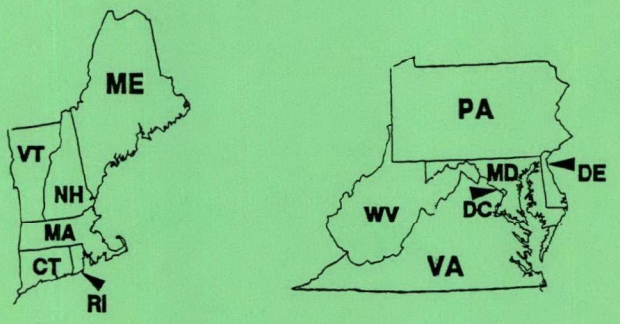
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER
GROUND WATER PROTECTION DIVISION (WH-550G)

GEOGRAPHIC INFORMATION SYSTEMS

TECHNOLOGY PROCESS DOCUMENTATION, REGIONS I AND III



Washington, DC
1992

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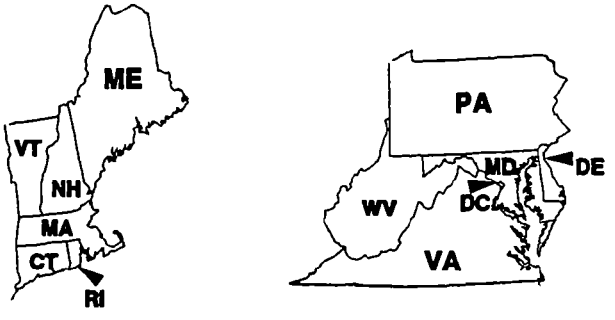

REGION I REGION III

Washington, DC
1992

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) requires significant data acquisition, data management, and data use to achieve an effective Ground Water Protection Program. Many tools are possible to achieve such a goal. This report gives a 5-year perspective on the experiences of two EPA Regions, Regions I and III, related to ground water data and information management using the evolving technology of geographic information systems (GIS).

GIS provides a geographically-based framework for the identification, display, and solution of ground water problems. The pictorial nature of geographic presentations facilitates problem-solving. GIS enables staff and management to make informed decisions using a comprehensive analytical perspective.

EPA Regions I (Boston) and III (Philadelphia) were among the first Regions to acquire GIS hardware, software, and personnel. Each Region has used GIS for ground water protection purposes, but their experiences are different in terms of strategy, priorities, and applications of GIS. Region I has emphasized site-specific applications; Region III has used a regional, prioritizing approach to help target its program activities, in addition to site-specific applications.

The Comprehensive Ground Water Protection Program places a premium upon ground water data and its application in helping protect the ground water resource. This document, by illustrating the GIS technology process and its application, is intended to stimulate continuing application of GIS technology to further programmatic goals. This stimulus will help protect the ground water resource both for safe human consumption and for the preservation of healthy ecosystems.

ACKNOWLEDGMENTS

This technology process documentation of geographic information systems represents a combined effort of Regions I and III, with direction and support from EPA Headquarters. EPA staff involved in managing, coordinating, and developing this document include the following: Miriam Romblad, Headquarters, Project Officer; Peter A. Weber, Region III, Work Assignment Manager; Dr. Ava Nelson Zandy, Region III, first GIS Coordinator; Sumner Crosby, GIS Programmer, Ground Water Protection Section; and David Delaney, Region I, Ground Water Management Section.

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1.0 INTRODUCTION

This report was developed to be both a guidance document and a technical reference for GIS applications in ground water programs at the U.S. Environmental Protection Agency (EPA). The target audience is EPA, States, and local ground water protection communities. The information in this document draws upon the experiences of EPA Regions I and III, where GIS has been implemented successfully into programmatic activities. This document is intended to be useful *not only* to managers concerned about such items as overall program direction, program costs, benefits, and organizational and resource requirements, *but also* to program and technical staff personnel who require specific knowledge about data, procedures, and applications. Although the information presented here is from EPA Regions I and III, and is concerned with ground water-related projects, the issues addressed are pertinent to any organization that uses GIS in environmental and health-related programs.

The Ground Water Protection Program at EPA has long recognized the fundamental need for enhanced data management to provide better information for program execution. A recent Ground Water Program management report (*Strategy for the 1990s*) characterized ground water data/information needs in three major categories: (1) Data Consistency, Quality and Automation; (2) Data Accessibility; and (3) Utilization of GIS and other applications.[1] Improved information management will lead to improved decisionmaking, which will support more efficient program administration, resulting in greater protection of the ground water resource. Communication, information-sharing, and partnership-building, which played key roles in the successes of the Regions I and III GIS programs, are also necessary for cogent information management.

GIS is a valuable technology for ground water protection. It is a data integration and analysis tool that combines sophisticated mapping and database capabilities with large computing capacity. It enables spatially-based data to be captured, stored, displayed, analyzed, and modeled. The implementation of GIS has become more feasible in recent years as a result of advances in computer hardware and software technologies, decreases in hardware costs, and advances in data-gathering techniques that have led to improvements in the accuracy of spatial data.[2] GIS is rapidly becoming one of the most efficient tools for comprehensive information management in environmental organizations.

