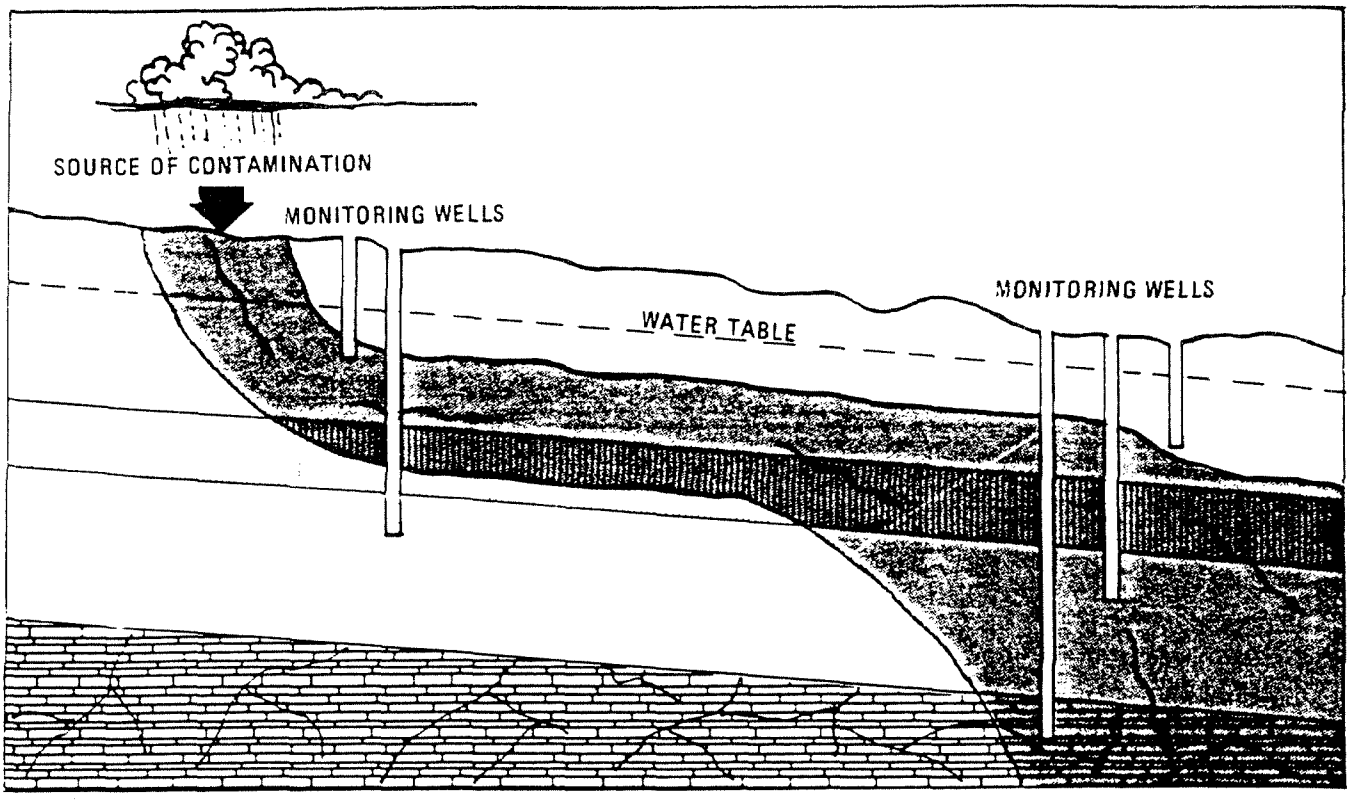

Ground Water Monitoring Strategy for Washington

V. Data Management Strategy

WASHINGTON STATE DEPARTMENT OF ECOLOGY

June, 1989
90-9

printed on recycled paper

GROUND WATER MONITORING STRATEGY FOR WASHINGTON

V. Data Management Strategy

June 1989

Laura Arnow

Principal Author

Water Quality Program
Washington Department of Ecology
Olympia, Washington 98504-8711

ACKNOWLEDGMENTS

The author wishes to thank all those who contributed towards this fifth and final Ground Water Monitoring Strategy for Washington report based on the context of the preceding four reports written by **Barbara M. Carey**. Funding for development was provided by the U.S. Environmental Protection Agency.

Special thanks goes to all former and current Staff of the Ground Water Unit under the supervision of Bob Monn, Water Quality's Management Section Head, and his Secretary, Denise Reynolds. Their assistence was fundamental in the completion of this report. Ground Water Unit Staff include: Nancy Darling, Russ Darr, Bert Bowen, Ginny Stern, Barb Stuart, Dayle Ann Stratton, Nancy Winters, and Douglas McGregor.

Valued written responses were received from: Bill Yake's Toxics Investigations/Ground Water Monitoring Section; Dave Garland of the Northwest Regional Office's Water Quality Technical Operations; Mat Gubitosa and Ray Peterson of EPA.

Valued verbal comments were received from: Central Regional Office's Bob Barwin; Eastern Regional Office's Carl Nuechterlein; Ed Hares from the Southwest Regional Office.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GROUND WATER DATA MANAGEMENT STRATEGY

EXECUTIVE SUMMARY

Effective data management can provide a needed link between ground water quality information gathered in the course of monitoring activities and management decisions made for protection of ground water. This is the fifth report in the five-part Ground Water Monitoring Strategy. Its purpose is to outline ways to integrate water quality data and other types of data in order to make sound management decisions based on the best available information. The data management strategy supports the five primary objectives of the Ground Water Monitoring Strategy:

-- Characterize the ground water resource.

-- Promptly identify new ground water problems.

-- Assess known problems to determine cause-and-effect relationships.

-- Ensure compliance with regulations.

-- Evaluate the effectiveness of ground water management programs.

Interviews with the Ground Water Quality Unit Hydrogeologists in the Water Quality Program at HQ and in Regions (called the Ground Water Quality Group in this report), and the Environmental Investigations and Laboratory Services' Toxics Investigations and Ground Water Monitoring Section (called EILS in this report), indicated that most staff members were unaware of the data resources available to them, or did not know how to use them. These staff expressed the following types of data management needs:

-- A central repository for monitoring data.

-- Information on what data resources are available.

-- Access to data.

-- Skills for using data resources and tools.

-- Agency-wide data systems.

This Data Management Strategy describes the data resources and tools that are available to meet these needs for ground water quality analysis, and evaluates the advantages and disadvantages of each option. The following four major types of data are discussed:

-- Parametric Data from Monitoring Work
-- Geographic data
-- Chemical Toxicological data
-- Bibliographic data
-- Statutory/administrative data

The Data Management Strategy also covers the following types of data management tools:

-- Data entry
-- Data storage and retrieval
-- Sorting, querying, organizing data
-- Verification of data quality
-- Statistical analysis
-- Spatial analysis
-- Cartography
-- Reporting and presentation
-- Communications

The Data Management Strategy's implementation plan provides a route to coordinated data management for ground water decision-making, and outlines the roles and responsibilities of major parties involved in ground water data management. The implementation plan is based on three components:

-- The establishment of agreements on procedures for handling information and on data formats for the central repository,

-- Technical assistance (including training) to bring the various users of ground water data into an effective information network, and

-- Design and development of an agency-wide data system, including a GIS, that can handle information important to ground water quality analysis.

By carrying out these steps, Ecology's ground water quality staff can develop a data management system that allows the agency to make informed management decisions for the protection of Washington's ground water.

GROUND WATER DATA MANAGEMENT STRATEGY

INTRODUCTION

Ground water management decisions are based on a wide variety of information, not just on water quality data. As a result, ground water data management is an interdisciplinary task, and involves several parts of Ecology and other agencies - local, state, and federal. The information needed to make sound decisions about ground water quality is not easily accessible or centrally located, and the network of people who use ground water-related information is also widely scattered.

This Data Management Strategy addresses this concern and represents Part V of the Ground Water Monitoring Strategy for Washington. Part III, Ground Water Monitoring Needs Evaluation, and Part IV, Recommended Strategy for Addressing Monitoring Needs, list specific ground water data management needs, including the following:

-- Integrate and coordinate ground water data management (e.g. Regional Offices and various programs);

-- Establish common data descriptors, definitions, units of measurement, and location identifiers;

-- Develop Geographic Information System (GIS) for overlaying, displaying, and interpreting complex data;

-- Develop ground water compliance monitoring data management capabilities.

By proposing ways to meet these needs, this Data Management Strategy outlines a way to improve Ecology's ability to apply ground water quality data to management decisions.

GROUND WATER DATA MANAGEMENT STRATEGY

PURPOSE

The purpose of the Data Management Strategy is to outline a path toward a data management system that allows the Ground Water Quality Group and EILS to integrate ground water quality data into management decisions. This strategy proposes a data management system defined to meet five objectives of the Ground Water Monitoring Strategy:

-- Characterize the ground water resource.

-- Promptly identify new ground water problems.

-- Assess known problems to determine cause-and-effect relationships.

-- Ensure compliance with regulations.

-- Evaluate the effectiveness of ground water management programs.

In doing so, this Data Management Strategy will provide the Ground Water Quality Group tools for developing preventive programs and developing policies, guidelines, and regulations for managing ground water. The Data Management Strategy gives staff access to information gathered through permitting and enforcement, site investigations, research projects, and monitoring programs, and to supporting information from a wide variety of sources outside the Department of Ecology. It provides a more coordinated information network and a more complete information base for making management decisions about ground water.

SCOPE

In creating the path to an integrated data management system, the Data Management Strategy evaluates data management requirements (both for information and for the tools for handling it), discusses and evaluates options to meet those requirements, and recommends necessary actions to accomplish the overall data management objective. It also includes an implementation plan which defines the process for meeting that overall objective.

The Data Management Strategy evaluates the need for ground water data management from the perspective of the Ground Water Quality Group, based on interviews with ground water staff and computer support staff at Ecology and at EPA, and on research into available computer technology. The Data Management Strategy outlines the ways that the Ground Water Quality Group currently uses information, the data management requirements of the Group that are not presently being met, and the tools and information that could meet those needs. It describes options for matching appropriate data management resources to Ground Water Quality Group needs, and offers plans for bringing these options into the Group, including training, acquisition of equipment and software, and development of databases.

A ground water quality database, parametric data based on samples of ground water from monitoring work, is the core of the data management system for the Group, but the Strategy also evaluates the use of four other kinds of supporting data that can be used to understand ground water problems:

-- Geographic data - information which may be useful in understanding or managing a ground water problem, such as: Lithology, well and aquifer locations, well construction, political boundaries, field observations, etc.

-- Chemical Toxicological data - contaminant attributes: health effects, physical characteristics, methods of removal from the ground water.

-- Bibliographic data - information on technical literature on ground water and related topics.

