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Environmental Protection
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Office of
Ground-Water Protection
Washington, D.C. 20460

Office of Information
Resources Management
Washington, D.C. 20460

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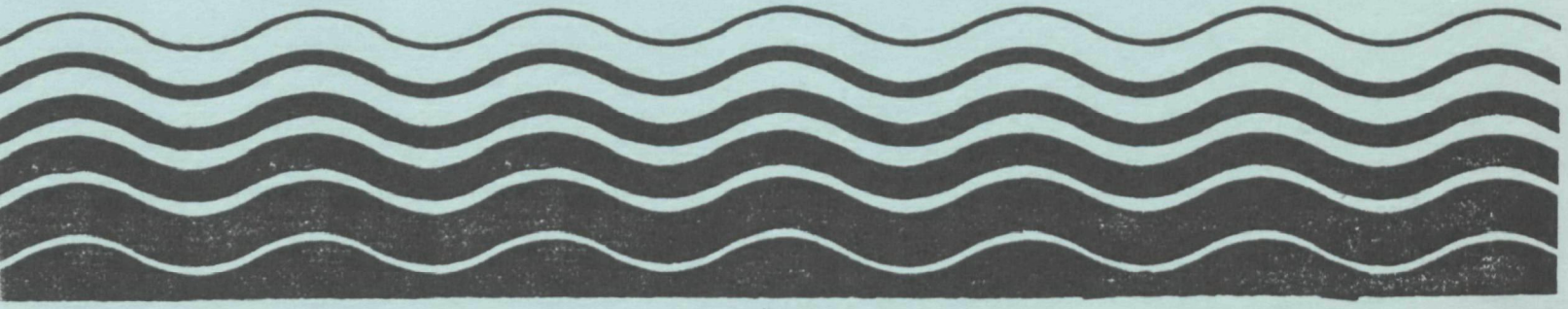
Water

EPA

Ground - Water Data Requirements Analysis



GROUND-WATER DATA REQUIREMENTS ANALYSIS

FOR THE

ENVIRONMENTAL PROTECTION AGENCY

This document was prepared as the result of a joint effort between the Environmental Protection Agency's Office of Ground-Water Protection, Marian Mlay, Director, and the Office of Information Resources Management, Edward J. Hanley, Director. Key contributors to this effort include:

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May 1987

Ground-Water Data Requirements Analysis Project

-- EXECUTIVE SUMMARY --

1. BACKGROUND

The Office of Ground-Water Protection (OGWP) and the Office of Information Resources Management (OIRM) are jointly conducting an analysis of EPA's ground-water data management requirements. The project describes the information needs of EPA and state decision makers, identifies existing data management policies and systems, and recommends specific projects to improve ground-water data management. This study is part of the continuing implementation of EPA's Ground-Water Protection Strategy and Ground-Water Monitoring Strategy.

The study focuses on the key role played by the states in implementing the nation's environmental programs. By focusing on the federal/state partnership in the area of ground-water data management, the project promotes the Agency's objective of "environmental federalism" and reinforces the state/EPA data management pilots being performed in each region.

1.1 Study Objectives

The objective of this study is to define a management framework and data utility that EPA and states can use to store, share, and manipulate ground-water data to support better environmental decision-making, and to identify specific initiatives by which this framework can be implemented.

1.2 Approach of the Study

The ground-water data requirements developed in this study are based on over 300 structured interviews conducted nationwide with EPA Headquarters, Regions, state and local governments, and other federal agencies. The work included a review of the relevant literature, documentation and demonstrations of existing ground-water data systems.

A Ground-Water Data Requirements Analysis Policy Committee -- comprised of senior managers from EPA Headquarters, EPA Regions, ASIWPCA, and states -- provided overall direction for the work. All detailed findings, conclusions, and recommendations developed during the project were thoroughly reviewed by a staff-level EPA work group.

The project began by assessing how EPA and state decision makers now use ground-water data to make decisions and defining key unmet needs. The analysis of these requirements against existing EPA and state ground-water data practices and systems led to the development of a series of conclusions and recommendations in areas such as data standards and policy, data access and sharing, data automation, and data analysis. These findings were used to develop a set of initiatives to improve ground-water data management.

2. REQUIREMENTS

2.1 Ground-water data management is growing more important and complex.

Because environmental programs have focused on ground-water for a relatively short period, EPA has only recently begun to assess ground-water issues, such as data management, on an Agency-wide basis.

Ground-water data management is becoming increasingly more difficult as a result of organizational and programmatic changes in several areas:

- **Programmatic growth**
- **Cross-program interactions**
- **Organizational diversity**
- **Volumes of data.**

EPA must act quickly to provide the necessary leadership to Regions, states, localities, and others to avoid development of duplicative, incompatible procedures and systems and implement a common approach to ground-water data management.

2.2 EPA and states have equivalent needs to store, access, and analyze ground-water data.

Together, EPA and the states implement the nation's ground-water protection and clean-up programs. EPA and the states both have operational responsibilities that require the use of ground-water data, such as issuing permits, selecting inspection targets, identifying areas of vulnerability and contamination, pursuing enforcement actions, and planning and executing site clean-ups. Because EPA and the states make similar decisions, efforts are ongoing in several states to integrate ground-water data across all relevant environmental programs, including drinking water, pesticides, RCRA, and well permitting. The focus of the state programs is currently operational support.

Similarly, EPA Regions -- in the role of program oversight and, in some cases, program operations -- have a need for ground-water data. In addition, EPA laboratories need accurate water quality data for research and special studies. EPA Headquarters needs information to analyze long-term trends, evaluate program effectiveness, and develop standards, policy, and guidance.

2.3 The most important ground-water data requirements can be best satisfied through management initiatives -- not a new data system.

Investments in management, data standards, procedures, and training will yield greater pay-offs than would a new computer system. The key characteristics of ground-water data management today are:

- There are no common standards or formats for collecting and storing ground-water data.

- Ground-water data is stored in many locations, organizations, files, and formats and little data is automated.

- The volume of ground-water data is large and growing rapidly.

- EPA Regions and states vary widely in their ground-water data management procedures and systems.

2.4 Decision makers need improved capabilities in three areas -- data access, data retrieval, and data analysis.

Three major needs were consistently identified by the interviewees:

- **Improved access to ground-water data.** There are four general types of ground-water data: (1) **well descriptors,** such as well location, type, purpose, elevation and status; (2) **hydrogeologic descriptors,** such as geologic structure, stratigraphy, and topography; (3) **water quality/sample descriptors,** such as sample type, sample identifiers, and analytic method; and (4) **related descriptors,** including site descriptors, health effects, and demographic data. Ground-water data users need access to these four major data types to support program operations, but there are currently several barriers which prevent data access, including:

  -- Lack of common data standards, formats, and guidance for ground-water data collection and storage

  -- Lack of knowledge on available sources of ground-water data

  -- High "transaction costs" of physically retrieving and interpreting the data.

  The ability to access data collected by other programs is one of the most important requirements of ground-water data users. Decision makers stressed the need to base their actions on all relevant information, not just data collected by a single program.

- **Easier retrieval of ground-water data.** While enormous amounts of ground-water data are collected from ambient ground-water monitoring networks, site monitoring reports, and special studies, data is not readily available. The users need to retrieve data from their own programs and sources to perform trend analysis used to identify potential problem areas and analyze program effectiveness. Barriers to easier retrieval include physical distance, lack of training, hardware incompatibilities, missing documentation, and limited resources for user support.

- **Simple data analysis.** EPA Regions and states stressed the need for basic data manipulation and analytic capabilities, not highly sophisticated features. Decision makers in states and EPA Regions need basic analytical tools, such as trend analysis, statistics, business graphics, and simple maps. Most users have a limited ability to take advantage of advanced tools such as complex models

and three-dimensional mapping. In contrast, EPA Headquarters users are more often interested in additional sophistication for detailed site-specific studies and regional or national surveys.

2.5 Enhanced ground-water data management procedures will apply to new information, not historical data.

EPA, states, localities, contractors, and regulated facilities have collected tremendous volumes of ground-water data. For example, a single RCRA facility can have dozens of wells, each being monitored for dozens of parameters on a quarterly basis; some RCRA land disposal sites are so complex and important that EPA has already accumulated many linear feet of manual ground-water data files for a single facility. This volume of ground-water data will grow rapidly as EPA and the states implement new or expanded programs (such as underground storage tanks and Superfund amendments) that stress ground-water protection and clean-up.

The quality and format of this data varies widely. Many different organizations collect and store ground-water data, each using their own scientific and management practices. In addition, some earlier data collection and laboratory analysis practices have produced data of unknown quality. It may be possible to clean up some of the historical data, but the costs would be high and the returns uncertain. Therefore, new ground-water data management procedures will apply only to newly collected information.

2.6 Investments in data standards and policies are essential to further promote effective sharing and use of ground-water data.

A fundamental building block necessary for sharing ground-water data is common standards and formats for the collection and storage of ground-water data. Ground-water data users, especially in the field, require the ability to share and integrate ground-water data across programs.

One major barrier to sharing data across programs is the lack of common data standards and formats. Many programs use different parameteric codes to identify ground-water contaminants. With standardized codes information collected by different programs could be integrated more easily. Standards may exist within a program such as the Superfund contract laboratory program and the chemical parameter codes associated with STORET, but they are not uniform across all programs. The results are a reduction in the quantity and value of data that is shared and barriers to integration of data to meet operational requirements to access, retrieve, and analyze ground-water data.

3. RECOMMENDATIONS

Several alternative scenarios were identified for improving ground-water data management, ranging from the continuation of existing activities to undertaking a set of new and ambitious initiatives to create a fully integrated ground-water data environment. In reviewing these options, the EPA and state managers that constitute the Ground-Water Data Requirements Analysis Policy Committee reached a consensus on several topics:

- **Investments in improved ground-water data management are necessary and justified, although improvements should be phased in over time to limit risk and minimize disruption.**

- **Existing and proposed projects for improving ground-water data management must be carefully coordinated and managed to maximize their pay-off.**

- **New ground-water data standards and practices must be voluntarily adopted by states, EPA Regions, and EPA program offices -- they cannot be imposed effectively from above.**

Based on the Policy Committee's input, there are three critical areas where action is required: (1) data management standards, policy, and guidance; (2) data access and automation; and (3) data analysis. In each area, a specific project or projects are recommended based on EPA's current activities and the potential for increased effectiveness and efficiency. Figure 1 identifies seven of the most important initiatives that should be implemented beginning in the next one-to-two years to begin improving ground-water data management. Early planning of these initiatives should begin as soon as practical to support the required budgeting actions.

3.1 Data Management Standards, Policy, and Guidance

Data management standards, policy, and guidance are the rules that determine how ground-water data is collected and stored. Users cannot now easily combine or aggregate ground-water data from different sources because it is stored in a variety of formats using incompatible codes and conventions.

3.1.1 Current EPA Activities in this Area

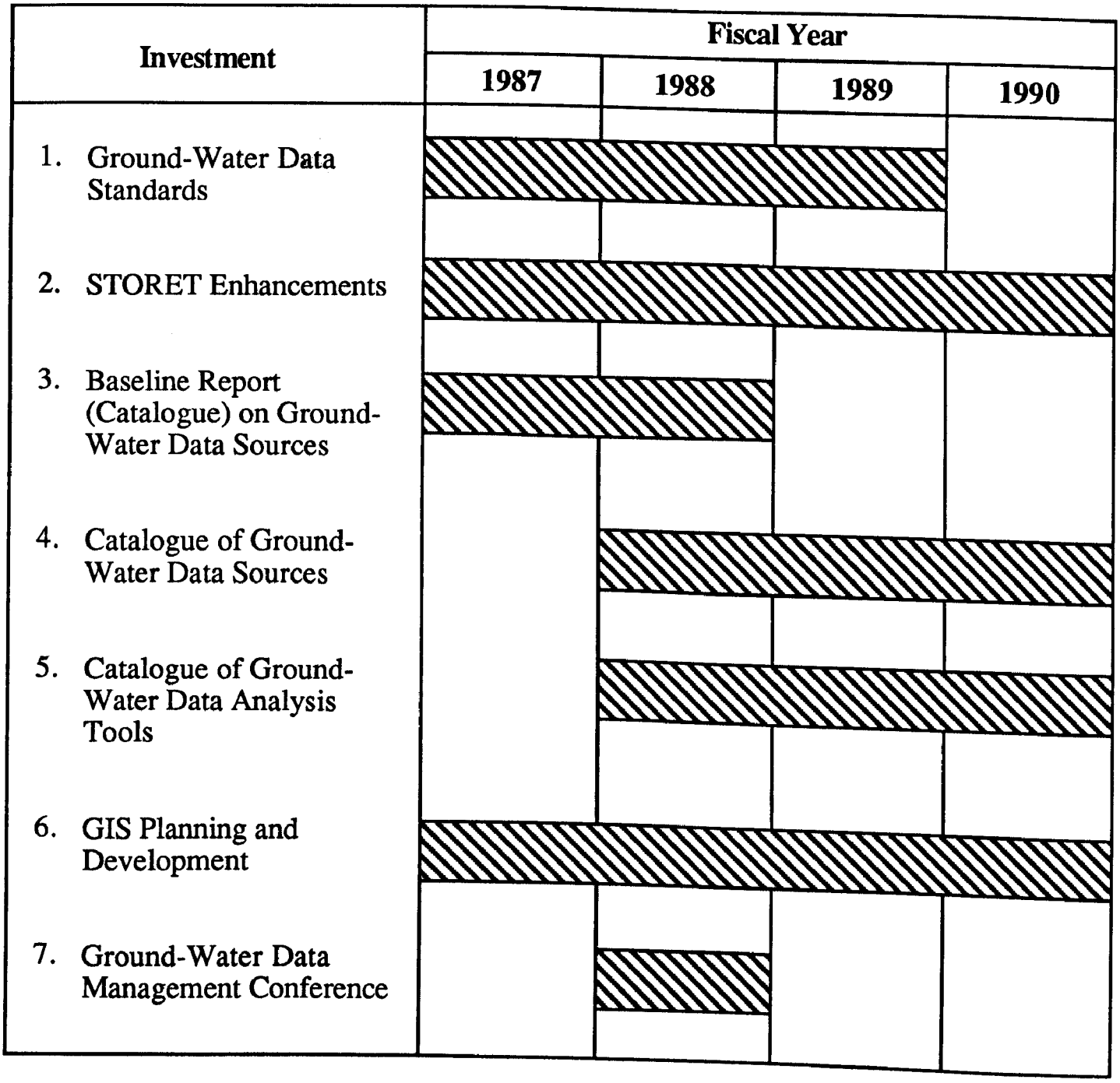
Full utilization of the ground-water data generated from existing EPA, state, and local programs will require a coordinated approach to collecting and storing such data. Ground-water data includes well descriptors, hydrogeologic descriptors, ground-water quality/sample descriptors, and related descriptors. Although EPA has not been organized to manage ground-water data as a shared resource, there are significant efforts currently underway to enhance ground-water data integration and use. These efforts when linked with the new projects recommended here will combine to remove one of the major barriers to sharing ground-water data.

OIRM has initiated several projects which focus specifically on data standards:

- An agency-wide data standards policy is currently in draft form and under review.

- Data standards policy guidelines are being developed in specific areas, including facility identification, geographic location, chemical substance code, and electronic data transmission.

Figure 1
Selected Investments to Improve Ground-Water Data Management



3.1.2 Recommended Initiatives

It is recommended that EPA compliment its current efforts by pursuing several additional initiatives in data management standards, policy, and guidance:

- **Establish a ground-water data standards work group.** The work group would be chaired by OGWP with membership from OIRM, states, key EPA offices, and other Federal agencies. Its charter should be to define and clarify specifically where ground-water data standards and quality assurance/quality control guidelines are needed (such as well descriptors, hydrogeologic descriptors, and water quality/sample descriptors) in light of factors such as cost-effectiveness and program-specific needs. This would be coordinated with the Office of Research and Development (ORD) and the program offices in the development of their data quality objectives.

