATSTORE). WATSTORE is the data system that generates much of the basis of WRD book and map reports which describe and analyze the Nation's water resources. The program was first initiated as a way to more effectively handle and make accessible the vast amount of data that is continually being collected by the Water Resources Division.

The types of data that are compiled in the WATSTORE system include files on surface water, quality of water, ground water, annual peak streamflow and gage height from surface-water stations, chemical quality analyses for both surface and ground water, geologic and inventory data for ground-water sites, and water use information for 12 types of uses (Figure 3-28). The WATSTORE system is able to store and retrieve data at about 50,000 locations that are a part of its nationwide telecommunications network. It has the ability to provide hydrologic data on a real-time or hourly basis and to provide that data in formats that are appropriate to user needs. Examples of data formats include computer printed tables and graphs, statistical analyses, digital plots, and magnetic tape.

The WATSTORE data base contains some 220 million daily observations of streamflow, reservoir contents, water temperature, stream sediment, and ground-water level data, as well as 2.5 million chemical, physical, biological, and radiochemical analyses from surface and ground water. It also contains hydrologic and geologic data on 900,000 inventoried wells.

Coordination of Federal Water-Data Acquisition. The Coordination of Federal Water-Data Acquisition is a long-term project managed by the Office of Water Data Coordination (OWDC). This program is designed to (1) assure that the need for water resources information is being met by effectively managed Federal programs, (2) that information on water data, and on existing and planned Federal programs is effectively cataloged and accessible, and (3) that the planning, design, and documentation of water data networks and information is properly coordinated.

The Office of Water Data Coordination conducts annual advisory committee meetings and advises the Secretary of the Interior on the status of water-data acquisition. It implements advisory committee recommendations and coordinates the Federal plan for water-data acquisition. As a product of these efforts, the OWDC publishes various documents and maps including "The National Handbook of Recommended Methods for Water Data Acquisition"; a catalog of information on water-data acquisition activities (now available through the National Water-Data Exchange); a Hydrologic Unit Map of the United States and hydrologic unit maps for each state; and a digitized data base of the hydrologic unit maps covering the United States (in Open-File Reports).

National Water Data Exchange. The National Water Data Exchange (NAWDEX) represents a direct effort on the part of the USGS to make federally acquired water data more accessible to all parties. The objective of this program is to serve effectively as a focal point or source for any group needing water-related data. The activities the National Water Data Exchange pursues to accomplish this goal are (1) operating a national water-data indexing program, (2) maintaining a national user-service program consisting of a nationwide network of assistance centers, (3) interacting with water-oriented organizations, and (4) assisting the Office of Water Data Coordination in cataloging water data acquisition activities.

Several accomplishments by NAWDEX demonstrate how it can effectively assist the EPA in its data and mapping needs:

- Implemented a program that directly linked two major water-data bases: EPA's STORET and USGS's WATSTORE.
- Processed about 85,000 requests for hydrologic information through a coordinated effort involving its nationwide network of 76 assistance centers.

Table 3-5. Type of Data Collected in the Hydrologic Data-Collection Program

	Number of Stations, by Source of Funding							
	Single Program Support			Combined Support				
Type of Station	Federal Program (Federal)	Federal-State Cooperative Program (COOP)	Reimbursement from Other Federal Agencies (OFA)	Federal, COOP	Federal, OFA	COOP, OFA	Federal, COOP, OFA	Total Stations
SURFACE WATER								
Discharge								
Continuous record	481	3,158	1,575	1,130	146	472	38	7,000
Partial record	99	2,880	273	268	91	12	1	3,624
Stage Only—Streams								
Continuous record	13	86	245	93	3	8	0	448
Partial record	1	166	28	33	0	1	0	229
Stage Only—Lakes/Reservoirs								
Continous record	12	274	277	210	1	4	1	779
Partial record	11	177	75	87	0	0	0	350
Quality								
Continuous record	66	243	217	62	9	2	0	599
Scheduled, long-term operation	389	1,109	330	312	24	19	2	2,185
Short-term or project stations	26	512	116	47	15	0	0	716
GROUNDWATER								
Water Levels								
Continuous record	90	1,413	200	656	14	0	0	2,373
Scheduled, long-term operation	656	17,089	1,098	3,791	0	0	0	22,634
Short-term or project stations	1,157	4,202	1,061	3,219	315	0	0	9,954
Quality								
Scheduled, long-term operaton	49	3,053	158	640	0	0	0	3,900
Short-term or project stations	560	3,475	730	429	26	0	0	5,220
SEDIMENT								
Daily sampling	29	65	72	5	1	2	0	174
Periodic sampling	460	225	161	17	10	5	0	878
PRECIPITATION								
Quantity	45	460	319	79	6	0	0	909
Quality	32	32	8	3	3	0	0	78

Source: U.S. Geological Survey Open-File Report 87-563.

- Developed and maintained the Master Water Data Index of more than 450,000 data-collection sites.
- Developed and maintained the Water-Data sources Directory for more than 750 organizations that are sources of water and water-related data.

Water Resources Scientific Information Center (WRSIC). The objective of this center is to function as a clearing house for water-related scientific and technical information. The center accomplishes its objective by abstracting water-resources publications, and making this information promptly and readily available to the water resources community and the public through publications and computerized bibliographic information services.

National Water Information System (NWIS). The National Water Information System (NWIS) was established in 1986 to create a master data base incorporating the WRSIC, WATSTORE, and NAWDEX files. These revisions to existing systems will improve the efficiency and utilization of computer resources. Inquiries should be directed to the NAWDEX program (see Appendix D).

3.4.4 Federal-State Cooperative Program

The Federal-State Cooperative Program is a partnership for water-resources investigations between the USGS and State, regional, and local agencies. The cooperating agencies contribute at least half the funds and the USGS usually contributes most of the work.

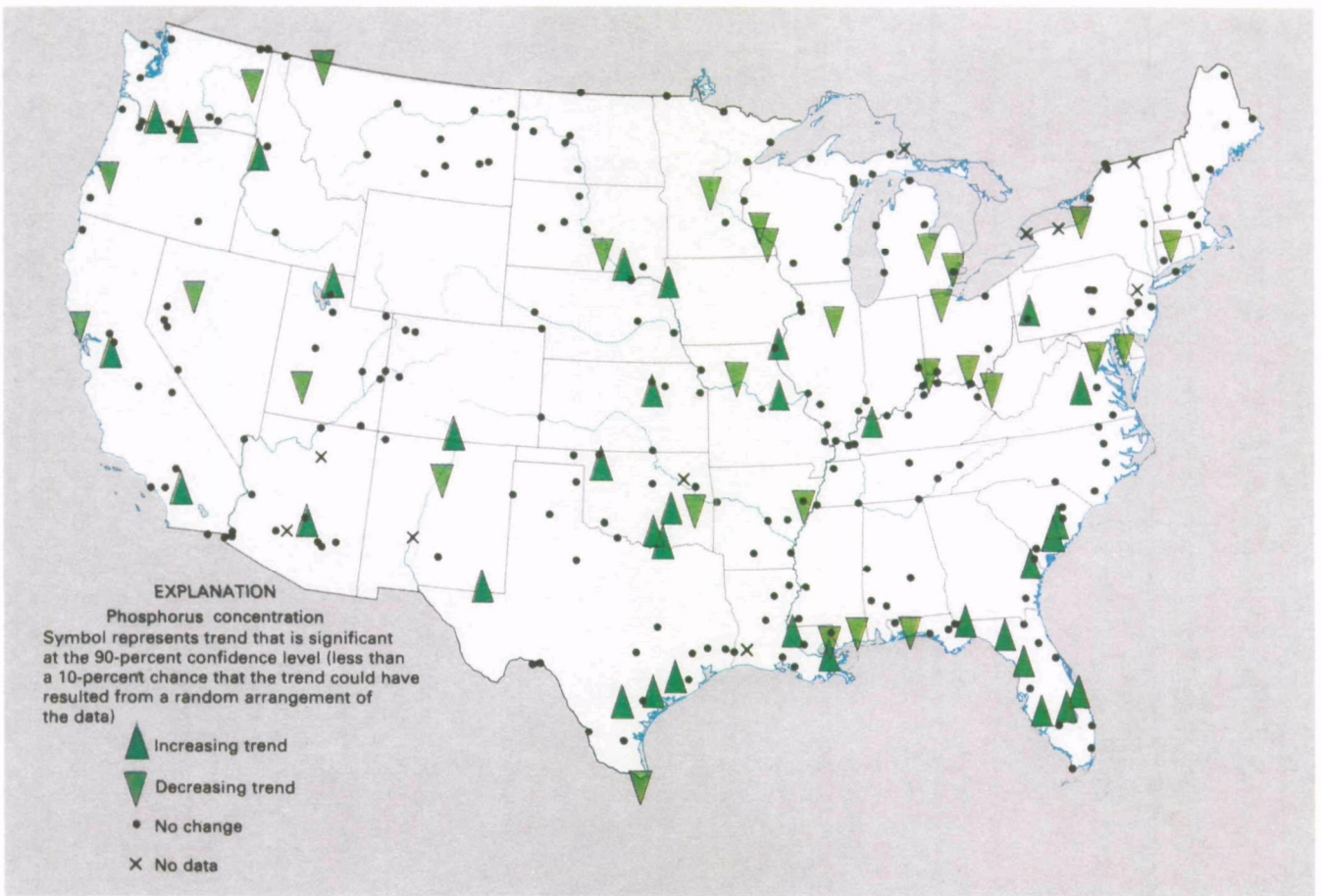


Figure 3-28. This map shows an example of the types of data compiled in the WATSTORE data base, which is national in scope. Here, trends in total phosphorous concentrations at U.S. Geological Survey National Stream Quality Accounting Network stations in the conterminous United States, 1975 to 1981, are shown. Source: Compiled from data in Smith and Alexander, 1983.

The program began in 1895 with a cooperative study with the State of Kansas. The Federal appropriations bill of 1929 established the 50-50 cost-sharing principle. In 1986, more than 900 agencies and the USGS were working together in a balanced program that recognizes the needs, priorities, and resources of all parties. These cooperative efforts generate much of the hydrologic information needed for planning, developing, and managing the water resources of the United States.

The program's purpose is

- To determine the quantity, quality, and use of surface and ground water;
- To define and evaluate the distribution and availability of water resources of drainage basins, counties, States, and hydrologic regions; and
- To conduct investigations and research on current water issues such as water quality, toxic waste disposal, erosion and sedimentation, water supply and demand, ground-water contamination, and hydrologic hazards.

Activities include the following:

- Supporting the collection of hydrologic data at about two-thirds of all USGS data-collection sites in every State, Guam, Puerto Rico, and several territories.
- Conducting hydrologic investigations and research projects (approximately 500 in Fiscal Year 1986) with increasing emphasis on water-quality issues, including aquifer contamination, ground-water protection strategies, river quality assessments, storm runoff, and acid precipitation.
- Assessing water resource conditions and water-supply problems related to coal mining and land reclamation under the cooperative coal hydrology program.

National Water-Use Information Program. The National Water-Use Information Program was designed to address the need for a single source of information on water use, thereby meeting the needs of State and Federal agencies (Figure 3-29). There are twelve categories of water use contained in the data base consisting of three basic types: agriculture, power generation, and other uses. The information is further delineated (USGS, 1986d) as follows:

Agriculture:

- Irrigation
- Nonirrigation

Power Generation:

- Fossil fuel
- Geothermal
- Hydroelectric

Other Uses:

- Domestic
- Commercial
- Industrial
- Nuclear
- Mining
- Public supply
- Sewage treatment

The water-use data base complements the WATSTORE data base which has information on long-term water availability and quality.

The information compiled and made available by the National Water-Use Information Program includes data on fresh and saline surface and ground water, defining how much of that water is withdrawn from reservoirs, consumptively used, or returned for future use. The data are available at the county and hydrologic subregion levels. The methods of recording and analyzing this data have been improved and standardized as the program has progressed. The data base is computerized, facilitating storage and retrieval processes and making the data base much more accessible and understandable to all interested parties. EPA may likely have many applications for this type of data base; one example is its use in assessing the potential impact that contamination of a water supply may have on the water supply users.

WATER USE IN WISCONSIN 1985

PUBLIC SUPPLY

Public supply refers to water withdrawn by public or private suppliers and delivered to domestic, commercial, and industrial users who do not supply their own water.

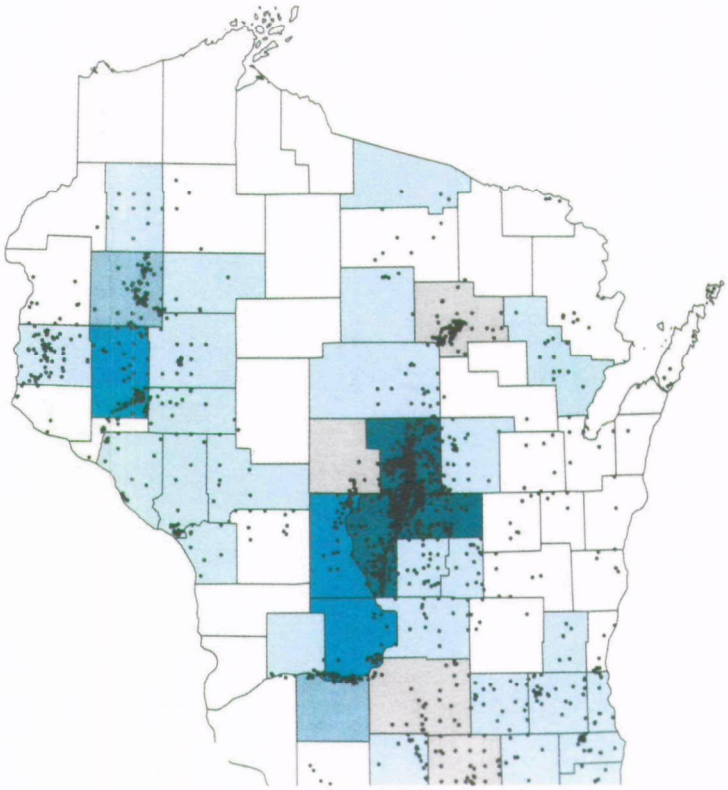
IRRIGATION

About 84 million gallons per day of water was used during 1985.

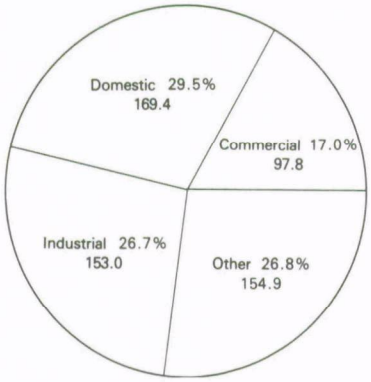
All irrigation reported in the State was spray type.

Ground-water accounts for 98 percent of the water used for irrigation.

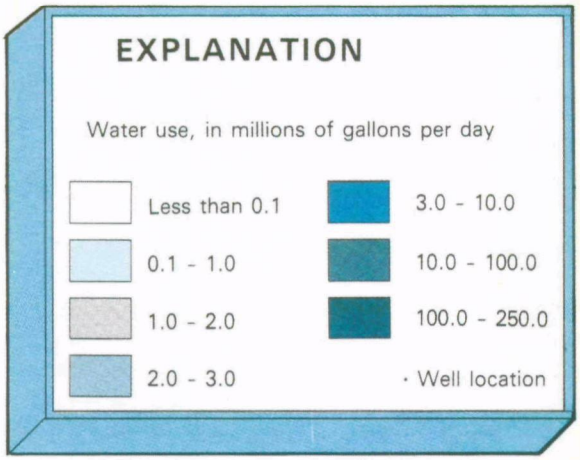
Consumptive use for irrigation was estimated to be 84 Mgal/d or 100 percent of the total amount withdrawn.