-- Statutory/administrative data - information on government programs, laws, regulations, enforcement, and activities at the federal, state, or local level, such as enforcement activities information, permit data, or databases of government documents.

The Data Management Strategy discusses databases available to meet the Group's needs for each type of data. It discusses problems associated with using these databases, including questions of compatibility and accessibility, and recommends ways to select and utilize appropriate sources of information. The Strategy also evaluates tools for handling data, and recommends which tools should be used to meet the Group's ob-

jectives. The Data Management Strategy considers issues related to intra- and inter-agency cooperation on data management for ground water, methods for helping users become more familiar with data management technology, and ways to link the various users of ground water information.

DATA REQUIREMENTS

The following sections describe the kinds of information the Ground Water Quality Group uses or could use to make sound, informed management decisions to protect ground water.

Central to the data needs of the Ground Water Quality Group is parametric data from monitoring work. In addition to parametric data generated by ground water monitoring activities, the Ground Water Quality Group needs a variety of data to support its work in carrying out the goals of the Ground Water Monitoring Strategy. For example, in order to characterize the ground water resource, the Group needs geographic information on lithology to help define aquifers. The staff might use background information on the chemical attributes of a particular contaminant in assessing whether its presence indicates a new ground water problem. To understand cause-and-effect relationships related to a known problem, the staff would need to consult technical literature (bibliographic data) to gain perspective on the issue. In order to ensure compliance with regulations and evaluate program effectiveness, Group members need information on agency actions, such as permit requirements and enforcement actions, and on programs, laws, and regulations in other states or at the federal level.

Presented below for each type of data is a brief description of the role of that data, the needs for that type of data, the options available to meet those needs, and recommended steps to address those needs. Table 1 presents a summary of these information needs and recommendatios.

PARAMETRIC DATA FROM MONITORING WORK

The critical core of ground water quality data is information about the water itself. The first four parts of the Ground Water Monitoring Strategy identify this as the essential element of ground water data needed to meet the goals of characterizing the resource, identifying new problems, assessing cause-and-effect relationships, ensuring compliance with regulations, and evaluating program effectiveness. Parametric data can include contaminant levels and a wide variety of other attributes of ground water.

Needs

The Ground Water Quality Group needs a reliable, complete set of information on ground water quality in Washington, with:

-- Consistent data formats for ground water information to allow statewide and chronological comparisons of parametric data, including systems for well identification and location and a standard list of parameters.

-- Standards for assurance of data quality and integrity.

TABLE 1. INFORMATION USED BY THE GROUND WATER QUALITY GROUP

Needs:	Recommendations:
PARAMETRIC DATA	
Consistent data formats	Adopt standardized formats
Standards for data quality	Develop data quality standards
Consistent coverage statewide	Prioritize data to acquire
	Support monitoring efforts
	Acquire data as needed
GEOGRAPHIC DATA	
Information on available coverages	Establish and maintain contact with other GIS users
Ability to integrate data into GIS	Design GIS-compatible databases
Input into GIS planning process	Establish and maintain involvement in GIS planning
Statewide aquifer information	Support well report database
	Acquire aquifer data
Information on available databases	Inventory background data
CHEMICAL TOXICOLOGICAL DATA	
Information on chemical attributes	Research chemical information
	Identify chemical databases
BIBLIOGRAPHIC DATA	
Skill with on-line services	Provide workshops on on-line services
Track ground water materials	Adapt bibliography for other media
Updated ground water bibliography	Include staff libraries
AGENCY/LEGISLATIVE DATA	
Information on agency actions	Arrange for data summaries
Information on ground water use	Support improvements to WRIS
Information on regulatory activity	Inventory government databases
Information on laws and regulations	" " "

-- Consistent coverage across all areas of the state, with special attention to threatened and vulnerable areas.

-- A process for staying informed on what data resources are available.

Available Options

STORET data. This database dates back to the early sixties, when EPA began storing water quality information on an IBM mainframe computer. STORET accepts tens of thousands of parameters, some basic information on the nature and location of the sampling station, and other information related to water quality monitoring. Mainframe STORET ground water data for Washington come mainly from either the U.S. Geological Survey (USGS) or the U.S. Forest Service. Because STORET is an open database, anyone can enter information in it; as a result, not all of the information is reliable.

Ecology-collected monitoring/intensive information. Much of the ground water information gathered by the Regional Offices is maintained either on paper or in individual spreadsheet files in SMART or other software systems. EILS' special investigations ground water data are stored in ENVIS, a database management system designed specifically for ground water quality information. The Hazardous Waste Investigations and Cleanup Program uses ENVIS, too, to store information from monitoring wells on its sites.

Local government data, e.g. county health/planning departments. At present, information from local government reports on ground water is available mostly in paper form, although more and more local agencies are using computers for ground water work. There is no standardized ground water quality data format for local governments.

Clean Water Act and Centennial Clean Water Fund grants-generated data. Information generated by grants projects is presently used as reference material by the Group. If future grantees are required to submit data in a standardized digital format, they could be more useful for statewide analysis.

Ground Water Management Area (GWMA) data. Although none of the GWMAs have submitted the data required by their contracts as of the date of this report, they are required to provide the Water Resources Program with ground water quality monitoring data in a strictly specified, STORET-compatible format, as outlined in the Ground Water Management Area Program's Data Reporting Manual. This manual, which also describes specific formats for WATSTORE-compatible physical well data and for other types of data gathered in ground water studies, could serve as a model for standardized ground water data format.

DSHS drinking water well data. Under a contract between DSHS and Ecology, DSHS provides quarterly updates of their statewide Class 1 and 2 drinking water well monitoring data in STORET format. Additional

information about Class 3 and 4 wells may be available as well. Although DSHS drinking water well information is in a STORET-compatible format, Ecology has not yet uploaded any of it to STORET. EILS maintains this information in the PC-STORET format on a personal computer with a Bernoulli box (a high-capacity, removable disk on a PC).

USGS water quality data. In the past, all water quality data from USGS work has been stored in WATSTORE, the USGS ground water database, and appropriate information is uploaded to EPA's STORET system quarterly. The USGS now uses NWIS, the National Water Inventory System, which is compatible with ARC/INFO geographic information system software. NWIS data are stored on regional minicomputers. NWIS water quality information is transferred to WATSTORE and uploaded to STORET.

Academic studies' databases. Because there is no standard for developing ground water databases, data from academic studies may be stored in any type of digital or paper form.

Recommendations

-- Adopt standardized data formats, numbering and identification procedures, and lists of required and acceptable parameters for state monitoring information, based on the Ground Water Management Area Program and the GWMA Data Reporting Manual. Develop agreements with Ecology programs and grantees, and with other agencies collecting ground water information if possible, to ensure that new data are stored in standard format.

-- Design standards for quality assurance and quality control of ground water quality data.

-- Identify the types and locations of parametric information still needed, and prioritize data to acquire.

-- Provide technical assistance in transforming existing data into the standard format, beginning with data that will satisfy high priority data needs.

-- Support the monitoring effort to expand and improve the parametric database.

-- Acquire and digitize additional databases as they are needed for particular projects by the Ground Water Quality Group.

-- Inventory annually the existing digital and hard-copy ground water data available from federal, state, and local agencies and private consultants working with ground water, using a questionnaire; keep a master file of ground water databases.

GEOGRAPHIC DATA

To get a whole picture of what is going on with ground water, decision-makers need to understand spatial patterns and interactions. Information on the locations of geographic features, both natural and human, allows the analyst to interpret interactions in the environment that are not obvious in strictly statistical analysis. Geographic information about a particular topic, when it is digitally recorded, composes a layer (also called a coverage) of data in a geographic information system. (See information on GIS functions under "Statistical Analysis" in the Data Management Tools section.)

Needs

The strength of a GIS is its ability to portray relationships between different types of geographic attributes, such as land use, geology, soil type, topography, demographics, etc. The system cannot, however, produce information. Before the Ground Water Quality Group can make use of a GIS, its members need to decide what kind of spatial information is important, and at what level of detail. After the data sets are identified and found (or collected from the field, if they do not already exist), the Group still has to acquire them in digital form. This may involve purchasing coverages or digitizing them from primary sources. In addition to finding needed coverages, the Group may look for ways to link background databases describing, for example, the characteristics of aquifers or the construction information for wells to the geographic databases.

Some of the kinds of geographic information that could be useful to the Ground Water Quality Group are listed in Table 2. The needs outlined in Table 2 can serve as a starting point for geographic data acquisition as the Group becomes involved in planning an agency-wide GIS. At present, the Group needs:

-- Up-to-date information on what coverages are available, at what scale.

-- The ability to integrate tabular ground water data into a GIS when the GIS becomes available.

-- Input into the GIS planning process that will determine the scale and structure of an agency-wide geographic data system.

-- Consistent, statewide information on aquifer attributes such as lithology, soils, depth to water table, in order to understand the character and extent of the state's aquifers.

Available Options

Some layers of digital geographic data developed by state and federal agencies, or by private entities, are available for purchase (or, in some cases, at no charge). EPA has just launched a GIS effort, and is

acquiring a number of coverages which it will make available to Ecology at no or low cost. Coverages which have not been created yet could be very costly to research, map, and digitize. The cost and difficulty of acquiring geographic information also depends on the level of detail and scale the Group requires. This outline of geographic coverages lists some of the kinds of information the Group could acquire in the course of a GIS planning and development effort.

Geology: DNR in the next several years may digitize its surface geology maps for Washington, which would make them available to us, at some cost. The USGS has mapped surface geology at a scale of 1:2,500,000, and this coverage will be available through EPA.

Well locations: Any database that includes a latitude/longitude identifier for each well can be converted into a coverage for a GIS. STORET, injection well data, GWMA information, and ENVIS files all fall into this category.

Injection well database: The location and status of injection wells is stored in a SMART database maintained on the Water Quality Program LAN. The information is uploaded to EPA twice yearly.

Land Use Patterns: After the 1990 census, the U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) files will include demographic information. Land use coverages are available through the USGS from aerial photo surveys carried out in the 1970's, but are highly inaccurate. Land use information could be developed from Water Quality's Waste Discharge Information System (WDIS) file, ENVIS files at the Hazardous Waste Investigations and Cleanup Program, the Solid Waste Program's database of landfills, and the Enforcement Data Base. Locations of public water supply versus private wells could be developed from DSHS drinking water well files.

Contamination database: Ground Water Quality Unit staff created this database in SMART in 1988 in order to assess the effects of nonpoint source pollution on ground water. It includes records for known sites or areas of ground water contamination in 1988, but does not contain actual parametric information.

Landforms (topography, elevation): Some landform information is included in DNR's system. The USGS has coverages for Washington elevation at a scale of 1:250,000, which will be available to us through EPA.

Hydrography: The DNR and STORET geographic databases both contain stream locations. STORET's file is the EPA River Reach file, a standardized nationwide stream catalog system, and will be available at 1:100,000 in 1990. USGS hydrography is available at 1:2,000,000, and the USGS Hydrologic Units boundaries are mapped at 1:2,500,000.