- **Develop standard record formats.** After the work group has defined the data standards, a standard record format would be developed for each of the relevant types of ground-water data. These formats would provide consistency in how key ground-water data would be recorded either in automated or manual systems. Standard record formats allow states and others to develop and use their own system and still provide EPA, when requested, compatible data.

- **Improve STORET to store new QA/QC data.** Ground-water data which meets the data standards developed by EPA and which elects storage in STORET, will need to be stored separately from historic data. Over time this process will produce a data base which meets the "good housekeeping seal of approval".

- **Hold data management conferences, presentations, and workshops.** In order to educate the states on the application and use of ground-water data standards and formats, workshops and conferences will be held, perhaps coordinated with the second ASIWPCA integrated data management conference. In addition, such training presentations may also focus on the use of other EPA or federal agency data bases which store ground-water data. EPA recognizes the importance of training ("technology transfer") in ensuring that improved standards and procedures are effectively implemented in states and EPA Regions.

3.2 Data Access and Automation

Data access is the ability to obtain and use data from other organizations, possibly including ground-water data bases tailored to program-specific needs. Most ground-water data is now stored in manual files, with access and retrieval complicated by a lack of knowledge of the locations and characteristics of that data.

3.2.1 Current EPA Activities in this Area

EPA recognizes that ground-water data is generated by many different Federal, state, and local programs and offices. This diversity of data

sources can make accessing needed information difficult. Even where data sources are known, transactions costs associated with accessing data are high. There are no current efforts agency wide to establish a method to inventory and locate ground-water data sources. In addition, several states currently use STORET for the storage and manipulation of ground-water data. To assist STORET ground-water data users, OGWP has prepared a manual that defines the procedures for entering ground-water data into STORET. This manual has been distributed to the states, EPA Regions, and other federal agencies.

3.2.2 Recommended Initiatives

It is recommended that EPA:

- **Develop a Baseline Report (Catalogue) on ground-water data sources.** A "how to" catalogue of relevant EPA, major state, and other national ground-water data systems and sources is recommended. The catalogue would define the location and types of data available from key ground-water data sources. Should this approach prove successful other catalogues may be developed. For example, a catalogue on available analytic tools or data stored in manual files may prove of value. Users of the baseline catalogue would be surveyed to evaluate how well it responds to their needs and to suggest future initiatives to further improve access to ground-water data.

- **Improve STORET user-friendly access and retrieval capabilities.** OIRM should identify specific enhancements to STORET to improve user access, storage, and analytical capabilities, including the development of user-friendly interface to aid the non-computer professional. In addition, STORET will be modified to provide for consistency with EPA's ground-water data standards.

3.3 Data Analysis

Data analysis is the manipulation of raw ground-water data to identify trends or patterns in ground-water quality. Data analysis tools include statistics, modelling, mapping, report generation, and graphics.

3.3.1 Current EPA Activities in this Area

There are several initiatives to enhance the EPA's ground-water data analysis capabilities. For example, the RCRA Ground-Water Task Force is implementing a PC-based workbench to support RCRA site management by storing and analyzing RCRA monitoring data, generating reports, and modelling migration of subsurface contaminants. It provides two-dimensional mapping capabilities to display the various data themes stored in the computer memory.

With the improvement of geographic information system (GIS) technology, many states are moving ahead with the development of state-based geographic information systems. EPA's Office of Information Resources Management recognizes the benefits of this emerging technology and is currently developing a GIS policy statement for the IRM Steering Committee and is working with ORD and OPPE to prepare a more detailed GIS guidelines document.

EPA is conducting GIS development and pilot projects in Region IV (Atlanta), ORD/EMSL (Las Vegas), the Chesapeake Bay Program, and the Corvalis Laboratory (acid deposition).

3.3.2 Recommended Initiatives

The growing volume and complexity of ground-water data has led many states to investigate the use of analytic tools for the manipulation of ground-water data. Several states have pursued the investigation of GIS capabilities. The study team proposes some activities to examine and evaluate the role of GIS's in the manipulation and analysis of ground-water data.

- **Geographic Information Systems.** There are several ongoing activities in the states and Regions, at EPA Laboratories, and Headquarters, which will better define any new needs in GIS. Further initiatives should await the Spring '87 release of the Agency's GIS Policy and Guidelines as well as the results of OIRM's GIS requirements analysis. Possible future initiatives might include the development of "centers of excellence" to promote use of GIS by EPA offices, acquisition of common data bases and other resources on a centralized basis for use by GIS managers, and promotion of linkages between EPA and state GIS applications.

3.4 Management Actions Needed to Improve Ground-Water Data Management

This summary has stressed the importance of management actions over the need for new technology and systems. In addition, the effective implementation of these initiatives requires the attention, support, and participation of the senior management at EPA. Specifically EPA can:

- **Develop a work group with representation from each AA level office.** The existence of a work group for these initiatives provides one unified, centralized, coordinating and planning focus in the area of ground-water data management. Such a group will require the active high-level participation of EPA senior managers to develop consensus on ground-water data management issues and problems. Cross-agency representation ensures that these efforts are coordinated with other efforts which may be pursued in each Office.

- **Maintain the existing policy committee under OIRM/OGWP.** Ground-water data management issues affect EPA Headquarters, Regions, states, and localities. Policy Committee oversight and direction ensures that the initiatives are coordinated with EPA policy directives. Members on this committee should be rotated to ensure broad participation in the effort.

- **Provide core funding for OGWP and OIRM.** Key projects should receive core funding for OGWP and OIRM to ensure ground-water data management initiatives retain the agency-wide perspective and focus required.

TABLE OF CONTENTS

FOR

GROUNDWATER DATA REQUIREMENTS ANALYSIS

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

EXHIBITS

CHAPTER I. PROJECT BACKGROUND AND APPROACH

The Office of Ground Water Protection (OGWP) and the Office of Information Resources Management (OIRM) are jointly conducting an effort to define ground-water data management requirements for the Environmental Protection Agency. This ground-water requirements analysis document is the result of over 300 interviews with EPA, State and local officials responsible for ground-water related activities. It defines key ground-water requirements and presents several alternative scenarios for improving ground-water data management, ranging from the continuation of existing activities to undertaking a set of new and ambitious initiatives to create a fully integrated ground-water data environment.

This document is accompanied by an Executive Summary which presents a brief outline of key ground-water data management requirements and initiatives to strengthen ground-water data management for EPA and States. It also includes a valuable set of appendicies which provide the analytic basis for the study and offer insights into the key program decisions supported with ground-water data. The chapters following the Executive Summary provide a detailed review of study findings and conclusions and are organized in the following manner:

- Chapter I: Project Background and Approach -- Provides an overview of the project purpose, structure and methodology.
- Chapter II: Findings and Conclusions -- Presents the ground-water data, organizational, and functional requirements within the framework of four major areas.
  - -- Types of Ground-Water Data Required
  - -- Ground-Water Data Management, Standards, Policy, and Guidance
  - -- Access to and Automation of Ground-Water Data
  - -- Ground-Water Data Analytic Capabilities
- Chapter III: Alternatives for Improving Ground-Water Data Management -- Provides an analysis and discussion of four possible alternatives or scenarios for addressing ground-water data management requirements.
- Chapter IV: Recommendations -- Presents report recommendations.

- Chapter V: Implementation Plan -- Presents the initiatives selected for implementation by the Ground-Water Data Requirements Policy Committee and the associated implementation schedule.

- Appendicies: Appendicies A-G -- Provides the analytic basis for the findings, conclusions, and recommendations of this study. Appendicies D, E, and F are particularly useful, providing an understanding of the data elements required, key decisions supported with ground-water data, and major ground-water related issues for each major EPA program.

A. Project Background

The Ground-Water Data Requirements Analysis was conducted as a cooperative effort by the Office of Ground-Water Protection (OGWP) and the Office of Information Resources Management (OIRM). A Policy Committee comprised of senior state and EPA officials for ground-water protection activities provided project direction and oversight. Policy Committee Members included:

COMMITTEE CO-CHAIRS

- Ed Hanley
- Marian Mlay

COMMITTEE MEMBERS

- Mary Blakeslee
- Brooks Bowen
- Ron Brand
- Ed Conley
- Tom Devine
- Jim Ferguson
- Carol Finch
- Joe Franzmathes
- Philip Ross
- Roberta Savage
- John Skinner
- Steve Wassersug
- Susan Wayland
- Marcia Williams

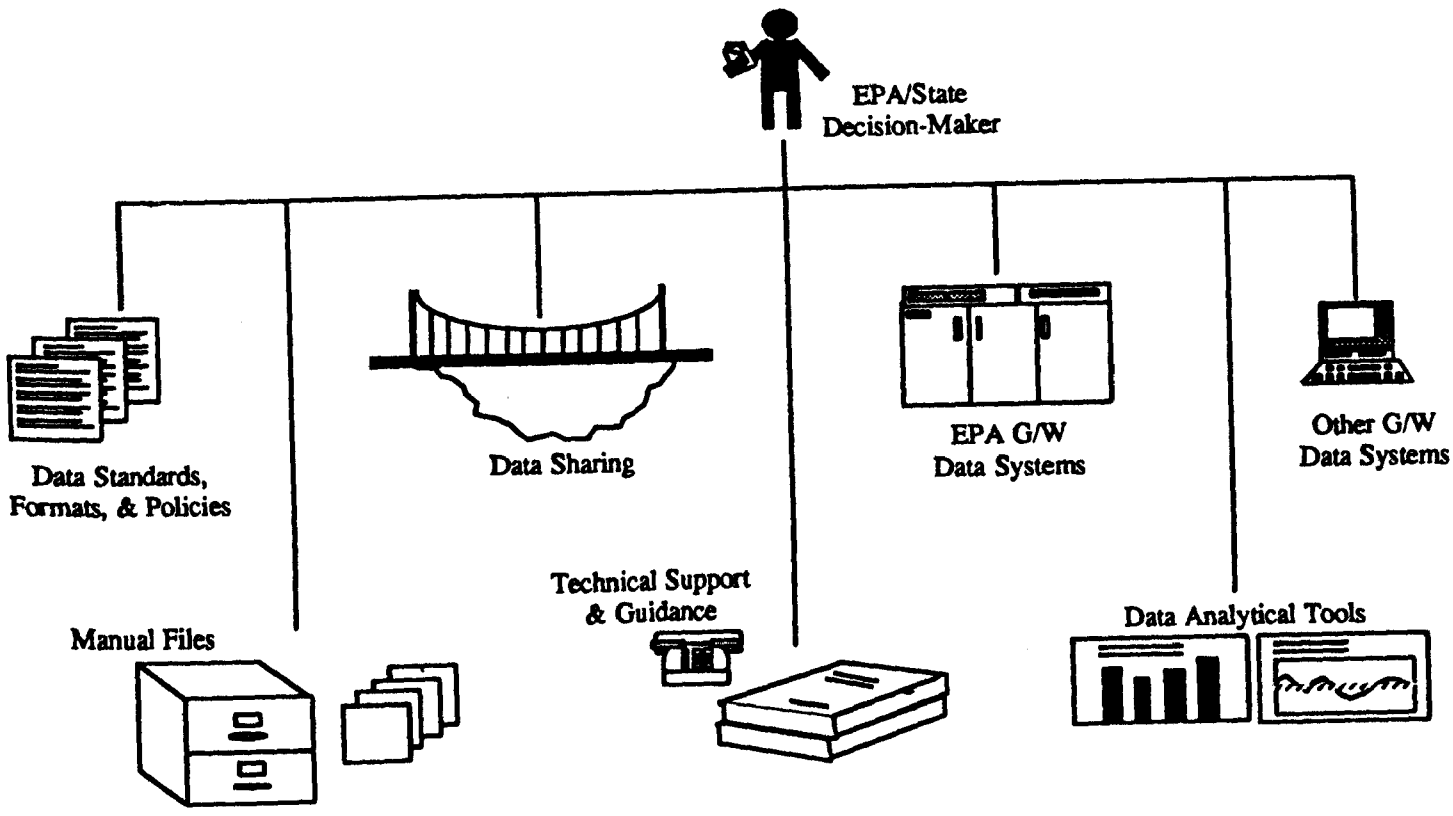
Project support was provided by an OGWP/OIRM workgroup with the contract assistance of American Management Systems, Inc. (AMS).

B. Study Purpose

There is a strong belief that ground-water data needs cut across EPA and State programs. EPA needs ground-water data to operate non-delegated programs, conduct program oversight, and develop regulations and policy. States and localities need ground-water data to implement EPA-delegated and unique local programs and to develop their own policies and regulations. To support these functions, a significant amount of ground-water data is collected, stored, and analyzed for each program.

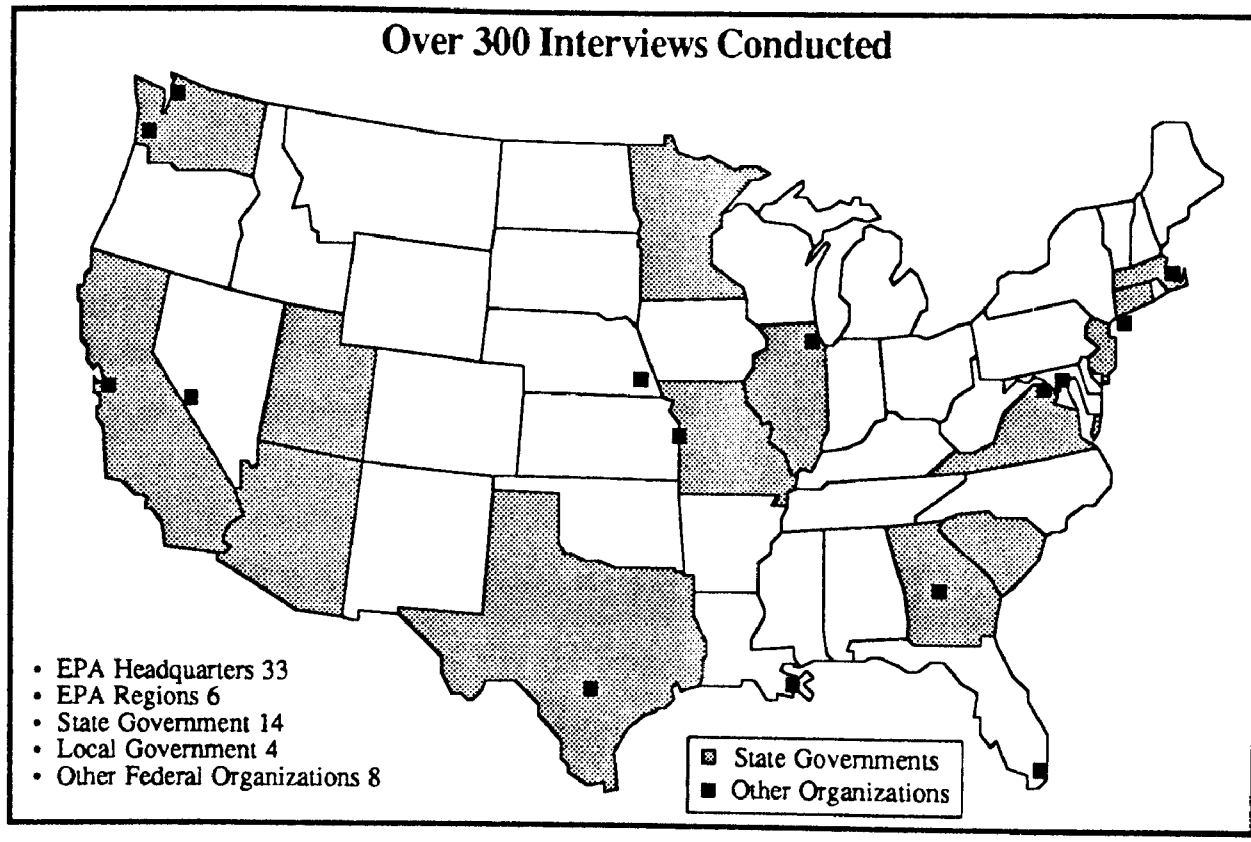
Although EPA has not been organized to manage ground-water data as a shared resource, there are significant opportunities for improving ground-water data management and sharing to support decision-making by EPA and States. The purpose of this study is to define a management framework and data utility that EPA and States can use to store, share, and manipulate ground-water data to support better environmental decision making. The components of the ground-water management framework are shown in the following figure.