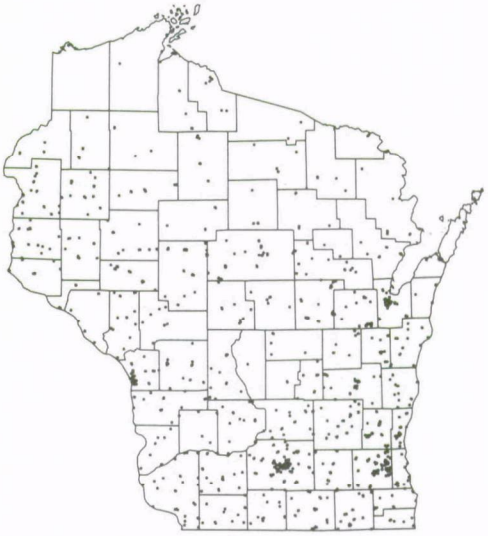


Locations of irrigation wells in Wisconsin, 1985



Total water use from public supply (MGD)





Locations of public supply wells in Wisconsin, 1985

Figure 3-29. This multipanel figure is an example of a water use map for a specific state—Wisconsin—in 1985. Public Supply refers to water withdrawn by public or private suppliers and delivered to domestic, commercial, and industrial users who do not supply their own water. In terms of agricultural uses, irrigation consumed about 84 million gallons of water per day in 1985. Source: Modified from USGS maps produced by Ellefson, B.R., Rury, K.S., and Krohelski, J.T., 1988.

3.4.5 Hydrologic Maps

WRD publishes a variety of hydrologically related maps from the various programs. The majority of these can be placed in one of three general categories: Hydrologic Investigations Atlases, Water Availability Maps, and Flood-Prone Area Maps. As stated in Thompson (1988):

> "Hundreds of different water reports and maps by Survey personnel are made available every year in Federal, State, and local publications, in technical journals, or in depositories for public inspection. For each State, the Survey issues a folder containing a brief description of its water-resources investigations in that State. The folder includes a principal map that shows the location of hydrologic data stations and the extent of the hydrologic investigations; smaller maps in the folder depict variations in hydrologic characteristics. State Hydrologic Unit Maps are also available."

State hydrological unit maps are available from the WRD Office of Water Data Coordination (see Appendix D). Categories of WRD mapping activities are discussed below:

Hydrologic Atlases. The Hydrologic Atlases are developed from basic data collection and special studies and are used to present a wide range of hydrologic and hydrogeologic facts concerning the Nation's water resources. More than 600 hydrologic atlases have been published by WRD. Most of these atlases have been prepared in cooperation with State, county, and municipal agencies and cover areas where general hydrologic mapping and inventory were desired. Atlases usually cover natural hydrologic units, such as drainage basins. Each map contained within an atlas presents one or more aspects of the area's hydrology (e.g., delineation of flood areas or water availability). Frequently mapped subject combinations may include information on aquifer framework, surface drainage, precipitation and climate, geology, availability of ground and surface water, water quality and use, and streamflow characteristics.

The scale of maps used for hydrologic atlases depends on the type of presentation and on the availability of base maps. The principal maps are most frequently presented at a scale of 1:24,000, however much smaller scales (e.g., 1:250,000) are used for larger areas of study. Atlas maps are usually superimposed on topographic or planimetric base maps that cover the study area. Relevant data, information, and analyses that support the principal atlas maps are often shown on smaller maps, graphs, tables, and text. Other supporting information is also often included, notably photographs and references.

Water Availability Maps. These maps are produced as part of project reports and indicate the groundwater potential throughout the mapped area and are intended for use as a convenient guide in planning water-supply projects for domestic, municipal, industrial, and irrigation uses. Information presented on these maps include well yield, depth to ground water, aquifer delineation, potentiometric surface, and water quality information (Figure 3-30).

The production of water availability maps has increased in recent years, with the level of effort on interpretive investigation projects exceeding 1,000 per year; however, at the time of publication of this document, coverage consisted of less than one half of the country. Currently, water availability projects are centered in areas of the country where population and water use are growing the fastest.

Flood-Prone Area Maps. Flood-prone area maps delineate areas that are subject to flooding. Efforts to produce these maps began in 1966. The maps serve as a general warning of potential flood hazards and as a basis for setting priorities for future studies. As of Fiscal Year 1976, over 12,000 quadrangles had been mapped. These maps would be useful in assessing or sitting waste disposal sites, as well as for other purposes.

3.5 Mapping Requirements Statement Development

A degree of familiarity with map products is necessary for development of a valuable mapping needs request. The content of this manual has been directed towards providing the reader with information on USGS capabilities and map products at a level sufficient to begin preparation of a request. Due to the great variety of USGS map products, not all are described in this Manual. It is suggested that interested map users research their desired map products by examining similar or related products already in use (Table 3-6). Please refer to the appendices for further detail. USGS provides indices of some map series for this reason (Table 3-7). New map products may also result from other Federal agency requests. The products and indices listed in Tables 3-6 and 3-7, respectively, present sufficient information to order existing map products (Table 3-8) or to indicate a mapping need.

Contacts within USGS and EPA who can assist in determining the optimum method to supply the cartographic information are listed in Appendices A, B, and C. In addition, the USGS contacts are resources for cartographic information, geological and hydrological data, and new map products (Appendices C and D). Please use these resources to refine your mapping needs requests.

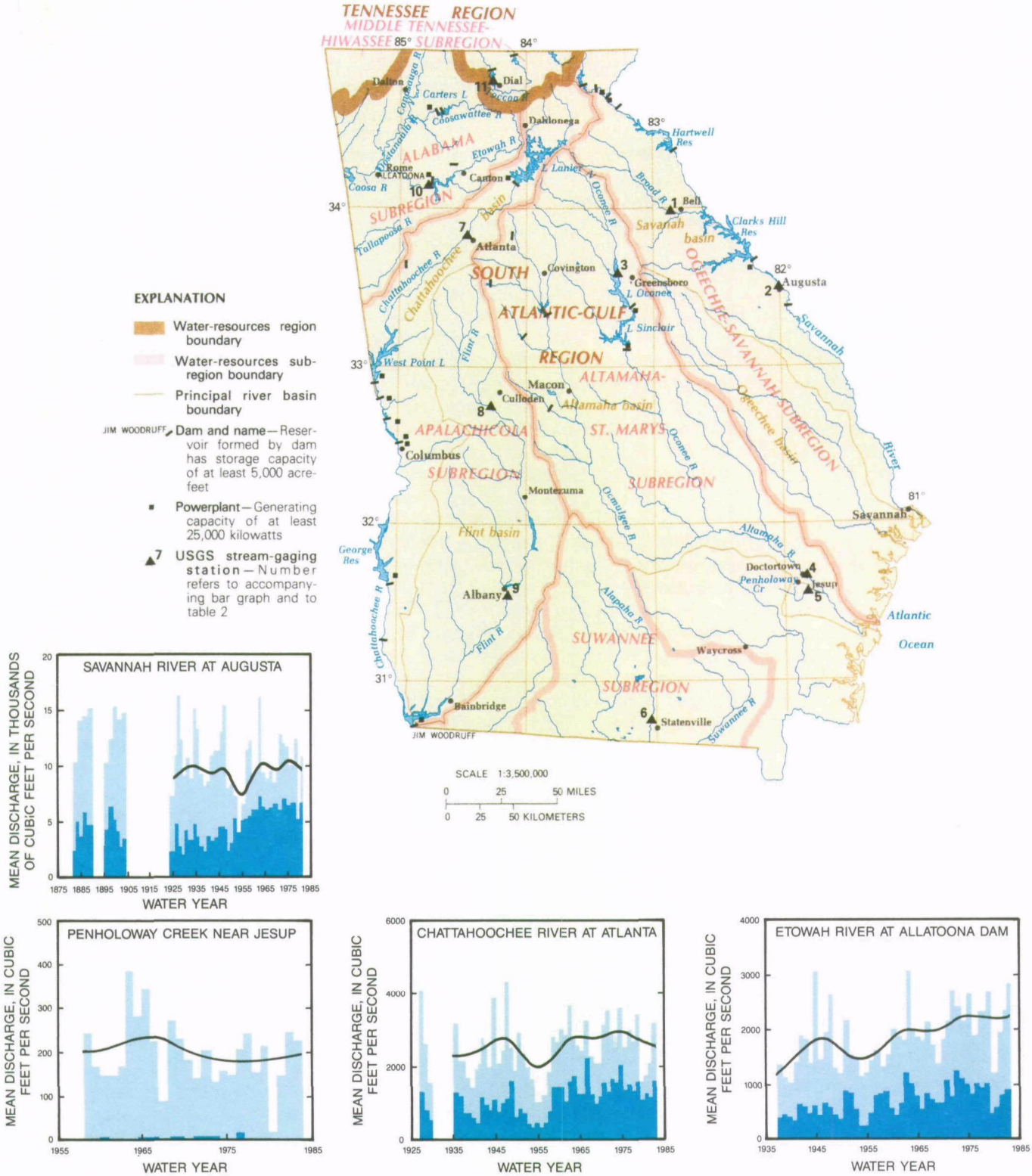


Figure 3-30. Water availability maps, such as this Georgia map, are becoming increasingly popular. Here, principal river basins and related surface water resources, along with selected discharge rates, are plotted and graphed for easy reference. Bar graphs show average discharge (light blue) and 30-day minimum discharge (dark blue) by water year at selected stream-gaging sites. The curve is a 15-year weighted average of the annual values. Source: Water resource regions and subregions from Seaber et al., 1984; surface water resources development from Hitt, 1986; discharge data from USGS files.

Table 3-6. Summary Listing of Map Products Available from USGS

Cartographic Products	Scale: Primary	Intermediate	Small	Special
Maps				
Puerto Rico	1:20,000	1:120,000	1:240,000	
Conterminous U.S. + Hawaii and Pacific Terr. 7.5′ × 7.5′	1:24,000			
U.S. Metric Series 7.5′ × 7.5′ (selected areas)	1:25,000			
U.S. Metric Series 7.5′ × 15′ (selected areas)	1:25,000			
USGS/DMA 15′ × 15′		1:50,000		
Alaska Series	1:63,360			1:25,000
County Format Series		1:50,000 1:100,000		
Counterminous U.S. 30′ × 60′		1:100,000		
U.S. 1° × 2°			1:250,000	
State Map Series			1:500,000	Various
*U.S. (IMW)			1:1,000,000	
U.S. Sectional Series			1:2,000,000	
Antarctica			1:250,000 1:500,000	
Orthophotoquads	1:24,000 (1:63,360 Alaska)			
Land Use/Land Cover		1:100,000 (proposed)	1:250,000	
National Park Series				Various
Aerial Photography (NHAP)		1:80,000 B/W 1:56,000 CIR		
Aerial Photography (NAPP)		1:40,000 CIR		
Aerial Photography (project)		Range: 1:15,000 to 1:40,000		
Satellite Image Maps		1:50,000	1:100,000	
Satellite Image Maps			1:250,000	
National Atlas Separates			1:7,500,000	
International Maps of the World			1:1,000,000	
World Maps				Various
Exclusive Economic Zone				Various
Alaska Map A, B, C				Various
Side Looking Airborne Radar			1:250,000	
Topographic Bathymetric	1:24,000	1:100,000	1:250,000 1:500,000	
*National Base Map Series			1:2,500,000	
			1:3,168,000	
			1:5,000,000	
			1:6,000,000	
			1:7,000,000	
			1:10,000,000	
			1:11,875,000	
			1:16,500,000	

Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986.
*Digital data available in Compact Disc/Read Only Memory (CD-ROM), floppy disks, and tapes.

Table 3-6. Summary Listing of Map Products Available from USGS (Continued)

Ditigal Data	Scale of Source Map			
Boundaries Digital Line Graphs	1:24,000 1:63,360	1:100,000	1:2,000,000	
Transportation Digital Line Graphs	1:24,000 1:63,360	1:100,000	1:2,000,000	
Hydrography Digital Line Graphs	1:24,000 1:63,366	1:100,000	1:2,000,000	
Public Land Survey System Digital Line Graphs	1:24,000 1:63,360	1:100,000		
Hypsograhy (contours) Digital Line Graphs	1:24,000 1:63,360	1:100,000		
Land Use/Land Cover DLG			1:250,000	
State Map Prototype Project DLG			1:500,000	
Digital Elevation Models (DEM)	1:24,000	1:63,360 1:100,000		
Other Significant Manmade Structures DLG	1:24,000			
Vegetative Surface Cover DLG	1:24,000			
Non-Vegetative Surface Cover DLG	1:24,000			
Survey Control DLG	1:24,000			
Geographic Names	1:24,000			

Map Publications

Geologic	Hydrologic
Antarctic Geologic Maps (A Series)	"Accounting Units of the National Water Data Network"
Coal Investigations Maps (C Series)	Flood-Prone Area Maps
Geologic Maps of Planets and Moons (in I Series)	Hydrologic Investigations Atlases (HA Series)
Geologic Quadrangle Maps (GQ Series)	Hydrologic Unit Maps, by States
Geophysical Investigations Maps (GP Series)	"Hydrologic Unit Map of the United States"
Marine Geology Atlas (in I Series)	Open-File Reports (OF Series)
Miscellaneous Field Studies Maps (MF Series)	Water-Resources Investigation Reports (WRI Series, and in OF Series)
Mineral Investigations Resource Maps (MR Series)	Water Supply Papers
Miscellaneous Investigations Series (I Series)	Professional Papers
Oil and Gas Investigations Charts (OC Series)	National Water Conditions
Oil and Gas Investigations Maps (OM Series)	
Open-File Reports (OF Series)	
Special geologic maps (no series)	
State geologic maps (no series)	
Alaska, Arizona, Arkansas, Colorado, Kentucky, Massachusetts, Montana, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, South Dakota, Wyoming	

Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986.
*Digital data available in Compact Disc/Read Only Memory (CD-ROM), floppy disks, and tapes.

All of USGS' holdings on its Automated Library System (LS-2000) are included on a CD/ROM which is distributed by Online Computer Library Center in Dublin, Ohio. A listing of all geologic maps is also available on the disk in the GEOINDEX system. A bibliography of USGS contributions to earth science literature is also available from the American Geological Institute on the CD/ROM entitled GEOREF.

There are some minimum types of information that must be determined or selected by the map user in order that a valuable request for a new map be transmitted to USGS. At a minimum, the user must consider and select the following:

- Geographic location, and extent, of interest (coordinates/quadrangle);
- Mapping scale desired for each location (necessary level of detail);
- Data type/layer and sources (which data and where is it);
- Availability of data (existing versus yet to be collected);
- Revision frequency (expiration of data value);
- Intended use of map (to aid in USGS evaluation); and
- Time constraint (when the map is needed).

The variety of maps and cartographic information provided by USGS is so extensive that these minimum map request selections are essential for the OIRM and USGS reviews. In the sections below, general description of USGS map series and areal coverage is presented. EPA staff desiring to submit a mapping request to the OIRM NMRP Manager should examine these descriptions, the information presented in Chapters 1, 2, and 3, and related references to avoid requesting an existing map product through OIRM.

Requests for USGS maps may result in (1) additions/revisions to a current map series; (2) existing cartographic data composited in a new fashion to create a modified map product; or (3) additional cartographic data for a new map product. It is also possible to obtain unfinished or partial maps from USGS by contacting the appropriate USGS office. Examples of such maps are advance prints of pre-final topographic maps, color separates from topographic maps, and feature separates from metric topographic maps.

Map revision requests should indicate the annual frequency with which EPA desires the revisions to be made and the types of data to be revised. Preferences as to the acquisition of revised data should also be given (e.g., the typical nondigital, photo-revision process versus the more rapid production of orthophotoquads).

3.5.1 The National Mapping Division

The Primary Mapping Program is dedicated to the production and revision of the 7.5-minute (1:24,000 scale) topographic maps for the conterminous United States and Hawaii, plus the 15-minute (1:63,360 scale) topographic maps for Alaska. At the present, not all States have been completely mapped. However, it is the intent of this USGS Program to do so, and a schedule has been formalized to complete the effort by 1991.

The intermediate- and small-scale mapping activities include the preparation of 1:50,000, 1:100,000, and 1:250,000 series maps. Of these maps, the small-scale map series at 1:250,000 has been completed and has begun a cycle of revision. Completion of the 1:100,000 scale map series is scheduled for Fiscal Year 1995. The 1:50:000 scale map series is produced on an as-needed basis with the majority of requests originating from the Defense Mapping Agency. The 1:50,000 and 1:100,000 scale maps series are also produced on a cost-share basis in a county map format. The type of information needed for NMD to comply with EPA requests and evaluate those requests have been identified to provide a maximum amount of detail. The summary below is based on "Instructions for Submitting Cartographic and Digital Data Requirements" (USGS 1988a) and consists primarily of standard product availability information.