Aquifer locations: In its Regional Aquifer System Analysis (RASA), the USGS is completing mapping the Columbia basalts and will move on to map the Puget Sound basin next with this ARC/INFO-based geographic informa-

tion system. The database includes information on the surface contours and thickness of the aquifer and much more data as well. Within Ecology, Major Geographic Aquifer Systems (MGAS) maps are being created by hand in the Ground Water Quality Unit; they should be digitized and could serve as basic aquifer location information. Because the delineation of aquifers demands highly technical (and subjective) decisions, it may be more accurate to store the geographic locations of aquifer attributes, rather than attempting to map the extent and location of the aquifers themselves.

Depth to water table: With considerable effort, the well reports now stored as paper files could be converted to a database of information on water levels. Well reports are not highly reliable sources of water level data, however, and should be treated cautiously.

Regional Offices Information: Regional Water Resources staff is responsible for maintaining information from well reports. Although this information could be useful in understanding the characteristics of aquifers, it is presently not organized enough to be put to use for statewide assessments. The Water Resources Program is looking for ways to keep track of these documents digitally.

Road locations: DNR has road coverages at 1:100,000 available for purchase. The Census Bureau TIGER files also include road coverages. USGS files include transportation coverage at 1:2,000,000.

Ground Water Management Areas: The GWMAs will be providing (as described in Part I of the Ground Water Management Area Data Reporting Manual) information on well construction. They may also provide other information, such as lithology, although it is not required.

USGS: The USGS gathers lithologic information and other data relevant to ground water quality analysis. The Ground Water Quality group may be able to arrange contracts with USGS to obtain information about particular aquifers.

Recommendations

-- Maintain contact with other agencies and consultants involved in ground water GIS applications (especially EPA and DNR) to learn what coverages are available and useful for ground water analysis.

-- Ensure that new databases designed by and for the Ground Water Quality Group are compatible with GIS data management. (For example, data records should include coordinate locations.)

-- Become actively involved with agency GIS planning. (This process will include a more specific evaluation of the Ground Water Quality Group's GIS needs than can be included in the scope of this document.)

-- Support the Water Resources Program's efforts to create a computer-

ized system for managing well log data.

-- Acquire information on aquifer attributes as it becomes available through USGS, pursue cost-share arrangements with USGS to develop this information across the state, and support further efforts to gather aquifer data as recommended by earlier parts of the Monitoring Strategy.

CHEMICAL TOXICOLOGICAL DATA

When contaminants are found in wells, the Group needs to know about their attributes: health effects, physical characteristics, methods of removing them from the ground water.

Needs

-- Information on chemical attributes, including treatability, environmental fate, health effects, etc.

-- Information on what databases are available and how to use them.

Available Options

Toxicity databases: A variety of databases, such as the Integrated Risk Information Service (IRIS), and AQuatic Information REtrieval (AQUIRE) system, maintained by EPA, are available free of charge, and include information on chemical toxicity, ongoing monitoring projects, and other ground water-related topics.

Treatability Database (WERL): This EPA database resides on the Water Quality Program LAN; the Ground Water Quality Unit is testing its usefulness for the developers. It includes information on chemical attributes and treatment methods for a variety of contaminants.

Chemical information databases: Information on the sources, by-products, uses, and health effects of toxic chemicals, on pesticide labelling, etc. is maintained in specialized, public databases in DIALOG. These carry a user fee, but might be very cost-effective for special projects, and are available through the Ecology Library.

Recommendations

-- Continue to research databases of chemical information.

-- Make training and documentation available to staff.

GROUND WATER DATA MANAGEMENT STRATEGY
TABLE 2: GEOGRAPHIC COVERAGE TYPES

	LOCAL COVERAGE	REGIONAL COVERAGE	STATE COVERAGE	PROJECT-SPECIFIC	GENERAL ASSESSMENT
Surface Geology	X	X	X	X	X
Soils	X	X	X	X	
Well locations, depths, types, etc.	X	X	X	X	X
Land Use Patterns					
urban/rural (housing density)	X	X	X		X
zoning (industry/agric./resid.)	X	X		X	
septic systems	X	X			
contamination sites					X
public/private water supply					X
crop type/livestock	X	X	X	X	X
irrigation	X	X	X	X	X
chemical use locations	X	X	X	X	X
permitted/actual uses	X	X			
Hydrography	X	X	X		
Aquifer locations	X	X	X		X
Depth to water table (contour maps)	X	X			
Topography	X	X	X	X	
Political boundaries	X	X	X	X	X
Primary and secondary road location	X	X	X		
Lithology		X			
Rainfall	X	X	X		X
Major Geographical Aquifer Systems		X	X		X
Aquifer Study Areas	X	X	X	X	X
Ground Water Management Areas	X	X	X	X	X

BIBLIOGRAPHIC INFORMATION

Bibliographic databases help staff locate literature both within and outside of Ecology, and could also be used for keeping track of other types of materials, such as slides, databases, and lecture notes.

Needs

-- Skill and familiarity with on-line services.

-- System for tracking slides, lecture notes, and other materials used by Ground Water Quality Group staff.

-- Updated bibliography of ground water literature, including materials available in the offices of Ground Water Quality Group staff, searchable based on geographic locations and subject areas covered in the reference and on type of reference material.

Available Options

Searchable bibliography on ground water (Water Quality Program LAN): This custom database was developed at Water Resources, and Ground Water Quality Unit staff has added to it. It can be searched based on keywords, locations, or parts of a title, and has ample extra space for adding additional searchable fields.

Searchable bibliography on general environmental topics (Ecology Library): This is accessible via modem from the Water Quality Library computer. Self-explanatory instructions are posted on the wall by the machine.

Commercial on-line bibliographies: Library staff can provide information on DIALOG and other on-line services available through the Ecology Library. Commercial database companies charge a fee for data searches, based on the amount of time on the system and the kind of operations executed.

Recommendations

-- Provide workshops on the use of on-line services.

-- Adapt the existing Ground Water Bibliography to include alternative reference materials, and allocate a searchable field for reference type. Improve use of the key fields already allocated for location and subject.

-- Develop a system for cataloguing references in staff's offices, and enter the information in the Ground Water Bibliography.

STATUTORY/ADMINISTRATIVE INFORMATION

This category encompasses information related to actions taken by Ecology and other agencies in carrying out their responsibilities related to ground water protection. It includes information on programs, regulations and laws within Washington, in other states, and at the federal level. It also includes mailing lists used to maintain contact with the public and other organizations interested in ground water quality issues.

Needs

-- Access to information on agency actions.

-- Access to information on ground water use.

-- Access to information on Washington laws and regulations, on other states' ground water programs and laws, and on federal programs and laws related to ground water.

-- Information on what databases are available in Washington related to regulation of activities that affect ground water.

Available Options

State Waste Discharge Permits (WDIS): This SMART-based database, maintained by the Point Source Section, includes information from the NPDES and State Waste Discharge permit systems on discharges to surface waters and to the ground. EPA depends on WDIS for data for its Permits Compliance System (PCS).

Enforcement Orders, Notices of Violation, and other agency actions: Information from enforcement actions, inspection reports, and cleanup summaries can be related to ground water quality. The SMART-based Enforcement Database maintained by Central Programs contains much of this information; their staff performs retrievals from the database on request.

Paper files on permits, inspections, enforcement: Because these are not always standardized or computerized, it is difficult to get access to them, or to know what information is available.

SEPA declarations: SEPA documents are an important part of many decisions affecting ground water. Ground Water Quality Unit staff is developing a SMART database to store SEPA checklist information.

Water Rights Information System (WRIS): Data on Water Rights Permits is stored in Water Resources' WRIS database on the state's mainframe computer. The Ground Water Quality Group could make use of WRIS to interpret patterns of ground water withdrawal state-wide. WRIS uses township-range-section location identifiers, and these would have to be translated, if greater detail were needed, to a coordinate system before

the data could be used in a GIS. The older data in the system is of inconsistent quality, some of the information from the older records is unavailable, and there is a backlog of recent information waiting to be entered.

Other state and federal regulations and legislation. Government documents are maintained at the Department of Ecology or the State libraries. LEGI-SLATE is an on-line service containing information on federal actions. Other on-line search services available through LEXIS (a legal on-line service system) and through DIALOG enable users to retrieve state and federal government information nationwide.
Pesticide Monitoring Inventory (PMI): EPA maintains this database of federally-funded projects monitoring pesticides in the environment; it is searchable based on contaminants, media, and other fields.

Washington state laws and regulations: Through the Water Quality Program LAN Gateway to the DIS mainframe, Water Quality staff has access to the PROFS system, which includes a searchable database of the Washington Administrative Code (WAC) and Revised Code of Washington (RCW).

Water Quality Mailing List: The Water Quality Program LAN has an annotated mailing list which the Group uses for pulling mailing lists and labels for its own needs. An agency-wide mailing list system has been proposed.

Recommendations

-- Arrange to receive regular summaries of information stored in WDIS and the Enforcement Database, and provide instructions to staff on how to request detailed information from these agency databases.

-- Support the Water Resources Program's efforts to improve WRIS, and provide training to staff in the use of this system.

-- Provide training in using on-line legal search services.

-- Inventory Ecology and other state and local agencies for data bases on legal actions, laws, or programs relevant to ground water protection and develop a catalog of these databases.

DATA MANAGEMENT TOOLS

Software and hardware tools enable the Ground Water Quality Group to work with ground water information. They range from word processing systems that most staff use daily to more technical geographic information systems available if and when they are needed. In order to take advantage of the potential strengths of the tools available to the Group, staff will need general information on what the tools can do and how they should be used, and more training in their use. Any new data systems that are added to the set already available should be chosen carefully to match them to the actual needs of the Group. Table 3 provides a summary of the Group's needs for data management tools and the recommended methods for meeting those needs.

DATA ENTRY

A data entry system provides a standard interface between the staff who gather ground water information in the field and the central database. It allows field staff to add information to the database efficiently and accurately.

Needs

-- A "user-friendly" system able to handle a variety of parameters and attributes of wells and ground water, acceptable to users in the Regional Offices, at EILS, and at Headquarters.

-- Compatibility with the central database.

-- Standards for parameter codes, well numbering and location systems, and other data formats.

Available Options

ENVIS. EILS and the Hazardous Waste Investigations and Cleanup Program are both using ENVIS, a dBASE III application developed specifically to store and retrieve ground water information for individual sites or special projects. Staff report that the system is easy to use for data entry, and that the developers of ENVIS are willing to make needed modifications to improve their product's usefulness, including adding an interface with STORET.

Locally maintained spreadsheets. Regional Office staff presently enter ground water quality data in spreadsheets using SMART or other software. Although it is easy to enter data in this form, the spreadsheets are not standardized and cannot readily be combined or compared.