COMPONENTS OF GROUND-WATER MANAGEMENT FRAMEWORK:



C. Project Methodology

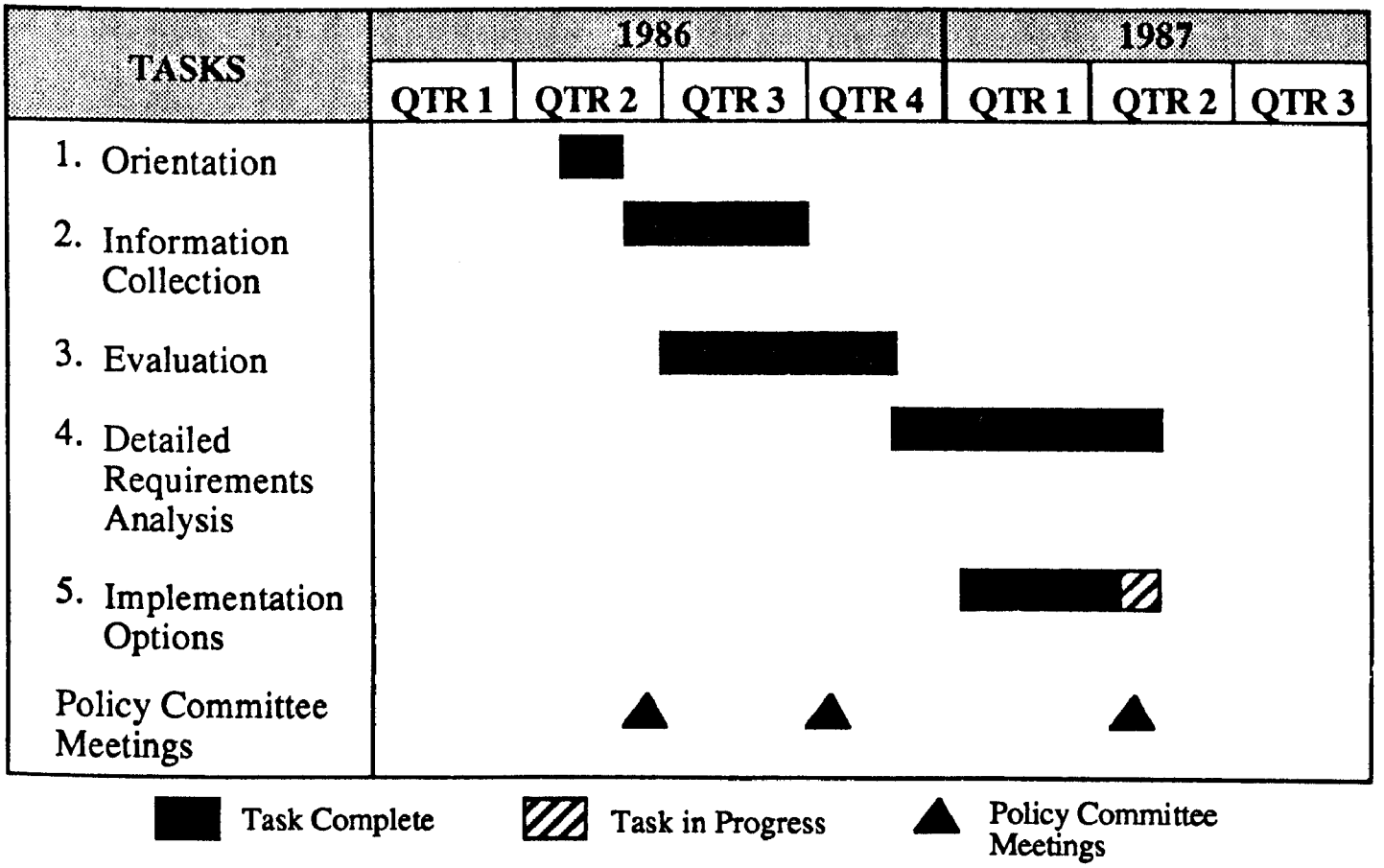
The ground-water data requirements developed in this study are based upon over 300 structured interviews conducted nationwide with EPA Headquarters, Regions, state governments, local governments and other federal organizations (see Appendix A, Interviewees For Ground-Water Requirements Analysis).



In addition the study team reviewed the relevant literature and documentation (see Appendix B, Documents Reviewed for Ground-Water Requirements Analysis) and attended demonstrations of existing ground-water data systems. The study team's progress was monitored by the Policy Committee.

Upon completion of a thorough review of the relevant documents and systems, the project study team proceeded to conduct over 300 structured interviews and develop a general framework for the analysis. The project schedule is displayed on the Gantt chart seen on the following page.

Project Schedule



The analytic framework developed was based upon several key principles:

- Management, standards and policies, training and organizational infrastructure are more important than technology.
- The most important ground-water data requirements can be best satisfied through management initiatives -- not a new data system.
- New initiatives MUST facilitate both State and EPA environmental decision-making.
- EPA and states have equivalent needs to store, access, and analyze ground-water data for effective operation of ground-water protection programs and will adopt new initiatives because it is in their best interests to do so.
- The solution is long-term in nature but significant improvements can be made in the near term.

Ground-water data management requirements were then developed within the following framework:

- Identify key ground-water data elements and volume required to support environmental decision making across EPA/State programs.
- Develop ground-water data management, standards, policy and guidance issues within ground-water related programs.
- Identify ground-water data access, sharing, and automation issues.
- Identify key ground-water data analysis and manipulation issues.

All findings, conclusions, and recommendations developed as a result of this study were thoroughly reviewed by the EPA work group and the Policy Committee. Both the work group and Committee were key participants in the study providing substantial direction and oversight to ensure all relevant ground-water protection issues were addressed.

CHAPTER II: FINDINGS AND CONCLUSIONS

The findings and conclusions in this chapter provide the basis for actions the Agency considers essential to the protection of groundwater. EPA's Ground-Water Protection Strategy seeks to build up institutional capability in the States and within EPA to cope with ground-water problems on a comprehensive basis. The Strategy promotes greater consistency and coherence among EPA programs aimed at protecting ground water and will initiate new steps to deal with major forms of ground-water contamination not now fully controlled. The core elements of the strategy are to:

- Strengthen State ground-water programs
- Cope with currently unaddressed ground-water problems
- Create a policy framework for guiding EPA programs
- Strengthen internal ground-water organization.

Pursuant to this overall direction, the Agency's Ground-Water Monitoring Strategy focuses on the actions necessary to implement these objectives and upon the fundamental activities of ground-water monitoring. The entire ground-water data requirements analysis project addresses one of the key action items identified in the monitoring strategy -- characterizing and improving ground-water data management.

To provide a framework, the findings and conclusions are organized into four areas: (1) types of ground-water data required, volume, and use; (2) ground-water data management policies and procedures; (3) access to and automation of ground-water data; and (4) ground-water data analysis capabilities. These categories are also the basis for the data management scenarios presented in Chapter III.

Exhibit II-1 summarizes key study findings and their implications for ground-water data management. The remaining sections of this chapter explain in more detail the study's findings in the four key areas mentioned.

Exhibit II-1
Key Findings and Their Implications for Ground-Water Data Management

Key Findings

- State operational environmental managers are the primary users of ground-water data.
- States and other users vary significantly in their levels of sophistication in ground-water data management.
  - -- Some states are relatively advanced and self-sufficient.
  - -- Many states are unsophisticated and seek support and guidance.
- The volume of ground-water data being generated is large and is growing rapidly -- due to Federal programs and state initiatives.
- Ground-water data is stored in many different locations, files, organizations, and formats.
  - -- Decision makers may not know about all relevant sources of data.
  - -- The "transaction costs" of obtaining data are usually high.
- Relatively little ground-water data is currently automated.

Implications for Ground-Water Data Management

- The most critical requirement is to share data for program operations and decision making -- especially within a state. Sharing of key well and facility data has the highest pay-off. Sharing of water quality data is less important.
- The general types of data and analytical capabilities required by decision makers are often similar across different programs.
- The required level of quality assurance/quality control varies by decision and program function. Most organizations are comfortable with the data that they collect, but are uncertain of the reliability of data from other programs.
- The most important analytic needs are for easy access to more data and simple analytical tools -- not sophisticated capabilities.
- To be most useful, ground-water data must be related spatially.

A. General Types of Ground-Water Data Required, Data Volume, and Use

For purposes of this study, "ground-water data" is broadly defined as the types of ground-water related information -- well descriptors, hydrogeologic descriptors, water quality and sample descriptors, and related data -- that EPA and state environmental decision makers need. This section discusses key findings and conclusions concerning the types of ground-water data required, the volume of data generated, and how that information is used.

1. The types of ground-water data collected across ground-water protection programs are similar and include four basic data classes:

-- **Well descriptors**
-- **Hydrogeologic descriptors**
-- **Water quality/sample descriptors**
-- **Related data (e.g., site descriptors, weather).**

These four data classes include the information most often needed to support program operations. While not all programs need exactly the same data elements or level of detail, they all use data from most of these categories. The most common data requirements include:

- **Well Descriptors** ... such as location (e.g., latitude and longitude), depth, type, elevation, construction method, casing material, screen size and material, and age.
- **Hydrogeologic Descriptors** ... such as geologic structure (e.g., Karst region), topography, and aquifer characterization
- **Water Quality/Sample Descriptors** ... such as contaminant names and concentrations, sample type, sample protocol, sample date and time, laboratory name, analytic method, and sampling organization
- **Related Data** ... site descriptors, land use/land cover, location of other relevant facilities, and demographic patterns.

The data elements needed to support decision making are listed in Appendix C, List of Key Ground-Water Data Elements.

Program requirements for these different data types vary according to mission and function, however, several general uses can be identified (see Exhibit II-2). EPA and states collect and analyze ground-water data to:

Exhibit II-2
WHAT TYPES OF GROUND-WATER DATA ARE NEEDED?

DATA TYPES	GENERAL USES
I. WELL DESCRIPTORS • Well location • Water level • Depth to ground-water • Aquifer code • Water quantity • Driller's log • Well characteristics/status • Well status	Needed to help interpret ground-water quality data; provides knowledge of well location; indication of construction integrity; helpful in aquifer and area geologic characterization.
II. HYDROGEOLOGIC DESCRIPTORS • Geologic structure • Aquifer characterization • Topography • Soil Characteristics	Needed in site specific hydrogeologic assessments performed to determine direction, magnitude and speed of contaminant transport; provides general indication of ground-water sensitive areas.
III. WATER QUALITY/SAMPLE DESCRIPTORS • Sample identifers • Sample protocol • Sample type • Analytic method • Water quality	Needed to understand and interpret nature and degree of ground-water contamination; provide an indication of data quality; depth from which sample was taken.
IV. RELATED DATA • Location of other regulated facilities • Other point/nonpoint sources of contamination • Site descriptors • Meteorlogic data • Location of other wells • Health effects • Land use/land cover • Environmental fate • Demographic data	Needed to identify other sources of contamination; provides context for evaluation of clean-up alternatives; provides site characterization and health effects data for contamination assessment.

***Please Refer to Appendix A for Complete List of Data Elements**

- Assess sites' hydrogeologic characteristics.
- Identify areas vulnerable to ground-water contamination.
- Determine the type and extent of ground-water contamination at a site, facility, or well.
- Help evaluate various site clean-up alternatives.

Each program's use of ground-water data is described in Appendix F, Questions and Answers About Ground-Water Data Management Issues by Program.

2. States are the primary users of ground-water data.

In most cases, it is the States -- not EPA -- that implement and operate the nation's environmental programs that address ground water. States play a key role in two areas:

- **National environmental programs.** For programs such as the Resource Conservation and Recovery Act (RCRA) program, Underground Injection Control (UIC), and Underground Storage Tanks (UST), EPA delegates authority for activities such as permitting and inspection to States with approved programs. EPA encourages States to seek delegation, although the number of delegated States varies from program to program; for example, every State has delegation for drinking water, while the UST program is so new that no State has yet received formal delegation. States also play an active role in national programs (such as Superfund and pesticides) without extensive delegation features.
- **State-specific programs.** In addition to national environmental programs, many States have developed their own programs to protect local ground-water resources. Such programs -- from ground-water discharge permitting to chemigation and zoning programs -- confirm that States are the most important users of ground-water data.

Because of their leading role in implementing environmental programs, States most often have responsibility for those functions requiring use of detailed ground-water data -- issuing permits, identifying inspection targets, pursuing enforcement actions, and planning and executing site clean-ups. Although EPA also uses data for these purposes, the Agency more often supports States with guidance, oversight, and technical assistance.

3. There is little need to share ground-water data among states.

States focus on environmental program operations -- permitting, inspection, enforcement, and clean-up. Data needs to support program operations tend to be limited to a specific site, facility, or local area. Ground-water data from other states is of little value in supporting program operations, except in the unusual situation in which a significant site or problem lies near a State border.

4. Large and growing volumes of ground-water quality (parametric) data are generated by national and state-specific programs.

As a result of regulatory reporting requirements, special studies, and ambient monitoring activities, states and EPA Regions now obtain extremely large volumes of ground-water data. For example, a single RCRA facility can have dozens of wells, each being monitored for dozens of parameters on a quarterly basis; some RCRA land disposal sites are so complex and important that EPA has already accumulated many linear feet of ground-water data files for a single facility. The volume of ground-water data will grow rapidly as EPA and the states implement new or expanded programs (such as underground storage tanks and Superfund amendments) that stress ground-water protection.

The tremendous volume of ground-water data collected can make manual data management and manipulation extremely difficult. If not effectively managed, ground-water data will impose significant costs for filing, office space, data manipulation (e.g., statistical calculations), and reproduction. Meaningful data analysis and interpretation can become almost impossible. In many organizations, the large volume of ground-water data is cited as a major justification for automation initiatives.

5. The level of detailed ground-water and related data needed varies by program and program decision.

Each program makes different decisions with ground-water data, and accordingly requires a different level of data support. For example, the water quality and hydrogeological information used by a delegated state to issue a RCRA permit must be more detailed than data used by EPA to conduct a

preliminary assessment of a potential Superfund site. Some decisions are based on limited information due to the expected costs and benefits of additional data collection; for example, a state may decide to collect limited well descriptor data in a study to identify counties that are most vulnerable to ground-water contamination by pesticides.

Conversely, different programs may have similar information needs if they make similar decisions. For example, the RCRA and Superfund programs both require detailed information about site hydrogeology to evaluate alternative ground-water clean-up options.

6. Many decision makers want more information on the health effects of ground-water contaminants.

Environmental managers want more detailed information about the possible health risks associated with ground-water contamination, especially where drinking water issues are involved. More specifically, they ask: "What is the human health risk associated with a finding of contaminant X in a concentration of Y?" Managers did not have ready access to such information, which is critical for risk-based decision making. Many decision makers expressed a desire for easy access to a full range of health risk information.