Topographic Maps. Requests for additional maps from an existing series should be related to NMD current mapping programs by using the indices in Table 3-7. Requests for new primary quadrangle maps (1:24,000) are no longer being accepted since that program is scheduled for completion within 2 years. However, revision requests may be made. The production of intermediate-scale (1:100,000) planimetric maps has been completed, and therefore USGS is now preparing the intermediate-scale topographic maps which are scheduled for completion in the mid-1990s. Requests are being accepted for priorities on the production of, and revision to incomplete versions of, those topographic maps. Small-scale mapping of the United States has been completed. Revisions to the following map series are being accepted: 1:250,000 scale topographic maps, State Base Map Series, and the U.S. base maps.

Digital Cartographic Data. Base map production of digital data is in progress. Production is controlled to yield maps produced at standard scales, accuracies, and with standard computer formats. The categories of

data currently being digitized at the 1:24,000 and 1:100,000 scales are the Public Land Survey System, boundaries, transportation, elevation data, and hydrography. Digitization at the 1:250,000 scale is being conducted for the following data categories: census tracts, land use and land cover, political boundaries, hydrologic units, and Federal land ownership. Digital data are available from the National Digital Cartographic Data Base which contains digital line graphs (DLGs) and digital elevation models (DEMs). For digital mapping requests the following items are required by NMD: data categories needed, source maps' scale, geographic location, and EPA's priority.

Digital Line Graphs (DLGs) and Digital Elevation Models (DEMs) are available at selected scales. The listing of scales and map content is provided in Table 3-9. Many of the small-scale land use and land cover maps have been digitized and requests for production priority are being accepted.

Land Use and Land Cover Mapping. Land use and land cover mapping is complete at small scales of 1:100,000 and 1:250,000 within the conterminous United States and Hawaii. Interim mapping of Alaska is being conducted.

Production of these maps at other scales will be dependent on Federal agency requests. Interested staff should review the land use and land cover index for product availability at other scales.

Special Map and Aerial Photography Products. The NMD makes special map products such as orthophotoquads (discussed in Section 3.2) at scales of 1:24,000 for the conterminous United States and Hawaii, and 1:63,360 for Alaska. Side-Looking Airborne Radar (SLAR) image maps are produced at 1:250,000 scale. However, NMD is to be contacted regarding SLAR since the data collection is mission-specific.

Over 6 million frames of photography have been acquired between 1940 and the present. Current programs include the National Aerial Photography Program (NAPP) which is a coordinated effort of several Federal agencies to acquire high-resolution, aerial photographic coverage of the United States from an elevation of 20,000 feet. This program began in 1987, will continue operation until 1991, and will replace the National High Altitude Photography Program (NHAP). Recent photographs, generated from NAPP, are at a scale of 1:40,000 and centered on a quarter section of a 7.5-minute quadrangle. The planned revision cycle is 5 years. The previous photography program, NHAP, generated maps at a scale of 1:80,000 in black and white, and 1:58,000 in color-infrared from an elevation of 40,000 feet. Complete national coverage is available for the NHAP series.

Nonstandard Map Products. Some very large-scale maps have been produced under cost—or work-share with the USGS. These very large-scale maps have primarily been 1:12,000 scale orthophotoquads.

3.5.2 The Geologic Division

Objective A.4 of the National Geologic Mapping Program is to "Solicit through meetings and questionnaires, the geologic map needs of other government agencies" (USGS 1987-Circular 1020).

Geologic Division mapping capabilities include several standard geologic map series (Section 3.3). Geologic map coverage is most comprehensive at the smaller scales where it is complete for the 1:2,500,000 scale (USGS 1987b). At the 1:62,500 scale about 30 percent of the United States has been covered. Geologic maps using the 7.5-minute quadrangle as a base (1:24,000 scale) have been completed for approximately 11 percent of the United States (USGS 1987b).

Details of geologic map product availability are not presented in this manual. To determine whether the desired geologic map is available, contact the Geologic Inquiries Group at (703) 648-4383. Alternatively:

(1) Use the nearest GD regional library and examine the index and publications list contained within the series of reports titled, "Publications of the United States Geological Survey."
(2) Within each State listing, find the location of interest.
(3) Obtain the map number from this report and order the geologic map. This report series has nine volumes which cover the period 1879–1978. If the location of interest is not listed, then the map may not yet be available for purchase and a request for a geologic map for that location may then be made. Please contact GD to confirm availability (Appendix E).

Table 3-7. National Mapping Division's Program Status Maps and Indices

1. Index to Digital Line Graph (DLG) and Digital Elevation Model (DEM) Data
2. Status and Progress of Topographic Mapping (7.5- and 15-minutes series)
3. Index to Orthophotoquad Mapping (monocolor 7.5-minute quadrangle format)
4. Index to Intermediate-scale Mapping (includes county formats)
5. Index to USGS/DMA 1:50,000-scale topographic maps (with terrain data)
6. Index to Small-Scale Maps of the United States (quadrangles, sectionals, states, U.S. maps)
7. Index to Land Use and Land Cover Information (digital data included)
8. Index to National High-Altitude Photography I and II (color infrared plus black and white for winter and growth seasons)
9. Index to Side-Looking Airborne Radar (SLAR) Acquisition Program
10. Index to USGS Topographic Map Coverage of National Park System
11. Index to Multi-year National Aerial Photography Acquisition Program

Table 3-8. Listings of USGS Maps and Associated Prices

Topographic, Image, and Related Maps		USGS Price
Standard Topographic Quadrangles (7.5 minute—1:24,000; 1:25,000; 7.5 × 15 minute—1:25,000; 15 minute—1:50,000; 1:62,500; 1:63,360)		$2.50
National Atlas Separates		3.10
1:100,000 Maps		3.10
1:250,000 Maps		4.00
International Map of the World (1:1,000,000) U.S. sheets only.	(per sheet)	4.00
Alaska Boundary Series Maps (1:250,000)		2.50
Alaska Federal Conservation Map		4.00
County Maps (1:50,000; 1:100,000)	(per sheet)	4.00
State Maps:		
No contours, black only (1:1,000,000)	(per sheet)	3.10
No contours, black and blue, planimetric (1:500,000)		3.10
No contours, multicolor, planimetric (1:500,000)	(per sheet)	4.00
Topographic or shaded relief 1:500,000	(per sheet)	4.00
The World (DMA physical relief map):		
(1:30,000,000)—single sheet 56″ × 42″		4.30
(1:22,000,000)—3 sheets $3.60 per sheet, 74″ × 55″ assembled	(set)	10.80
(1:14,000,000)—6 sheets $6.00 per sheet, 9′8.5″ × 7′2″ assembled	(sets)	36.00
Political Map of the World (1:40,000,000) 41″ × 22″		3.10
The World (outline map):		
(1:40,000,000) 48″ × 33″		3.10
(1:80,000,000) 25″ × 18″		1.70
World Seismicity Map (1:39,000,000) 48″ × 36″		3.10
National Park Maps		4.00
Coastal Ecological Inventory Maps		4.00
Antarctic Topographic maps		2.40 to 4.00
Satellite Image Maps		2.50 to 7.00

Topographic, Image, and Related Maps		USGS Price
U.S. Base Maps:		
2-A. (1:2,500,000) 5 colors, including buff land tint; State & county boundaries	(set)	$6.10
2-B. (1:2,500,000) same as 2-A except 4 colors and no land tint	(set)	6.10
3-A. (1:3,168,000) 3 colors, State boundaries, National parks & forests		3.10
3-B. (1:3,168,000) same as 3-A except 7 colors & historical boundaries & surveys		4.00
6-A. (1:6,000,000) 4 colors, State boundaries, National parks, roads & railroads, Alaska and Hawaii shown in correct geographical location		4.00
7-A. (1:7,000,000) 2 colors, State boundaries, 48 States only		2.40
8-A. &1:8,300,000) 6 colors, State boundaries, routes of U.S. explorers		2.40
10-A. (1:10,000,000) same content as 6-A		3.10
11-A. (1:11,875,000) 2 colors, State boundaries, 48 States only		1.20
16-A. (1:16,500,000) same content as 11-A		.70
U.S. Contour Map:		
7-B. (1:7,000,000) 3 colors, State boundaries, 48 States only, contours		2.40
U.S. Outline Map:		
5-E. (1:5,000,000) 1 color, State boundaries only		1.90
U.S. Physical Divisions Map:		
7-C. (1:7,000,000) 3 colors, State boundaries, 48 States only, physical divisions shown in red		2.40
North America Map:		
10-B. (1:10,000,000) 2 colors		3.10

Thematic Maps		USGS Price
Hydrologic Unit Map of (State)		$2.10 to $7.30
Hydrologic Unit Map of U.S.	(set)	6.10
Basement Rock Map of U.S.	(set)	6.10
Basement Rock Map of North America		2.10
Bouguer Gravity Anomaly Map of U.S.		1.90
Coal Fields of U.S.		4.30
Coal Fields of Alaska		3.60
Fold and Thrust Belts of U.S.	(set)	9.90
Geologic Map of (Selected States)		7.30 to 16.90
Geologic Map of U.S.	(set)	9.90
Geothermal Gradient Map of N.A.		7.90
Preliminary Metallogenic Map of N.A.	(set)	12.00
Subsurface Temperature Map	(set)	7.90
Tectonic Map of North America	(set)	9.90
World Seismicity Map		3.10
GQ's Geologic Quadrangles		3.60
MF's Miscellaneous Field Studies		Varies
I's Miscellaneous Investigations		Varies
GP's Geophysical Investigations		Varies
HA's Hydrologic Investigations		Varies
C's Coal Investigations		Varies
MR's Mineral Investigations—Resource		Varies
OC's Oil and Gas Investigations—Charts		Varies
OM's Oil and Gas Investigations—Maps		Varies
L's Land Use Maps		Varies
A's Antarctic Geologic Maps		Varies

Table 3-8. (Continued)

Digital Elevation Model (DEM)
A. Large Scale (1:24,000 7.5′ × 7.5′ unit
B. Small Scale (1:250,000) 1° × 1° unit (DMA Arc Second)
Digital Line Graph (DLG)
A. Large Scale (1:24,000/1:62,500) 7.5′ × 7.5′ and 15′ × 15′ units
U.S. Public Land Survey
Boundaries
Transportation
Hydrography
Hypsography
B. Intermediate Scale (1:100,000) 30′ × 30′ unit
U.S. Public Land Survey
Boundaries
Transportation
Hydrography
Hypsography
**Sample Data (30′ × 60′ unit)
C. Small Scale (1:2,000,000) Sectional unit
Boundaries
Transportation
Hydrography
Geographic Names Information System (GNIS)
A. State
B. Populated Places in the U.S.
C. Topographic Map Names
D. Concise (abridged U.S.)
E. Custom Search—call for price

**The 1:100,000-scale DLG SAMPLE units (transportation and hydrography categories only) for the Chickamauga, GA-AL-TN quadrangle is available for a total cost of $25.

Land Use and Land Cover
Intermediate/Small Scale (1:100,000/1:250,000) 30′ × 60′ and 1° × 2° unit
Land Use and Land Cover
Census Tracts
Political Units
Hydrologic Units
Federal Land Ownership
Composite Grid Cell

USGS Price

Purchase prices and availability are subject to change. This information is current as of Summer 1989.

Number of units per order	Total price
1	$ 40
2	60
3	80
4	100
5	120

Prices for orders of six or more units consist of a **base charge of $90 plus $7 per unit.**

Special handling may require additional charges that will be detailed upon request.

A single tape may contain more than one product type.

To order maps, call 1-800-USA-MAPS. In Washington, D.C. call FTS 959-6045.

Table 3-9. Listing of DLG and DEM Scales and Content

DLG Scale	Content
1:2,000,000	boundaries, transportation, hydrography
1:250,000	land use and land cover, census tracts, political boundaries, hydrologic units
1:24,000 (under production)	public land survey system data, boundaries, transportation, hydrography, contours
DEM Scale	**Content**
1:24,000 (derived)	terrain elevations from 30-m grid using 1:24,000-scale topographic maps as base

3.5.3 Water Resources Division

The WRD provides interpretive investigations that include hydrologic maps and hydrogeologic maps. These maps use planimetric or topographic map bases, while the hydrogeologic map may also include thematic information on geology. In addition, WRD collects a wide variety of data that are suitable for spatial analysis (Section 3.4). WRD publications contain a wide variety of hydrologic maps: the large-scale versions are maintained in the WRD office which authored the publication.

The reports and maps produced by WRD are published as part of Professional Papers, Water Supply Papers, Water Resource Investigation Reports, Hydrologic Atlases (HA), Flood-Prone Area Maps, and Open-File Reports. The only numbered map series are the Hydrologic Atlases. Refer to Section 3.4.5 for greater details on hydrologic maps.

Contact your local WRD District or the office located close to your area of interest for assistance (see Appendix C). The USGS Public Inquiries Office recommends that the following general procedure be used to determine product availability:

(1) Use the nearest WRD regional office library and examine the index and publications list contained within the series of reports titled, "Publications of the United States Geological Survey."
(2) Within each State listing, find the location of interest.
(3) Obtain the map number from this report and order the WRD map.

This USGS report series has nine volumes which cover the period 1879–1987. If the location of interest is not listed, then the map is not yet available for purchase and a request for a hydrologic or hydrogeologic map may then be made.

3.6 Conclusion

This chapter has presented a detailed description of the three technical USGS Divisions and their mapping-related activities. The information has been provided in sufficient detail for EPA map users to preliminarily investigate likely options, and to develop a set of questions for use in refining their mapping needs. Use of the cartographic information sources described in Appendices C, D, E, and F is recommended. In addition, the EPA and USGS contacts in Appendices A, B, and C are willing and able to assist in the determination of EPA mapping needs.