Custom database. Ecology, through its own staff or a consultant, could create a specialized ground water database to the specifications of the Ground Water Quality Group to be used for data entry. This would require considerable expense and effort on the part of the Group to

GROUND WATER DATA MANAGEMENT STRATEGY
TABLE 3. DATA TOOLS USED BY THE GROUND WATER QUALITY GROUP

Needs:	Recommendations:
DATA ENTRY	
User-friendly, adaptable system	ENVIS, with training & support
Compatibility with central database	Agree on format for data entry
Standards for codes and formats	Assign database administrator
DATA STORAGE AND RETRIEVAL	
Local access to local data	Use ENVIS and provide training
Central access to statewide data	Use STORET, provide training
Agreement on a central database	Ground Water Quality group agreement
Procedures for data transfer	ENVIS-STORET transfer utility
	Assign database administrator
	Technical support from EPA
SORTING, QUERYING, ORGANIZING DATA	
Ability to manipulate data	Training in data management
Awareness of data management tools	Catalog of data management systems
VERIFICATION OF DATA QUALITY	
Standards for data verification	Data verification manual
Proofreading field data	Automated error-check programs
Compatibility with central database	
STATISTICAL ANALYSIS	
Ability to analyze/graph trends	Assess needs for analysis
	Acquire statistical software
	Provide training
	EILS staff to perform analysis
SPATIAL ANALYSIS	
GIS for gr. water decision-making	Active role in agency planning
Hardware, software, skills	
Understanding of GIS capabilities	Training in GIS concepts
Access to relevant coverages	GIS-compatible databases
	Inventory available coverages
Telecommunications and data sharing	Technical assistance from EPA
CARTOGRAPHY	
Produce maps for presentations	Training in CADD and ARC/INFO
REPORTS AND PRESENTATIONS	
Visual aids and publications	Training in SMART and PageMaker
	Technical assistance: visual aids
COMMUNICATIONS	
Access to data resources elsewhere	Support Ecology network
Data transfer to central database	Install LAN at EILS

ensure that the design met the Group's needs.

Recommendations

-- Use ENVIS as the standard for ground water quality data entry, and provide ENVIS training and user support.

-- Before installing ENVIS in the Regional Offices and at the Ground Water Quality Unit at Headquarters, adopt standards on well numbering and location systems, on a parameter code list, and on any other data formats.

-- Assign a staff person the responsibility for handling data entry problems, maintaining a data dictionary, providing user support, and serving as the contact person between Ecology's users and ENVIS user support staff at Kleinfelder Co.

DATA STORAGE AND RETRIEVAL

To make effective use of information, the Group needs a systematic way to keep track of it. This system could be as simple as a file cabinet or Rolodex, if our data needs were straightforward and compact enough for such a format. More complex databases, especially large sets of information, are more efficiently managed with computers. Parts of the information needed for a particular project can be pulled out of the data set based on particular attributes of the information, such as location, sample type, time period, etc.

Needs:

-- Ability to access local information locally.

-- Ability to access statewide information from a central database.

-- Agreement on the content, location, and format of a centralized database.

-- Established procedures and adequate staff support for transferring information from the local to the centralized level.

Available Options:

STORET: The STORET database has its own command language, which enables the trained user to store and retrieve information from the system, but the language is complicated to learn. EPA offers extensive user support for STORET, and has enhanced the system with analytical software, geographic functions, menu-driven interfaces, and a PC-based version of STORET that assists users in preparing data to be stored on the mainframe. A new communications package may help with translations between STORET files and dBASE, Lotus, or SMART files. STORET system time, training, and user support are available to Ecology essentially free of

charge. Ecology's telecommunications network enables agency staff to use mainframe STORET via LAN gateways. In addition, PC-STORET, which runs on a personal computer fitted with a math co-processor, provides flexibility in adding data to the mainframe database and especially in doing retrievals for analysis on short notice. A primary advantage of using STORET is that it offers unlimited storage space and a predefined, standardized, GIS-compatible data format already accepted by many agencies for water quality information. In addition, EPA is willing to provide considerable technical support to enable Ecology to use STORET as its ground water data repository.

ENVIS: ENVIS can store smaller sets of data, such as site-specific information (such as monitoring data from a hazardous waste site) or project-based information (such as data gathered during a onetime contaminant study). ENVIS offers retrieval and report functions, and its files can also be exported to other systems, such as contouring or statistical packages, for analysis, or to another database system, such as STORET, for larger-scale storage. ENVIS' developers are willing to develop a utility to transfer files between ENVIS and STORET.

Locally maintained databases and spreadsheets: At present, some of Ecology's ground water databases are kept on personal computers; the information is stored on floppy disks or on the hard drive of a PC. Local databases are usually small and limited in scope to a small area or a single project. Only one person or a small group of users has access to the information, although it can be transformed into a shareable format. Some locally maintained databases are shared on a Local Area Network (LAN), rather than on a single PC. LAN-based systems can store more information than PC-based systems, and can be used by more than one person.

Custom database: Ecology, through its own staff or a consultant, could design a database application to the specific requirements of the Ground Water Quality Group. A custom database application for the Ground Water Quality Group could be expensive, both in dollars and in the amount of time the Group would have to spend on design. The customized application could be developed for a LAN or a mainframe computer.

Recommendations

-- Use ENVIS for local access to local information.

-- Use STORET as a central repository for statewide information, combining data from the local ENVIS databases.

-- Develop agreements about using STORET and ENVIS among members of the Ground Water Quality Group.

-- Purchase ENVIS-STORET transfer utility from Kleinfelder Co.

-- Assign a database administrator to handle transfers between ENVIS and STORET.

-- Solicit technical support for data transfers from EPA.

-- Provide training on ENVIS and STORET.

-- Study for custom database

SORTING, QUERYING, AND ORGANIZING DATA

It is not enough to have a place to keep information and a way of putting it there and getting it out. To make sense of the data, users need to be able to put it in order, ask questions about its composition, and maintain it in a systematic way. Computerized data management lets the machine do the tedious work of paging through the "notecards" and "file folders" of the information base.

Needs

-- Ability to manipulate databases of various formats.

-- Awareness of what data management tools are available and how to use them.

Available Options

dBASE III Plus: This is the industry standard for data management; it includes a programming language that can be used to develop customized applications or to perform multi-step operations to analyze, error-check, or execute calculations in a database. Its format requirements are compatible with those of SMART, Lotus, and most major software packages. Once a user is familiar with the dBASE environment, it is a powerful tool for exploring and analyzing one or more databases. Modifications to database structure and contents are fairly simple to make.

SMART Data Manager: Like dBASE, SMART can be used to develop "user-friendly" applications. With the Toolbox, it is relatively easy to create project applications. Because the Data Manager is menu-driven, some users find it easier than dBASE to run; it is, however, less flexible than dBASE, and much slower at handling large databases. The data manager enables the user to develop queries to explore the database, and allows the user to relate two databases to each other. Modifying the structure of an existing database can be difficult and time consuming.

STORET: The complex retrieval system in STORET enables the user to specify exactly which samples and/or sampling stations are desired for data manipulation operations. The system also includes various levels of analysis, which allow the user to explore the contents of the data set.

(Note: The Department of Ecology at this writing is examining other data base management systems with a view toward acquiring a system with application portability among PC, mini, and mainframe environments.)

Recommendations

-- Offer training in SMART, dBASE, and STORET data manipulation techniques.

-- Catalog existing data management systems.

VERIFICATION OF DATA QUALITY

Before committing a batch of information to a permanent data file, it is essential to check the data to ensure that it is up to the standards of the existing set. Without this error-checking, the entire database is no more valid than the worst of the information that is entered into it.

Needs

-- Standard procedures for data verification.

-- Proofreading of data entered from field information, including checking that values fall into reasonable ranges.

-- Ensuring that data format is compatible with the central database.

Available Options

dBASE or SMART applications: Both dBASE and SMART can be used for digital error-checking, by looking for values out of range.

ENVIS: ENVIS includes a dual-data-entry option, in which field data are entered twice and the computer compares the files and flags any discrepancies.

Manual data checking: Although it is extremely time-consuming, this is a time-honored way of looking for typographical errors or values out of range.

Ambient monitoring system: EILS is collaborating with the Department of Information Services (DIS) to develop programs to verify surface water data. These could potentially be adapted to verify ground water quality data.

Recommendations

-- Produce a manual of suggested data verification methods, including ways to check manually (spot-check, proofread, dual data entry) and techniques for computerized error-checking, with recommendations about when each method is most appropriate.

-- Develop automated programs for error-checking.

STATISTICAL ANALYSIS

In developing reports on ground water, Group staff analyzes parametric and other data statistically to show trends and patterns numerically or graphically. The statistical operations can range from simple averages and sums to more complex graphing and mathematical modeling.

Needs

-- Ability to analyze and graph ground water trends.

Available Options

SMART and other data managers: These packages include some simple statistical and graphic capabilities.

SAS: This state-of-the-art statistical system is available through STORET. SAS is also available on the DIS mainframe at a charge.

Statistical software: There are a number of statistical packages available on the market which are less powerful, but easier to use, than SAS.

Recommendations

-- Assess the specific needs of Group staff for statistical analysis capabilities.

-- Acquire a statistical package that is user-friendly and could meet most of the staff's needs.

-- Provide training for the chosen statistical package for all staff, and provide SAS training for staff who need more advanced statistical capabilities.

-- Make arrangements with EILS staff to perform statistical analysis for other Group staff upon request.

SPATIAL ANALYSIS

Because environmental issues, including ground water concerns, are spatially based, effective environmental data management requires spatial analysis of environmental trends and parameters. For example, the distribution of agricultural chemical contamination of ground water is related in part to the distribution of farmlands and to the aquifers beneath the croplands. In making policy decisions to protect citizens from that contamination, the Ground Water Quality Group could use information on where agricultural chemicals are used, what aquifers are affected in the areas they are used, and how ground water from those

aquifers is used (e.g. where are the drinking water wells that depend on that aquifer). This type of analysis depends on regionally based information, organized by the location of particular features, qualities, or events.

Geographic information systems can create a set of digital maps that reference and relate information based on location. By combining information from several computerized maps, the GIS user can, for example, identify areas of special concern, such as aquifers where both agricultural chemical use and drinking water wells are found. Environmental information, which is important not only to Ecology but to other state agencies concerned with natural resources or geographic systems (like transportation or utility distribution), can be shared through compatible geographic information systems to enhance all users' ability to interpret geographic patterns.

Needs

-- GIS designed to aid ground water decision-makers.

-- Understanding of GIS systems, their capabilities and limitations.

-- Ability to access GIS coverages relevant to ground water decision-making.

-- Adequate hardware, software, and skill for analyzing ground water information within the Group.

-- Telecommunications networks and data sharing agreements for acquiring other coverages as needed.