The EPA Ground Water Protection Program has been evolving quickly. The EPA Ground-Water Task Force set the Agency strategy for the 1990s and the Comprehensive State Ground Water Protection Program (CSGWPP) implements this strategy.[3] One of the six strategic activities of a comprehensive program is **coordinated information collection and management**. Record-keeping, monitoring, and gathering of other necessary information, within and across the many ground water-related programs, are essential aspects

of a comprehensive program. The EPA ground water program managers believe GIS is an essential technology to achieve this strategic activity.

The Ground Water Program has for many years been collecting data and using this information for ground water protection efforts. Numerous ground water-related programs require ground water data. All of the following Federal laws mandate ground water data collection and management[4]:

- Clean Water Act
- Safe Drinking Water Act
- Resource Conservation and Recovery Act
- Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
- Federal Insecticide, Fungicide, and Rodenticide Act
- Toxic Substances Control Act

These laws generate regulatory and enforcement data, that are deposited in individualized databases. To facilitate cross-program and multi-media data integration these databases also may be indexed using EPA identification numbers, addresses, and geographic coordinates.

Obstacles to managing ground water data can be grouped into three general problem areas:

1. Inadequate data

   - Ground water data are not being collected at all, or are being collected with an insufficient number of parameters to represent water quality adequately.
   - Accurate locational data or other baseline information may be unavailable; consequently, the value of the data is limited.
   - Data quality control procedures are nonexistent or highly variable; thus, data usage may yield uncertain results.

2. Decentralized data

- Information is highly compartmentalized by program, agency, and manager, thus requiring massive data identification, re-collection, and integration efforts.

- Data are in various agency locations as a result of delegation and cooperative arrangements with States, local governments, and other Federal agencies; therefore, significant effort is required for data sharing and compilation.

3. Variable data formats

- Data may be in only hardcopy or non-computer-readable format, thus requiring painstaking data automation.

- Data may be housed on various computer systems in incompatible national, State, or local databases, and may thus require additional processing before the data are fully useful.

To meet The Ground Water Program's requirement of implementing tasks using a comprehensive analytical/managerial perspective, these data use obstacles need to be continually surmounted. The use of GIS will aid in this effort. Specifically, GIS will:

- Provide a tool that enables the aggregation/assessment of massive amounts of ground water data;

- Provide a common reference point (i.e., geographic location) for single and cross-program discussions;

- Enable accomplishment of data integration efforts on a manageable scale; and

- Require the use of better quality data, which will ultimately improve decision-making.

GIS operation requires several elements. EPA programs require management and staff who develop program strategies that include the use of GIS as a tool to meet specific program needs. Program personnel then require a partnership with information resource management personnel (i.e. GIS technical staff) familiar both with computer operations and technical issues at the core of GIS infrastructure. In addition, data issues drive the actual GIS operation in terms of scope and amount of resources required to perform a particular project.[5] One or more database(s) contain locational data associated with descriptive data or attributes. The levels of data are termed "layers" or "themes." Coupled with the software

tools of the GIS, the layers can be combined to perform various analyses and to generate or display maps. Since geographic datasets are generally large, and graphical operations require good computer response time, sufficient disk storage, and computing performance. The integration of various data components with a GIS database paves the way for examination of data that would be difficult, if not impossible, to perform using traditional analog methods.

The Federal Interagency Coordinating Committee for Digital Cartography (FICCDC) identified 10 general uses for GIS within the Federal Government (Table 1-1). Of the 10 uses, the following have specific ground water applications [6]:

- Terrain maps, where ground watersheds can be determined;
- Data display analysis;
- Mineral resource assessment, for geological data;
- Environmental assessment and monitoring;
- Thematic map data, which are relied upon extensively;
- Resource inventory; and
- Base map development.

EPA Regions I and III use GIS to identify and analyze environmental problems; to prioritize and allocate program resources for managing environmental problems; and to perform site-specific data management tasks. In Region III, during 1988, ground water staff interviewed program managers and other staff to identify essential program management needs that could be accomplished with GIS. An application inventory was developed and prioritized and then a series of pilot projects was identified and initiated.[7] Primary goals of the GIS program at Region III were *first* to develop an overview of problems and activities in the region, and *then* to focus program efforts and resources where they were most needed. Cooperative relationships were built with the States so that the evaluation of GIS needs for a particular project addressed not only EPA's requirements but also the States' needs. From the experiences of these activities, the process has been refined. Region III has more than 20 GIS projects ongoing or completed, more than half of these are used for regional assessment and planning. The other applications address specific programs such as CERCLA and RCRA.

Table 1-1. Ten General Uses for GIS in the Federal Government[6] (Ground Water Applications Underlined)

1. Terrain maps	Topographic maps, elevation models, slope maps, aspect maps, shaded relief maps, and perspective views
2. Data display analysis	Map data access and display, merging and integrating databases, and image maps
3. Navigation systems	Air traffic control systems, in-flight navigational data, nautical
4. Network simulation models	National Rail Network Model and National Rail Defense Essential Network
5. Mineral resource assessment	Geologic maps, mineral and mineral fuel resource assessment, engineering geology, and geologic hazards
6. Environmental assessment and monitoring	Environmental impact assessment, irrigation suitability, irrigation development monitoring, contamination and pollution studies, soil conservation, and flood mapping
7. Thematic map data	Socioeconomic, demographic, soil, and other characteristics at the state, county, congressional district, and Standard Metropolitan Statistical Area levels; National Airspace System; and feature analysis
8. Land and water resource inventory, planning, and management	Site design and screening, road design, land management, prime farm and forest land surveys, cultural land mass information, wetland maps, habitat assessment, and water quality and quantity studies
9. Trainers and simulators	Radar trainers and flight simulators
10. Base map development	Analysis, plotting, modification, and revision of quadrangle maps, aeronautical charts, marine information, cadastral maps, ocean surveys, base charting, and navigation

Region I similarly identified pilot applications for initial GIS efforts, through its water programs. Unlike Region III however, States in Region I already had generated a substantial amount of digital data, and therefore were experienced in working with this type of information. The relationship Region I built with State organizations consisted of technical assistance to State information resource management groups. Region I also has been involved in more than 20 projects. Most applications are used to address site-specific program needs.