7. Conclusions

The key findings about the types and use of ground-water data are:

- **The ground-water data needed to support environmental decision-making falls into four basic categories: well descriptors, hydrogeologic descriptors, water quality/sample descriptors, and related data.**
- **Large volumes of ground-water quality data are generated -- and the amount is growing. This tremendous volume of data has significant implications for ground-water data management.**
- **States are the primary users of ground-water data. EPA data management efforts should focus on state needs.**

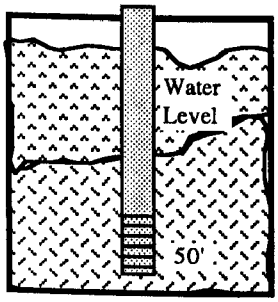
These findings lead to three major conclusions. **First, large volumes of ground-water quality (parametric) data are being generated -- even though ground water is a relatively new focus in environmental protection.** Without better management, decision makers may soon find it impossible to access and manipulate ground-water data. In many organizations, the large volume of data is a major justification for automation. Many states plan to move ahead with ground-water data management initiatives -- with or without the benefit of EPA direction and guidance.

Second, EPA ground-water data management initiatives should focus on the states. States are the primary recipients and users of ground-water data and are responsible for day-to-day decision making in ground-water protection programs. With some important exceptions, EPA Headquarters and Regions need ground-water data for program oversight and policy development, but not for operations. States analyze ground-water quality at key sites, issue permits, monitor ambient ground-water quality, and perform a host of other ground-water protection and clean-up activities. EPA should focus first on initiatives that benefit the states, next the Regions, and last EPA Headquarters.

Third, the identification of four data classes has positive implications for ground-water data management. These data classes provide a framework for improving the way in which ground-water data is captured, stored, and analyzed. While programs vary in terms of the exact types and amount of data required, they all need some information in at least one of the four major categories. As shown in Exhibit II-3, the most important data to be shared across programs is well descriptor and hydrogeologic descriptor information.

Exhibit II-3
PRIORITY FOR GROUND-WATER DATA SHARING

Well Descriptors



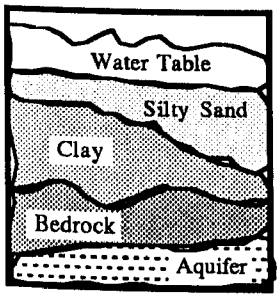
- Location
- Construction Characteristics
- Depth to Screen

To interpret groundwater quality data

High Priority

- Attribute most important for sharing is well location. Utility of other attributes varies by program and decision.

Hydrogeologic Descriptors



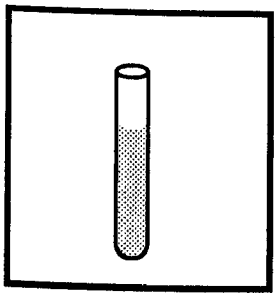
- Geologic Structure
- Stratigraphy
- Topography
- Soils

To characterize hydrogeologic descriptors of site

High to Medium Priority

- Site specifice nature of RCRA and Superfund sites make detailed hydrogeologic data very important.
- General hydrogeologic characteristics are needed in identification of "groundwater sensitive areas"

Groundwater Quality/Sample Descriptors



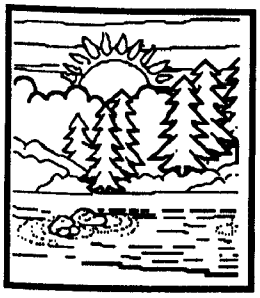
- Water Quality
- Sample Protocol
- Analytic Method

To define nature of groundwater contamination

Medium to Low Priority

- Few EPA delegated or state programs are required to report parametric data; most programs require compliance. Ground water quality data -- or some
- aggregate -- are essential for knowledge of contamination at a site, facility or within a monitoring network.

Related Data



- Site Descriptors
- Land Cover/Land Use
- Health Effects

To characterize the site and effects of site contamination

Medium Priority

- Utility of these data vary by program. Site descriptors are extremely valuable for many programs; Land use can help identify other sources of contamination; Health effects data assists in exposure/risk assessment.

B. Findings Related to Ground-Water Data Management, Standards, Policy, and Guidance

1. Ground-water quality and related data are not collected or stored using any standard conventions.

EPA Headquarters, Regions, and states do not use standard data collection, coding, and reporting conventions that would facilitate sharing of ground-water data. While standards may exist within a program -- such as the Superfund contract laboratory program and the chemical parameter codes associated with STORET -- they are not uniform across all programs. Many organizations have developed unique forms, codes, and formats to meet their own requirements. This lack of standardization reduces the value of data that is shared and makes it difficult to integrate data from many sources.

In addition, there is no common set of data that is always collected by different programs and organizations for every sample or well. A fundamental problem in ground-water data management is the inability to link ground-water quality data with other critical descriptors to enable an analyst to interpret the data. For example, well location and depth to screen can help determine the aquifer from which a sample was taken. Missing information often includes well depth, location, and data type (e.g., drinking water data, RCRA monitoring data). Similarly, limited information is often available about the sample itself -- such as the type of sample, collection protocol, and name of analyzing laboratory.

2. Decision-makers did not identify data quality as a major barrier to sound decision making. Managers understand the limits of their own data, but data from other programs may be questioned.

Data quality and quality assurance/quality control (QA/QC) procedures are not limiting factors in making decisions on ground-water issues. While most decision makers want and are working to achieve improved data quality, they cited few instances in which poor quality data led to an improper decision or higher quality data would have resulted in a different decision.

A wide variety of QA/QC initiatives are being implemented by EPA and states, including certified laboratories, prescribed sampling protocols,

replicate/spike sampling, formal QA/QC plans, organizational and staffing assignments, and data verification and validation. The exact procedures vary among organizations and there is little agreement on what QA/QC data is most important for inclusion in a data management system. For example, some users prefer a summary evaluation of data quality (e.g., valid for all purposes, valid for limited purposes), while others want to review detailed QA/QC information (e.g., laboratory testing procedures, spike/replicate sample results, laboratory instrument calibrations) to draw their own conclusions.

3. The need for "high quality" data varies by program and decision.

The need for high quality data varies by program and by decision within program. For example, the Superfund program requires extremely high data quality and complete "chain of custody" procedures for data used in cost recovery actions against potentially responsible parties. Similarly, RCRA Part B permits include data quality assurance plans to ensure that the monitoring data collected and submitted by facility owners and operators is reliable for detecting significant deterioration in ground-water quality. Where necessary, decision makers initiate special data collection programs to ensure the availability of highly accurate, precise data.

In other cases, the requirements for data quality are less extensive. For example, states rely primarily on data from existing wells in operating ambient monitoring networks and conducting special surveys. Although these existing wells often have certain features -- such as casing materials or construction method -- that make water quality results somewhat less reliable than data from special monitoring wells, the resulting data is of acceptable quality for certain purposes. Decision makers often make conscious trade-offs between the quality of ground-water data and the time and resources required to ensure high quality.

4. Some decision makers in states, EPA Regions, and EPA Headquarters, want "representative" aggregate (e.g., nation-wide, regional, state) ground-water data.

Program officials at all organizational levels expressed the desire to obtain an overview of ground-water contamination problems. These decision

makers are interested in ground-water information -- well descriptors, hydrogeologic descriptors, water quality/sample descriptors, and related data -- that goes beyond site-specific data. At present, it is difficult to obtain aggregate level information within a program, state, or region. Questions such as, "How many incidents of ground-water contamination were recorded for chemical X in 1986?", cannot be easily answered at this time.

States are pursuing a variety of strategies in collecting "representative" ground-water data. Some states -- such as California and Illinois -- are implementing ambient monitoring networks based on existing wells. Other states do not view monitoring networks as worthwhile due to costs and other factors. In general, representative ground-water quality data would be most useful to policy makers -- such as EPA's Office of Policy Planning and Evaluation and similar organizations at the state level -- by providing more macro-level data on ground-water issues.

5. In most EPA and state programs, there is little interest in testing for ground-water contaminants beyond those that make sense for a particular site or study.

States and EPA Regions sample for those contaminants defined by regulations or that are most likely to be found given the location and features of the site and monitoring well. Although some data is available for practically all samples (such as ph, temperature, and total dissolved solids), there is significant diversity in the contaminants measured. For example, wide-area surveys focus on different parameters in urban and rural areas due to expected differences in the likely contaminants -- volatile organics in urban areas versus nitrates and pesticides in rural areas.

6. Many states want EPA to provide additional guidance and leadership in ground-water data management. Other states have made a significant investment in ground-water data management procedures and would resist major changes.

Many states have expressed a desire for EPA to provide additional guidance and leadership in ground-water data management issues. General areas of concern include:

- Common Data Standards ... standards codes for well type, location, chemical parameters, and other elements to promote sharing among programs and systems.

- Quality Assurance and Quality Control Standards ... guidance on the proper application and use of ground-water quality sampling and analytic techniques to meet various sampling objectives and field conditions.

- Training, Documentation, and User Support ... workshops, user hot-lines, classroom and computer-based training, manuals and guidance documents to ensure that available procedures, analytical tools, systems, and data bases are properly used.

- Technical Consulting ... specialized expertise and experience to support states and EPA Regions in establishing sound, consistent ground-water data management procedures, policies, and systems and in addressing specific problems.

- Promotion of Information Sharing Across Programs ... seminars, newsletters, electronic bulletin boards, and publications to keep different programs and organizations informed about each other's activities in ground-water related areas.

7. Conclusions

Key conclusions regarding ground-water data management, standards, policies, and guidance are:

- **The fundamental building blocks necessary to improve ground-water data management begin with common standards and formats for the collection and storage of ground-water data.**

- **Data quality issues are not a major barrier to better ground-water data management.**

- **Some decision makers want representative aggregate ground-water data -- well descriptors, hydrogeologic descriptors, water quality/sample descriptors, and related data.**

- **EPA should act now to improve ground-water data management -- the longer EPA waits, the harder it will become to change the way states deal with ground-water data.**

Ground-water data users, especially in the field, want the ability to share and integrate ground-water data across programs. The quality of decisions would improve if decision-makers could use all relevant information,

not just data collected by a single program. One major barrier to sharing data across programs is the lack of common data standards and formats. For example, many programs now use different parameter codes to identify ground-water contaminants; if these codes could be standardized, information collected by different programs could be integrated more easily.

In addition to establishing and using common data codes and formats, programs need to collect a few common data elements (a minimum data set) for every ground-water quality sample and well. For example, many programs fail to enter a well's location (e.g., latitude and longitude) in a way that allows other programs to determine if that well is near any facilities of interest. EPA standards and guidance for a "minimum data set" to be associated with each sample and well would improve data management in this area.

Some program officials need "representative" summary ground-water data. There is clearly a need for ground-water data that goes beyond site specific data, yet any attempt to aggregate all ground-water data would prove to be an overwhelming burden. Instead, the collection and compilation of key site/facility data elements -- such as site or well location and major contaminants found -- would facilitate policy making and other functions.

Some states are already moving ahead with their own individual efforts to improve ground-water data management. As state investments in policies, procedures, and systems increase, there will be an increasing reluctance to accept and implement direction and guidance from EPA. For example, once a state has established common codes and adopted data management procedures, it will be difficult for EPA to implement changes. EPA should move quickly to establish a common framework for improved ground-water data management, before individual state efforts make any standardization impossible.

C. Findings Related to Access to and Automation of Ground-water Data

1. Ground-water data is generated by many different sources.

Ground-water data -- well descriptors, hydrogeologic descriptors, water quality/sample descriptors, and related data -- is generated as the natural result of the operation of a large number of ground-water protection programs at all levels of government. EPA programs more commonly associated with the generation and use of ground-water data include:

- Solid and hazardous wastes (RCRA)
- Superfund (CERCLA)
- Underground storage tanks
- Drinking water
- Underground injection control
- Pesticides
- Toxics.

Even within these programs, ground-water data may be generated and stored by many different organizations. For example, a RCRA permit may be developed using data from the state, the responsible EPA Region, the regulated facility, contractors, and other Federal agencies. Many states also implement delegated programs in a way that expands the number of sites subject to regulatory requirements. The Federal underground storage tank program, for example, excludes certain classes of tanks that may be covered by state UST programs.

There are also a large number of state and local ground-water protection programs that do not result from the delegation of Federal programs. Examples of such programs include:

- Ground-water discharge permit programs
- Public water well monitoring and contamination investigation
- Well-head and aquifer protection programs
- Land use and zoning programs.

The existence of such programs means that the data management "solution" resulting from this project must be flexible -- a solution tailored totally to the needs of specific Federal programs will not provide all of the capabilities needed to support these other functions.

Federal agencies can also be sources of ground-water data. For example, the U.S. Geological Survey supports states through cooperative agreements and collects data in its own right. Other agencies (such as the Department of Defense) are effectively part of the regulated community.

2. There are few central repositories of ground-water data. Programs that generate data usually store that data in their own files.

There are few central, easily-accessible repositories of ground-water data. Individual programs typically collect and store the data needed to support their own operations. For example, states that collect ground-water quality data in their drinking water programs usually store the data apart from monitoring data from RCRA sites. There are typically few formal links -- either manual or automated -- between data stored in different programs.

Some states are beginning to recognize the benefits associated with an integrated approach to ground-water data management. For example, all ground-water data in Minnesota is stored in a single integrated system known as the Integrated Ground-Water Information System (IGWIS). The State of Texas allows its program offices to voluntarily integrate ground-water data through the use of TNRIS, the Texas Natural Resources Information System.

At the Federal level, there are two major repositories of ground-water quality data -- STORET and WATSTORE. Many EPA Regions and states use STORET to store some of their ground-water data. For example, Georgia uses STORET to store water quality data from its ambient ground-water monitoring network. Although STORET can support many ground-water data management functions, few users take full advantage of it. The U.S. Geological Survey maintains the National Water Data Storage and Retrieval System (WATSTORE), containing data from USGS projects and state cooperative studies.

3. Some states have difficulty locating ground-water data within their state. Even where data sources are known, transaction costs associated with obtaining data from "outside" sources are high.

Many states are aware of the different sources of ground-water data in various state agencies. Some states, however, do not always access all

relevant ground-water data. This problem can be caused by many factors -- including lack of necessary organization structures and responsibilities, personnel turnover, absence of certain management processes, inexperience, and failure to recognize the value of sharing ground-water data.

Even in states where data sources are well known, transaction costs associated with "outside" sources are usually high. Data might be located in unfamiliar automated systems, requiring investments in hardware and training before it can be used. Paper files might be stored in a different building or city. Even if the required records are physically nearby, they may not be indexed or filed to facilitate quick and easy use.

4. Other Federal agencies have data bases containing ground-water data.

Several Federal agencies other than EPA collect and store ground-water data -- including well descriptors, hydrogeologic descriptors, water quality sample descriptors, and related data. These agencies and data bases include:

- **USGS -- WATSTORE.** WATSTORE is a USGS data base of water quality and use data, including daily and annual statistics, water quality descriptions, and a well inventory. USGS also has valuable data on topography and other geographical features.

- **Census -- Demographic Data Bases.** The Bureau of Census compiles demographic, social, and economic data resulting from the Federal census. Such data can be used to characterize population conditions for use in ground-water risk assessment.

- **USDA -- Soil Survey Maps.** The Soil Conservation Service maintains a soil classification data base for selected regions of the county. This data can be used to analyze issues such as flooding characteristics, depth to bedrock, and soil types.

- **Other Federal Agencies.** The Nuclear Regulatory Commission, U.S. Army, National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and other Federal agencies maintain data bases which contain data of interest to ground-water programs. Some agencies' files are detailed site-specific ground-water quality and hydrogeologic information, while other agencies store area-wide data.