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Glossary

GLOSSARY

accuracy Degree of conformity with a standard. Accuracy relates to the quality of a result and is distinguished from precision which relates to the quality of the operation by which the result is obtained.

adjustment Process designed to remove inconsistencies in measured or computed quantities by applying derived corrections to compensate for random or accidental errors.

adjustment, land-line Positioning land lines on a map to indicate their true, theoretical, or approximate location relative to the adjacent terrain and culture, by reconciling the information shown on Bureau of Land Management plats and field records with the ground evidence of the location of the lines.

adjustment, standard-accuracy Adjustment of a survey resulting in values for positions and (or) elevations that comply with the National Map Accuracy Standards.

aerotriangulation (bridging) The process of developing a network of horizontal and (or) vertical positions from a group of known positions using direct or indirect measurements from aerial photographs and mathematical computations.

alidade Instrument, or part of an instrument, for determining direction, either horizontal or vertical. In its simplest form, a peepsight or telescope mounted on a straightedge and used for plotting directions graphically. In such instruments as transits and theodolites, the alidade is the part containing the telescope and its attachments.

altimeter Instrument for measuring altitudes or elevations with respect to a reference level, usually mean sea level. The most common type is an aneroid barometer. A radar altimeter determines the height of an aircraft above the terrain by measuring the time required for an electromagnetic pulse to travel from aircraft to the ground and back.

azimuth Horizontal direction reckoned clockwise from the meridian plane.

backshore Part of a beach that is usually dry and is reached only by the highest tides; by extension, a narrow strip of relatively flat coast bordering the sea.

base map See **map, base**.

bathymetric map See **map, bathymetric**.

bathymetry Science of measuring water depths (usually in the ocean) to determine bottom topography.

beach (seabeach) Zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). A beach includes foreshore and backshore.

bench mark Relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known.

boundary monument Material object placed on or near a boundary line to preserve and identify the location of the boundary line on the ground.

boundary survey Survey made to establish or to reestablish a boundary line on the ground, or to obtain data for constructing a map or plat showing a boundary line.

cadastral map See **map, cadastral**.

cadastral survey Survey relating to land boundaries, made to create units suitable for title transfer or to define the limitations of title. Derived from "cadastre" meaning a register of land quantities, values, and ownerships used for levying taxes, the term "cadastral survey" is used to designate the surveys of the public lands of the United States. Although the term may properly be applied to surveys of a similar nature outside the public lands, such surveys are more commonly called "land surveys" or "property surveys."

cartography Science and art of making maps and charts. The term may be taken broadly as comprising all the steps needed to produce a map: planning, aerial photography, field surveys, photogrammetry, editing, color separation, and multicolor printing. Mapmakers, however, tend to limit use of the term to the map-finishing operations, in which the master manuscript is edited and color separation plates are prepared for lithographic printing.

chain Unit of length equal to 66 feet, used especially in the U.S. public land surveys. The original measuring instrument (Gunter's chain) was literally a chain consisting of 100 iron links, each 7.92 inches long. Steel-ribbon tapes began to supersede chains around 1900, but surveying tapes are often still called "chains" and measuring with a tape is often called "chaining." The chain is a convenient unit in cadastral surveys because 10 square chains = 1 acre.

chart Special-purpose map designed for navigation or to present specific data or information. The term "chart" is applied chiefly to maps made primarily for

nautical and aeronautical navigation, and to maps of the heavens, although the term is sometimes used to describe other special-purpose maps.

chart, aeronautical Chart designed to meet requirements of aerial navigating, produced in several series, each on a specified map projection and differing in scale, format, and content, for use as dictated by type of aircraft and whether flight is to be conducted under visual or instrument flight rules.

chart, bathymetric See **map, bathymetric.**

chart, nautical Representation of a portion of the navigable waters of the Earth and adjacent coastal areas on a specified map projection and designed specifically to meet requirements for marine navigation. Included on most nautical charts are depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration and characteristics of the coast, the shoreline (usually the mean high water line), dangers, obstructions and aids to navigation, limited tidal data, and information about magnetic variation in the charted area.

choropleth map See **map, choropleth.**

clinometric map See **map, slope.**

color separation Process of preparing a separate drawing, engraving, or negative for each color required in the printing production of a map or chart.

compilation Preparation of a new or revised map or chart, or portion thereof, from existing maps, aerial photographs, field surveys, and other sources.

continuous tone Image not broken into dots by photographic screen; contains unbroken gradient tones from black to white, and may be either in negative or positive form. Aerial photographs are examples of continuous-tone prints. Contrasted with halftone (screened) and line copy.

contour Imaginary line on the ground, all points of which are at the same elevation above or below a specified datum.

contour interval Difference in elevation between two adjacent contours.

control, mapping Points of established position or elevation, or both, which are used as fixed references in positioning and correlating map features. Fundamental control is provided by stations in the national networks of triangulation and traverse (horizontal control) and leveling (vertical control). Usually it is necessary to extend geodetic surveys, based on the fundamental stations, over the area to be mapped, to provide a suitable density and distribution of control points.

Supplemental control points are those needed to relate the aerial photographs used for mapping with the system of ground control. These points must be positively photo-identified; that is, the points on the ground must be positively correlated with their images on the photographs.

control station Point on the ground whose position (horizontal or vertical) is known and can be used as a base for additional survey work.

coordinates Linear and (or) angular quantities that designate the position of a point in relation to a given reference frame.

coordinates, origin of Point in a system of coordinates which serves as the zero point in computing the system's elements or in prescribing its use.

culture Features constructed by man that are under, or, or above the ground which are delineated on a map. These include roads, trails, buildings, canals, sewer systems, and boundary lines. In a broad sense, the term also applies to all names, other identification, and legends on a map.

datum (pl **datums**) In surveying, a reference system for computing or correlating the results of surveys. There are two principal types of datums: vertical and horizontal. A vertical datum is a level surface to which heights are referred. In the United States, the generally adopted vertical datum for leveling operations is the National Geodetic Vertical Datum of 1929. The horizontal datum is used as a reference for position. The North American Datum of 1927 is defined by the latitude and longitude of an initial point (Meade's Ranch in Kansas), the direction of a line between this point and a specified second point, and two dimensions that define the spheroid. The new North American Datum of 1983 is based on a newly defined spheroid (GRS80); it is an Earth-centered datum having no initial point or initial direction.

datum, national geodetic vertical See **national geodetic vertical datum of 1929.**

declination In astronomy, the angular distance of a celestial body above (north, plus) or below (south, minus) the celestial Equator. Magnetic declination is the angular difference between magnetic north and true (geographic) north at the point of observation; it is not constant but varies with time because of the "wandering" of the magnetic north pole.

depth curve Line on a map or chart connecting points of equal depth below the datum.

diazo process Rapid method for copying documents in which the image is developed by exposure to ammonia.

dike Bank of earth or stone used to form a barrier, frequently and confusingly interchanged with levee. A dike restrains water within an area that normally is flooded. See **levee.**

electronic distance measuring (EDM) devices Instruments that measure the phase difference between transmitted and reflected or retransmitted electromagnetic waves of known frequency, or that measure the round-trip transit time of a pulsed signal, from which distance is computed.

elevation Vertical distance of a point above or below a reference surface or datum.

ellipsoid See **spheroid.**

engineering map See **map, engineering.**

ER-55 plotter Double-projection plotting instrument utilizing ellipsoidal reflectors for light projection.

erosion Group of natural processes including weathering, dissolution, abrasion, corrosion, and transportation that remove material from any part of the earth's surface.

estuary That portion of a stream influenced by the tide of the body of water into which it flows; an arm of the sea at a river mouth.

feature separation Process of preparing a separate drawing, engraving, or negative for selected types of data in the preparation of a map or chart.

flood control map See **map, flood control.**

flood plain Belt of low flat ground bordering a stream channel that is flooded when runoff exceeds the capacity of the stream channel.

forestry map See **map, forestry.**

formlines Lines, resembling contour lines, drawn to present a conception of the shape of the terrain without regard to a true vertical datum or regular spacing.

geodesy Science concerned with the measurement and mathematical description of the size and shape of the Earth and its gravitational field. Geodesy also includes the large-scale, extended surveys for determining positions and elevations of points, in which the size and shape of the Earth must be taken into account.

geoid Figure of the Earth visualized as a mean sea level surface extended continuously through the continents. It is a theoretically continuous surface that is perpendicular at every point to the direction of gravity (the plumbline).

geologic map See **map, geologic.**

graticule Network of parallels and meridians on a map or chart.

graticule, geographic System of coordinates of latitude and longitude used to define the position of a point on the surface of the Earth with respect to the reference spheroid. (Note that use of the word "grid" with "geographic" in this application is incorrect.)

grid Network of uniformly spaced parallel lines intersecting at right angles. When superimposed on a map, it usually carries the name of the projection used for the map—that is, Lambert grid, transverse Mercator grid, universal transverse Mercator grid.

hachure Any of a series of lines used on a map to indicate the general direction and steepness of slopes. The lines are short, heavy, and close together for steep slopes; longer, lighter, and more widely spaced for gentle slopes.

halftone A picture in which the gradations of light are obtained by the relative darkness and density of tiny dots produced by photographing the subject through a fine screen.

high water Maximum height reached by a rising tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions. Use of the term "high tide" is discouraged.

high water line Intersection of the land with the water surface at an elevation of high water.

high water mark Line or mark left upon tidal flats, beach, or alongshore objects indicating the elevation or the intrusion of high water.

hydrographic survey Survey of a water area, with particular reference to submarine relief, and any adjacent land. See **oceanographic survey.**

hydrography Science that deals with the measurement and description of the physical features of the oceans, seas, lakes, rivers, and their adjoining coastal areas, with particular reference to their use for navigation.

hydrology Scientific study of the waters of the Earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of ground water.

hypsographic map See **map, hypsographic.**

hypsography Topography referred to the national geodetic vertical datum of 1929. The science or art of describing heights of land surfaces with reference to this datum.

hypsometric map See **map, hypsometric.**

hypsometry Science or art of determining terrain relief, by any method.

imagery Visible representation of objects and (or) phenomena as sensed or detected by cameras, infrared and multispectral scanners, radar, and photometers. Recording may be on photographic emulsion (directly as in a camera or indirectly after being first recorded on magnetic tape as an electrical signal) or on magnetic tape for subsequent conversion and display on a cathode ray tube.

infrared scanner (thermal mapper) Instrument that detects infrared radiation and converts the detected energy to an electrical signal for recording on photographic film or magnetic tape.

isogonic chart Chart showing isogonic lines properly labeled with their magnetic declinations.

isogonic line Line joining points on the Earth's surface having equal magnetic declination as of a given date.

isopleth map See **map, isopleth.**

Kelsh plotter Double-projection plotting instrument utilizing swinging lamps to transmit light through contact-size diapositives (positive transparencies).

land use classification system Coding system of categories and subcategories designed for use on a map to designate land or water use.

land use map See **map, land use.**

landmark Monument or material mark or fixed object used to designate a land boundary on the ground; any prominent object on land that may be used to determine a location or a direction in navigation or surveying.

latitude Angular distance, in degrees, minutes, and seconds, of a point north or south of the Equator.

lead line Line weighted with lead for making depth soundings in water.

levee Artificial bank confining a stream channel or limiting adjacent areas subject to flooding; an embankment bordering a submarine canyon or channel, usually occurring along the outer edge of a curve.

level surface Surface which at every point is perpendicular to the plumbline or the direction in which gravity acts.

leveling Surveying operation in which heights of objects and points are determined relative to a specified datum.

line copy (line drawing) Map copy suitable for reproduction without the use of a screen; a drawing composed of lines as distinguished from continuous-tone copy.

line map See **map, line.**

longitude Angular distance, in degrees, minutes, and seconds, of a point east or west of the Greenwich meridian.

low water Minimum height reached by a falling tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of meteorological conditions.

low water line Intersection of the land with the water surface at an elevation of low water. Not to be confused with mean low water line.

magnetic declination See **declination.**

map Graphic representation of the physical features (natural, artificial, or both) of a part or the whole of the Earth's surface, by means of signs and symbols or photographic imagery, at an established scale, on a specified projection, and with the means of orientation indicated.

map, base Map on which information may be placed for purposes of comparison or geographical correlation. The term "base map" was at one time applied to a class of maps now known as outline maps. It may be applied to topographic maps, also termed "mother maps," that are used in the construction of other types of maps by the addition of particular data.

map, bathymetric Map delineating the form of the bottom of a body of water, or a portion thereof, by the use of depth contours (isobaths).

map, cadastral Map showing the boundaries of subdivisions of land, often with the bearings and lengths thereof and the areas of individual tracts, for purposes of describing and recording ownership. It may also show culture, drainage, and other features relating to land use and value. See **plat.**

map, choropleth Thematic map in which areas are colored, shaded, dotted, or hatched to create darker or lighter areas in proportion to the density of distribution of the theme subject.

map digitization Conversion of map data from graphic to digital form.

map, engineering Map showing information that is essential for planning an engineering project or development and for estimating its cost. It usually is a large-scale map of a small area or of a route. It may be entirely the product of an engineering survey, or reliable information may be collected from various sources for the purpose, and assembled on a base map.

map, flood control Map designed for studying and planning control projects in areas subject to flooding.

map, forestry Map prepared principally to show the size, density, kind, and value of trees in a designated area.

map, geologic Map showing the structure and composition of geologic features.

map, hypsographic Map showing relief with elevations referred to the national geodetic vertical datum of 1929.

map, hypsometric Map showing relief by any convention, such as contours, hachures, shading, or tinting.

map, isopleth Map consisting of lines connecting places of equal value of distribution for a given theme such as rainfall or temperature.

map, land use Map showing by means of a coding system the various purposes for which parcels of land are being used by man.

map, line Map composed of lines as distinguished from photographic imagery.

map, orthophotographic See **orthophotographic map.**

map, photographic See **photomap.**

map, planimetric Map that presents only the horizontal positions for features represented; distinguished from a topographic map by the omission of relief in measurable form. The features usually shown on a planimetric map include rivers, lakes, and seas; mountains, valleys, and plains; forests, and prairies; cities, farms, transportation routes, and public utility facilities; and political and private boundary lines. A planimetric map intended for special use may present only those features essential to the purpose to be served.

map projection Orderly system of lines on a plane representing a corresponding system of imaginary lines on an adopted terrestrial or celestial datum surface. Also, the mathematical concept of such a system. For maps of the Earth, a projection consists of (1) a graticule of lines representing parallels of latitude and meridians of longitude or (2) a grid.

map series Family of maps conforming generally to the same specifications and designed to cover an area or a country in a systematic pattern.

map, slope (clinometric map) Map showing the degree of steepness of the Earth's surface by the use of various colors or shading for critical ranges of slope.

map, soil Map that shows the constitution, structure, and texture of the soil and identifies ongoing erosion.

map, storm evacuation Map designed to identify coastal areas subject to flooding, to indicate recommended areas of refuge, and to emphasize available evacuation routes.

map, thematic Map designed to provide information on a single topic, such as geology, rainfall, population.

map, topographic Map that presents the horizontal and vertical positions of the features represented; distinguished from a planimetric map by the addition of relief in measurable form.

marsh, coastal Area of salt-tolerant vegetation in brackish and (or) saline-water habitats subject to tidal inundation.

marsh, freshwater Tract of low wet ground, usually miry and covered with rank vegetation.

mean high water Tidal datum that is the arithmetic mean of the high water heights observed over a specific 19-year Metonic cycle (National Tidal Datum Epoch). For stations with shorter series, simultaneous observations are made with a primary control tide station to derive the equivalent of a 19-year value. Use of "mean high tide" is discouraged.

mean high water line Intersection of the land with the water surface at the elevation of mean high water. See **shoreline.**

mean low water Tidal datum that is the arithmetic mean of the low water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observations are made with a primary control tide station in order to derive the equivalent of a 19-year value. Use of the synonymous term "mean low tide" is discouraged.

mean low water line Intersection of the land with the water surface at the elevation of mean low water.

mean sea level Tidal datum that is the arithmetic mean of hourly water elevations observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Shorter series are specified in the name; that is, monthly mean sea level and yearly mean sea level. See **datum.**

meanderline Metes-and-bounds traverse approximately along the mean high water line of a permanent body of water. By following the sinuosities of the bank or shoreline, the meander line provides data for computing the area of land remaining after the water area has been segregated. A meander line differs from other metes-and-bounds surveys in that it does not ordinarily determine or fix boundaries.

meanderable Capable of being depicted by reference to a meander line.

meridian Great circle on the surface of the Earth passing through the geographical poles and any given point on the Earth's surface. All points on a given meridian have the same longitude.

metes and bounds Method of describing land by measure of length (metes) of the boundary lines (bounds).

Metonic cycle Period of 235 lunations or about 19 years. Devised by Meton, an Athenian astronomer (5th century B.C.) for the purpose of obtaining a period at the end of which the phases of the Moon recur in the same order and on the same days as in the preceding cycle.

metric system Decimal system of weights and measures based on the meter as a unit length and the kilogram as a unit mass.

monoscopic Pertaining to the observation of a single photograph or other view.

monument (surveying) Permanent physical structure marking the location of a survey point. Common types of monuments are inscribed metal tablets set in concrete posts, solid rock, or parts of buildings; distinctive stone posts; and metal rods driven in the ground.

mosaic, aerial Assembly of aerial photographs whose edges usually have been torn or cut selectively and matched to the imagery on adjoining photographs to form a continuous representation of a portion of the Earth's surface.

multiplex Stereoplotter of the double-projection type characterized by its use of reduced-scale diapositives and stationary lamphouses with condensing lenses.

multispectral scanner (MSS) Device for sensing radiant energy in several channels of the electromagnetic spectrum.

national geodetic vertical datum of 1929 Reference surface established by the U.S. Coast and Geodetic Survey in 1929 as the datum to which relief features and elevation data are referenced in the conterminous United States; formerly called "mean sea level 1929."