(Also see needs on page 11 under Geographic Data.)

Available Options

ARC/INFO: Because USGS, EPA, DNR, and other agencies involved with environmental spatial analysis are already using this software package for their geographic analysis, the Ground Water Quality Group can benefit from using the same system. ARC/INFO is a powerful GIS with good user support. Although other systems are less expensive and equally useful, the costs of ensuring compatibility with existing ARC/INFO systems would likely outweigh the benefits of the Group adopting an alternative system.

Shared station with Soil Conservation Service (SCS): The Water Quality Program has halftime access rights to one of two ARC/INFO stations located at Headquarters, which the Program shares with the Soil Conservation Service. The Ground Water Quality Group could use these stations, but realistically the Unit is not ready to take advantage of a GIS yet. The stations can run ARC/INFO locally or can link to DNR's Prime minicomputer and its GIS.

PC-based ARC/INFO: Although ARC/INFO and some other geographic information systems are available for use on PCs, the smaller computers limit the scope and effectiveness of the GIS software. The PC-based system could be useful for developing small-scale demonstration projects. It is already available on the SCS stations.

DNR Prime: DNR has developed the state's most extensive GIS, and the SCS stations can link to it for a fee. DNR sells its coverages to other agencies, in addition to charging for the use of its system. Minicomputers like DNR's Prime are standard hardware for operating ARC/INFO; they can serve many users at once and can store a great deal of information.

EPA Prime: EPA's Region X office has a GIS section now, and the agency is willing to assist Ecology by providing telecommunications technical assistance and by sharing free of charge any coverages it acquires for its system.

Stand-alone workstations: A dedicated ARC/INFO workstation is more powerful than a PC and more flexible and responsive than a system of terminals sharing a minicomputer. The user pulls selected coverages from a library stored on a larger mini or mainframe computer, then manipulates them locally without having to compete for time on the central computer.

Department of Ecology telecommunications network: In the next two to five years, the entire agency will need a shared computer system in order to organize and analyze environmental data for all of Washington. A minicomputer, smaller and more accessible than a large mainframe but larger and more powerful than networked personal computers, could meet Ecology's need for a central GIS computing platform. Minis have already been installed an headquarters and the Eastern Regional Office, and more are scheduled to arrive soon. A network of communications lines will link the minicomputers to each other, to the LANs in the Programs and Regions, and to mainframes and minicomputers at other state and federal agencies. The network will serve GIS users in addition to meeting a variety of other data management needs.

Agency GIS Planning: The strength of the GIS Ecology will eventually develop will come from full participation of all parts of the agency in its design; the Ground Water Quality Group should take an active role in that process to ensure its needs are met. Because a GIS is complex and expensive, it is important to allow sufficient time and resources for design and development of the system. System design is the most critical element of a GIS and is far more expensive in time and effort than the hardware, software, and data combined. Some essential design criteria are:

-- Base map scale.
-- How to break the map into component parts (e.g. counties, Water Resource Inventory Areas (WRIAs), or quadrangles).
-- What data layers to use and what level of detail each should have.
-- How the layers should be related to each other.

-- What types of supporting data are required.
-- Who will maintain, who will use, and who will enter data into the system.
-- What products the system should provide.

Recommendations:

-- Take an active role in agency-wide GIS planning so that the system adopted by Ecology meets the Group's hardware, software, coverage, access, and training needs.

-- Provide training in GIS concepts to all staff.

-- Design ground water databases to be able to be integrated into a GIS.

-- Develop an inventory of coverages needed by and available to the Group, at what scale, and at what cost.

-- Pursue arrangements for technical assistance from EPA.

CARTOGRAPHY

A map is the best way to display information about geographic environmental concerns. For public hearings, lectures, and other presentations, and for reports and other documents, the Group needs to be able to produce high-quality cartographic images.

Needs

-- Visually attractive, technically accurate maps related to ground water issues.

Available Options

Hand-drawn maps: At present, most of the Group's maps, such as the MGAS maps and maps developed for special projects, are produced on paper or mylar, and are reproduced by photocopying or printing. These maps will need to be digitized before they can be incorporated into a GIS.

Computer-Aided Design: The Water Quality Program LAN contains a copy of Generic CADD, a drafting package that is capable of creating maps. The Laser printers attached to the LAN can draw graphics from CADD, but are limited to a page size of 8 1/2 by 11 inches. (The Ground Water Quality Unit has a plotter, but it is not used because no one here knows how to make it work, and it has no documentation.) CADD is not a GIS; it does not have associated databases that would make it possible to perform geographic analysis. CADD files can be transformed for use in ARC/INFO, although this operation requires some digital acrobatics.

ARC/INFO: ARC/INFO is certainly capable of producing very high-quality maps, and the map format can be manipulated to portray special analytical themes. When the ARC/INFO GIS is in place for the agency, the Ground Water Quality Group will be able to use it for cartographic tasks; even now, the Group could use the SCS stations for some cartographic projects.

Recommendations

-- Encourage the use of digital, rather than hand-drawn maps; use Generic CADD as an interim digital cartographic tool until ARC/INFO training is available.

REPORTS AND PRESENTATIONS

Everyone in the Ground Water Quality Group creates reports, documents, and presentations. To develop these products, staff use word processing software, spreadsheets, graphics packages, and a variety of non-digital tools like flip chart pads, overhead acetates, and slides.

Needs

-- Ability to create attractive visual aids and publications.

Available Options

SMART: SMART includes word processing, spreadsheet, and graphics packages capable of producing documents that integrate all three of these kinds of information.

PageMaker: This powerful desktop publishing software allows the user to lay out graphics on a PC. The Water Quality Management Section has a copy available for the Ground Water Quality Unit staff to use.

Screen-to-slide service: Within Ecology, staff has access to the technology needed to create photographic slides from computer screens to be included in slide presentations. (Before this would be useful, staff needs to acquire more skill in creating graphic screens on a computer.)

Computer overhead projector: To demonstrate computer applications, it may be valuable to project the computer screen for an audience. In the future, this type of equipment may be available in many lecture halls; at present it is probably more expensive than useful to the Ground Water Quality Group.

Plotted flip charts: Better flip charts could be produced on a plotter, if the software and hardware could be matched up; it may be possible to print CADD files on the plotter as flip charts, or to work with the equipment in the Cartography Lab at Headquarters.

Recommendations

-- Provide training for staff in using SMART graphics capabilities and PageMaker, for those who are engaged in producing graphic publications and presentations.

-- Provide technical assistance for transferring screens to slides and for making flip charts on the plotter.

COMMUNICATIONS

The key to sharing and utilizing information is being able to link the many users who deal with ground water issues. Telecommunications networks tie computers together, enabling a user at one PC to use another PC, a minicomputer, or a mainframe machine within the network. The communications network functions as a system of pathways for information flowing from collection points to a central repository to analysis points.

Needs

-- Access to hardware and software in other parts of Ecology and at other agencies.

-- Ability to transfer data from regional collection points to a central storage point and to transfer other files between Group members.

Available Options

Mail, Facsimile (FAX), Modem: At present, some computers are equipped with modems, which allow the user to call another computer over a telephone line and send files or use software. A FAX machine allows staff to send graphic images over telephone lines more rapidly than a document can be sent in the mail. Most data transfer happens through the mail, when people send floppy diskettes to each other (this is somewhat risky, since the mail can get lost, and is very slow).

Gateway: The Water Quality Program LAN's Gateway software allows Headquarters ground water staff to use mainframe computers , either downtown or on the EPA network that includes STORET. As the Ecology telecommunications network expands, this will also allow staff anywhere on the network to use machines anywhere on the network, or any machine linked to the network. Ecology has recently installed a high-speed (9600 baud) line to EPA's computer center in North Carolina, where STORET is maintained.

Other offsite links: Gateway software will soon be compatible with graphics-intensive programs. To make a PC emulate a Tektronix terminal (needed for working in ARC/INFO and for retrieving graphic screen files from STORET), there is a copy of TGRAF, a graphics communication pack-

age, on one PC in the Water Quality Program. That same computer is configured in a way that will enable it to connect to DNR's Prime for Timber, Fish, and Wildlife work, using PrimeLink. The system uses a modem to connect outside the Water Quality building.

Recommendations

-- Support development of agency telecommunications network, including minicomputers at each Regional Office, a LAN for each program, and links within Ecology and between Ecology and computers at other state agencies and at EPA.

-- Install Novell LAN at EILS.

GROUND WATER DATA MANAGEMENT STRATEGY

IMPLEMENTATION PLAN

OVERVIEW

The objective of the implementation plan is to outline a logical grouping of steps to accomplish the recommendations in DATA REQUIREMENTS and DATA MANAGEMENT TOOLS. The Ground Water Quality Group's data management needs, which are outlined in these sections, fall into five major categories:

-- A central repository for monitoring data;

-- Information on what data resources are available;

-- Access to data;

-- Skills for using data resources and tools;

-- Agency-wide data systems.

In order to meet these needs, data management for ground water depends on three major areas of action:

-- the establishment of agreements on procedures for handling information and on data formats for the central repository,

-- technical assistance (including training) to bring the various users of ground water data into an effective information network, and

-- design and development of an agency-wide data system, including a GIS, that can handle information important to ground water quality analysis.

These three action items are listed in order of priority. The first two are essential to developing an effective data management system. They form an essential foundation for the third item, a successful GIS, but they can serve as a ground water data management system with or without a GIS.

As the group of people working to implement the Data Management Strategy make agreements about procedures and formats to use, those agreements can be implemented through the technical assistance components of the Data Management Strategy. Figure 1 depicts the relationship between the three components of the Implementation Plan, outlining the steps that the Ground Water Quality Group staff will take to develop a data management system.