Chapter 2 of this document, **GIS Program Development**, details information on management, planning and implementation issues. Chapter 3, **Summary GIS Process**, describes how projects are administered and implemented. Chapter 4, **Components of the GIS Operation**, discusses the elements required in GIS implementations, including personnel, hardware/software, and data. In Chapter 5, **GIS Uses and Users**, general users and uses are briefly described, and a catalog of uses implemented in both Regions is presented. Chapter 6, **Program Benefits**, presents basic benefits associated with GIS implementation. The Appendix presents a State GIS Survey (Vermont), which indicates GIS activities in the state, and assesses their future GIS needs.

The diverse nature of GIS operations in EPA did not permit comprehensive coverage of items such as data-specific and project-specific processes. However, various projects are presented to illustrate the details of such issues.

2.0 GIS PROGRAM DEVELOPMENT

SUMMARY

Geographic information systems had to be introduced and developed in the regional offices by deliberate management, planning and implementation actions. This GIS program development occurred in both Regions I and III. Region III was led by the Water Management Division Director, who secured EPA Headquarters delivery/installation of GIS hardware/software in the Regional Information Resources Management Branch in December 1987. Region I started its operations by using the existing GIS located at a district office of the U.S. Geological Survey. It subsequently acquired its own GIS in December 1987. Since then, each Region has developed more than a score of GIS projects.[8]

EPA has developed effective GIS programs both in Regions I and III. There are three basic requirements for program development: management, planning, and implementation. Each of these requirements is discussed in sections that follow.

2.1 MANAGEMENT REQUIREMENTS FOR PROGRAM DEVELOPMENT

2.1.1 Justifying the Project

To obtain required funding, it is necessary to justify to upper management the need for the project (and the required resource and staff support). The GIS project lead needs to demonstrate that the project will: (1) promote Agency objectives, and (2) be used to assist managers with making decision and attaining program goals. Therefore, it is critical to define the project's goals and objectives clearly:

- Identify management applications (e.g., resource prioritization and allocation, problem identification, risk assessment);
- Identify specific program applications (e.g., technical assistance for Wellhead Protection Program development);
- Set priorities for the proposed project, relative to other potential applications (e.g., employ a ranking methodology); and
- Conduct a cost-benefit analysis of the proposed project (i.e., assess the project's projected costs relative to its anticipated benefits).

2.1.2 Obtaining Financial Support

Where financial resources required for project development are limited, develop cooperative arrangements ("joint ventures") with other interested parties to defray costs by "pooling" resources. Potential partners may include State government counterparts, other Federal agencies (e.g., U.S. Department of Agriculture, U.S. Geologic Survey), local governmental agencies, watershed managers, and universities. Within the Region, there is a need to develop interdivisional GIS initiatives to promote mutual program needs. Cooperative ventures may include water, hazardous waste, and toxic programs, which frequently are located in different divisions. Senior management and staff need to establish working relationships with their counterparts across divisional lines. GIS partnerships formed in Region III have included the following:

- Jefferson County, WV, Pesticides Project [9]: EPA Region III; West Virginia Department of Natural Resources; West Virginia Department of Health; U.S. Department of Agriculture, Soil Conservation Service and Cooperative Extension Service; U.S. Geological Survey; West Virginia Geological and Economic Survey; Eastern Panhandle Regional Planning and Development Council (Jefferson County); and West Virginia Department of Agriculture, and West Virginia University with technical assistance provided by EPA Information Resources Management Branch (IRMB).

- Anne Arundel County, Maryland, Wellhead Protection Project: EPA Region III; Maryland Department of the Environment; Maryland Geological Survey; U.S. Geological Survey; Anne Arundel County Department of Utilities; Public Water Supply Program in Maryland, with technical assistance provided by EPA IRMB.

- Superfund Hazard Ranking System Development Project: EPA Region III Water Management Division and Hazardous Waste Management Division, with technical assistance provided by the Temple University Laboratory for GIS.

- New Castle County Wellhead Protection Project: EPA Region III; New Castle County Water Resources Agency; Delaware Department of Natural Resources and Environmental Control, technical assistance provided by EPA IRMB.

2.1.3 Assessing Institutional Barriers

Obstacles to interagency initiatives also can result from institutional barriers between different levels of government. Relevant parties need to emphasize their overlapping needs. Also, the purpose of information exchange is to improve environmental assessment and management capabilities at all levels of responsibility. Within an organization, it is

important to promote the use of GIS as an integration tool (for pollution prevention and other multi-media applications).