National Map Accuracy Standards Specifications promulgated by the U.S. Office of Management and Budget to govern accuracy of topographic and other maps produced by Federal agencies.

navigable waters Waters usable, with or without improvements, as routes for commerce in the customary means of travel on water.

neatline Line separating the body of a map from the map margin. On a standard quadrangle map, the neatlines are the meridians and parallels delimiting the quadrangle.

oceanographic survey Survey or examination of conditions in the ocean or any part of it, with reference to animal or plant life, chemical elements present, temperature gradients, etc. See **hydrographic survey**.

offshore Comparatively flat zone of variable width that extends from the outer margin of the rather steeply sloping shoreface to the edge of the continental shelf.

orientation Establishing correct relationship in direction with reference to points of the compass; the state of being in correct relationship in direction with reference to the points of the compass.

origin of coordinates Point in a system of coordinates that serves as a zero point in computing the system's elements or in prescribing its use.

orthophotograph Photograph having the properties of an orthographic projection. It is derived from a conventional perspective photograph by simple or differential rectification so that image displacements caused by camera tilt and terrain relief are removed.

orthophotographic map Map produced by assempling orthophotographs at a specified uniform scale in a map format.

orthophotomap Orthophotographic map with contours and cartographic treatment, presented in a standard format, and related to standard reference systems.

orthophotomosaic Assembly of orthophotographs forming a uniform-scale mosaic.

orthophotoquad Monocolor orthophotographic map presented in a standard quadrangle format and related to standard reference systems. It has no contours and little or no cartographic treatment.

orthophotoscope Photomechanical device used in conjunction with a double-projection stereoplotter for producing orthophotographs.

overedge Any portion of a map lying outside the nominal map border (neatline).

overlay Printing or drawing on a transparent or translucent medium intended to be placed in register on a map or other graphic and which shows details not appearing or requiring special emphasis on the base material.

overprint New material printed on a map or chart to show data of importance or special use, in addition to those data originally printed.

parallel of latitude A circle, or approximation of a circle, on the surface of the Earth, parallel to the Equator, and connecting points of equal latitude; a circle of the celestial sphere parallel to the ecliptic, and connecting points of equal celestial latitude.

photogrammetry Science or art of obtaining reliable measurements or information from photographs or other sensing systems.

photomap (photographic map) Map made by adding marginal information, descriptive data, and a reference system to a photograph or assembly of photographs.

plain Region of uniform general slope, comparatively level, of considerable extent, and not broken by marked elevations and depressions (it may be an extensive valley floor or a plateau summit); an extent of level or nearly level land; a flat, gently sloping, or nearly level region of the sea floor.

planetable Instrument consisting essentially of a drawing board on a tripod and some type of sighting device (alidade) with attached straightedge, used for plotting the lines of survey directly from observation in the field.

planimetric map See **map, planimetric.**

planimetry Plan details of a map—those having no indications of relief or contour.

plat Diagram drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land, as determined by survey or protraction. As used by the Bureau of Land Management, the drawing which represents the particular area included in a survey, such as township, private land claim, or mineral claim, and the lines surveyed, established, or retraced, showing the direction and length of each such line; the relation to the adjoining official surveys; the boundaries, descriptions, and area of each parcel of land subdivided; and, as nearly as may be practicable, a representation of the relief and improvements within the limits of the survey.

prime meridian Meridian of longitude 0°, used as the origin for measurements of longitude. The meridian of Greenwich, England, is the internationally accepted prime meridian on most charts. However, local or national prime meridians are occasionally used.

projection, map. See **map projection.**

public land system Public lands are subdivided by a rectangular system of surveys established and regulated by the Bureau of Land Management. The standard format for subdivision is by townships measuring 6 miles (480 chains) on a side. Townships are further subdivided into 36 numbered sections of 1 square mile (640 acres) each.

quad-centered photograph Middle exposure of a phototriplet (three consecutive aerial photographs) taken so that the middle photograph is exposed directly above the center of the quadrangle and the preceding and following photographs are exposed directly above the boundaries of the quadrangle. The flying height is set such that the quad-centered photograph covers the entire quadrangle.

quadrangle Four-sided area, bounded by parallels of latitude and meridians of longitude used as an area unit in mapping (dimensions are not necessarily the same in both directions). Also, a geometric figure of significance in geodetic surveying.

radial-line plotting Determination of the location of points by successive intersection and resection of direction lines radiating from the radial centers of overlapping aerial photographs.

rectification, differential The process of scanning and reprojecting a photograph onto a horizontal plane in differential elements to remove displacements caused by tilt and relief. The process may be accomplished by any one of a number of instruments developed specifically for the purpose.

rectification, simple Projection of an aerial photograph (mathematically, graphically, or photographically) from its plane onto a horizontal plane by translation, rotation, and (or) scale change to remove displacement due to tilt of the camera.

relief Elevations and depressions of the land or sea bottom.

relief shading Technique for making hypsography on a map appear three dimensional by the use of graded shadow effects. Generally, the features are shaded as though illuminated from the northwest.

remote sensing Process of detecting and (or) monitoring chemical or physical properties of an area by measuring its reflected and emitted radiation.

representative fraction Scale of a map or chart expressed as a fraction or ratio that relates unit distance on the map to distance measured in the same unit on the ground.

reproduction Summation of all the processes involved in printing copies from an original drawing. A printed copy of an original drawing made by the processes of reproduction.

scale Relationship existing between a distance on a map, chart, or photograph and the corresponding distance on the Earth.

sea level (water level) Height of the surface of the sea at any time.

section Unit of subdivision of a township; normally a quadrangle 1 mile square with boundaries conforming to meridians and parallels within established limits, and containing 640 acres as nearly as practicable.

sensor Technical means, usually electronic, to extend man's natural senses by detecting emitted or reflected energy. The energy may be nuclear, electromagnetic (including the visible and invisible portions of the spectrum), chemical, biological, thermal, or mechanical.

shoreline Intersection of the land with the water surface. The shoreline shown on charts represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this line of contact is usually the mean high water line. In confined coastal waters of diminished tidal influence, the mean water level line may be used.

slope map. See **map, slope.**

soil map See **map, soil.**

spheroid Mathematical figure closely approaching the geoid in form and size and used as a surface of reference for geodetic surveys. A reference spheroid or ellipsoid is a spheroid determined by revolving an ellipse about its shorter (polar) axis and used as a base for geodetic surveys of a large section of the Earth (such as the Clarke spheroid of 1866 which is used for geodetic surveys in the United States).

spot elevation Point on a map or chart whose height above a specified datum is noted, usually by a dot or a small sawbuck and elevation value. Elevations are shown, on a selective basis, for road forks and intersections, grade crossings, summits of hills, mountains and mountain passes, water surfaces of lakes and ponds, stream forks, bottom elevations in depressions, and large flat areas.

stadia Technique of distance measurement wherein the observer reads the intercept subtended on a graduated rod between two marks on the reticle of the telescope.

standard-accuracy adjustment See **adjustment, standard-accuracy.**

state plane coordinate systems Coordinate systems established by the U.S. Coast and Geodetic Survey (now the National Ocean Survey), usually one for each State, for use in defining positions of points in terms of plane rectangular (x,y) coordinates.

stereocompilation Production of a map or chart manuscript from aerial photographs and geodetic control data by means of photogrammetric instruments.

stereoplotter Instrument for plotting a map by observation of stereomodels formed by pairs of photographs.

stereoscopic Pertaining to the use of binocular vision for observation of a pair of overlapping photographs or other perspective views, giving the impression of depth.

storm evacuation map See **map, storm evacuation.**

subsidence Decrease in the elevation of land surface due to tectonic, seismic, or artificial forces, without removal of surface material.

survey Orderly process of determining data relating to any physical or chemical characteristics of the Earth. The associated data obtained in a survey. An organization engaged in making a survey.

tachometer (tachymeter) Surveying instrument designed for use in the rapid determination of distance, direction, and difference of elevation from a single observation, using a short base which may be an integral part of the instrument.

thematic map See **map, thematic.**

theodolite Precision surveying instrument for measuring horizontal and vertical angles.

tide Periodic rise and fall of the water resulting from gravitational interactions between the Sun, Moon, and

Earth. The vertical component of the particulate motion of a tidal wave. Although the accompanying horizontal movement of the water is part of the same phenomenon, it is preferable to designate this motion as tidal current.

topographic map See **map, topographic.**

topography Configuration (relief) of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or a surface of given characteristics within the water mass.

township Unit of survey of the public lands of the United States, normally a quadrangle approximately 6 miles on a side with boundaries conforming to meridians and parallels within established limits, containing 36 sections. Also, in certain parts of the country, the term designates a minor governmental subdivision.

transit Precision surveying instrument; a theodolite in which the telescope can be reversed in direction by rotation about its horizontal axis.

traverse Sequence of lengths and directions of lines connecting a series of stations, obtained from field measurements, and used in determining positions of the stations.

triangulation Method of extending horizontal position on the surface of the Earth by measuring the angles of triangles and the included sides of selected triangles.

trilateration Method of surveying wherein the lengths of the triangle sides are measured, usually by electronic methods, and the angles are computed from the measured lengths. Compares with triangulation.

Universal Transverse Mercator (UTM) grid Military grid system based on the transverse Mercator projection, applied to maps of the Earth's surface extending from the Equator to 84° N. and 80° S. latitudes.

upland Highland; ground elevation above the lowlands along rivers or between hills.

zenith telescope Instrument for observing stars near the zenith (a point on the celestial sphere directly above the observer's position).

Exhibit A
EPA Mapping Request Form

Exhibit A

EPA MAP AND DATA REQUEST FORM

The following instructions have been provided to assist you in completing the Map and Data Request Form (see subsequent pages). Use one form for each request submitted. DO NOT put multiple requests on one form! Please contact your Regional GIS coordinator to determine if the map or data (geographic information) are currently available, or call USGS at 1-800-USA-MAPS (703-648-6045 in the Washington D.C. area). If you require further assistance or clarification regarding any aspect of the National Mapping Requirements Program (NMRP), please contact Jeffrey Booth, EPA/OIRM, at (703) 883-8533, or E-MAIL at J.BOOTH EPA3767. After this form is **completed** and **authorized**, please submit the request to:

Jeffrey Booth
U. S. Environmental Protection Agency
Office of Information Resources Management
Mail Code PM-218B
401 M Street, S.W.
Washington, D.C. 20460

(1) MAP PROJECT NAME: This is the name or title by which you refer to the project requiring the geographic information.

(2) REQUESTED BY: Provide the name of the individual who could be contacted regarding further clarification of the map request.

(3) AUTHORIZED BY: Provide the name of the Branch Chief or Division Chief who has authorized this request.

(4) PHONE #: List the FTS and commercial phone numbers where the requesting individual can be reached.

(5) ORIGIN: List the Region/Laboratory and Program Office of the requesting individual.

(6) MAIL CODE/ADDRESS: Provide the mailing address where the requesting individual can be reached.

(7) PROJECT PURPOSE/INTENDED USE: Provide a description of the project, summarizing its purpose, objectives, and expected benefits to be derived from the requested geographic information.

(8) TOTAL NUMBER OF QUADS REQUESTED: This is the total number of quadrangles requested at the scale designated from the Map Selection Tables (Table 3-6, page 3-58, 3-59). (Note: A maximum of 40 quads for each request will be accepted).

(9) GEOGRAPHIC COVERAGE: Provide an index map (available from the NMRP Manager or Regional GIS team) or photo copy with the desired area of coverage(s) delineated to assist in an accurate identification. List on a separate piece of paper (or color code on index map), the names of the quadrangles in order of highest priority (this is especially important when requesting a large number of quadrangles).

(10) MAP REQUEST PRIORITY: Include a realistic estimate of when you will <u>use</u> the requested information. This will be important to determine possible rescheduling of the map production process or to provide an interim product for initial use.

(11) MONTH/YEAR NEEDED: Include the deadline by which you can still accept the requested geographic information. This will assist in determining possible options for product and/or interim generation (i.e., in-house production, cost-share, work-share, MOU, contracting, etc.).

(12) PROJECT DURATION: Provide the effective starting date and the expected completion date for the project.

(13) WILLING TO ACCEPT INTERIM PRODUCTS: Are you willing to accept interim products? This will assist in determining alternative production schedules for the creation of interim products to meet your time constraints.

(14) ESTIMATED REVISION FREQUENCY: How often do you estimate the need for updating the map information you have requested? This will assist in evaluating the importance EPA places upon a particular "type" of geographic information.

(15) PLEASE INDICATE THE MOST APPROPRIATE CATEGORY OF THE REQUESTED MAP INFORMATION:

A. BASE CARTOGRAPHIC DATA
B. CADASTRAL
C. CERTAIN INTERNATIONAL BOUNDARIES AND NAMES
D. CULTURAL AND DEMOGRAPHIC
E. GEODETIC
F. GEOLOGIC
G. GROUND TRANSPORTATION
H. HYDROLOGIC
I. SOILS
J. VEGETATION
K. WETLANDS
L. OTHER (Specify)

(16) SUBMISSION CRITERIA: Information on funding availability, state and other Federal agency participation, and direct legislative or regulatory requirements will be used to prioritize requests.

EPA MAP AND DATA REQUEST FORM

EPA RANK _____
(internal use only)

Date Submitted _____

(1) **MAP PROJECT NAME:** _____

(2) **REQUESTED BY:** _____

(3) **AUTHORIZED BY:** (Branch or Division Chief Signature) _____

(4) **PHONE NUMBER:** (FTS)_____-_____-_____ (COM)_____-_____-_____

(5) **ORIGIN:** (Region/Lab) _____(Program Office) _____

(6) **MAIL CODE/ADDRESS:** _____

(7) **PROJECT PURPOSE/INTENDED USE:** _____

_____
_____
_____
_____
_____
_____
_____

(8) **TOTAL NUMBER OF QUADS REQUESTED** (based upon scale in the Map Selection Tables on page 3-58 and 3-59): _____

(9) **GEOGRAPHIC COVERAGE:** (attach index map and quadrangle names list in order of highest priority);

(10) **MAP REQUEST PRIORITY:** I = 1 yr _____, II = 1-2 yrs _____, III = 2-3 yrs _____, IV = 3-4 yrs _____, V = > 4 yrs _____

(11) **MONTH/YEAR NEEDED:** _____

(12) **PROJECT DURATION:** _____

(13) **WILLING TO ACCEPT INTERIM PRODUCTS:** _____

(14) **ESTIMATED REVISION FREQUENCY:** _____;

(15) **PLEASE INDICATE THE MOST APPROPRIATE CATEGORY FOR THE REQUESTED MAP INFORMATION (Check One):**

- ☐ A. BASE CARTOGRAPHIC DATA
- ☐ B. CADASTRAL
- ☐ C. INTERNATIONAL BOUNDARIES AND NAMES
- ☐ D. CULTURAL AND DEMOGRAPHIC
- ☐ E. GEODETIC
- ☐ F. GEOLOGIC
- ☐ G. GROUND TRANSPORTATION
- ☐ H. HYDROLOGIC
- ☐ I. SOILS
- ☐ J. VEGETATION
- ☐ K. WETLANDS
- ☐ L. OTHER (Specify)

COMMENTS: _____

(16) **SUBMISSION CRITERIA**

A. **IS THERE ANY COST-SHARING OR FUNDING MECHANISMS AVAILABLE IF NECESSARY?** YES __ NO __ IF YES, PLEASE DEFINE: _____

B. **ARE ONE OR MORE STATES ACTIVELY PARTICIPATING IN YOUR PROJECT?**
YES __ NO __
IF YES, PLEASE LIST STATES: _____

C. **ARE OTHER FEDERAL AGENCIES INVOLVED WITH YOUR PROJECT?**
YES __ NO __
IF YES, PLEASE LIST AGENCIES: _____

D. **IS THERE A DIRECT LEGISLATIVE OR REGULATORY REQUIREMENT(S) FOR YOUR PROJECT?** YES __ NO __
IF YES, PLEASE SPECIFY: _____

TO SELECT A MAP PRODUCT, PLACE AN "X" IN THE APPROPRIATE PRODUCT/SCALE BOX ON THE FOLLOWING PAGES:

EPA National Mapping Requirements Program
Map Selection Table

Scale

GRAPHIC DATA	1:12,000	1:20,000[1]	1:24,000	1:25,000 (Metric)[2]	1:40,000 (B/W)	1:50,000	1:63,360[3]	1:100,000 (Metric)	1:250,000	1:500,000	1:2,000,000	1:7,500,000	Other
Conterminous U.S. and Hawaii Quadrangles													
Alaska Quadrangles													
Puerto Rico, Virgin Islands, and Pacific Territory Quadrangles													
Topographic/Bathymetric Quadrangles													
Orthophotoquads													
Land Use/Land Cover Quadrangles													
County Maps													
State Base Maps													
U.S. Base Maps													
National Atlas Separates													
National Atlas Sectionals													
Aerial Photography (NAPP)													
Side Looking Airborne Radar													
Satellite Image Maps													

[1] Puerto Rico, Virgin Islands, and Pacific Territories only
[2] Selected areas in the conterminous U. S. and Alaska
[3] Alaska only

Please check with the Regional or HQ NMRP Manager for product availability.