5. **The level of automation varies by state and by program, but few states take an integrated approach to ground-water data management.**

   - **Ground-water quality (parametric) data is the data class most often automated.**
   - **The most commonly automated non-parametric data includes well location, land use, and hydrogeologic data.**
   - **Most data are not automated.**

The level of ground-water data automation varies by state and by program within states. More sophisticated states -- such as Texas, Minnesota, and Illinois -- have automated some of their ground-water data. Some states are also planning or implementing Geographic Information Systems (GIS). While most states are planning at least some ground-water data automation, few states are taking an integrated, state-wide approach. Automation often occurs on an ad hoc, program-by-program basis. Where automated systems are used, the most commonly automated information is ground-water quality, well location, land use, and hydrogeologic data. Many states now use manual files to store ground-water data, but are considering automation in selected programs.

6. **States are interested in PC-based software and micro-to-mainframe links to enhance ground-water data management.**

Many users of automated ground-water data find mainframe computers hard to access and use, slow, and expensive. Personal computers (PC's), on the other hand, are often perceived as simple to learn and use, easy to control, less expensive, and less intimidating. PC's, however, are not easily able to store and manipulate the large amounts of data generated by ground-water programs. Many states want EPA to provide the ability to upload and download data from a central data management utility. South Carolina has already developed software to transfer data between STORET and state PC's. Such software could help managers supplement the limited amount of sophisticated data processing and programming skills within their programs.

7. **Some states want access to an EPA "system", while others prefer to develop their own capabilities.**

Just as states' data automation capabilities vary, so do their feelings concerning a central EPA data utility. Some advanced states are not

interested in participating in an EPA "system", although they are generally willing to share data. Other states find use of an EPA central system to be much less expensive than developing and maintaining their own systems. For example, Georgia and South Carolina believe that STORET has saved the time and resources that normally would have been incurred in developing a custom system. Similarly, EPA Regions IX and IV use STORET for certain ground-water data management functions and are pleased with the resulting improvements.

8. Conclusions

Two major conclusions emerge from the findings in the area of access and automation of ground-water data:

- **There is a need to improve access to ground-water data and lower the transaction costs associated with obtaining and using such data.**
- **To be successful, any EPA approach to ground-water data management must recognize the significant variation in state ground-water data management capabilities.**

The ability to access and use data collected by others is the most important requirement of ground-water data users. The quality of decisions would be improved if decision-makers could base their actions on all relevant information, not just the data collected through a single program.

Ground-water data is generated by many different Federal, state and local ground-water protection programs and studies. This diversity of data sources can make accessing needed information difficult. For example, no single organization is usually responsible for well location information within a state. Inconsistent data definitions and formats and lack of centralized data repositories increase the transaction costs associated with obtaining ground-water data.

Every program has a different level of technical sophistication. Some use program-specific PC applications for ground-water data management, while others are planning more centralized and integrated approaches. Still others consider manual data manipulation sufficient to meet their needs. Accordingly, any approach to improving ground-water data management must be flexible, providing a sound overall framework while allowing each program and organization to decide how to make best use of the capabilities available.

D. Findings Related to Ground-Water Data Analysis Capabilities

1. EPA Regions and states need basic ground-water data management and analytic capabilities -- not highly sophisticated features.

Decision makers in states and EPA Regions need very basic analytical capabilities (such as trend analysis, basic statistics, business graphics, and simple maps). Most users have a limited ability to take advantage of advanced tools -- such as complex models and three-dimensional mapping. In contrast, EPA Headquarters users are more often interested in additional sophistication for detailed site-specific studies and regional or national surveys.

Overall, decision makers are more interested in increasing the amount of data available than in using better analytical tools. In particular, sophisticated analyses and models face contraints in three areas:

- They may require more data than is readily available, especially on site geology and hydrology.
- Staffing contraints may limit users' ability to calibrate, run, and interpret the results from complex capabilities.
- Many decisions may not require sophisticated analysis.

2. Sophisticated ground-water modelling is not performed routinely.

With some exceptions, EPA and states do not use sophisticated ground-water models. With the exception of a few programs and organizations, decision makers do not have enough data and skilled personnel to support reliable model runs. Even where such models are used, the actual modelling work is more often performed by contractors than by EPA or state staff.

Major exceptions in the use of ground-water flow models are found in EPA's Pesticides, Toxics, and Superfund programs and the US Army's Hazardous Waste Management program. Using contractor support or special in-house studies, these programs have the data and staff expertise to calibrate, run, and interpret the results of ground-water flow models. While such modelling capabilities are not commonly used in most programs at the present time, the need for such features is likely to increase as ground-water programs mature.

3. Users of ground-water models in states and EPA Regions want guidance on the use and applicability of available ground-water models.

Those states and EPA Regions that perform ground-water modelling want guidance in two areas: (1) identifying the models currently available for use; and (2) determining which model is appropriate for a given situation. There are a number of different types of ground-water flow models available -- two- and three-dimensional models; "forward-looking" models that predict the spread of contaminant plumes from a known source and "backtracking" models that identify the source of the pollution based on data about the plume; and contaminant and hydrogeologic specific flow models. Given the increasing number and diversity of ground-water flow models, many users are unaware of all of their options in selecting a model.

In addition, each model has its own specific strengths and weaknesses. For example, a model which is excellent for predicting the movement of a benzene plume in sand may not be applicable for a different type of contaminant and hydrogeology. Model users need help selecting ground-water flow models, perhaps in the form of an index on the available models, their strengths and weaknesses, operating instructions, and other information.

4. Most decision makers place a high priority on spatial integration and display of ground-water and related information; some states and Regions are proceeding with the development of GIS capabilities.

Many decision makers consider maps to be a vital output of an improved ground-water data management capability. Ideally, mapping capabilities should be adequate to produce on-line displays as well as printed copies, integrating data from different sources into a single output and allowing the user to control the types of data (e.g., topography, cultural features, political boundaries, geology) to be displayed in two and three dimensional color graphic formats.

Longitude and latitude are the most frequently preferred mechanism for relating data geographically, although some data sources use other coordinate systems that would need to be translated into latitude and longitude for use by a geographic information system. In addition, rough

regional maps can be generated if information is referenced by township, range, section, and (ideally) quarter-quarter-quarter -- a land ownership reference grid that exists for most of the United States.

The need for mapping applications exists at several levels:

- **Detailed site mapping ...** areas of only a few square miles; often linked to ground-water modelling; very high level of resolution is required (e.g., locate objects to within a few feet, show buildings and other features in outline form rather than as points); often requires intensive, special-purpose data collection; latitude and longitude may not provide a sufficiently detailed coordinate system; site-specific coordinate systems may be acceptable for relating points within a site.

- **Detailed regional mapping for special areas of concern ...** medium sized areas are to be mapped (e.g., counties, cities, 20 square mile parcels); may require some special data collection, but ideally should be based on existing data.

- **General mapping for background and confirmation of other data ...** medium and large areas to be mapped (e.g., counties, aquifers, states, 500 square mile parcels); likely to be based almost entirely on existing data.

5. Conclusions

These findings about ground-water data analysis capabilities demonstrate:

- **Decision makers need a set of simple ground-water data analysis and manipulation tools -- statistical analysis, tables and data listings, graphics, mapping -- to support program operations.**

Decision makers need basic data management and analytical tools more than sophisticated modelling or complex GIS capabilities. Many programs would like to perform trend analysis or prepare basic listings of summary level data, and find it difficult due to a lack of automated tools and data. Use of complex models, statistical analysis, mapping, and other tools is currently limited, in part because of difficulty in manually manipulating large volumes of data. The quality of decision making would improve if appropriate analytical tools could be more easily applied to existing ground-water data.

CHAPTER III: ALTERNATIVES FOR IMPROVING GROUND-WATER DATA MANAGEMENT

A. Overview of Data Management Scenarios

Four alternative solutions have been developed to address the data management requirements associated with the monitoring and protection of ground-water. These four scenarios provide EPA with a choice of options, ranging from the continuation of existing activities to undertaking a set of new and ambitious initiatives to create a fully integrated ground-water data environment. The scenarios and initiatives presented here are for EPA's consideration and evaluation. They do not represent the selection of a specific course of action. The final choices selected by EPA will most likely represent a mix of the options presented in this chapter. The scenarios are:

- **Scenario A: Continue Current Activities; No Major New Initiatives**
- **Scenario B: Put in Place Basic Building Blocks For Improved Ground-Water Data Management**
- **Scenario C: Integrate Ground-Water Data Capabilities in Selected Areas**
- **Scenario D: Achieve Fully Integrated and Consistent Ground-Water Data Management**

These four scenarios are alternative sets of actions by which EPA can improve ground-water data management. The alternatives are not mutually exclusive, but instead represent incremental improvements to ground-water data management -- each scenario builds upon the initiatives in the prior scenario. As the scenarios grow in sophistication and complexity, the resources (and "organizational pain") necessary for implementation also increase. Exhibit III-1 highlights the differences among the four options.

The initiatives in the four scenarios can be grouped into three major areas: (1) data management standards, policy, and guidance; (2) data access and automation; and (3) data analysis.

- **Data management standards, policy, and guidance** are the rules that determine how ground-water data is collected and stored. For example, decision makers cannot now easily combine or aggregate ground-water data from different sources because it is stored in a variety of formats using incompatible codes and data conventions.

Exhibit III-1
Key Initiatives by Scenario

SCENARIOS	KEY INITIATIVES
SCENARIO A **Continue Current Activities; No Major New Initiatives**	• No new EPA initiatives • EPA continues implementation of existing ground-water data management initiatives • States and other Federal agencies pursue their own, independent ground-water data management initiatives
SCENARIO B **Put in Place Basic Building Blocks For Improved Ground-Water Data Management**	• Establish an EPA/State work group • Develop comprehensive but voluntary ground-water data standards, formats, and procedures • Improve data access through development and use of indexes, site/facility summaries and selected system linkages • Provide better access to existing systems and documentation of existing analytical tools (e.g., models, statistics); GIS strategy and pilots
SCENARIO C **Integrate Ground-Water Data Capabilities in Selected Areas**	• "Required" use of data standards, formats, and procedures for all new national systems • Further improvements in data access through automation of ground-water indexes, reporting site/facility summaries, and more extensive system linkages • Development of more powerful analytical capabilities through limited investment in selected high pay-off tools, selected GIS implementation
SCENARIO D **Achieve Fully Integrated and Consistent Ground-Water Data Management**	• "Required" use of data standards, formats and procedures in ALL systems and data management activities • Linkages of all EPA, state and other Federal agency data systems to facilitate easy access to and transfer of ground-water data • Development of a full array of powerful, easy to use analytical tools for use in supporting ground-water decision-making; widespread implementation of GIS strategy

- **Data access and automation** refer to the ability of decision makers to obtain and use data from other organizations and automate ground-water data within their own programs. Most ground-water data is now stored in manual files, with access and retrieval complicated by a lack of indexes to the locations and characteristics of that data.

- **Data analysis** is the manipulation of raw ground-water data to identify trends or patterns in ground-water quality. Data analysis tools include statistics, modelling, mapping, and graphics.

In Scenario A -- Continue Current Activities; No Major New Initiatives -- EPA, states, and other Federal agencies continue with existing initiatives, such as EPA's STORET enhancements, USGS's redesign of the WATSTORE system, and the State of Missouri's data standards program. There is no new emphasis on coordinating these independent, on-going initiatives or managing ground-water data as a common resource across many programs.

Scenario B -- Put in Place Basic Building Blocks for Improved Ground-Water Data Management -- creates a foundation for improved ground-water data management. The emphasis is on assigning responsibilities and allocating resources to address key tasks and problem areas, implementing selected improvements in the current data management environment, and establishing a common approach to ground-water data management, especially by standardizing data management procedures, formats, policy, and guidance.

In Scenario C -- Integrate Ground-Water Data Capabilities in Selected Areas -- automation of key data management activities is pursued for all major program areas. The focus is on delivering improved data management capabilities to state and EPA decision makers. To improve access and sharing of ground-water data, high pay-off ground-water systems are linked together. In addition, important summary level information is collected for use by EPA and state program managers and policy makers.

Scenario D -- Achieve Fully Integrated and Consistent Ground-Water Data Management -- is the most aggressive alternative. The data management environment from Scenario C is used as the basis for a fully integrated ground-water data network. The state, EPA, and other data systems that previously operated independently are tied together to permit the electronic transfer and sharing of ground-water data. The focus of ground-water data management shifts from a program-by-program perspective to an integrated view.

B. Scenario A -- Continue Current Activities; No Major New Initiatives

In Scenario A, there are no major new ground-water data management initiatives. Scenario A does not represent "no action", however -- EPA, states, and other Federal agencies continue with existing and already-planned efforts to improve ground-water monitoring, protection, and data management. Exhibit III-2 summarizes how the current data management environment will change as a result of the existing and already-planned initiatives that constitute Scenario A.

Exhibit III-3 describes the many recently completed, on-going, and currently planned initiatives that together make up Scenario A. For example, EPA's Office of Ground-Water Protection recently issued a ground-water monitoring strategy and established ground-water offices in each of EPA's ten Regions. Similarly, the Office of Information Resources Management has enhanced STORET to store and analyze ground-water data. In addition, OIRM is developing information resources management policies -- covering topics such as data standards and State/EPA data management -- that will help lay the basis for better ground-water data management.

States, EPA program offices, and other Federal agencies are also moving ahead with ground-water data initiatives. OSWER's Hazardous Waste Ground-Water Task Force is developing an automated ground-water data analysis workstation to help hydrogeologists and others store and manipulate ground-water data for RCRA facilities. Some states are addressing data management issues by implementing data standards, pilot GIS applications, and integrated environmental data bases. Other Federal agencies -- such as USGS and the U.S. Army -- continue to develop and enhance their own systems to support specific ground-water functions.

These on-going efforts will yield some benefits in ground-water data management, even without any new EPA actions. For example, EPA's Region IV and Region IX are improving RCRA permitting and monitoring decisions by using STORET's new capabilities; other EPA Regions and states use STORET to store and analyze ground-water data in a variety of programs. In addition to using STORET, Region IV is applying a prototype GIS to Superfund and other programs.

The State of Missouri is establishing a common well coding scheme to integrate data from various programs. The U.S. Army is enhancing an existing system (with GIS capabilities) to help manage its RCRA and Superfund sites. Most of these initiatives entail little organizational disruption, since each is tailored to the specific needs and constraints of a single office or program.

For the most part, however, the improvements generated by these on-going initiatives will be fragmented and uncoordinated. Some EPA programs will use sophisticated ground-water data analysis tools, while others will not. Some states -- those with the necessary resources and expertise -- will install integrated information systems, while others will continue to store ground-water data manually. The result will be wide variation in approaches to ground-water data management and substantial duplication of effort. Perhaps most important, these separate initiatives will do little to address decision makers' top priority for ground-water data -- improved access and sharing.

Scenario A: Initiatives and Impact
Exhibit III-2

AREAS OF ACTIONS	SCENARIO A ACTIONS, BENEFITS, AND PAIN
DATA MANAGEMENT, STANDARDS, POLICY AND GUIDANCE	● No new EPA initiatives. Continue current activities. * Current actions result in limited consistency in data management standards, formats, and procedures; some duplication of effort among EPA regions and States. ▲ EPA continues current activities. No new action is taken.
DATA ACCESS AND AUTOMATION	● No new EPA initiatives. Continue current activities. * Current actions result in limited access and sharing of critical ground-water data. ▲ EPA continues current activities. No new action is taken.
DATA ANALYSIS	● No new initiatives. Continue current activities. * Current actions result in limited array of analytical tools for ground-water decision-making. ▲ EPA continues current activities. No new action is taken.