GROUND WATER DATA MANAGEMENT STRATEGY

FIGURE 1: Flow Chart of Implementation Plan Steps

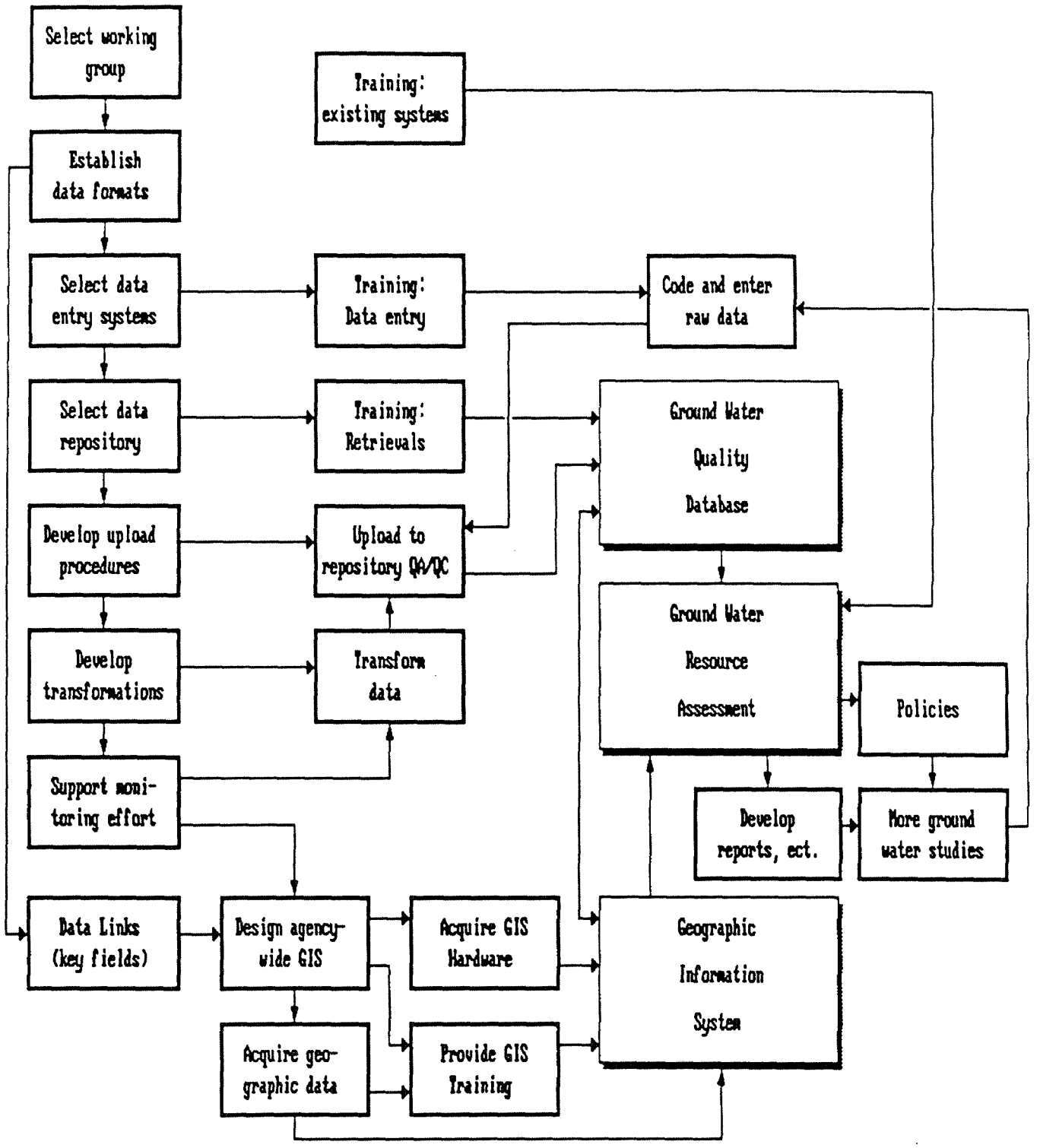

Table 4 summarizes the tasks required to implement the Data Management Strategy, focusing on the year beginning October 1989. Eventually, when the procedures for creating the ground water database are in place and information is flowing from monitoring programs to the central database, the focus of ground water data management work will shift to agency-wide planning.

TABLE 4. GROUND WATER DATA MANAGEMENT STATEGY
ONE-YEAR WORK PLAN, BEGINNING OCTOBER 1, 1989

Task	Schedule	Essential Players	Other Players	Role of the GWQU Data Management Staff
Establish procedures and formats				
Define interested parties and establish working group	10/89-11/89	GWQU EILS Regional Offices EPA	Water Resources Solid/Haz. Waste Haz. Waste Cleanup Information Mgmt. Dept. of Health Dept. of Agriculture USGS Local government	Assess interest. Convene initial meeting. Develop agenda/schedule. Setup and run meetings.
Agree on central data repository	1/90	Working group		Present options to working group. Setup/run meetings.
Agree on data format and select data entry system	12/89-1/90	Working group		Present options to working group. Setup/run meetings.
Agree on uploading data	1/90-2/90	Working group EILS EPA	Regional Offices GWQU GWMA, local agencies	Research staffing,technical options. Setup/run meetings
Agree on data transformations	10/89-2/90	Working group EILS Kleinfelder Co.	Regional Offices GWQU GWMA, local agencies	Research staffing,technical options. Setup/run meetings Serve as technical liaison.
Support monitoring and aquifer characterization efforts	ongoing	Working group		
Provide technical assistance				
Install hardware and software	10/89-1/90	EILS GWQU Kleinfelder Co. Regional Offices		Serve as technical liaison.
Provide training	ongoing	Working group All staff		Develop training plans schedule trainings/workshops.
Data entry (ENVIS)	1/90-2/90	Kleinfelder Co. Headquarters staff Regional Offices staff		Arrange with Kleinfelder Company
Storage/retrieval (STORET)	2/90-3/90	EPA Headquarters staff Regional Offices staff		Arrange with EPA
Background data access	ongoing	Headquarters staff Regional Offices staff	EPA Ecology data stewards	Plan and run or schedule workshops.

ACRONYMS: GWQU (Ground Water Quality Unit) GWMA (Ground Water Management Area)
EILS (Environmental Investications and Laboratory Services)

TABLE 4. GROUND WATER DATA MANAGEMENT STATEGY
ONE-YEAR WORK PLAN, BEGINNING OCTOBER 1, 1989

Task	Schedule	Essential Players	Other Players	Role of the Ground Water Data Management Staff
Database design	5/90	Headquarters staff Regional Offices staff		Plan and run or schedule workshops.
Communications systems	ongoing	Working group Information Systems Div.	Regional Offices GWQU	Inform working group and staff on new developments.
Improved database access	ongoing	All staff		
Catalog of databases	11/89-2/89		Regional Offices Ground Water Unit Local & State Agencies EPA USGS	Conduct survey and report on results.
Documentation for database access	11/89-2/89			Write documentation
Ground Water Bibliog. improvements	11/89-2/89		Regional Offices GWQU	Gather and enter bibliographic data
Data coding and conversion	from 2/90	Regional Offices GWQU	EILS	Maintain ENVIS-STORET relationships, transformations, uploading, data conversions, etc.
Geographic Information System				
Support an agency-wide GIS	from 10/89	Working Group		
Design GIS system	from 10/89	Working Group		
Acquire needed data	from 10/89	Working Group		
Train GIS users	from 10/89	Working Group		

ESTABLISH PROCEDURES AND FORMATS

The Ground Water Quality Group needs to establish common procedures and formats in order to facilitate the exchange of data between agencies, programs, and projects. This section outlines steps that will help the Ground Water Quality Group formulate agreements on procedures and formats.

Define the parties

The first step is to define the parties needed to implement the strategy. As many as possible of the staff who use ground water data, both within Ecology and in other agencies, should agree to common protocols and formats. The advantage of consensus to each party is the improved access and consistency the centralized database will offer. Paricipants should include:

- Department of Ecology
  - Ground Water Quality Unit in the Water Quality Program
  - Environmental Investigations and Laboratory Services
  - Regional Offices Water Quality staff
  - Water Resources Program
  - Hazardous Waste Investigations and Cleanup Program
  - Solid and Hazardous Waste Program
  - Information Management
- Department of Health
  - Environmental Health Programs
- U.S. Environmental Protection Agency
- U.S. Geological Survey
- Local agencies involved in ground water management

Establish a working group

From the list of interested parties, the Ground Water Quality Group will pull a group of individuals willing to work on forging data management agreements. This group should focus on the coordination of ground water information, but should also be closely involved in agency-wide data management planning, which will have a strong effect on ground water data management and access in the future. Ground Water Quality Group staff are likely to take the most active roles in this group, but will need input from other groups, especially Water Resources, Hazardous Waste Investigations and Cleanup, and EPA.

Agree on a central data repository

STORET could serve as an appropriate place to maintain a statewide ground water quality database. The system is extremely stable, accessible via modem or the Ecology network, available to state agencies free of charge, and includes free user support and training. The new flexibility of STORET, with PC-based versions of the system, utilities that transform data from STORET to locally usable formats, and a menu-driven STORET interface, should help to win the confidence of reluctant STORET

users. The value of having a central data repository available at low or no cost to all users should outweigh the problems associated with learning to use the system.

Agree on data format

Although some users may choose to include additional information in the databases they work with most closely, all data to be included in the central repository must contain common information, with standardized quality control, in a common format. The chosen data format must be compatible with a GIS. The Ground Water Management Area Data Reporting Manual format requirements are compatible both with STORET and with WATSTORE, and include data standards for additional information not included in the STORET and WATSTORE files. Three essential areas to discuss in setting standards are:

-- Data attributes. The central database format agreement will need to cover specific attributes of the data, such as the units of measurement to be used and a list of accepted STORET parameter codes. Each required field should be carefully described to clarify coding and data entry questions. Any special codes should be defined. Numerical formats should be described, and null-value codes defined for cases where there is no data for a particular field. The GWMA Data Reporting Manual could be adopted as a data attribute guide.

-- Well identifiers. Presently, the number and variety of systems for identifying wells in Washington seems to reflect the wide range of groups and agencies that take an interest in ground water in the state. Unfortunately, because there are so many different systems, two or more agencies may refer to a single well by different names or numbers. Most of the systems are concerned with locating the well accurately and with preventing two wells from having the same number. In order to develop a single central database, ground water data users need to agree on a single system for identifying wells, and on a method for assessing whether several records under several different numbers might refer to a single actual well. A 15-character identifier made up of latitude, longitude, and a 2-digit number to separate closely-spaced wells serves as a numbering system for GWMA data. The central repository may have to include several different identification numbers assigned to a single well, to link the database to databases using different numbering systems.

-- Well locations. Any GIS developed by Ecology should require coordinate locators for wells in the database. STORET and WATSTORE use latitude-longitude locators, and ENVIS can use either latitude-longitude or state plane coordinates, but other existing databases of wells, such as the injection well database and Water Rights Information System, use township-and-range locators. The coordinate systems provide more precise location of individual wells in a GIS because they describe a point (the intersection of a meridian and a parallel), rather than a polygon (such as the rectangle of a quarter-quarter section). It is possible to transform township-range locations to coordinate locations, although

this requires extensive computing time and causes some loss of accuracy. It is much simpler to transform one coordinate system to another (e.g. latitude-longitude to state plane).

Select a data entry system

The working group should act quickly to enable regional staff to begin adding field data to the database as soon as possible. The working group should choose a system that is easy to use, and is compatible with the central data repository's requirements. ENVIS is a strong candidate for a data entry system because it is "user-friendly", has good training and user support, is compatible with many other software systems and with STORET, and is already in use at Ecology. ENVIS can provide local storage and retrieval in addition to serving as a data entry interface for the central database.