Upon completion and authorization, submit to: **Jeffrey Booth, U.S. EPA, OIRM, Mail code PM-218B, 401 M St., SW, Washington, DC 20460**

EPA National Mapping Requirements Program
Map Selection Table

Scale

DIGITAL DATA	1:12,000	1:20,000[1]	1:24,000	1:25,000 (Metric)[2]	1:40,000 (B/W)	1:50,000	1:63,360[3]	1:100,000 (Metric)	1:250,000	1:500,000	1:2,000,000	1:7,500,000	Other
Boundary DLG's[4]													
Transportation DLG's													
Hydrography DLG's													
Hypsography (contours) DLG's													
Other Significant Manmade Structure (culture) DLG's													
Vegetative Surface Cover DLG's													
Non-Vegetative Surface Features DLG's													
Survey Control DLG's													
Level 1 DEM's[5] (profile)													
Level 2 DEM's (conversion of hypso/hydro DLG's)													
Digital Orthophotoquads													
Land Use/Land Cover Digital Data													

[1] Puerto Rico, Virgin Islands, and Pacific Territories only
[2] Selected areas in the conterminous U. S. and Alaska
[3] Alaska only
[4] Digital Line Graphs
[5] Digital Elevation Models
[6] Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986.

Please check with the Regional or HQ NMRP Manager for product availability.

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EPA National Mapping Requirements Program
Map Selection Table

Scale

GEOLOGIC	1:12,000	1:15,000	1:20,000	1:24,000	1:25,000	1:40,000	1:50,000	1:56,000 B/W	1:62,500	1:63,360[1]	1:80,000 CIR	1:100,000	1:250,000	1:500,000	1:1,000,000	1:2,000,000	1:2,500,000	1:7,500,000	Other
Geologic Quadrangle Maps (GQ Series)[2]																			
Miscellaneous Investigation Maps (I Series)[3]																			
Miscellaneous Field Study Maps (MF Series)[4]																			
Open File Maps (OF Series)[5]																			
Special Purpose Maps[6]																			
Mineral Investigations Resource Maps (MR Series)																			
Geochemical Maps and Data																			
Geophysical Maps and Data (GP Series)																			
Marine Mapping and Data																			
Exclusive Economic Zone (EEZ)																			
Continental Margin Mapping Series																			
Coastal Mapping Series																			
Assessment Maps																			
Mineral Resources																			
Energy Resources																			
Earthquake Hazard																			
Volcano Hazards																			
Landslide and Subsidance																			

Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986, and the Catalog of Maps.
These maps are produced by USGS, other individual State maps may be available from the State Geological Survey Office.

[1] Alaska Only

[2] GQ series maps are multi-color with accompaning text and provides the greatest detail of Geologic Division Products. This map may show the bedrock, surficial, or engineering geology and is available in 1:24,000 and 1:62,500 scales.

[3] I series maps are multi-colored with brief accompaning text and provide good detail. These maps may show hydrogeologic , marine geologic and other resource study data, and may be available at various scales other than standard 1:24,000.

[4] MF series maps are available in various scales, various sizes, are in black and white, with a third color, and have less detail than the GQ or the I series. These maps are preliminary reports on geologic aspects of mineral and environmental studies.

[5] OF series maps are available in various scales, various sizes, are in black and white, and have the least amount of detail of Geological Division products. These maps are preliminary draft reports.

[6] The following maps may be available in the GQ, I, MF, or OF series. Contact the USGS Office of Scientific Information at (703) 648-6045 for further information.

Please check with the Regional or HQ NMRP Manager for product availability.

Upon completion and authorization, submit to: **Jeffrey Booth, U.S. EPA, OIRM, Mail code PM-218B, 401 M St., SW, Washington, DC 20460**

EPA National Mapping Requirements Program
Map Selection Table

Scale

GEOLOGIC	1:12,000	1:15,000	1:20,000	1:24,000	1:25,000	1:40,000	1:50,000	1:56,000 B/W	1:62,500	1:63,360[1]	1:80,000 CIR	1:100,000	1:250,000	1:500,000	1:1,000,000	1:2,000,000	1:2,500,000	1:7,500,000	Other
Special Purpose Maps[2]																			
Coal Investigations Maps (C Series)																			
Antarctic Geologic Maps (A Series)																			
Oil and Gas Investigations Charts (OC Series)																			
Oil and Gas Investigations Maps (OM Series)																			
Special Geologic Maps (no series)																			
State Geologic Maps (no series)																			
Alaska																			
Arizona																			
Arkansas																			
Colorado																			
Kentucky																			
Massachusetts																			
Montana																			
Nevada																			
New Hampshire																			
New Jersey																			
New Mexico																			
North Dakota																			
Oklahoma																			
South Dakota																			
Wyoming																			

Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986.
These maps are produced by USGS, other individual State maps may be available from the State Geological Survey Office.

[1] Alaska Only

[2] The following maps may be available in the GQ, I, MF, or OF series. Contact the USGS Office of Scientific Information at (703) 648-6045 for further information.

Please check with the Regional or HQ NMRP Manager for product availability.

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EPA National Mapping Requirements Program
Map Selection Table

Scale

HYDROLOGIC[1]	1:12,000	1:15,000	1:20,000	1:24,000	1:25,000	1:40,000	1:50,000	1:56,000 B/W	1:62,500	1:63,360[2]	1:80,000 CIR	1:100,000	1:250,000	1:500,000	1:1,000,000	1:2,000,000	1:2,500,000	1:7,500,000	Other
Flood-Prone Area Maps																			
Hydrologic Investigations Atlases (HA Series)																			
Hydrologic Unit Maps, by State																			
Water Resources Investigation Reports[3] (WRI Series, and in OF Series)																			
Water Supply Papers[3]																			

Source: Part of this information is from USGS Circular 900, Guide to Obtaining USGS Information, 1986.

[1] Most data gathering activities conducted by the Water Resources Division are on a project specific basis. Scales may vary by project.

[2] Alaska Only

[3] These reports may not contain map products.

Please check with the Regional or HQ NMRP Manager for product availability.

Upon completion and authorization, submit to: **Jeffrey Booth, U.S. EPA, OIRM, Mail code PM-218B, 401 M St., SW, Washington, DC 20460**

Appendices

APPENDIX A

KEY CONTACTS FOR THE EPA NATIONAL MAPPING REQUIREMENTS PROGRAM

APPENDIX A

KEY CONTACTS FOR THE EPA NATIONAL MAPPING REQUIREMENTS PROGRAM

NATIONAL MAPPING REQUIREMENTS PROGRAM MANAGEMENT

Jeffrey T. Booth - NMRP Manager
OIRM (PM-218B)
EPA
401 M Street, S. W.
Washington, D.C. 20460
703-883-8533

GEOGRAPHIC INFORMATION SYSTEMS

Thomas Dewald - GIS Coordinator
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REMOTE SENSING

Ross Lenetta - Environmental Monitoring Systems Laboratory (EMSL)
Office of Acid Deposition, Environmental Monitoring
and Quality Assurance
ORD
Las Vegas, Nevada 89109
702-798-2175
FTS:545-2175

AERIAL PHOTOGRAPHY

Donald Garafolo - Environmental Photographic Interpretation
Center (EPIC)
Vint Hill Farms Station
P.O. Box 1587, Building 166
Warrenton, Virginia 22186
703-349-3110
FTS:557-3110

RESEARCH AND DEVELOPMENT

Mason Hewitt - EMSL/ORD
944 East Harmon Avenue
Las Vegas, Nevada 89109
702-798-2377
FTS:545-2377

APPENDIX B

MAPPING REQUIREMENTS USER GROUP (MRUG) MEMBERSHIP

APPENDIX B

MAPPING REQUIREMENTS USER GROUP (MRUG) MEMBERSHIP

Name and Address	Telephone
Ken Andrasko OPPE (PM-218B)	202-382-5603 FTS:382-5603
Lowell Bahner CBPO	301-266-6873 FTS:266-6873
Larry Burns ORD/ERL-Athens	FTS:250-3501
Sandy Braswell OMPC (WH-595)	202-382-7300 FTS:382-7300
Mickey Cline OIRM, AA (MD-34)	919-541-2500 FTS:629-2500
Thomas Curran OAR Air Quality Planning and Standards (OAQPS) (MD-14)	919-541-5467 FTS:629-5467
Kevin Donovan OERR (OS-230)	202-475-9749 FTS:475-9749
Catherine Eiden OPP Hazard Evaluation Division (TS-769C)	202-557-1450 FTS:557-1450
Rod Frederick OWRS Monitoring and Data Support Division (WH-553)	202-382-7046 FTS:382-7046
Glen Galen OSW (O5-321)	202-475-7370 FTS:475-7370
Donald Garafalo ORD/EMSL Las Vegas (Warrenton, VA) Environmental Photo Interpretation Center (EPIC)	703-349-8970 FTS:557-3110
William Gill OIRM (PM-218B)	703-883-8774
Marilyn Ginsburg OGWP (WH-550G)	202-475-8804 FTS:475-8804
Lore Hantske OMEP	202-475-7111 FTS:475-7111

Name and Address	Telephone
Loren Hall OTS Exposure Evaluation Division (TS-798)	202-382-3931 FTS:382-3931
Mason Hewitt ORD/EMSL-Las Vegas	702-798-2100 FTS:545-2377
Roger Holtorf OPP (TS-768C)	202-557-0532 FTS:557-0532
Thomas Mace EMSL-LV EPIC	FTS:545-2260
David Norwood OAR/ORP (Montgomery, AL)	202-272-3402 FTS:534-7615
James Omernik ORD/ERL-Corvallis	FTS:420-4666
Edward Partington OIRM (PM-218-B)	202-475-9348 FTS:475-9348
Thomas Peake OAR Office of Radiation Programs (ANR-464)	202-475-9605 FTS:475-9605
Bob Pease OIRM (PM-218B)	202-382-2341 FTS:382-2341
Glen Galen OSW Office of Program Management Support (WH-565E)	202-382-4678 FTS:382-4678
Bill Sanville ORD/ERL-Duluth (OS-321)	218-720-5500 FTS:780-5500
Franklin Smith OAR, OAQPS (EN-341)	202-382-2881 FTS:382-2881
Phil Taylor OWRS/MDSD (WH-553)	202-382-7046 FTS:382-7046
Larry Turner OPP Hazard Evaluation Division (TS-769C)	202-557-1007 FTS:557-1007
Dennis White ORD/ERL-Corvallis	503-757-4666 FTS:420-4666

REGIONS

I.	Michael MacDougall, Information Management Branch	617-565-3377 FTS:835-3377
II.	Andrew Barris, Water Management Division	212-264-5635 FTS:264-5635
III.	Robert Braster, Information Resources Branch	215-597-4831 FTS:597-4831
IV.	Rebecca Slack, Information Management Branch	404-347-2316 FTS:257-2316
V.	John Anagnost, Information Management Branch	312-886-0143 FTS:886-0143
VI.	Dave Parrish, Environmental Services Division	214-655-2289 FTS:255-2289
VII.	Lynn Kring, Environmental Review Branch	913-551-7456 FTS:276-7456
VIII.	Larry Svoboda, Environmental Services Division	302-293-5102 FTS:776-5102
IX.	Cheryl Henley, Information Management Branch	415-974-7415 FTS:454-7415
X.	Mat Gubitosa, Environmental Services Division	206-442-1219 FTS:399-1219

APPENDIX C

U.S. GEOLOGICAL SURVEY OFFICES

Appendix C

U.S. Geological Survey Offices

Office	Name	Telephone Number	Address
NATIONAL MAPPING DIVISION			
Regional Centers			
Eastern	Lee Spencer	(703) 648-5569	National Center, Stop 559
Mid-Continent	Bill Good	(314) 341-0896	1400 Independence Rd., Rolla, MO 65401
Rocky Mountain	Lee Aggers	(303) 236-5835	Box 25046, Stop 510, Federal Center, Denver, CO 80225
Western	Bill Johnson	(415) 329-4326 ext. 2411	345 Middlefield Rd., Menlo Park, CA 94025
EROS Data Center	Wayne Rohde	(605) 594-6080	USGS Sioux Falls, SD 57198
PUBLIC INQUIRIES OFFICES			
Alaska	E. C. Behrendt	(907) 561-5555	Room 101, 4230 University Dr., Anchorage, AK 99508-4664
		(907) 271-4307	E-146 Federal Bldg., Box 53, 701 C St., Anchorage, AK 99513
California:			
Los Angeles	Lucy E. Birdsall	(213) 894-2850	7638 Federal Bldg., 300 N. Los Angeles St., Los Angeles, CA 90012
Menlo Park	Bruce S. Deam	(415) 323-8111 ext. 2817	345 Middlefield Rd., Stop 533, Bldg. 3, Menlo Park, CA 9402
San Francisco	Patricia A. Shiffer	(415) 556-5627	504 Customhouse, 555 Battery St., San Francisco, CA 94111
Colorado	Irene V. Shy	(303) 844-4169	169 Federal Bldg., 1961 Stout St., Denver, CO 80294
District of Columbia	Bruce A. Hubbard	(202) 343-8073	1028 GSA Bldg., 18th and F Sts., NW., Washington, DC 20405
Texas	John P. Donnelly	(214) 767-0198	1C45 Federal Bldg., 1100 Commerce St., Dallas, TX 75242
Utah	Wendy R. Hassibe	(801) 524-5652	8105 Federal Bldg., 125 S. State St., Salt Lake City, UT 84138
Virginia	Margaret E. Counce	(703) 648-6892	1C402, National Center, Stop 503

Office	*Name*	*Telephone Number*	*Address*
Washington	Jean E. Flechel	(509) 456-2524	678 U.S. Courthouse, W. 920 Riverside Ave., Spokane, WA 99201
Distribution Branch Offices			
Alaska	Natalie Cornforth	(907) 456-0244	101 12th Ave., Box 12, Fairbanks, AK 99701
Colorado	Dwight F. Canfield	(303) 236-7477	Box 25286, Stop 306, Denver Federal Center, Denver, CO 80225
GEOLOGIC DIVISION			
Regional Offices			
Eastern	Jack H. Medlin	(703) 648-6660	National Center, Stop 953
Central	Harry A. Tourtelot	(303) 236-5438	Box 25046, Stop 911, Denver Federal Center, Denver, CO 80225
Western	Bill Normark	(415) 323-8111 ext. 2214	345 Middlefield Rd., Menlo Park, CA 94025
Geological Inquiries Group	Virginia Majors	(703) 648-4383	National Center, Stop 907
Office of Regional Geology, Chief	Michell W. Reynolds	(703) 648-6960	National Center, Stop 908
Branch of Eastern Regional Geology, Chief	John F. Sutter	(703) 648-6900	National Center, Stop 926A
Branch of Central Regional Geology, Chief	Glen A. Izett	(303) 236-1258	Box 25046, Stop 913, Denver, CO 80225
Branch of Western Regional Geology, Chief	Rowland W. Tabor	(415) 329-4909	345 Middlefield Rd., Menlo Park, CA 94025
Branch of Isotope Geology, Chief	Carl E. Hedge	(303) 236-7880	Box 25046, Stop 963, Denver, CO 80225
Branch of Astrogeology, Chief	Hugh H. Kieffer	(602) 765-7015	2255 Gemini Drive, Flagstaff, AZ 86001
Branch of Paleontology & Stratigraphy, Chief	Richard Z. Poore	(703) 648-5288	National Center, Stop 982
Office of Earthquakes, Volcanoes, and Engineering	Robert L. Wesson	(703) 648-6714	National Center, Stop 905
Branch of Engineering Seismology & Geology, Chief	Thomas L. Holzer	(415) 329-5634	345 Middlefield Rd., Menlo Park, CA 94025
Branch of Global Seismology & Geomagnetism, Chief	Robert P. Masse	(303) 236-1510	Box 25046, Stop 967, Denver, CO 80225
Branch of Seismology, Chief	William H. Backun	(415) 329-4793	345 Middlefield Road, Menlo Park, CA 94025
Branch of Geologic Risk Assessment, Chief	Kaye M. Shadlock	(303) 236-1585	Box 25046, Stop 966, Denver, CO 80225