● Initiatives * Impact ▲ Organizational Pain

Scenario A: Initiatives and Current Activities
Exhibit III-3

AREAS OF ACTIONS	SCENARIO A: INITIATIVES AND CURRENT ACTIVITIES
DATA MANAGEMENT, STANDARDS, POLICY AND GUIDANCE	• No new EPA initiatives • Ground-water data accumulates in manual files at state/program level • Some integration of intra-state data systems • Some interfaces between state, EPA and other Federal data systems
DATA ACCESS AND AUTOMATION	• No new EPA initiatives • OGWP implements ground-water monitoring strategy • Some states develop local GIS strategies/ capabilities • Some states develop their own ground-water data analysis tools
DATA ANALYSIS	• No new EPA initiatives • OIRM implements current EPA systems initiatives • States develop local, unique data management solutions • Other Federal agencies continue existing ground-water initiatives/activities • EPA develops and issues institutional, systems and technological policies

C. Scenario B -- Put in Place Basic Building Blocks for Improved Ground-Water Data Management

Scenario B establishes the fundamental framework needed to create a coordinated ground-water data management environment. This framework consists primarily of:

- **A consensus for common data formats and procedures to be implemented over time.** If ground-water data is to be shared effectively, different organizations and programs must adhere to a standardized set of procedures and formats. Examples of such standards are common codes for certain data values (such as counties and facility identifiers) and a small set of data elements to be collected and stored for each facility, well, and sample (such as well location). In Scenario B, these standards are defined as a long-term target, although they may not all be immediately adopted by all programs and offices.

- **A clear definition of tasks, deadlines, resource commitments, and organizational responsibilities, based on the recognition of the importance of ground-water data as a shared resource.** Scenario B includes the development and implementation of a detailed workplan for improving ground-water data management across all EPA programs and responsible offices. In addition to assigning responsibilities for each specific initiative, Scenario B confirms the on-going roles of selected EPA offices -- primarily OGWP and OIRM -- in leading ground-water data management at EPA. One focus of the workplan is to ensure the active participation of states and EPA Regions in planning and implementing specific initiatives.

- **Selected investments in training, system enhancements, and pilot projects.** Existing ground-water data resources -- such as data sets, computer systems, and analytical tools -- are not fully utilized. Accordingly, many Scenario B initiatives are designed to help decision makers make the most of existing capabilities. In addition, Scenario B includes studies and pilot efforts that will assist EPA in planning for additional improvements in ground-water data management.

Exhibit III-4 summarizes the initiatives that comprise Scenario B and outlines their impact on ground-water data management. Each initiative is described in more detail in Exhibit III-5.

In Scenario B, the initiatives already in progress -- that is, the efforts listed under Scenario A -- continue. In addition, EPA more aggressively directs and coordinates state, EPA, and other Federal agency activities in the area of ground-water data management, recognizing that ground-water data is a

common resource that must be shared across offices and programs. For example, Scenario B includes developing and promoting ground-water data standards, enhancing selected EPA systems to improve access and ease-of-use, preparing inventories and "how-to" primers covering major national data systems and key analytical tools, and constructing indexes to the sources of manual ground-water data in each state.

Scenario B provides for significant improvements in ground-water data management over the next three-to-five-years. In the short term, decision makers will gain better access to existing data sources and analytical tools through a combination of training, manual indexes, documentation, and software enhancements. In addition, a framework will be established upon which future ground-water activities and improvements can be built. Although adoption of common ground-water data definitions and "minimum data sets" is potentially disruptive, Scenario B implements these standards gradually over time at the discretion of individual programs and offices.

Scenario B: Initiatives and Impact
Exhibit III-4

AREAS OF ACTIONS	SCENARIO B ACTIONS, BENEFITS, AND PAIN
DATA MANAGEMENT, STANDARDS, POLICY AND GUIDANCE	● Develop comprehensive but voluntary ground-water data standards, formats, and procedures. * Actions enhance ability to use data collected by others, reduces reporting of contradictory data and promotes development of compatible systems. ▲ Participate in EPA/State work group to develop data standards and minimum data set and over time modify systems to incorporate use of common data standards and summary level reporting.
DATA ACCESS AND AUTOMATION	● Improve access to ground-water data across programs through the development of a ground-water clearinghouse and implementation of high-payoff system linkages and enhancements. * Actions improve decision-making by providing access to relevant data (sharing). ▲ Participate in EPA sponsored effort to identify/ access key sources of ground-water data and implement summary level reporting.
DATA ANALYSIS	● Enhance ground-water data analysis capabilities through education on use of existing tools and pilot test of GIS strategy. * Actions improve awareness of analytic tools available and pioneer efforts to generate spatial displays of data. ▲ Participate in GIS strategy and pilot.

● Initiatives * Impact ▲ Organizational Pain

Scenario B
Exhibit III-5A

Data Management Standards, Policy and Guidance Initiatives

- **Establish an EPA/state work group.** First, a joint EPA/state work group is established. This work group is comprised of representatives from relevant offices within EPA Headquarters, EPA Regional offices, and state agencies/programs. The function of the work group is to provide one unified, centralized coordinating and planning focus in the area of ground-water data management. The work group defines the priority of the initiatives, assigns and allocates responsibilities among the organizations involved in ground-water data management and generally manages the implementation of the initiatives. In addition, the work group can serve as a forum to discuss alternative approaches and resolve resource or organizational conflicts.

- **Develop and issue organization mission statements.** Once established, the first action of the work group is to define and assign organizational responsibilities for on-going as well as the proposed Scenario B ground-water data management initiatives. The work group will develop and issue clear mission statements for each EPA organization involved in ground-water. These mission statements outline the appropriate responsibilities of each organization in the design, development and implementation of all ground-water activities and initiatives. Voluntary guidelines and charters may also be developed for the non-EPA organizations involved in ground-water data management.

- **Develop standard ground-water data formats.** A third initiative is the development of standard data formats for all relevant classes of ground-water data. This includes the identification of the data elements required and creation of a "Minimum Data Set" for ground-water. The minimum data set includes that basic information that should be collected every time a sample is taken, a well drilled or facility permitted. The voluntary use of the data standards and the minimum data set by the states must be promoted extensively by the work group and EPA.

- **Develop ground-water data summaries.** As an outgrowth of the data standards and minimum data set, the work group will develop a set of ground-water data summaries. The data summaries must be developed for each EPA program, and state programs where appropriate. The summaries are intended to provide regional and national decision-makers with key locational and environmental data on the ground-water activities of an EPA program. This information could be used in problem identification and performing general environmental assessment (e.g., has ground-water contamination increased or decreased). EPA must also promote the voluntary use and reporting of the data summaries by programs and Regions.

Scenario B
Exhibit III-5A
(cont'd)

Data Management Standards, Policy and Guidance Initiatives

- **Hold data management conferences, presentations and workshops.** In order to educate the states in a variety of ground-water activities, issues and topics, EPA will hold workshops and management conferences. These training workshops and conferences will instruct state personnel in the uses/applications of the data standards and summaries; provide additional, hands-on training in STORET and other EPA or federal agency databases (e.g., WATSTORE) as appropriate. The management conferences will focus on explaining new EPA policies and procedures, detail planned EPA actions in ground-water data management, address special topics and collect input and feedback from the states on current and proposed ground-water activities and initiatives. In addition, both the workshops and conferences offer excellent opportunities to promote the voluntary adoption and use of the data standards and summaries.

- **Provide limited technical consulting.** In this scenario, EPA also provides some limited technical consulting and support to the states. This assistance will focus on aiding state development of their own ground-water data systems, policies and analytical tools. By providing this technical support, EPA ensures that all future state systems, and their designers, are aware of EPA standards and policies and can take the appropriate steps to remain compatible with EPA data systems.

- **Increase cross-program training/support resources.** EPA also increases the amount of resources available, across all programs/offices, to disseminate to all EPA personnel information on ground-water data systems, activities, and initiatives. Some suggested actions in this initiative include training in ground-water data uses/analyses, documentation of existing EPA systems and seminars emphasizing the cross-program nature of ground-water protection and data management. The intent of this initiative is to educate EPA personnel and program offices so that they can extract the maximum possible benefits from existing ground-water systems, policies, and analytical tools.

- **Assess impact of initiatives on EPA ADP resources.** The last initiative in the area of data standards is the evaluation of the impact of scenario B on existing ADP resources. It is important to assess the "growth" in demand for EPA systems that will be generated by the increased promotion and enhancement of current EPA data systems. In addition, it is necessary to begin to coordinate ground-water data management systems requirements with overall EPA Information Resource Management (IRM) activities to ensure that improvements in ground-water data management are not slowed by insufficient computer processing and storage capabilities.

Scenario B
Exhibit III-5B

Data Access and Automation Initiatives

- **Perform specific enhancements to selected EPA systems.** EPA will first identify specific enhancements which can be made to STORET and other EPA systems to improve user access, storage and analytical capabilities. Some examples of possible enhancements include development of a user-friendly menu interface with STORET and improvement of remote user dial-up access to EPA systems.

- **Develop an inventory and "how-to" primer of all national ground-water data systems.** A second initiative is the development of an inventory of relevant EPA and other national ground-water data systems. A guide will be published detailing the capabilities, location and access requirements and procedures for each of these systems.

- **Develop links between ground-water data systems with high data utility.** In order to improve the access and transfer of ground-water data which is already automated, EPA will establish links between selected, ground-water data systems. The systems to be linked are those which contain information with the greatest potential utility to environmental managers. These selected linkages will be implemented by a series of pilot tests. The knowledge and experience gained from these initial pilots should pay dividends in the future when more data systems are integrated.

- **Establish EPA clearing-house to provide information on analytical tools and data management systems available to states, Regions and programs.** This initiative in the area of data access and automation develops a clearing-house function to provide information on the analytical tools and ground-water data management systems available for use by EPA, Region and state ground-water protection programs. EPA should perform a feasibility study to clearly define clearing-house functions, costs and benefits.

- **Establish manual indexes to sources of ground-water data at the state level.** Another major initiative is the development of an index to existing sources of ground-water data. This index will be established and maintained at the state level and linked to the ground-water clear-house. It will contain pointers to the nature and location of ground-water data collected within the state.

- **Automate selected state manual indexes. For those states which collect large amounts of ground-water data, or have a large number of collecting organizations involved in ground-water activities, automation of the manual index is strongly recommended. Automation will reduce search time for data sources, improve the timeliness and currency of the index listings and eliminate unnecessary manual files.**

Scenario B
Exhibit III-5C

Data Analysis Initiatives

- **Develop a Geographic Information System (GIS) Strategy.** As a first step, EPA should develop a strategy for the use of GIS applications in ground-water data management. At present, a number of states have acquired, or plan to acquire, their own GIS applications and plan to use them in managing environmental data on a state-wide basis. EPA at its Las Vegas lab has been experimenting with a mixture of GIS software packages and hardware. One of the advantages of a GIS application is that it allows users to spatially relate land use, sampling, locational and other ground-water data classes. Given the potential strengths of GIS and the frequent EPA/state requirement to generate two- or three-dimensional maps and execute ground-water flow modelling, it is extremely important for EPA to determine if GIS has a major, small or no role in ground-water data management. The development of a GIS strategy will ensure that if GIS does have a role in ground-water data management, EPA can harness and direct the development of this new technology into those areas with the highest benefit to EPA and the environment.

- **Pilot test aspects of GIS strategy.** Once EPA has developed its GIS strategy, the next logical step is to pilot test the strategy. This pilot test should be performed in conjunction with one or more states and will attempt to validate the assumptions made in the strategy regarding the usefulness of GIS. In addition, the pilot test must test GIS applications in the regulatory process. To present, there have been few, if any, direct uses of a GIS application in any of the normal regulatory activities performed by EPA. Of course, if it is decided that GIS does not have a role in ground-water data management, then no pilot tests should be undertaken.

- **Develop an inventory and "how-to primer" of ground-water data analytical tools.** A third initiative in this area is the development of an inventory of existing automated ground-water analysis tools. The inventory will list ground-water flow models, statistical routines and techniques and other data analysis computer software packages currently available. The inventory will also provide information on the appropriate contact person or organization for the analytical tool. In addition, EPA should develop a primer on the uses of a given tool. For example, the primer might outline the hydrogeological conditions and the specific contaminants for which a certain ground-water flow model could be used and the confidence level for the model's resulting predictions.

Scenario B
Exhibit III-5C
(cont'd)

Data Analysis Initiatives

- **Validate high-use ground-water flow models.** The last initiative for this scenario is the validation of existing ground-water flow models. This validation might entail conducting "live" tests of the predictive capabilities of certain, high use models. The actual movement of a contaminant in the subsurface can then be compared with the predictions generated by the model. A comparison of the actual and predicted plume movements will evaluate the validity and usefulness of the model.

D. Scenario C -- Integrate Ground-Water Data Capabilities in Selected Areas

In Scenario B, EPA develops a solid foundation for ground-water data management through improvements in three critical areas: data formats and procedures; organizational and management infrastructure based on the recognition of ground-water data as a common resource; and selected investments in system enhancements, training, and analytical tools. Scenario C is based on the adoption of Scenario B initiatives and includes the logical next steps in most areas -- additional integration and enhancement of ground-water data systems, further investments in training and support, more aggressive promotion and implementation of common ground-water data standards, and further development of more sophisticated analytical capabilities.

Exhibit III-6 depicts how the initiatives in Scenario C will affect the ground-water data management environment. Exhibit III-7 describes each initiative in more detail. In each area, Scenario C represents a more aggressive approach than Scenario B. The scope of EPA's actions in Scenario C, however, is limited by resource constraints and a desire to avoid the organizational disruption that would be imposed by total and immediate implementation of ground-water data standards. For example, Scenario C requires data standards for all new national systems, but existing systems and programs are considered for "retro-fitting" on a case-by-case basis. Similarly, investments in training, technical support, and system enhancements are targeted at high pay-off areas. Additional data analysis tools (e.g., geographical information systems) are implemented on a pilot study basis or only at sites where it makes sense to do so.

By implementing Scenario C, EPA could achieve a more standardized, integrated ground-water data management environment more quickly than would be possible with Scenario B:

- A greater proportion of ground-water data would be stored in a consistent format ... Scenario C includes more aggressive promotion of ground-water data standards and requires the use of EPA standards in selected situations (i.e., for new national systems and programs).

- Data would be more accessible to decision makers ... In Scenario C, every state would use an automated index to manual ground-water records. In addition, additional linkages would be constructed between automated ground-water data systems.

- Powerful analytical tools would be more widely available ... Scenario C initiatives include more extensive application of geographical information systems and incorporate additional modelling capabilities into existing systems.

Scenario C requires more resources than Scenario B -- in several areas, the primary difference between the two options is the level of resources available to fund improved procedures, systems, and analytical tools. Scenario C is also riskier than Scenario B. Because EPA would be committing to a larger number of more complex initiatives now, there is an increased likelihood that the pay-off from some efforts would not justify the cost and that different initiatives will be inadequately coordinated.

Exhibit III-6
Scenario C: Initiatives and Impact

AREAS OF ACTIONS	SCENARIO C ACTIONS, BENEFITS, AND PAIN
DATA MANAGEMENT, STANDARDS, POLICY AND GUIDANCE	● Require use of common data standards, definitions and procedures for all new national systems and require mandatory reporting of summary level data. * Actions ensure collection of compatible ground-water data and facilitates transfer of data across programs. ▲ Implement policy directives requiring use of common data standards and new reporting requirements.
DATA ACCESS AND AUTOMATION	● Automate selected clearinghouse functions for State ground-water data sources and implement links among selected State/Federal sources of ground-water data. * Actions provide environmental managers with access to additional data sources for analysis and decision-making. ▲ Modify existing systems to facilitate data sharing, transfer, and exchange.
DATA ANALYSIS	● Develop more powerful analytic capabilities through limited investments in selected high-payoff tools, develop additional micro to main-frame links, and implement selected GIS applications. * Actions provide States with automated access to fundamental data analytic and manipulation tools and leverages use of personal computers. ▲ Develop user friendly "front-ends" to existing systems and enhance existing analytic tools available (e.g., automate RCRA Students T-Test).