2.2 PLANNING REQUIREMENTS FOR PROGRAM DEVELOPMENT

2.2.1 Reviewing Data Quality/Data Management Needs

With a number of databases, information generally is not sufficiently comprehensive or accurate to enable definitive assessments using GIS. Locational inaccuracies exist within certain databases, such as Superfund's CERCLIS database, where a facility's "latitude and longitude" are sometimes represented by a ZIP code centroid. There also are problems with the comprehensiveness of various databases, such as the water quality database STORET, where data collection may have been incomplete or inconsistent. Temporal gaps can make it difficult to conduct trend analyses. Moreover, statistics collected often are restricted and only reflect the purposes of the authorizing regulation; consequently, the data may not be comprehensive enough to enable desired assessments. For example, Region III's Phase II (Pennsylvania) project intended to identify potential water quality violators by correlating certain disposal practices with Public Water Supply well locations showing significant levels of contaminants associated with those practices. The analysis was limited by the fact that the desired "indicator" contaminants were generally not sampled for in STORET, the U.S. Geological Survey ground water database GWSI, or various other State water quality databases.

The following measures should be undertaken to address data management issues:

- Identify the gaps, errors, or inconsistencies in existing databases.

- Cooperate with other organizations. Wherever possible, develop cooperative initiatives with other agencies, universities, etc., to correct and expand existing databases. For example, for the Surface Water Intakes Project, EPA Region III worked cooperatively with State agencies to correctly identify intake locations.

- Identify alternative (existing) data sources that can meet information needs. Examples include county tax parcel maps, aerial photographs, or remote sensing imagery.

- Examine the design and content of the databases (i.e., their stated purposes and uses). Assess the feasibility of deriving the desired results from those databases and determine if the project can use the databases for additional purposes. Redefine and modify data collection efforts to focus on needed areas.

- Improve data retrieval methods. Substantial amounts of useful data at the Federal, State, and local levels are not being used because they are not easily retrievable. Frequently, it may not be necessary to generate new data for a given project. Efforts can be focused on locating and transferring such data to a retrievable form.

- Determine and recognize data quality. If a decision is made to use databases with known inaccuracies or gaps, it is important that the decisionmaker clearly understands the data quality limitations when interpreting the results. Otherwise, there will be a temptation to ascribe a higher degree of accuracy than is warranted. There also will be the temptation to interpret the results as definitive, rather than as a generalized assessment or "screening" mechanism.

- Maintain flexibility. Modify objectives as projects develop, if necessary, to conform to unanticipated data quality/availability limitations.

- Create reusable datasets. Ensure that data are saved for further use in other types of projects for the same geographic area.

- Develop and implement data quality assurance/quality control procedures.

- Document any data used or developed.

- Develop key datasets. These datasets include base layers, such as geography, geology, soils, and other commonly needed information. Examples include EPA river REACH files and U.S. Census TIGER files. Construct these basic datasets in a way that allows subsets of the data to be accessed, as needed.

- Understand data collection protocols. Quality assurance/quality control measures can differ among data collecting organizations and among databases. The EPA Information Resources Management Branch and the database systems managers can work together to improve existing databases.

2.2.2 Evaluating Resource Limitations

Because GIS is resource-intensive, particularly during the initial phase, resource constraints are common. Limitations include a shortage of available funding (for hardware/software, data acquisitions and transfer costs, etc.), as well as a shortage of qualified staff. As stated earlier, cooperative working arrangements will help ameliorate resource limitations.

2.2.3 Defining Analytical Limitations

The underlying philosophy and purpose of GIS assessments must be well understood for their analytical implications. For example, it must be determined whether the GIS objective is (1) to conduct "compartmentalized" analyses, such as definitive site-specific assessments, or (2) to develop comprehensive assessments, such as "the state of the environment" in a larger geographic area. Neither of these two approaches is the inherently "more correct" than the other yet each has implications that must be considered. In conducting a definitive, site-specific assessment, resource costs and data restrictions are limiting factors in the scope of analysis. In conducting a generic "broad-brush" assessment, data quality objectives may not be met within a short time-frame, so quality procedures (and "flagging" poorer quality data) must be emphasized. The project output will need to be regarded as generalized guidance, rather than as a definitive assessment.

2.3 CAUTIONARY NOTES FOR PROGRAM IMPLEMENTATION

2.3.1 Understanding GIS Capabilities

It is important to understand the capabilities of GIS as an analytical tool. Tendencies exist to underuse, over-use, or misuse this technology:

- Underuse - There is a tendency to view GIS as a "flashy" presentation gimmick rather than as a legitimate analytical tool. Another misconception equates GIS simply with the geographic/cartographic display aspects, ignoring the technology's sophisticated analytical capabilities.

- Over-use - GIS is a powerful analytical tool, but it is important to understand its limitations. There is a tendency to have unrealistic expectations of GIS capabilities, based on (1) exaggerated expectations of the system's technical capabilities, and (2) misunderstanding of data limitations. To ensure that objectives are met, the user must verify that the intended use is consistent with the system's capabilities.

- Misuse - GIS is most useful as a dynamic (versus static) tool. It is most useful as a fully-functioning information system, with both graphic and attribute components. It should not be used to prepare maps for one-time use with no intention of making updates or showing trend development. It should not be used to prepare maps solely for thematic display without providing interpretation and analysis of the environmental data being displayed on the map output. GIS consists of both *geographic* and *information* components, in a systems setting. It does not just generate maps, nor does it just display tabular data.