Office	Name	Telephone Number	Address
Branch of Tectonophysics, Chief . .	William H. Prescott	(415) 329-4810	345 Middlefield Road, Menlo Park, CA 94025
Branch of Igneous & Geothermal . Processes, Chief	Robert L. Christiansen	(415) 329-5228	345 Middlefield Road, Menlo Park, CA 94025
Office of Energy and Marine Geology, Chief	Gary W. Hill	(703) 648-6472	National Center, Stop 915
Branch of Petroleum Geology, . . . Chief	Donald L. Gautier	(303) 236-5711	Box 25046, Stop 934, Denver, CO 80225
Branch of Coal Geology, Chief . . .	Harold J. Gluskoter	(703) 648-6401	National Center, Stop 956
Branch of Sedimentary . . . . . Processes, Chief	Walter E. Dean	(303) 236-1644	Box 25046, Stop 916, Denver, CO 80225
Branch of Pacific Marine . . . . . Geology, Chief	David A. Cacchione	(415) 329-3184	345 Middlefield Road, Menlo Park, CA 94025
Branch of Atlantic Marine . . . . . Geology, Chief	Bradford Butman	(508) 548-8700	Woods Hole Oceanographic Inst., Woods Hole, MA 02543
Office of Mineral Resources, Chief	Glen H. Allcott	(703) 648-6100	National Center, Stop 913
Branch of Geochemistry, Chief . . .	Lorraine H. Filipek	(303) 236-1800	Box 25046, Stop 973, Denver Federal Center, Denver, CO 80225
Branch of Alaskan Geology, ... Chief	Donald J. Grybeck	(907) 786-7403	4200 University Drive, Anchorage, AK 99508
Branch of Western Mineral . . . . . Resources, Chief	Edwin H. McKee	(415) 329-5477	345 Middlefield Road, Menlo Park, CA 94025
Branch of Resource Analysis, ... Chief	William D. Menzie	(703) 648-6125	920 National Center, Reston, VA 22092
Branch of Central Mineral . . . . . Resources, Chief	David A. Lindsey	(303) 236-5568	Box 25046, Stop 905, Denver, CO 80225
Branch of Eastern Mineral . . . . . Resources, Chief	Bruce R. Lipin	(703) 648-6327	954 National Center, Reston, VA 22092
Branch of Geophysics, Chief	Thomas H. Hildenbrand	(303) 236-1212	Box 25046, Stop 964, Denver, CO 80225
Office of International Geology, Chief	A. Thomas Ovenshine	(703) 648-6047	National Center, Stop 917
WATER RESOURCES DIVISION			
Regional Offices			
Northeastern	Stanley P. Sauer	(703) 648-5817	National Center, Stop 433
Southeastern	James L. Cook	(404) 331-5174	Richard B. Russell, Federal Bldg., 75 Spring St., SW., Suite 772, Atlanta, GA 30303

Office	Name	Telephone Number	Address
Central	James F. Blakely	(303) 236-5920	Box 25046, Stop 406, Denver Federal Center, Denver CO 80225
Western	John T. Conomos	(415) 329-4403 ext. 2337	345 Middlefield Rd., Stop 470, Menlo Park, CA 94025
District Offices			
Alabama	D. Brian Adams	(205) 752-8104	520 19th Ave., Tuscaloosa, AL 35401
Alaska	Philip A. Emery	(907) 271-4138	4320 University Dr., Suite 201, Anchorage, AK 99508
Arizona	Robert D. MacNish	(602) 629-6671	Federal Bldg., FB-44 300 W. Congress St., Tucson, AZ 85701
Arkansas	Ector E. Gann	(501) 378-6391	2301 Federal Office Bldg., FB-44 700 W. Capital Ave., Little Rock, AR 72201
California	John M. Klein	(916) 978-4633	Room W-2234, Federal Bldg., 2800 Cottage Way, Sacramento CA 95825
Colorado	Charles A. Pascale	(303) 236-4882	Box 25046, Stop 415, Denver Federal Center, Denver, CO 80225
Connecticut (See Massachusetts)			
Delaware (See Maryland)			
District of Columbia (See Maryland)			
Florida	Irwin H. Kantrowitz	(904) 681-7620	227 North Bronough St., Suite 3015, Tallahassee, FL 32301
Georgia	Jeffrey T. Arbruster	(404) 331-4858	6481 Peachtree Industrial Blvd., Suite B, Doraville, GA 30360
Hawaii	Will Meyer	(808) 541-2653	P.O. Box 50166, 300 Ala Moana Blvd., Rm 6110, Honolulu, HI 96850
Idaho	Jerry Hughes	(208) 334-1750	230 Collins Rd., Boise, ID 83702
Illinois	Richard Novitsky	(217) 398-5353	102 E. Main St., 4th Floor, Urbana, IL 68101
Indiana	Dennis K. Stewart	(317) 290-3333	5957 Lakeside Blvd., Indianapolis, IN 46278

Office	Name	Telephone Number	Address
Iowa	Richard A. Engberg	(319) 337-4191	P.O. Box 1230, Room 269, Federal Bldg., 400 S. Clinton St., Iowa City, IA 52244
Kansas	Thomas Huntsinger	(913) 864-4321	1950 Constant Ave., Campus West, University of Kansas, Lawrence, KS 66044
Kentucky	Alfred L. Knight	(502) 582-5241	2301 Bradley Ave., Louisville, KY 40217
Louisiana	Darwin D. Knochenmus	(504) 389-0281	P.O. Box 66492, 6554 Florida Blvd., Baton Rouge, LA 70806
Maine (See Massachusetts)			
Maryland	Herbert J. Freiberger	(301) 828-1535	208 Carroll Bldg., 8600 La Salle Rd., Towson, MD 21204
Massachusetts	Ivan C. James II	(617) 565-6860	150 Causeway St., Suite 1309, Boston, MA 02114
Michigan	T. Ray Cummings	(517) 377-1608	6520 Mercantile Way, Suite 5, Lansing, MI 48911
Minnesota	William Herb	(612) 229-2600	702 Post Office Bldg., St. Paul, MN 55101
Mississippi	Michael Gaydos	(601) 965-4600	Suite 710, Federal Bldg., 100 West Capitol St., Jackson, MS 39269
Missouri	Daniel P. Bauer	(314) 341-0824	1400 Independence Rd., Mail Stop 200, Rolla, MO 65401
Montana	Joe A. Moreland	(406) 449-5263	428 Federal Bldg., 301 South Park Ave., Drawer 10076, Helena, MT 59626
Nebraska	Michael V. Shulters	(402) 471-5082	406 Federal Bldg., 100 Centennial Mall, North, Lincoln, NE 68508
Nevada	William J. Carswell		Federal Building, Rm. 244, 705 N. Plaza St., Carson City, NV 89701
New Hampshire (See Massachusetts)			
New Jersey	Donald E. Vaupel	(609) 771-3900	Suite 206, Mountain View Office Park, 810 Bear Tavern Rd., West Trenton, NJ 08628

Office	Name	Telephone Number	Address
New Mexico	Robert L. Knutilla	(505) 262-6630	Pinetree Office Park, 4501 Indian School Rd., NE, Albuquerque, NM 87102
New York	L. Grady Moore	(518) 472-3107	343 Post Office and Courthouse, Albany, NY 12201
North Carolina	James F. Turner	(919) 856-4510	P.O. Box 2857, Rm. 436, Century Postal Station, 300 Fayetteville Street Mall, Raleigh, NC 27602
North Dakota	Vacant	(701) 250-4601 ext. 601	821 East Interstate Ave., Bismarck, ND 58501
Ohio	Steven M. Hindall	(614) 469-5553	975 West Third Ave., Columbus, OH 43212
Oklahoma	Charles R. Burchett	(405) 231-4256	Rm. 621, 215 Dean A. McGee Ave., Oklahoma City, OK 73102
Oregon (See Washington)			
Pennsylvania	David E. Click	(717) 782-4514	P.O. Box 1107, 4th Floor, Federal Bldg., 228 Walnut St., Harrisburg, PA 17108
Puerto Rico	Allen Zack	(809) 783-4660	GPO Box 4424, Bldg. 652, GSA Center, San Juan, PR 00936
Rhode Island (See Massachusetts)			
South Carolina	Rodney N. Cherry	(803) 765-5966	Suite 677A, 1835 Assembly St., Columbia, SC 29201
South Dakota	Richard E. Fidler	(605) 353-7176	Rm. 317, Federal Bldg., 200 4th St., SW., Huron, SD 57350
Tennessee	Ferdinand Quinones-Marquez	(615) 736-5424	A-413 Federal Bldg., U.S. Courthouse, Nashville, TN 37203
Texas	Charles W. Boning	(512) 832-5791	Building 1, 8011 Cameron Road, Austin, TX 78753
Utah	Harvey Lee Case	(801) 524-5663	Room 1016 Administration Bldg., 1745 W. 1700 S. Salt Lake City, UT 84104
Vermont (See Massachusetts)			
Virginia (See Maryland)			
Washington	Garald G. Parker	(206) 593-6510	1201 Pacific Ave., Suite 600, Tacoma, WA 98402

Office	Name	Telephone Number	Address
West Virginia	David H. Appel	(304) 347-5130	603 Morris St., Charleston, WV 25301
Wisconsin	Vernon W. Norman	(608) 274-3535	6417 Normandy Ln., Madison, WI 53719
Wyoming	James Kircher	(307) 772-2153	P.O. Box 1125, 2120 Capital Ave., Rm. 4006, Cheyenne, WY 82003

APPENDIX D

GUIDE TO INFORMATION AND PUBLICATIONS OF THE U.S. GEOLOGICAL SURVEY

APPENDIX D

GUIDE TO INFORMATION AND PUBLICATIONS OF THE U.S. GEOLOGICAL SURVEY

To buy maps of all areas of the United States and to request Survey catalogs, pamphlets, and leaflets (limited quantities free), call, write or visit:

U.S. Geological Survey
Office and Customer Services Section
Federal Center, Box 25286
Denver, CO 80225
FTS:776-7477

To obtain information on cartographic data, write or visit the U.S. Geological Survey Earth Science Information Centers (ESIC) in the following States:

Alaska:
U.S. Geological Survey
Earth Science Information Center
4230 University Dr.
Anchorage, AK 99508-4664
(907) 271-4159
FTS:907-271-4159

California:
Western Mapping Center
Earth Science Information Center
345 Middlefield Rd
Menlo Park, CA 94025
(415) 328-4309
FTS:907-459-4309

Colorado:
Rocky Mountain Mapping Center
Earth Science Information Center
Box 25046, Stop 504
Bldg. 25, Federal Center
Denver, CO 80225
(303) 236-5829
FTS:776-5829

Mississippi:
National Space Technology Laboratories
Earth Science Information Center
U.S. Geological Survey
Bldg. 3101
Stennis Space Center, MS 39529
(601) 688-3544
FTS:494-3544

Missouri:
Mid-Continent Mapping Center
Earth Science Information Center
National Cartographic
1400 Independence Rd.
Rolla, MO 65401
(314) 341-0851
FTS:227-0851

Virginia:
Earth Science Information Center
507 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092
(703) 648-5963
FTS:959-5963

To obtain information on programs, publications, and services or to obtain copies of reports and maps, visit the U.S. Geological Survey Public Inquiries Offices at the following addresses:

Alaska:
Room 101
4230 University Dr.
Anchorage, AK 99508-4664
(907) 561-5555

E-146 Federal Bldg.
Box 53
701 C St.
Anchorage, AK 99513
(907) 271-4307

California:
7638 Federal Bldg.
300 N. Los Angeles St.
Los Angeles, CA 90012
(213) 894-2850

Bldg. 3, Stop 533
345 Middlefield Rd.
Menlo Park, CA 94025
(415) 329-4390

504 Customhouse
555 Battery St.
San Francisco, CA 94111
(415) 556-5627

Colorado:
169 Federal Bldg.
1961 Stout St.
Denver, CO 80294
(303) 844-4169

1C45 Federal Bldg.
1100 Commerce St.
Dallas, TX 75242

Utah:
8105 Federal Bldg.
125 S. State St.
Salt Lake City, UT 84138
(801) 524-5652

Virginia:
503 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092
(703) 648-6892

Washington:
678 U.S. Courthouse
W. 920 Riverside Ave.
Spokane, WA 99201
(509) 456-2524

Washington, DC:
1028 General Services Admin. Bldg.
18th and F Sts., NW
Washington, DC 20405
(202) 343-8073

To obtain information on aerial photographs and satellite and space images, call, write or visit:

U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
(605) 594-6123

To obtain information on geology topics, such as earthquakes, energy and mineral resources, the geology of specific areas, and geologic maps and mapping, write or call:

U.S. Geological Survey
Geologic Inquiries Group
907 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092
(703) 648-4383

To subscribe to Earthquakes and Volcanoes, write:

Superintendent of Documents
Government Printing Office
Washington, DC 20402

To obtain assistance in locating sources of water data, identifying sites at which data have been collected, and specific data, write:

U.S. Geological Survey
National Water Data Exchange
421 National Center
2201 Sunrise Valley Dr.
Reston, VA 22092

To obtain information on ongoing and planned water-data acquisition activities of all Federal agencies and many non-Federal organizations, write:

U.S. Geological Survey
Office of Water Data Coordination
417 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092

To obtain information on water resources in general and about the water resources of specific areas of the United States, write or call:

U.S. Geological Survey
Hydrologic Information Unit
419 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092

To buy Alaskan maps, residents of Alaska may write or visit:

U.S. Geological Survey
Alaska Distribution Section
101 12th Avenue, Box 12
Fairbanks, AK 99701

To buy Survey book publications, to request Survey circulars, or to obtain information on the availability of microfiche or paper-duplicate copies of open-file reports, write:

Publications and Open-File Services Section
Federal Center, Box 25425
Denver, CO 80225

To get on the mailing list for the monthly list of New Publications of the Geological Survey (free), write:

U.S. Geological Survey
Computer Operations Office
582 National Center
12201 Sunrise Valley Drive
Reston, VA 22092

This information is modified from USGS (1987a).

APPENDIX E

MAP PRODUCTS AND MAPPING AGENCIES

APPENDIX E

MAP PRODUCTS AND MAPPING AGENCIES

TABLE E-1. MAP PRODUCTS AND SOURCES[a]

Products	Producing agency	Available from
Aeronautical charts	NOS	**NOS**
Boundary information:		
United States and Canada	IBC	**IBC**
United States and Mexico	IBWC	**IBWC**
Boundary and annexation surveys of incorporated places with 2,500 or more inhabitants	BC	**GPO**
Civil subdivisions and reservations	BLM	**BLM**
State/Federal	DOS	**DOS**
Census data (social and economic)	BC	**GPO**
Climatic maps	NWS	**NWS**
Earthquake hazard maps	USGS	**USGS**
Federal property maps:		
Water and Power Resources Service	WPRS	**WPRS**
Fish and Wildlife Service	FWS	**FWS**
National Aeronautics and Space Administration	NASA	**NASA**
National forests	FS	**FS**
National Park Service	NPS	**NPS**
Military reservations:		
Air Force	USAF	**USAF**
Army	USA	**USA**
Coast Guard	USCG	**USCG**
Marines	USMC	**USMC**
Navy	USN	**USN**
State maps of lands administered by Bureau of Land Management	BLM	**BLM**
U.S. maps of lands administered by Bureau of Land Management	BLM	**BLM**
Flood-plain maps	DRBC	**DRBC**
	FIA	**FIA**
	MRC	**MRC**
	NOS	**FIA**
	SCS	**SCS**
	USCE	**USCE**
	USGS	**USGS**
Geodetic control data	NOS	**NOS**
	USCE	**USCE**
	USGS	**NOS&ESIC**

[a]Addresses of Federal, State, and other agencies identified by acronyms are listed in Appendix Table E-2. Modified from Thompson (1988).