● Initiatives * Impact ▲ Organizational Pain

Scenario C
Exhibit III-7A

Data Management Standards, Policy and Guidance Initiatives

- **Require use of data standards, formats, and procedures for all new national systems and require the mandatory reporting of ground-water summary data for ground-water related programs.** Scenario B developed and established the voluntary use and reporting of the ground-water data summaries for each program. In Scenario C, EPA and delegated state programs are required to report summary level ground-water data (e.g., water quality, site and facility information) to the extent possible by regulation, grant guidance, etc. For example, such summary data may include state incidents of well contamination or background water quality at RCRA facilities. The amount of data required would be relatively small (e.g., one page per site, updated on an annual basis), but would help ensure that "pointers" to relevant ground-water data exist at a single source.

  Initially, the data summaries are to be reported manually by the programs, or states, to the Region, and there assembled and forwarded to EPA Headquarters. The electronic transfer of this information should be implemented as soon as possible where capabilities exist and it is cost-justified to do so.

- **Hold data management conferences, presentations, and workshops to encourage intra-state integration of ground-water data.** Many sources of ground-water data are outside the control of EPA delegated programs (e.g., State Geologic Survey, County Health Department), but many of these "outside" programs and organizations generate, collect and store ground-water data. To emphasize the importance of a coordinated approach to ground-water data management, EPA will expand the number and the nature of its training workshops and conferences. As in Scenario B, these workshops and conferences will continue to address the use of the data standards, data summaries and technical issues and concerns, but stress intra-state cooperation, integration, and coordination. Such an approach may include the creation of a single office to coordinate and collect ground-water data within the state or even the development of an integrated ground-water data management system.

- **Provide ADP technical consulting services to assist state programs in the development of ground-water data management systems.** In Scenario B, technical consulting assistance focused upon state development of ground-water data requirements and proper use of common data standards and formats within each program. In Scenario C, technical consulting services are expanded to focus upon the development of state program systems. The goals of such assistance are to encourage the automation of ground-water data and help the state implement tools that effectively support program operations using EPA data standards and common formats. Services provided to the states include support in the development of state requirements analysis studies, evaluation of different data management systems and systems project management/development tools and techniques.

Scenario C
Exhibit III-7A
(cont'd)

Data Management Standards, Policy and Guidance Initiatives

- **Provide guidance to states in the development of micro-based program specific application software for use in ground-water related programs.** The fourth initiative provides technical guidance to states in the acquisition and development of micro-computer software. Many states would like the capability to locally manipulate ground-water data and micro-computers provide an excellent mechanism to perform this local analysis. However, in many cases, the states and programs are unaware of the existence of computer resources which could provide these key analytical capabilities. Also, some states may not have in place the necessary resources (e.g., hardware, software) to implement local ground-water data analysis. Lastly, the data analytical tools required may not exist. In all three of these cases, EPA will provide the assistance necessary for states and programs to implement the local analysis and manipulation of ground-water data. Some examples of EPA aid to be provided as part of this initiative include assisting states in the identification of any special programmatic needs, determining if there are existing vendor products which can meet these needs and guidance in the development and/or acquisition of suitable software.

- **For automated systems, publish ground-water technical data interchange standards to make utilities available to a wide variety of terminals (e.g., such a data exchange standards would allow the exchange of information between state systems and STORET).** In this initiative EPA supports the sharing of data between different systems, through the publication of technical specifications for EPA and other national data systems. These standards would define ground-water data exchange formats for magnetic tape, floppy diskette, and telecommunication protocols. In addition, standards are developed to ensure that ground-water data systems are readily accessible to a wide range of computer terminals and micro-computer workstations. These standards establish one national set of "rules" to guide the electronic transfer of ground-water data among any state, EPA or other Federal agency data systems.

Scenario C
Exhibit III-7B

Data Access and Automation Initiatives

- **Automate state ground-water data sources indexes.** In Scenario B, manual indexes to existing sources of ground-water data for each state and for major sources of ground-water data available outside state programs (e.g. USGS atlas, USDA soil maps) were developed. Automated indexes were developed for states which collect large amounts of data. In Scenario C, the remaining manual state indexes are converted to automated indexes with the capability of searching for ground-water data based upon a number of key descriptors (e.g., aquifer, contaminant, location, program). Automation of state ground-water data indexes will improve search time for index entries, facilitate the identification of cross-organization and cross-program data sources and eliminate unnecessary manual files. As part of this initiative, EPA provides grants and technical support to aid in the state index conversion effort.

- **Develop and implement links between selected, high pay-off state and federal sources of ground-water data.** In Scenario B, a number of high pay-off, ground-water data systems were identified (e.g., STORET, WATSTORE). As part of that scenario, links were proposed between these high pay-off systems in order to facilitate the electronic transfer of data, increase the amount of ground-water data automated, improve data analysis and retrieval and gain valuable experience in interconnecting data systems. The majority of the systems targeted for linkage in Scenario B were national systems. In Scenario C, EPA develops automated links between all major, important national ground-water data systems and key state data systems (e.g., state of Minnesota, state of Texas, etc.). Linkages may be implemented in the form of a common user-friendly gateway to various systems, data sharing/exchange to collect all useful information into a single data base (e.g., WATSTORE, STORET) or other techniques.

Scenario C
Exhibit III-7C

Data Analysis Initiatives

- **Enhance relevant EPA systems (e.g., FINDS, IRIS, STORET,) by providing user-friendly access tools, improved data manipulation capabilities and other enhancements.** In Scenario B, the focus of data analysis improvement was on the identification and dissemination of information on existing analytical tools and systems. One of the initiatives proposed was an inventory of currently available tools and a "how-to" primer on their use. In this scenario, EPA targets selected program-specific analytical procedures for automation (e.g., the RCRA Student's T Test). The implementation of these new capabilities might include the development of new EPA systems/software to execute the analysis, enhancements to existing EPA data systems, the introduction of user friendly front-ends to existing systems to encourage their utilization (e.g., system menus, "bundled" data analysis routines) and other actions.

- **Develop micro to mainframe upload/download links for state users of EPA utilities.** In the discussion of data access and automation issues for Scenario C, it was proposed that EPA provide assistance to states who are developing ground-water related micro-computer applications. Many states are pursuing the development of these applications. While central storage of ground-water data is desired, most interviewees preferred to manipulate the data locally on their own workstations. In order to implement this type of data system configuration, it is necessary to electronically transmit data back and forth between locations. The process of extracting data from a centralized mainframe computer and transmitting it to a local workstation (e.g., IBM XT) is called downloading. Sending local data for storage into a mainframe computer is termed uploading. Many states and EPA programs, have requested the development and implementation of such upload/download computer software. EPA can improve the frequency and efficiency of automated ground-water data analysis by playing an active role in the development, standardization and distribution of such data transfer software. EPA activities may include assisting states in defining their requirements, working with vendors in the development/testing process and subsidizing the issuance of software to states.

- **Implement or test as appropriate selected portions of GIS strategy (e.g., develop state pilot).** In Scenario C, selected aspects of the EPA Geographic Information System (GIS) strategy are implemented. The GIS strategy was originally developed and pilot tested in Scenario B. In Scenario C, the GIS strategy is revised to reflect experience gained in

Scenario C
Exhibit III-7C
(cont'd)

Data Analysis Initiatives

the pilot tests. Then, the individual components of the strategy are evaluated considering their utility and contribution to the improvement of ground-water data management. Those aspects of the strategy which offer immediate utility and high pay-off are implemented. The remaining portions of the GIS strategy are deferred. Of course, if it was determined in Scenario B that GIS has no role in ground-water data management, this initiative is not undertaken in Scenario C. Similarly, if based upon the pilot tests, it is determined that there are no immediate gains from implementing the GIS strategy, then this initiative is not pursued.

E. Scenario D -- Achieve Fully Integrated and Consistent Ground-water Data Management

Scenario D presents EPA with the most aggressive approach to improving ground-water data management. Scenario D assumes that the initiatives proposed in Scenarios B and C in the areas of data management standards, data access and automation, and data analysis are successfully implemented. Scenario D focuses on the integration of independent state and federal ground-water systems into a single national ground-water data network, primarily through two mechanisms:

- Mandatory use of applicable technical formats and data standards ... An integrated and consistent ground-water data network must be based on the many systems that states and federal agencies use to store the ground-water data that they collect. In order to share data successfully, these different systems must communicate with each other using a common set of technical formats and data standards defined and promoted by EPA.

- Routine access to data from all significant automated systems ... A truly integrated ground-water data network must provide decision makers with easy access to data from all major sources of information. Through physical sharing of copied data or computer-to-computer access, the national network must provide users with all relevant data, regardless of the system in which it was originally stored.

Such a network would facilitate the electronic transfer and reporting of ground-water data and provide users throughout the nation with easy, rapid automated access to the ground-water data available. At the same time, Scenario D is the costliest and riskiest of the four options. Exhibit III-8 outlines key initiatives in Scenario D and their impact while exhibit III-9 provides a detailed presentation of all initiatives in the scenario.

Scenario D: Initiatives and Impact
Exhibit III-8

AREAS OF ACTIONS	SCENARIO D ACTIONS, BENEFITS, AND PAIN
DATA MANAGEMENT, STANDARDS, POLICY AND GUIDANCE	● Require use of common data standards, definitions, and procedures for use in all appropriate EPA and EPA-funded State ground-water systems. Require routine transfer of ground-water data to EPA ground-water data utility. * Action implements common framework for management of ground-water data for State and EPA systems and creates central repository of key data elements. ▲ Requires major modification of existing systems and procedures and for all program areas.
DATA ACCESS AND AUTOMATION	● Provide for full integration and sharing of ground-water data among organizations and systems. * Action provides automated access and interfaces to all major sources of ground-water data for use in program management and decision-making. ▲ Requires a substantial investment in automated systems at State and Federal level.
DATA ANALYSIS	● Implement full array of powerful, easy-to-use analytic tools for use in supporting ground-water decision-making widespread implementation of GIS. * Action provides ready access to the analytic tools required to support ground-water program decisions. Spatial display of ground-water data will significantly enhance cross-program analysis of ground-water data. ▲ Requires a substantial investment in a new technology by EPA and participating States. Program offices must provide data themes for use in various GIS applications.

● Initiatives * Impact ▲ Organizational Pain

Scenario D
Exhibit III-9A

Data Management Standards, Policy and Guidance Initiatives

- **Require use of all applicable data standards, formats, policies and procedures for use in all EPA-funded state ground-water system.** In Scenario B, EPA and the states developed a set of common ground-water data standards and a minimum data set to be associated with the collection of ground-water quality data. These common standards and the minimum data set were required for use in all new ground-water data systems supported with EPA funding.

  Scenario D requires the use of ground-water data management standards, policies, and procedures in all new and existing EPA-funded systems and data collection efforts, both within EPA and in the states. These requirements are imposed as appropriate through grant guidance, regulations, contract terms, etc., and includes the revision of existing systems and procedures to meet the necessary standards. This conversion of existing systems to incorporate ground-water data standardization may require large scale system design and development efforts. The EPA/state work group will be responsible for defining the necessary modifications, the establishment of a general approach and workplan and the assignment of organizational responsibilities to oversee this initiative.

- **Require transfer of data into the EPA ground-water data utility for EPA-funded ground-water data collection.** In this initiative all EPA and state programs are required to transfer a minimum data set to the EPA ground-water data management utility. The transfer of this data will ensure widespread data availability, access, and sharing. The transfer of the minimum data set is achieved electronically and is facilitated by use of the EPA common ground-water data standards, policies, and procedures. The transfer is required to the fullest extent possible through regulations, grant guidance, contract terms, technical guidance and other mechanisms.

- **Provide cross-program resources and support.** In Scenario D the emphasis is placed upon a cross-program and cross-organizational approach to ground-water data management. EPA allocates resources to ground-water activities in the areas of technical support, training, user assistance, documentation, and guidance. For example EPA might establish a common ground-water "help center" to act as a focal point for use of other federal agency systems (e.g. USGS, Census, NASA), ground-water modelling expertise, technical consulting to states and other functions. The EPA/state work group will take the lead in the development of additional training courses, the improvement of system documentation, analysis of appropriate data management tools and techniques, and the identification of new initiatives to improve ground-water data integration.

Scenario D
Exhibit III-9B

Data Access and Automation Initiatives

- **EPA develops interfaces to routinely transfer data between EPA ground-water utilities and other state or federal systems.** In Scenarios B and C, a number of ground-water data systems were linked to improve remote access to ground-water data and facilitate data exchange, transfer and sharing among organizations. Specifically, Scenario B implemented links between EPA and other national ground-water data systems (e.g. STORET, WATSTORE). Scenario C linked these national data systems with selected, high pay-off state ground-water data systems. In Scenario D, EPA implements and operates interfaces to routinely transfer data between all significant EPA ground-water utilities and other state or federal ground-water systems. The result is an extensive data sharing mechanism among EPA, state and other Federal ground-water protection programs.

- **EPA continues to enhance EPA systems to provide for routine data transfer and access.** All EPA and state programs are required to transfer a minimum data set and the ground-water data summaries to the EPA ground-water data management utility. The EPA/state work group, in association with the individual states and programs, is responsible for the design, development and implementation of all systems-related enhancements necessary to permit the electronic transfer of this ground-water data.

- **Automate the collection of data summaries required of EPA programs and delegated states.** EPA automates the collection of data summaries required from EPA programs and delegated states. In Scenario B, the data summaries were developed and their voluntary use and reporting encouraged. In Scenario C, voluntary reporting became mandatory, but data collection and reporting was primarily manual. In Scenario D, data summary reporting is automated for every EPA and delegated state program. The reporting procedure does not change. The Region still collects and forwards the data summaries, however this data is now transferred electronically to the EPA ground-water data utility.

Scenario D
Exhibit III-9C

Data Analysis Initiatives

- **Implement all cost-justified aspects of the GIS strategy.** The EPA GIS strategy was developed and pilot tested as part of Scenario B. In Scenario C, EPA implemented the high pay-off, immediate impact segments of the strategy. Those portions of the GIS strategy lacking immediate benefit were deferred. In Scenario D, EPA implements its overall GIS strategy in all geographical areas where benefits out-weigh costs. It is important to note that many states, programs and EPA Regions may have already implemented GIS capabilities/applications of their own. When EPA presents its national GIS strategy, it may be necessary to develop links between its master GIS and these other GIS applications to facilitate the integration of GIS data. In addition, the EPA/state work group should take the lead in enforcing compatibility, consistency, and non-duplicative data collection and entry among these various GIS applications.

- **Develop ground-water analytical tools which permit the cross-program and cross-organizational analysis of ground-water data by EPA and states.** In Scenario C, EPA first addressed the creation of new analytical tools for ground-water data analysis, but the focus in Scenario C was on the development of tools for program-specific data analysis procedures. In Scenario D, the ground-water data management environment has changed significantly. Now, EPA has established an integrated, nationally oriented ground-water data management environment. Data is collected, reported and stored across different programs, states, Regions and federal agencies. The next step is to develop automated tools which can draw upon this cross-program and cross-organizational data to perform analyses. The EPA/state work group will identify the ground-water activities which can benefit from this type of analysis, define the necessary specific analytical tools and supervise the development and implementation of those tools which can be justified on a cost/benefit basis. These tools will be developed for and reside on the EPA national ground-water data utility but will be accessible by all state, regional and national ground-water analysts.