2.3.2 Interpreting Results

GIS has potential shortcomings, as noted below.

- GIS can "give a false sense of numeric precision."

  Using GIS for DRASTIC applications can result in " . . . a situation which graphically appears to be very exact and accurate, [but] may be, in fact, a very poor representation of reality. If we do not keep these qualities in mind, we will fall into the attractive and easy trap of imputing absolute accuracy to . . . tools . . . which are only approximations."[10]

- GIS representations "often represent only the present."

  Furthermore, using GIS "should be tempered by what the future may hold. We should not, for instance, be less concerned about activities in a sparsely populated area if we know that population growth trends are such that the area will eventually see more dense habitation. We should not minimize protection of an area that does not contain a public water supply well if we know that the adjacent cities' water supply wells are currently in an industrial area and therefore will see inevitable degradation, and the area for which we are determining protection will eventually be the most probable location of the new city wells. Our GIS representation of the current situation must be tempered by some understanding of what the future will bring. In fact, GIS can help us make some of these future projections and predictions."[10]

3.0 GIS PROCESS

SUMMARY

The EPA GIS is a tool both for program personnel and for management. To better serve the EPA Regions, the GIS process must be flexible enough to support a wide variety of applications and to accommodate the dynamic nature of Regional activities. EPA Regions I and III have met these needs and have successfully implemented GIS operations using two different approaches to planning and implementation. Region III's "Top-down" approach is more management-oriented and emphasizes cross-programmatic applications. Region I's "Bottom-up" style is task-driven to address the needs of a particular program activity.

EPA has established effective GIS organizations at both Region I and Region III. These organizations have approached the planning and implementation of GIS applications using two different strategies. The process for GIS tasks in both Regions is described in this chapter. Specific projects have been used to illustrate this process.

3.1 REGION III

Region III attempted to use geographic analysis tools before a computerized GIS was installed in the Region. In FY 86, the Ground Water Mapping Program was initiated in the Ground Water Protection Section. This program was funded by a regional competitive proposal program, the Measurable Environmental Results Initiatives (MERITs). This first year's project used USGS topographic sheets for the base maps with acetate overlays of various risks to ground water. The project ranked all counties in Region III on the basis of ground water sensitivity and significance. The criteria were as follows: percentage of industrial development within a county; evidence of ground water contamination; potential for ground water contamination; type, toxicity, and level of contamination; aquifer use (e.g., drinking water); and number of people using the aquifer as a drinking water source.

In FY 87, a second project was initiated, the Hazardous Waste Impacts on Ground Water. This effort also was funded by MERITs. The project evaluated the impact from the two major hazardous waste laws, CERCLA and RCRA, on ground water at sites within the most environmentally sensitive/significant counties as determined by the previous year's MERITs project. Subsequently, the RCRA Corrective Action Enforcement Program used this information to target facilities in implementing their regulatory program. Therefore, a basic geographic information system methodology was being used prior to the installation of GIS hardware and software.

An automated GIS was initiated in the spring of 1988 and funded through the MERITs proposal process. Using the MERITs funding, a multi-phased pilot project (one phase had a single county as a focus and the other included all the counties in the Region to prioritize program actions) was initiated to demonstrate ground water protection applications of GIS technology "to more efficiently and effectively address ground water problems.[11]"

3.1.1 New Castle County, Delaware, Pilot Project

New Castle County, Delaware is the northernmost county in Delaware and contains the city of Wilmington and heavy industrial development. This county was selected as the pilot county for the following reasons: (1) both the County and the State were interested in developing a Wellhead Protection Program (WHPP) in this area; (2) EPA has a mandate to facilitate and promote the development and implementation of WHPP; and (3) data were available (e.g. local Water Resources Agency database consisting of approximately 75 geographically based files in digital form). Although other data were collected for the project, the availability of this database significantly reduced both the time and costs required for the data gathering process.

The project development process was composed of four basic steps (Figure 3-1). To illustrate phases and schedules for this pilot project, an EPA-generated Gantt chart is included (Figure 3-2). The **Application** phase was used to define the management objective or need. In the **Data Coverages** phase, both location and descriptive data needs were assessed along with data quality and availability issues. Methods and procedures to implement the project were determined in the **Analysis** phase. In the final step, **Composite Maps** were developed as the end product to define the solution. Various personnel were utilized in the management and implementation of this pilot project. EPA employees from the Water Management Division and the Information Resources Management Branch participated as project lead and technical lead, respectively. In addition, EPA provided management personnel to oversee the project.

Data were provided by the EPA Chesapeake Bay Program and the New Castle County, Delaware Water Resources Authority (NCC WRA), while technical assistance was provided by the Temple University Laboratory for GIS and the USGS Richmond, Virginia Office.[12] About 60% of the data were computer readable, so a significant part of the actual process was gathering, (not automating) integrating and assuring the quality of the data. [13]