Products	Producing agency	Available from
Geologic maps:		
Coal investigations	USGS	USGS
General geologic	SGA	SGA
	USGS	USGS
Geophysical investigations	NOAA	EDIS
	NOAA	ERL
	USGS	USGS
Mineral investigations	USGS	USGS
Mines	BM	BM
Oil and gas investigations	USGS	USGS
Geochemical maps	USGS	USGS
Geographic maps:	NOS	NOS
Land use	USGS	USGS
Highway maps:		
Indian lands	BIA	BIA
Federal lands	FHWA	FHWA
Federally funded roads	FHWA	GPO
Federal primary and secondary	FHWA	GPO
Interstate	FHWA	FHWA
Federal highway maps of the U.S.	FHWA	GPO
Historical maps and charts	LC	LC
	All Federal agencies	NARS
Hydrographic charts and bathymetric maps:	NOS	NOS
Bottom typography	USCE	USCE
	USGS	USGS
USGS/NOAA	USGS/ NOAA	USGS
Hydrographic surveys	NOS	NOS
	USGS	USGS
Nautical charts	NOS	NOS
	USCE	USCE
Navigable waterways maps	USCE	USCE
River and stream surveys	MRC	MRC
River basin/watershed studies	ERC	ERC
	SCS	SCS
	USGS	USGS
River surveys	WPRS	WPRS
	USGS	USGS
Wildlife and scenic river jurisdiction	BLM	BLM
Offshore mapping	NOAA/ USGS	USGS

Products	Producing agency	Available from
Hydrologic investigations atlases	USGS	USGS
Indian reservations:		
Land surveys	BIA	GPO
U.S. maps of Indian lands	BIA	GPO
Land plats	BLM	BLM
	BLM	NARS
	NPS	NPS
	USCE	USCE
National Atlas of the U.S.	USGS	USGS
Photographic products:		
Aerial photographs	ASCS	ASCS
	BLM	BLM
	BLM	EDC
	BPA	BPA
	DMA	DMA
	NASA	EDC
	FHWA	FHWA
	FS	EDC
	FS	USGS
	FWS	EDC
	FWS	USGS
	NOS	NOS
	NPS	NPS
	SCS	SCS
	USCE	USCE
	FS	FS
	USGS	USGS
Orthophotomaps	BIA	BIA
	NOS	NOS
	USGS	USGS
Space imagery:		
Landsat (ERTS)	NASA	ASCS
	NASA	EDC
	NASA	EDIS
Thematic Mapper	NASA	NASA
NASA manned spacecraft	NASA	EDC
Nimbus	NWS	NWS
Skylab	NASA	ASCS
	NASA	USGS
Tiros	NWS	NWS
Recreation maps	BLM	BLM
	NPS&USGS	NPS&USGS

Products	Producing agency	Available from
Seismicity maps and charts	ERL	**ERL**
	USGS	**USGS**
Soils	SCS	**SCS**
Soils--substation quality	BPA	**BPA**
Topographic maps	USGS	**USGS**
	MRC	**MRC**
	NASA	**NASA**
Utilities:		
Ground conductivity maps of the U.S.	FCC	**GPO**
Principal electric-facilities maps of the U.S.	ERC	**GPO**
Principal natural-gas-pipelines maps of the U.S.	ERC	**GPO**
Water resources development data	USGS	**USGS**
Miscellaneous data:		
Clinometric (slope) maps	USGS	**USGS**
Gravity survey charts	EDIS	**EDIS**
	NOS	**NOS**
	USGS	**USGS**
Income distribution maps	BC	**GPO**
Isogonic charts	USGS	**USGS**
Isomagnetic charts	NOS	**NOS**
Magnetic charts	EDIS	**EDIS**
National science trail maps	SCS	**SCS**
State indexes of fish hatcheries and national wildlife refuges	FWS	**FWS**
Storm evacuation maps	NOS	**NOS**
Tree danger (to powerlines) detection maps	BPA	**BPA**
U.S. location maps of fish hatcheries and national wildlife refuges	FWS	**FWS**

TABLE E-2. ADDRESSES OF MAPPING AGENCIES[a]

Agricultural Stabilization and Conservation Services (ASCS)
Aerial Photography Field Office
Agricultural Stabilization and Conservation Service
P.O. Box 30010
Salt Lake City, UT 84130-0010
(801) 524-5856 FTS (801) 588-5856

Bonneville Power Administration (BPA)
Public Involvement
Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208-3621
(503) 230-3478 FTS 8-429-3478
Oregon toll free - 1-800-841-5867
Other toll free - 1-800-624-9495

Bureau of the Census (BC)
Data Users Service Division, Customer Service
Bureau of the Census
Washington Plaza
Washington, DC 20233
(301) 763-4100 FTS 8-763-4100

Bureau of Indian Affairs
Few Maps Available
18th and C Streets, NW
MS 4640
Washington, DC 20240
(202) 343-1710 FTS 8-343-1710

Bureau of Land Management (BLM)
Bureau of Land Management
Division of Cadastral Survey
18th and C Street, NW
MS 201
Washington, DC 20240
(202) 653-8798 FTS 8-653-8798

Bureau of Mines (BM)
Mine Map Repository
Office of Surface Mining and
Reclamation Enforcement
Department of Interior
10 Parkway Center
Greentree, PA 15220
(412) 937-3001 FTS 8-726-3001

Bureau of Reclamation
Bureau of Reclamation
Public Affairs Office
7644 Interior Building
18th and C Street, NW
Washington, DC 20240
(202) 343-4662 FTS 8-343-4662

Defense Mapping Agency (DMA)
Programs, Production and Operations
Division
Defense Mapping Agency HTC
Naval Observatory, Building 56
Washington, DC 20315-0030
(202) 227-2495/2534

Delaware River Basin Commission (DRBC)
Executive Director
Delaware River Basin Commission
(25 State Police Drive)
P.O. Box 7360
West Trenton, NJ 08628
(609) 883-9500 FTS 8-483-2077

Department of Energy (DOE)
Office of Scientific and Technical Information
Department of Energy
Oak Ridge, TN 37831
(615) 576-1301 FTS 8-576-1301

Department of State (DOS)
Maps not available to the public
Office of the Geographer
Bureau of Intelligence and Research
Department of State
Room 8742 INR/GE
Washington, DC 20520
(202) 647-2022 FTS 8-647-2022

Environmental Protection Agency
Office of Public Awareness
Environmental Protection Agency
401 M Street, SW
Washington, DC 20460
(202) 382-2080 FTS 8-382-2080

Federal Energy Regulatory Commission
Reference and Information Center
Federal Energy Regulatory Commission
825 North Capitol Street, NE
Washington, DC 20426
(202) 357-8118 FTS 8-357-8118

Federal Highway Administration
Limited number of maps available; none produced
Office of Public Affairs
Federal Highway Administration
Room 4210
400 7th Street, SW
Washington, DC 20590
(202) 366-0660

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[a]See Appendix Table E-1 for map products available from these agencies. Modified from Thompson (1988).

Federal Insurance Administration (FIA)
Flood Map Distribution Center
6930 Santomas Rd.
Baltimore, MD 21227-6227
1-800-333-1363

***International Boundary Commission, United States and Canada* (IBC)**
International Boundary Commission
United States and Canada
United States Section
Room 150
425 I Street, NW
Washington, DC 20001
(202) 632-8058 FTS 8-632-8058

Library of Congress (LC)
Geography and Map Division
Library of Congress
1st and Independence Avenue, SE
Washington, DC 20540
(202) 707-6277 FTS 8-707-6277

Mississippi River Commission (MRC)
Mississippi River Commission
U.S. Army Corp of Engineers
USACE - Vicksburg Division
Attention: Map Sales
P.O. Box 60
Vicksburg, MS 39180-0060
(601) 631-5002

National Aeronautics and Space Administration (NASA)
Contact the facility office of the installation concerned

National Archives and Record Service (NARS)
Cartographic and Architectural Division
National Archives and Records Administration
Pennsylvania Avenue at 8th Street, NW
Washington, DC 20408
(703) 756-6700 FTS 8-756-6700

National Oceanic and Atmospheric Administration
Refer to National Ocean Service

Environmental Research Laboratories (ERL)
Environmental Research Laboratory
National Oceanic and Atmospheric Administration/NGDC
3025 Broadway
Boulder, CO 80303
(303) 497-6419 FTS 8-320-6419

National Ocean Service (NOS)
Distribution Branch
NCG 33
6501 Lafayette Avenue
Riverdale, MD 20737
(301) 436-6990 FTS 8-436-6990

National Park Service (NPS)
Office of Public Inquiry
National Park Service
Room 1013
18th and C Street
Washington, DC 20242
(202) 343-4747 FTS 8-343-4747

National Weather Service (NWS)
Refer to National Ocean Service

Soil Conservation Service (SCS)
Cartographic and Geographic Information Systems
Soil Conservation Service
P.O. Box 2890
Room 6245
Washington, DC 20013
(202) 447-5421 FTS 8-447-5421
Contact each State Geologist for specific information

State Geologic Agencies
Contact the State Geologist or other cognizant official in each State

Tennessee Valley Authority (TVA)
Maps and Surveys Department
Tennessee Valley Authority
101 Haney Building
Chattanooga, TN 37402-2801
(615) 751-MAPS

U.S. Air Force (USAF)
Contact the information office of the base concerned

U.S. Army (USA)
Contact the commander of the base concerned

U.S. Army Corps of Engineers (USCOE)
Office of Chief of Engineers
U.S. Army Corps of Engineers
Washington, DC 20314
(202) 272-0660

U.S. Coast Guard (USCG)
Refer to National Ocean Service and The Defense Mapping Agency

U.S. Fish and Wildlife Service (FWS)
U.S. Fish and Wildlife Service
Division of Realty
Washington, DC 20240
(703) 358-1713 FTS 8-921-1713

U.S. Forest Service (FS)
U.S. Forest Service
Office of Public Affairs
P.O. Box 96090
Washington, DC 20250
(202) 447-3760 FTS 8-447-3760

U.S. Geological Survey (USGS)
Earth Sciences Information Center (ESIC)
U.S. Geological Survey
507 National Center
Reston, VA 22092
(703) 648-4000 FTS 8-959-4000

APPENDIX F

STATE MAPPING ADVISORY COMMITTEES AND CONTACT NAMES

APPENDIX F

STATE MAPPING ADVISORY COMMITTEES AND CONTACT NAMES

Alaska

Mr. Jerome Page
State of Alaska
Division of Land & Water Management
3601 C Street, Suite 1116
Anchorage, AK 99510
(907) 271-4149

Alabama

Dr. Ernest A. Mancini
State Geologic and Oil and Gas Supervisor
Geologic Survey of Alabama
P.O. Box O, University Station
Tuscaloosa, AL 35846
8-205-349-2852

Arizona

Mr. William Bayham, Chairman
Arizona State Mapping Advisory Committee
Arizona State Land Department
1616 West Adams
Phoenix, AZ 85007
8-602-255-2613

California

Mr. David E. Pelgen, Chairman
California State Mapping Advisory Committee
Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001
(916) 445-8322

Colorado

Mr. Greg Fulton
Colorado Department of Highways
Division of Transportation Planning
Programs Support Branch
4201 E. Arkansas Avenue
Denver, CO 80222
(303) 757-9813

Delaware

Dr. Thomas E. Pickett
Associate Director
Delaware Geological Survey
University of Delaware
101 Penny Hall
Newark, DE 19716
8-302-451-2833

Hawaii

Mr. Paul Nuha, Chairman
Hawaii State Mapping Advisory Committee
Department of Accounting and General Services
P.O. Box 119
Honolulu, HI 96810
8-808-548-7422

Idaho

Mr. Ray A. Miller, Chairman
Idaho Geographic Information Advisory Committee
Department of Lands
801 South Capitol Boulevard
Boise, ID 83702
(208) 334-3816

Illinois

Dr. Richard E. Dahlberg
Chairman, Illinois Mapping Advisory Committee
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Davis Hall
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8-815-753-6827

Kentucky

Dr. Donald C. Haney
Chairman, Kentucky Mapping Advisory Committee
Director and State Geologist
Kentucky Geological Survey
University of Kentucky
228 Mining and Mineral Resources Bldg.
Lexington, KY 40506-0107
8-606-257-5865

Maine

Dr. Walter A. Anderson
State Geologist
Maine Geological Survey
Department of Conservation
State House Station 22
Augusta, ME 04333
8-207-289-2801

Maryland

Dr. Kenneth N. Weaver
Director
Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218
9-301-554-5559

Michigan

Mr. R. Thomas Segall
Chairman, Michigan Mapping Advisory Committee
State Geologist and Chief
Geological Survey Division
Michigan Department of Natural
Resources
P.O. Box 30028
Lansing, MI 48909
8-517-334-6923

Mississippi

Mr. Paul Davis
Coordinator, Mississippi Mapping
Advisory Committee
Director, Mississippi Automated
Resources Information System
Center for Policy Research and
Planning
3825 Ridgewood Road
Jackson, MS 39201
8-601-982-6354

Missouri

Dr. Keith Wedge
Chairman, Missouri Mapping Advisory Committee
Department of Natural Resources
P.O. Box 250
Rolla, MO 65401
8-314-364-1752

Montana

Mr. Don Cromer
State of Montana
Montana Department of Highways
2701 Prospect
Helena, MT 59620
(406) 444-5358

Nevada

Mr. Jonathan Price, Chairman
Nevada State Mapping Advisory
Committee
Nevada Bureau of Mines and Geology
Reno, NV 89557-0088
8-702-784-6691

New Hampshire

Mr. James McLaughlin
Senior Planner
Office of State Planning
2-1/2 Beacon Street
Concord, NH 03301
8-603-271-2155

New Jersey

Mr. Lawrence Schmidt
Acting Director, Planning Group
Environmental Protection
Office of the Commissioner
CN 402
Trenton, NJ 08625
(609) 292-2885

New Mexico

Mr. Michael H. Inglis
Technology Application Center
University of New Mexico
2808 Central Ave., S.E.
Albuquerque, NM 87106
(505) 277-3622

North Carolina

Mr. Stephen G. Conrad
Director
Division of Land Resources
Department of Natural Resources and
Community Development
P.O. Box 27687
Raleigh, NC 27611
8-919-733-3833

Oregon

Dr. John D. Beaulieu, Chairman
Oregon State Mapping Advisory
Council
Department of Geology and Mineral
Industries
1060 State Office Building
Portland, OR 97201
(503) 229-5580

South Carolina

Mr. Norman K. Olson
State Geologist
South Carolina Geological Survey
Harbison Forest Road
Columbia, SC 29210
8-803-737-9440

Texas

Mr. Tommy Knowles
Texas Water Development Board
P.O. Box 13087
Capital Station
Austin, TX 78711
(512) 884-3011

Utah

Ms. Genevieve Atwood
Director
Utah Geological and Mineral Surveys
606 Black Hawk Way
Salt Lake City, UT 84108
(801) 581-6831

Vermont

Dr. Charles A. Ratte
State Geologist
Agency of Natural Resources
Office of the State Geologist
103 South Main Street, Center Building
Waterbury, VT 05676
8-802-244-5164

Washington

Ms. Christine Reinhard, Chairperson
Washington State Mapping Advisory Committee
Department of Natural Resources
1065 Capitol Way - AW-11
Olympia, WA 98504
8-206-753-5340

Wisconsin

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Chairman, Wisconsin Topographic Mapping Committee
State Geologist and Director
Wisconsin Geological and Natural History Survey
3817 Mineral Point Road
Madison, WI 53705
8-608-263-7384

Wyoming

Mr. Gordon W. Fassett
Wyoming State Engineer's Office
Herschler Building
Cheyenne, WY 82002
(307) 777-7354