The working group should decide how many sites will be using ENVIS, and assign a single contact person to coordinate training, field user support questions, and handle communications between the company and the users. Under this arrangement, Kleinfelder Co. could offer a single training session for the entire Group, and could provide a single service contract for all the Group's ENVIS sites, at considerably less expense than if the Group were to purchase each site license and training separately.

Agree on how to transfer data

Because up until now EILS staff have had the main responsibility for handling the state's STORET data, EILS is a likely candidate for the job of uploading data to mainframe STORET. The Ground Water Quality Group should seek agreements about data delivery from the Regional Offices, from EILS special studies, and from other programs in Ecology that gather ground water data; these could be based in part on the existing data transfer agreement for drinking water well information from DSHS. These agreements must specify the data format and a schedule for data delivery. EPA will provide technical support for data transfer.

Transform Data

Kleinfelder Co. has already modified ENVIS to include STORET parameter codes, and can further modify ENVIS to allow the transfer of files between ENVIS and STORET. (ENVIS is already capable of producing files that can be used with a variety of other kinds of software.) EILS is now responsible for uploading GWMA data delivered in GWMA Data Reporting Manual format, and could also upload other data delivered in that format (e.g. from non-GWMA grant projects, etc.), as long as the data has been checked for errors before it is submitted to EILS. Other significant data sets (not in ENVIS or GWMA-style format) may require extensive effort before they can be brought into the central database; these should be evaluated on a case-by-case basis to determine if the effort required to transform them is worth the benefit of including them in the central database.

Prioritize data acquisition

The working group should set priorities for acquiring ground water monitoring data, in order to ensure consistent coverage statewide, with particular attention to threatened and vulnerable areas. The working group should also outline priorities for acquiring other types of data, such as lithology, soils data, and other aquifer characteristics, which will help the Group predict the effects of human actions on the ground water resource.

TECHNICAL ASSISTANCE

Many of the data resources and tools needed for ground water data management are already available, but are not being used. The implemented Data Management Strategy can bridge the gap by installing hardware, providing training, improving and updating existing databases, and making use of other kinds of technical assistance.

Install hardware and software

The Ground Water Quality Group staff will need good access to computer terminals and communications lines to develop a strong information network. Each Regional Office and the Ground Water Quality Unit at Headquarters will also need a copy of ENVIS on their LAN. (ENVIS will be compatible with the Novell LAN by early 1990.)

The LANs at each Regional Office will solve existing problems of data storage, since individual users can keep their files on the LAN and have access to them from any networked machine. The agency network will enable the Regional Office staff to communicate electronically with Headquarters and EILS staff and with EPA mainframe (and possibly mini) computers. Installation of the LANs and of regional and Headquarters minicomputers is scheduled to take place this summer, and does not require any Ground Water Quality Group action, although the working group and data management staff will need to track developments in the network.

For the Group to take full advantage of the telecommunications network, it will be necessary to make the following hardware improvements:

-- Install a Novell LAN at EILS;

-- Assign staff to administer the EILS LAN;

-- Install a math co-processor in one PC at the Ground Water Quality Unit in order to run PC-STORET.

This hardware configuration plan would cover the Group's needs for data management in the immediate future; when a GIS becomes available to the Group, more specialized equipment (such as a minicomputer, plotters,

Tektronix terminals, and large digitizing tablets) will be required. These future equipment needs should be addressed as part of an agency-wide GIS plan rather than as part of the Group's smaller-scale plan.

Provide Training

The objective of training is to help people learn to use equipment and software, and also to help them understand how the parts of a data management system fit together. Each member of the group should have a data management training plan to address skills needed for existing and new equipment and software. In addition to the categories listed below, staff may need training for specific software packages already available at Ecology, such as SMART, dBASE, and Generic CADD.

-- Data entry. Once the working group has decided which data entry system to use, the ground water staff responsible for collecting and maintaining data will need to learn to use it. The developers of ENVIS provide training at the sites that use their system; staff would have to set up the training and installation times for each site (probably at Headquarters and at each Regional Office).

-- Storage/retrieval. STORET training is available free of charge through EPA. Ground water data users at Headquarters and the Regional Offices should receive training to facilitate their information retrievals from STORET. The training should also include information on how to access the mainframe computer via modem and on the relationship between data entered in ENVIS and data stored in STORET.

-- Background data access. In order to help staff learn about on-line bibliographic and legal search services, EPA databases (other than STORET), and databases in other programs at Ecology, ground water data management staff could develop workshops or arrange presentations from resource people outside the Unit (such as EPA staff or Ecology library staff). Another way to provide training in using these open database systems is to develop "cheat sheets" describing how to get access to the system, who takes care of it, what it does, and how to use it.

-- Spatial analysis and geographic data. Before Ecology has its own complete GIS, its staff may be able to use the systems belonging to other agencies, especially EPA, and should receive ARC/INFO training when they need to use these systems. All staff should receive enough training to understand what a GIS does, what its uses and limitations are, how it could apply to ground water, and what GIS applications are already in existence at DNR, EPA, USGS, and other agencies. By coming to understand the principles of geographic information management, the staff will be prepared to take full advantage of this powerful tool when it becomes more available to the agency, and will also be strong advocates for the development of an agency-wide system.

-- Statistical analysis. Data management staff should assess the Group's need for statistical analysis capabilities, and should research

available software to meet that need. For example, staff members whose work demands statistical analysis of ground water data would benefit from formal training in SAS, the statistical package available through STORET. In the interim, EILS could provide statistical analysis for Group projects.

-- Database design. From time to time, a special need will demand that staff create a specific database other than the central ground water quality database. Training in database development would help staff design their databases effectively, efficiently, and in a way that will enable other users to access them easily. Database design training will also help staff understand the issues involved in linking to a central database and in connecting databases into a GIS.

Provide communications systems

Users of and contributors to the ground water database are scattered across the state, and need to be linked electronically. The communications network should enable every user to connect to the Water Quality Program LAN in order to use the Ground Water Bibliography and other data stored there, and to link to EPA systems as well. EPA will help Ecology develop high-speed links to its systems once the Ground Water Quality Unit shows it is serious about using STORET as a primary data repository; these links could potentially provide access to EPA's GIS and a wide variety of other systems.

Improve database access

The primary obstacle for Ground Water Quality Unit staff wanting to use background databases is their lack of information about what is available. In some cases, what they need is not immediately available; the database needs to be acquired or developed. These problems can be addressed by developing catalogs of available databases, and by assisting staff in creating, researching, acquiring, and improving databases to expand and enhance the Unit's collection of data resources.

-- Catalog of databases. To assess what information is available on ground water and related areas, the Ground Water Quality Group could survey state, federal, and local agencies about their data management systems for all five categories of information. As an incentive for participation in the survey, the Group should offer to send a copy of the resulting catalog to all respondents. The catalog would serve as a guide to help ground water data users locate data relevant to ground water quality.

-- Documentation for database access. A notebook of "cheat sheets" to facilitate using the databases that already exist (and new ones as they are added) would help Ground Water staff take advantage of the databases included in the data management system. This would be particularly helpful for simple systems that do not require formal training, but may seem obscure to the first-time user.

-- Special database development. Specialized databases could improve the staff's ability to manage information specific to one or more Ground Water Quality Group functions. For example, the public education staff could use a database to keep track of slides available for presentations on ground water. Staff involved in ground water grants need a database to track grants activity. In the Regional Offices, where data is presently stored in numerous spreadsheets, a database could help staff locate information kept in those spreadsheets. All staff would benefit from an improved, updated ground water bibliography. These specialized databases, and others, could be developed as needed by staff in consultation with the Group's data management staff person. For complex database projects, the Group could consider hiring a database design consultant.

-- Summary report arrangements. A great deal of useful information on agency actions is contained in databases like WDIS and the Enforcement Database. The Group can request information from these systems whenever it is needed, but could also try to set up a regular schedule for receiving summary reports. The summaries may point out potential areas of concern that staff might otherwise miss. Data management staff should support efforts to improve other databases, such as the well report database and WRIS, that could be useful to the Ground Water Quality Group.

-- Improvements to the Ground Water Bibliography. The Ground Water Bibliography could be very useful to staff in doing background research, especially if it included more of the documents that are on staff members' bookshelves. Data management staff should develop a cataloging form and a procedure for entering this information into the Bibliography.

Data acquisition

The Ground Water Quality Group data management staff will work on acquiring data for inclusion in the database as it is needed. This may involve:

-- Determining whether a particular data set is appropriate for inclusion.
-- Developing methods to code data from paper files or reports.
-- Modifying existing digital files for compatibility with the central database.
-- Developing procedures and automated programs for data-checking.
-- Maintaining data access relationships with other agencies.
-- Creating and maintaining an inventory of ground water data.

Data acquisition efforts should also focus on supporting data, such as aquifer information, identified as necessary by the working group. Data acquisition is a continual process of finding and converting available information as it is needed for particular projects, and of supporting efforts to encode new information as it is gathered.

DEVELOP GEOGRAPHIC INFORMATION SYSTEM

By becoming actively involved in agency-wide GIS planning, and by learning about concepts of geographic analysis, the Ground Water Quality Group can prepare to make effective use of GIS technology when it is more widely available at Ecology.

Support an agency-wide GIS

By strongly supporting the agency GIS, and by representing the needs and interests of ground water data users in the decision-making process that shapes that GIS, the Ground Water Quality Group can help create the kind of system that will enable staff to make sound ground water management decisions. In particular, the Group should stay closely in touch with the Water Resources Program's current GIS efforts.

Design system

As the agency-wide GIS is created, the Ground Water Quality Group should put considerable effort into assessing its own needs for GIS. Training in GIS database development will help staff understand some of the issues central to GIS design, such as what data to include, how to link data and locations, how to divide the GIS into pieces of usable size, and how to develop a data library to organize storage of geographic information. Staff could learn about applications of GIS to ground water problems by observing the systems developed by EPA or the Intergovern- mental Resource Center in Clark County, to come to understand some of the GIS design issues that face the Group.

Acquire needed data

The ground water quality staff can begin to research the kinds of information it will need to make good use of a GIS, and to determine the costs and effort required to obtain that information. This information will be useful to ensure that the agency-wide GIS includes the data coverages needed by the Ground Water Quality Group. As the agency begins to acquire data for the GIS, it will be helpful to have a catalog of what is available where, and of what steps are needed to get it on line. EPA can provide technical support and access to many relevant coverages.

Maintain contact with other GIS users

By keeping abreast of GIS developments in other federal, state, and local agencies, the Ground Water Quality Group can take advantage of data sharing opportunities, and can learn from the design and operation of other systems.

ROLES AND RESPONSIBILITIES

In order to develop a sound, coordinated data management system for ground water information, a variety of participants need to become involved in the planning and implementation process. Anyone who works with ground water information will be encouraged to become involved; the staff of the Ground Water Quality Group will be most directly involved.