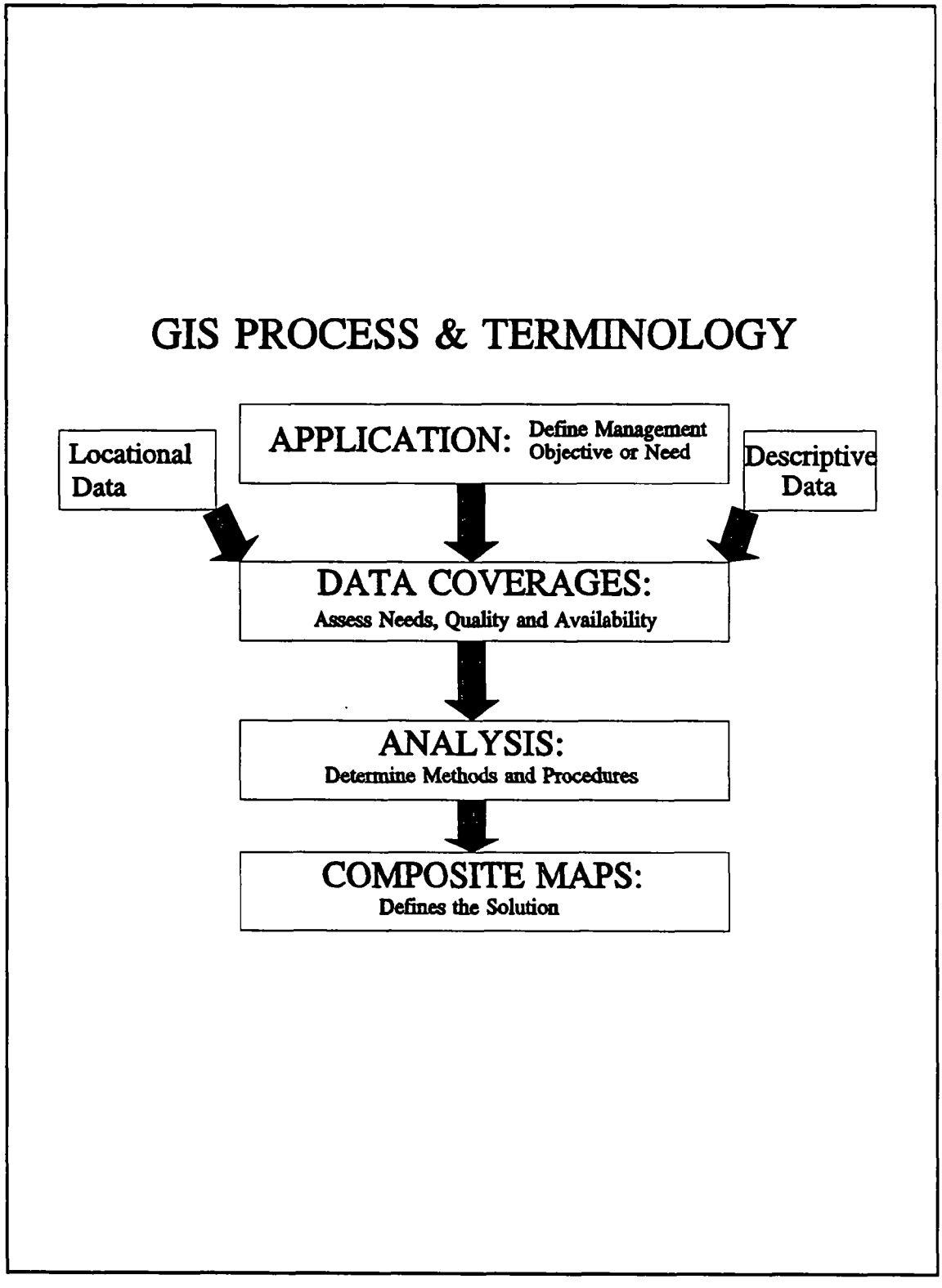

Figure 3-1 - Region III Pilot Project Process [12]