CHAPTER IV: RECOMMENDATIONS

A. Decision Framework

EPA has the opportunity to improve the quality of environmental decision making by enhancing ground-water data management. In the past, the Agency has not been organized to manage ground-water data as a shared resource. EPA should take action now, however, to respond to the new requirements imposed by the growing importance and complexity of ground-water data management. Failure to act promptly will lead to duplication of effort, incompatible procedures and systems, and greater barriers to data sharing and access.

The study team has identified four alternative scenarios for meeting these new requirements:

- **Scenario A: Continue Current Activities; No Major New Initiatives**
- **Scenario B: Put in Place Basic Building Blocks for Improved Ground-Water Data Management**
- **Scenario C: Integrate Ground-Water Data Capabilities in Selected Areas**
- **Scenario D: Achieve Fully Integrated and Consistent Ground-Water Data Management**

These four scenarios provide a range of options, from continuing existing activities to undertaking a set of new and ambitious initiatives to create an integrated ground-water data management network. The alternatives are not mutually exclusive -- each consists of many different projects and actions, with the more aggressive options building on the accomplishments of previous scenarios.

In acting on the results of this study, EPA decision makers should address two issues. First, which scenario should EPA attempt to achieve over the next three to five years? In other words, what is the target for ground-water data management in the next few years, in light of resource constraints, current

data management practices and systems, and other factors. Second, what specific projects and initiatives should be started now to begin moving EPA in the right direction? There is no need to develop a totally comprehensive, detailed plan for all actions over the next five years, but selected high pay-off initiatives should be clearly identified and begun.

B. EPA Should Implement Scenario B -- Put in Place Basic Building Blocks for Improved Ground-Water Data Management -- Over the Next Three Years

The study team recommends that EPA implement Scenario B (Put in Place Basic Building Blocks for Improved Ground-Water Data Management) over the next three years. At the end of that period, the Agency should conduct a formal re-assessment of progress to date and develop a new 3-year action plan for implementing additional improvements in ground-water data management.

Scenario B is an intermediate approach. It requires EPA to take new action in selected areas and to consider ground-water data as a critical shared resource -- unlike Scenario A (Continue Current Activities; No Major New Initiatives), which involves no such changes. Compared to Scenario C (Integrate Ground-Water Data Capabilities in Selected Areas) and Scenario D (Achieve Fully Integrated and Consistent Ground-Water Data Management), however, Scenario B consists of fundamental management initiatives to be implemented gradually, rather than more ambitious automatation efforts to be completed more quickly.

In particular, the following factors were of primary importance in the study team's decision to recommend Scenario B:

- Although Scenario A will generate some improvements, it fails to establish a common approach to managing ground-water data. As a consequence, the resulting improvements will be fragmented and uncoordinated. In fact, Scenario A does little or nothing to address decision makers' top priority for ground-water data -- improved access and sharing.

- The initiatives that comprise Scenario B are critical to Scenarios C and D as well. In implementing Scenario B over the next three years, EPA builds a foundation for attaining improvements in the longer run.

- Scenario B is less risky than Scenarios C or D. Scenario B provides for fewer, less ambitious projects, and consequently involves less likelihood of failure. The risks of Scenarios C and D are especially increased by the need to implement certain initiatives very quickly and to coordinate many related projects.

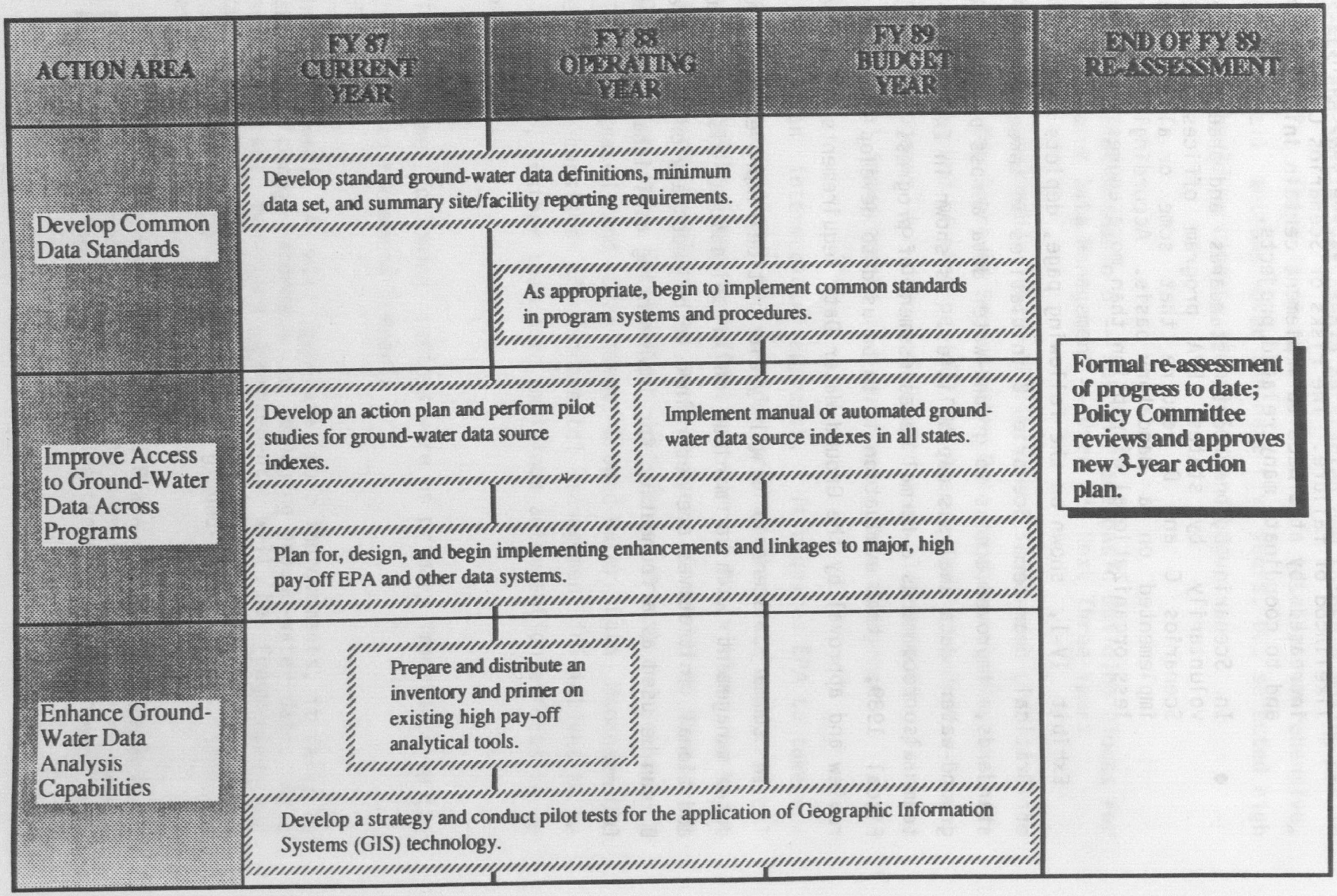
- In Scenario B, new data standards and practices are implemented voluntarily by states, EPA program offices, and EPA Regions. Scenarios C and D require that some or all of these changes be implemented on a mandatory basis. Accordingly, Scenario B entails less organizational disruption than more aggressive alternatives.

Exhibit IV-1, shown on the following page, depicts the nature and timing of critical near-term Scenario B initiatives in three areas -- common data standards, improved access to ground-water data across programs, and enhanced ground-water data analysis capabilities. As shown in Exhibit IV-1, the study team also recommends a formal re-assessment of progress to date at the end of Fiscal 1989; that evaluation is to be used to develop a new action plan for review and approval by the Ground-Water Data Requirements Policy Committee.

In summary, Scenario B will yield critical improvements in ground-water data management with a minimum of organizational disruption and risk. If additional initiatives are determined to be necessary or beneficial, Scenario B can be used as a foundation for implementing additional improvements in the future.

Exhibit IV-1

CRITICAL NEAR-TERM INITIATIVES FOR SCENARIO B



CHAPTER V: IMPLEMENTATION PLAN

The Ground-Water Data Requirements Analysis Policy Committee has reviewed the alternatives for improving ground-water data management and reached consensus on a set of specific initiatives to provide the fundamental building blocks to enhance ground-water data management in the follow areas:

- Data management standards, policy, and guidance
- Data access and automation
- Data analysis.

This chapter describes the implementation plan developed for these key initiatives. The implementation plan describes the near term actions -- those scheduled to occur in FY 87 through FY 90 -- for each activity.

A. Initiatives in Data Management Standards, Policy, and Guidance

Data management standards, policy, and guidance are the rules that determine how ground-water data is collected and stored. One of the major barriers to effective ground-water data management identified in this study is lack of common data standards among EPA Headquarters, Regions, and states. Data collection, coding, and reporting conventions are not uniform across all programs. This lack of standardization makes it difficult to integrate data from many sources and reduces the value of data that is shared.

1. Develop Ground-Water Data Standards

Perhaps the most important initiative is the development of standard data formats for all relevant classes of ground-water data. Key tasks in this initiative include:

- **Establish an EPA/State/Other Federal Agencies work group ...** to provide one unified, centralized coordinating and planning

source in the area of ground-water data management. This group would direct the task of developing a consensus on ground-water data standards.

- **Document Current Standards Across Different Programs ...** to determine the basis for the development of common data standards and record formats for manual and automated systems.

- **Develop Common Data Standards and Record Formats ...** to provide a common basis for the storage of the four major types of ground-water data. This task would identify the critical data elements for each ground-water data type and define common standards.

- **Develop a Minimum Data Set for Ground-Water Data ...** to ensure uniformity in the collection and storage of ground-water data. The minimum data set includes that basic information (e.g., well location, sample method, etc.) that should be collected every time a sample is collected, a well drilled or facility permitted.

- **Analysis of Needs for Minimum Common Reporting Requirements ...** to assess requirements for standard ground-water reporting requirements (e.g., at the site level) across all programs to facilitate cross-program coordination.

2. Hold a Ground-Water Data Management Conference and Other Workshops

In order to inform the states and others in a variety of ground-water activities, issues, and topics, EPA will sponsor a ground-water data management conference (perhaps in conjunction with other groups). The conference will help EPA, states, and other groups understand the purpose and uses of the ground-water data standards and formats and provide additional, hands-on training in STORET and other EPA or federal agency databases. The conference will focus on the explanation of new EPA policies and procedures, detail planned EPA actions in ground-water data management, address special topics, and collect input and feedback from the states on current and proposed ground-water activities and initiatives.

B. Initiatives in Data Access and Automation

Data access and automation refer to the ability of decision makers to obtain and use data from other organizations and automate ground-water data

within their own programs. This study found that most ground-water data is now stored in manual files, with access and retrieval complicated by the lack of indexes to the locations and characteristics of that data. Ground-water data within one state may reside with several different organizations, from the Department of Public Health to the State Geologic Survey, making data collection most difficult. Where automated data does exist, users were frequently not aware of its availability or of the specific access procedures necessary to obtain it.

The Policy Committee selected three initiatives to improve the accessibility of ground-water data to EPA and state decision-makers: (1) develop STORET enhancements; (2) develop a catalogue of ground-water data sources; and (3) develop a baseline report on ground-water data sources.

1. Develop STORET Enhancements

STORET currently serves as a repository for ground-water data of many states and EPA Regions. Enhancement of STORET to more readily accept and easily retrieve ground-water data would provide states with a more user-friendly tool for collecting, storing, and manipulating ground-water data. Possible task areas in this effort include:

- **Identify Appropriate Enhancements** ... to ensure more efficient and effective utilization of existing and planned capabilities.
- **Develop User-friendly Menu Structure** ... to facilitate access for the non-computer professional.
- **Enhance Remote User Dial-up/ Communications** ... to improve access for remote users, including upload/download capabilities.
- **Modify STORET Input and Update Processing** ... to ensure data quality. Software will be developed to provide routine error checking to better regulate STORET ground-water data quality.
- **Continue Training in Use of STORET for Ground-Water Data Management** ... to provide users with full awareness of the system's capabilities.

2. Develop a Baseline Report (or Catalogue) on Ground-Water Data Sources

The Ground-Water Data Requirements Analysis study found that there are few central repositories of ground-water data. Individual programs typically collect and store the data needed to support their own operations. At the state level, some states have begun efforts to develop an integrated approach to ground-water data management. For example, Minnesota is developing the Integrated Ground-Water Information System (IGWIS) and Texas has the Texas Natural Resources Information System (TNRIS). At the Federal level there are two major repositories of ground water quality data -- STORET and WATSTORE. A "how-to" catalogue on existing ground-water data sources and systems would facilitate data access. Activities on this project include:

- **Develop Inventory of Relevant EPA, Major State, and Other National Ground-Water Data Systems and Sources ...** to provide environmental decision makers with location of available automated data.
- **Identify Data Types Stored in Each Source and System ...** to enable ground-water data users to more quickly identify the type of ground-water data available (e.g., well descriptors, hydrogeologic descriptors, water quality/sample descriptors, and related descriptors).
- **Provide a System Characterization ...** detailing system capabilities, location, access requirements, point of contact, and other relevant information for all systems in the catalogue.

3. Develop Catalogue of Ground-Water Data Sources

Should the Baseline Report or Catalogue prove successful, that basic information could be enhanced. To supplement the information available from automated ground-water data sources and systems, an index or catalogue of existing sources of ground-water data is a useful tool. The catalogue would contain pointers to the location (e.g., State Geologic Survey, Department of Agriculture) of ground-water data collected within a state or EPA Region. Key activities include:

- **Select Pilot States ...** to develop the proper mix of states (e.g., including advanced states as well as those with more fundamental needs) for participation in development of a pilot catalogue.

- **Develop Pilot Catalogue ....** to provide pointers to the various data types and sources of ground-water data within a state.

- **Evaluate Catalogue and Continue to Full Implementation ...** to assess the strengths and weaknesses of the pilot project and implement an appropriate set of catalogues nationwide.

C. Initiatives in Data Analysis

Data analysis refers to the manipulation of raw ground-water data (e.g., water quality/sample descriptors, well descriptors) to identify trends or patterns in ground-water quality. Data analysis tools include statistics, modelling, mapping, and graphics. The development of these tools and the education of the user community could enhance the quantitative basis for ground-water decision making. There are two major initiatives in this area: (1) development of a catalogue of ground-water analytic tools; and (2) geographic information system projects, studies, and pilots.

1. Develop a Catalogue of Ground-Water Analytic Tools

Based upon an evaluation of the utility of the ground-water data sources catalogues EPA may proceed with the development of an inventory of existing automated tools. Decision makers need the right tools to analyze ground-water data. This initiative develops a catalogue of existing ground-water data analysis tools. Key activities include:

- **Development of an Inventory of Existing Automated Tools ...** to establish a baseline for the development of additional capabilities and provide a convenient reference for the user community.

- **Validate High-Use Ground-Water Flow Models ...** to ensure that the models currently used provide accurate predictive capabilities and to provide guidance to users on the advantages of various models in different situations.

- **Develop a Catalogue of Ground-Water Analysis Tools ...** for use by ground-water data users. For each tool, the catalogue would include the tool's purpose (e.g., modelling, statistical analysis), a contact person and organization, data requirements, and other general information.

2. Conduct Geographic Information System (GIS) Projects/Studies/Pilots

EPA is currently developing an Agency policy on GIS applications. In addition to the development of an overall policy and guidance statement, EPA will consider GIS applications in ground-water data management. Given the potential strengths of GIS and the frequent EPA/state requirement to generate maps overlayed with relevant data themes (e.g., soils, topography, facility location), it is important for EPA to determine the role of GIS in ground-water data management. To this end EPA will conduct a series of projects, studies, and pilot efforts to determine the role of GIS applications in ground-water data management.

A preliminary schedule for the implementation of these initiatives is provided below.

Actions Required from EPA/States