WORKING GROUP ON GROUND WATER QUALITY DATA MANAGEMENT

The working group, composed of members of the Ground Water Quality Group and other parties concerned with Ecology's ground water data management system, is faced with the following tasks and decisions in implementing the Data Management Strategy:

-- Adopting standard data format and quality standards (based on the Ground Water Management Area Data Reporting Manual).
-- Agreeing on STORET as a central data repository.
-- Setting priorities for data acquisition in all five categories.
-- Agreeing to purchase ENVIS and an ENVIS-STORET transfer utility.
-- Taking an active role in agency data management planning.
-- Supporting the development of a strong monitoring network.
-- Supporting data management activities elsewhere at Ecology that could assist the Group in its ground water quality work.

The definition of specific roles and responsibilities outlined here is based on the assumption that no new resources are presently available for implementing the Data Management Strategy. If new resources do become available, roles and responsibilities will need to be reevaluated.

GROUND WATER QUALITY UNIT

In the absence of a position funded collectively by the affected programs, the Ground Water Quality Unit's Computer Information Consultant (CIC) should take on the coordinating function for the working group and for ENVIS users. This should be viewed as an interim role with the intent of eventually having a position funded by several programs but located in Information Management. The role of the Ground Water Quality Unit's CIC should include the following tasks:

-- Working group support

    - o Coordination of working group meetings and activities.
    - o Providing information to the working group.
    - o Documentation of working group decisions.

-- Developing the central database

- o Installation of ENVIS at Headquarters and Regional Offices.
- o Coordinating ENVIS training and user support.
- o Developing a data verification methods manual and automated error-checking programs.
- o Developing data transfer and technical assistance arrangements with EPA.
- o Acquiring and converting data for use by the Group.

-- Technical assistance for the Group

- o Arranging for data summaries from relevant Ecology databases.
- o Helping develop special databases and improve existing databases, and ensuring that databases developed by the Group are GIS-compatible.
- o Developing training plans and scheduling training sessions for Ground Water Quality Group staff.
- o Assessing the Ground Water Quality Group's needs for statistical software and other tools, and recommending ways to meet those specific needs.
- o Creating inventories of available parametric, geographic, background, agency/legislative, and bibliographic data resources and of data management tools that could be acquired by the Group.
- o Providing technical assistance and user support to Group members.

-- Agency-wide data management planning

- o Representing the Ground Water Quality Group's interests in agency data management planning.
- o Maintaining contact with GIS users at Ecology and in other federal, state, and local agencies.

ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES

EILS staff who work closely with ground water data will be part of the working group. In particular, because of their strong expertise in data management, they will have valuable input into the working group's decisions about a data entry system, data formats, data transformation, and training. In addition, it is proposed that EILS have the following responsibilities in implementing the Data Management Strategy:

-- Upload data to STORET.
-- Perform statistical analysis as needed.
-- Install Novell LAN and link to agency network.
-- Provide data generated from investigations work.

REGIONAL OFFICES

The regional hydrogeologists will be part of the working group. After the working group approves a data entry system, and the system is installed at Regional Offices, the regional staff will be trained to use the data entry software and to submit data for inclusion in the central database.

EPA

EPA has a strong interest in receiving ground water data from Ecology, and so their staff should be represented in the working group. EPA data management staff can assist the Ground Water Quality Group by providing technical assistance in developing data transfer capability and communications systems between the two agencies.

-- Providing technical assistance and training for using STORET.
-- Seeking and installing technical improvements in telecommunications between Ecology and EPA.
-- Providing GIS coverages needed for ground water analysis.

OTHER INTERESTED PARTIES

Within Ecology, other programs that deal regularly with ground water information may be interested in participating in the working group's activities. Some programs that are likely to be interested in participation are:

-- Hazardous Waste Investigations and Cleanup Program.
-- Water Resources Program.
-- Solid and Hazardous Waste Program.

Outside of Ecology, state agencies such as Department of Health, the Department of Agriculture, and DNR, who share data with the Ground Water Quality Group, may be interested in participating in the working group. Local government agencies, including GWMAs, health departments, and planning departments, should also be invited to participate.

APPENDIX: GROUND WATER QUALITY GROUP FUNCTIONS

The members of the Ground Water Quality Group, composed of staff from the Ground Water Quality Unit in the Water Quality Program, the Regional Offices, and the Environmental Investigations and Laboratory Services Program, handle ground water data management activities as part of their overall functions in protecting ground water. The following is an outline of Ground Water Quality Group functions as they relate to data management.

Headquarters - Ground Water Quality Unit in Water Quality Program

-- Ground Water Pesticide and Nutrient Strategy: The Ground Water Quality Group is working to prevent agricultural impacts on ground water. Group staff is developing a process for responding to contamination of ground water by agricultural activities. The process will include a public involvement/education component, a delineation of the roles of various agencies, a process for developing strategies to deal with particular agricultural chemicals, and a database for making management decisions.

-- Nonpoint Source Pollution Activities: In cooperation with the Nonpoint Source Unit of the Water Quality Program, the Ground Water Quality Unit produces input to reports required by sections 305(b) and 319 of the federal Clean Water Act. The reports require an assessment of nonpoint source impacts on ground water.

-- Ground Water Management Areas (GWMA): As the GWMA database grows, the Unit will take responsibility for melding it into a statewide database of ground water quality.

-- Major Geographic Aquifer Systems (MGAS) Mapping: The Unit is in the process of mapping aquifers by county at the 1:100,000 scale, and providing written descriptions of them. These maps are based on technical literature, agency records, field observations, and Department of Transportation county base maps.

-- SEPA Review: Unit staff reviews and comments on SEPA applications they pertain to ground water quality and resource protection issues, tracks the issues identified, and reports on these reviews to the Unit and to the SEPA Review Coordinator. The Unit tracks surface mining permits through the SEPA review process, and serves as a contact for surface mining issues for the Regional Offices. Staff also reviews drywell projects and ground water-related projects in Island County.

-- Centennial Clean Water Fund and CWA 205(j) Grants: Staff reviews grant proposals and provides technical assistance for proposal review for ground water related projects, supporting the Water Quality Financial Assistance Program. Unit staff also meets with grant administrators and grantees to review technical requirements of ground water related grants, and supervises the transmittal of grant-generated data

to Ecology. This task also involves providing information on current grants and their status.

-- Data Management: The Unit is working to develop better data sharing with EPA. For example, the regional GIS being developed in Seattle may be available to the Unit, and EPA may be able to help with improving access to federal computer systems. The Ground Water Quality Unit is also working to improve intra-agency and inter-agency data sharing.

-- Wellhead Protection: The Ground Water Quality Unit provides technical review and technical support for local wellhead protection efforts, works with DSHS and EPA for Wellhead Protection Area (WHPA) programs, and offers information on wellhead protection to other programs within Ecology.

-- Sea-Water Intrusion Team: The Unit provides technical support on water quality issues to this group and serves as a contact on this issue for Ecology and EPA.

-- Sole Source Aquifers: Unit staff provides coordination with EPA and within Ecology (between programs and with the Regional Offices) for this work.

-- Public Information and Education: All Unit staff is involved in informing the public about ground water issues, but one staff member coordinates the public education effort. This person develops and distributes written and audiovisual materials for public schools and for the general public (such as brochures, a quarterly newsletter, lesson plans, public service announcements, posters, bumperstickers, and informative bulletins), works with local groups to solve local problems, and maintains a mailing list of people interested in ground water issues. This task also involves keeping the public, organizations, agencies, and other groups aware of Ground Water Quality Unit activities, and helping involve them in Ecology's ground water decision-making process. The public education staff is also responsible for developing an educational strategy for the Unit.

-- Underground Injection Control: The UIC staff monitors the injection of wastes to the ground and their impacts on ground water. The staff person responsible for UIC revises standard state waste discharge permit conditions, and develops or revises state policies, guidelines, and rules for activities such as constructing and operating aquifer recharge wells, salt water intrusion wells, and chemigation wells. The UIC staff administers the EPA grant that funds UIC work in Washington, and maintains a digital inventory of injection wells which is uploaded to EPA periodically. The UIC staff is required to send Non-Compliance Summaries to EPA quarterly and annually. The UIC staff prepares reports on the effectiveness of best management practices for ground water protection. The UIC staff also responds to public inquiries about locations and types of injection wells and their effects on drinking water or public health, and on impacts of stormwater on ground water and on ways to treat contaminants in ground water.

Regional Offices

The Regional Offices vary in the kind of information they collect and in the way they store and manipulate it. Depending on the staffing resources of a particular office and the equipment available to that office, the Region establishes its own method of managing data, often very different both from the way that Headquarters handles data and from the way other Regions handle data.

-- Northwest Regional Office: The regional hydrogeologist collects information from single-well complaint response incidents, from responses to complaints from groups of well owners with a shared local ground water problem, from sampling studies and surveys, and from ground water monitoring by dischargers. Information from some of these sources ends up in a file cabinet on paper; other data sets are stored on SMART spreadsheets on diskettes. The spreadsheets are transformed to graphs using GRAPHER software; the NW hydrogeologist uses WORD word processing software or the SMART word processor for developing reports. Other than parametric data gathered in the field, the NWRO ground water staff mainly uses paper data resources, such as USGS publications.

-- Southwest Regional Office: Few of Southwest's permitted dischargers are required to monitor ground water quality, but the SWRO staff hopes to require ground water monitoring and characterization on new discharge permits, both before start-up of the permitted project and during its operation. Existing monitoring wells are analyzed routinely and tracked by the regional permit staff, but the resulting data are kept in paper files.

-- Central Regional Office: Ground water quality information at CRO comes from a few sources: GWMAs, such as the Methow; monitoring from State Waste Discharge Permits, when the permit requires ground water monitoring; data from grantees, like the Yakima Council of Governments or Conservation Districts; and data generated by investigations carried out by the RO staff. (This last category has been very sparse in the past, but with an expanded water quality staff, it may grow considerably.)

-- Eastern Regional Office: Ground water monitoring information from discharge permittees in the eastern region provides the bulk of ERO's ground water data. For each permitted site, the RO staff creates a separate spreadsheet, stored on a personal computer in SuperCalc or SMART software. There is no standardized structure for these spreadsheets, but the office has computerized files for permitted sites back to 1980. The wells are numbered according to the permittee's system (not a unique well identifier), and the spreadsheets do not contain any coordinate location information. The office uses paper well log records to look up background information, such as well locations.

Environmental Investigations and Laboratory Services

EILS performs a variety of functions for the Ground Water Quality Group. Their primary role is to conduct investigations on ground water quality, including designing projects, carrying out field work, arranging for laboratory analysis, assuring data quality, tabulating and interpreting data, and reporting on results. EILS maintains STORET databases of drinking water information (from DSHS) and of GWMA-generated information, and performs retrievals from STORET on request. EILS staff also uses ENVIS for site-specific and project-specific ground water data management.