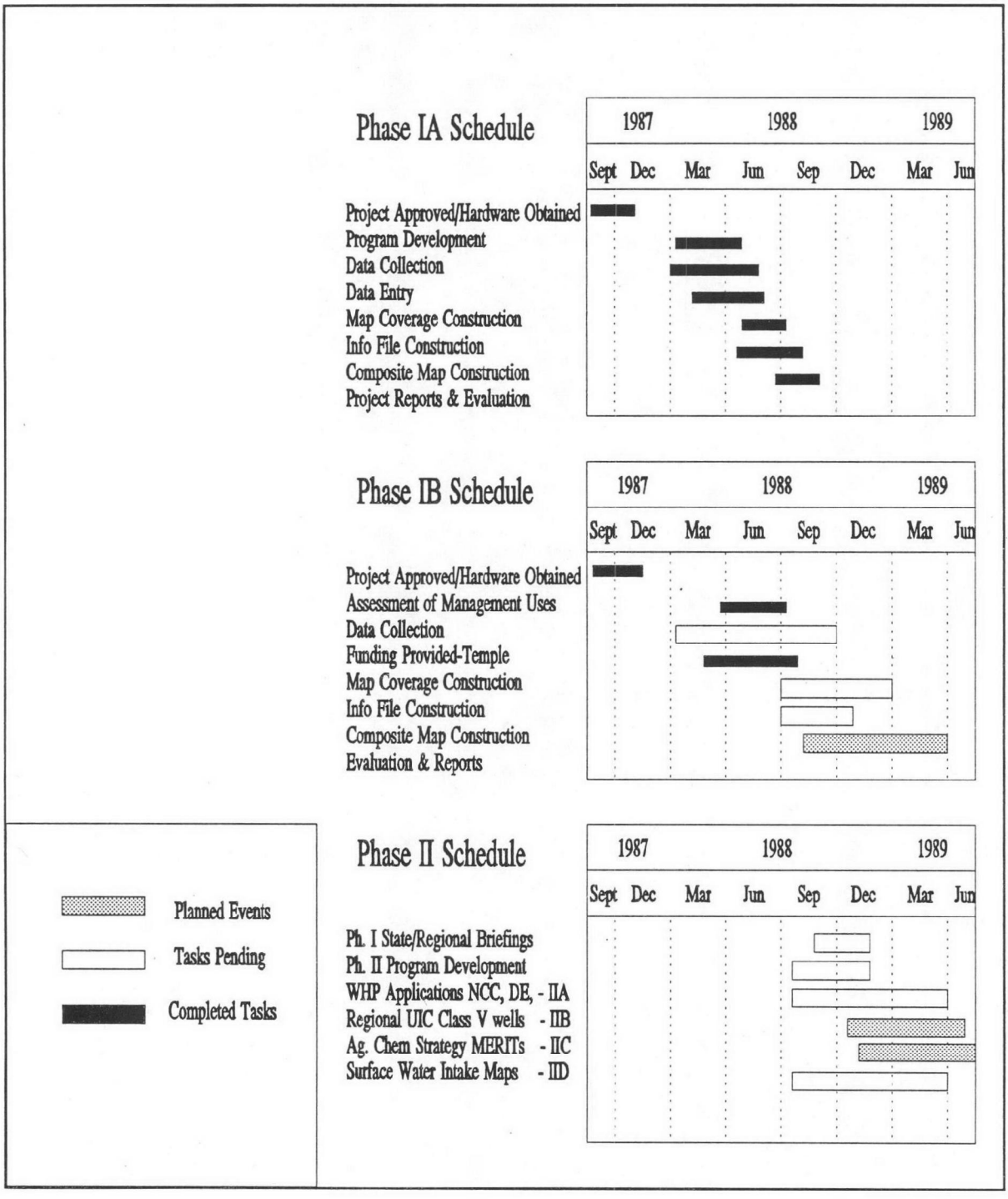

Figure 3-2 - Phases and Schedules for Region III Pilot (as of October 1988) [12]

Among other objectives, the purpose of the pilot project was to demonstrate data collection, conversion, and evaluation procedures using GIS.[14] Some data were already in the correct format while others required conversion and still others needed digitizing. Test plots of facility site locations were constructed and compared to source maps to evaluate the quality of the data. The following map products were constructed:

- Locations of EPA-regulated facilities, including major NPDES surface water discharges, CERCLA sites, and RCRA facilities;
- Location of high-risk underground storage tanks;
- Location of public water supply (PWS) wells;
- Location of PWS surface water intakes;
- County/subcounty DRASTIC evaluation;
- Population density;
- Land use applications;
- Septic tank suitability evaluation; and
- Recharge areas, aquifers, slope, soils, geology, and hydrology.

The information was then used to identify areas that were vulnerable to contamination. This effort also involved using the DRASTIC methodology to help evaluate ground water pollution to assess the county's vulnerability to ground water contamination.[15] From this pilot project, a formal process for completing GIS projects evolved.

3.1.2 Regional Assessment Pilot Project

The Ground Water Protection Section needed to determine which areas of the six-State Region were most vulnerable to both actual and potential ground water pollution. This need had been met somewhat during the pre-GIS years mentioned earlier. With GIS technology installed however, a Region-wide assessment could be made with the stronger presentation, reproduceability, and analytical capabilities of GIS. The Section's GIS Coordinator arranged database retrievals by the appropriate database managers from the following systems: Superfund (CERCLIS), RCRA (HWDMS, now RCRIS), drinking water (FRDS), high-risk underground injection wells (UICTS), soluble pesticide usage (National Pesticide Survey database), hydrogeological/soils vulnerability (DRASTIC), and ground water contamination incidents (a regional compendium).

A Ground Water Risk Assessment Methodology was created to prioritize the counties

in terms of ground water protection. The following factors were used: population dependent on ground water; pesticide usage; drinking water maximum contaminant level (MCLs) violations; risks posed by RCRA and CERCLA National Priority List facilities contaminating ground water; and actual incidents of ground water contamination (reported to EPA, as derived from news reporting). All these layers were considered individually and in aggregate. The ground water program ranked the top 30 counties requiring priority action.

3.1.3 Implementation Structure in Region III

In summary, Region III established GIS as an essential tool to accomplish programmatic tasks and to aid management in focusing its pollution control efforts. Management agreed to incorporate GIS activities into their fiscal budgets and resources were set aside for GIS application work. A formal GIS program was established and is supported by an infrastructure composed of four elements:

1. The GIS Management Steering Committee;
2. The GIS Users Group;
3. The Geographic Information Center (GIC), consisting of
   - A GIS Administrative Liaison,
   - GIS Project Leads,
   - GIS Technical Support personnel, and
   - GIS Operations Support personnel; and
4. The Ground Water Program Coordinator/Project Leads.

THE GIS USERS GROUP

The GIS Users Group, organized in 1989, is an inter-divisional forum for end users of GIS whose purpose is to share data and experiences in applying GIS techniques, define viable multi-media applications, and assist the Information Resources Management Branch (IRMB) in developing GIS user support and procedural guidance for the Region. Typical activities for this management forum will include periodic meetings to review regional project plans and ideas, presentation of project results, evaluation of data quality assurance procedures, development of planning processes to assure adequate GIS support, and recommendations to senior managers for beneficial applications of this technology within EPA and externally.

Figure 3-3 - The Mission of the GIS Users Group

The GIS proposal selection process includes the following steps[16]:

1. Program proposal submittal;
2. Geographic Information Center evaluation;
3. GIS Users Group evaluation;
4. GIS Management Steering Committee evaluation; and
5. Program implementation.

1. Program Proposal Submittal

   Project proposals are developed by the program offices with technical advice and assistance provided by the Geographic Information Center and by the GIS Users Group. The proposals also are submitted in a form consistent with GIS guidelines. Since 1988, the Ground Water Protection Section has staffed a GIS Coordinator who expedites GIS program development for ground water protection. In 1991, the Section hired a GIS technical expert and secured a GIS workstation to facilitate GIS usage.

2. Geographic Information Center (GIC)

   The GIC is composed of regional GIS program staff, with direct ties to the national GIS program. The GIS program is organized within the Information Resources Management Branch, Office of Policy and Management. This group provides technical support for all regional GIS-related activities, as needed. The project proposals are submitted to the GIC for review of technical feasibility and resource requirements.

3. GIS Users Group

   Proposals are sometimes discussed preliminarily in the GIS Users Group, a group that consists of EPA program staff interested in applying GIS. Meetings are attended by the EPA regional GIS technical team, who provide an immediate response to the project originator. The GIS Users Group evaluates the project in a technology-transfer forum. Additional information from the originator may be solicited to conduct this review. If the project is not found to be technically feasible, the proposal is returned to the originating program office (Step 1) with recommendations for scope of work changes.

4. GIS Management Steering Committee

   The GIS Management Steering Committee, headed by the Region's senior management, functions as the regional policy maker. The Committee makes long-range strategic planning decisions. It also can allocate resources.

Key items of considerations that the Region III GIS program has used in its GIS process are listed in Figure 3-4. These considerations place any individual GIS need or action in a larger, comprehensive planning process.

CONSIDERATIONS FOR GIS DEVELOPMENT PLANNING

Step 1: Compile an inventory of potential management applications that could be addressed with the GIS

- Identify GIS applications that would support your program's activities and decision-making functions.
- Assess the program management needs that could be satisfied by a GIS project (e.g., resource prioritization and allocation, problem identification, risk assessment). Anticipate specific program applications (e.g., prioritizing permitting, inspections, and enforcement actions).
- Identify the primary and secondary users of the project results (e.g., EPA programs, State agencies, local agencies)

Step 2: Prioritize potential GIS applications

- Employ methodology to rank potential applications; consider benefits, costs, and feasibility.
- Address factors relevant to investing regional resources for GIS projects, including:

  - Fiscal savings: FTE savings, direct cost savings, time savings, benefits to other agencies.
  - Program need: Use of application to one or more programs.
  - Cross-media impact: More efficient cross-media program management.
  - Environmental benefit.
  - Costs.
  - Feasibility.

Step 3: Design GIS application

- Specify project objectives.
- Select geographic boundaries and desired scale of data.
- Identify (locational and descriptive) data needs. Assess availability, cost, quality, and usability (e.g., conversion requirements, procurement time).
- Identify staff support required.
- Develop QA/QC procedures.
- Select analytical methodologies (e.g., weight tables, flow models).
- Specify tasks, schedule, and outputs (e.g., composite maps).

Step 4: Implement GIS application

- Acquire data.
- Design database.
- Automate and input data.
- Manipulate and analyze data.
- Evaluate results.

Figure 3-4 - Items to Consider When Planning a GIS Project [17]

3.2 REGION I

Region I's bottom-up approach to GIS is application-driven. Projects are evaluated on a case-by-case basis; no formal process exists in which various projects are rated against one another. Applications are project-specific with project-specific goals.

> Anticipate pitfalls when planning GIS projects. Consider data availability, quality, cost, viability factors, and required procurement times and staff support. Adopt a "teamwork" approach; cooperation is key. Start simply, maintain flexibility, and realistically assess goals and capabilities.

3.2.1 Upjohn Prototype Project

A prototype project that used GIS as a RCRA site management tool will be described to illustrate how GIS is used in Region I. The goals of this particular project included the following:

1. To provide a tool that would support site management decisions for corrective action.

2. To manage large volumes of data in accessible formats, and to develop interactive links between program staff and that data.

3. To effectively translate the program manager's requirements into GIS products.

4. To characterize the site both historically and currently.

5. To demonstrate GIS techniques to the Waste Division. These techniques include overlays, interactive query, 3D display, and statistical calculations.

The site chosen was the Upjohn Company's Fine Chemicals Division in North Haven, Connecticut, a 74-acre site located along the west bank of the Quinnipiac River. As mentioned earlier, most of the challenges in any GIS project are data-related. This particular site had extensive data from two sources, an engineer's site map and aerial photographs. The Topographic Map and Property Line Survey conducted in March 1989 provided Region I with strong base map layers. The site boundary was surveyed and provided the following in geometric calculations: bearings, distances, and a State plane northing and easting starting point. This coverage was created independently from the site map using the TRAVERSE command in ARC/INFO. Coverages digitized from the site plan included contour lines, buildings, tank areas, roads, and railroads. Average registration errors represented less than 3 feet on the ground. The topography of the site was generated using the contour coverage and ARC/INFO's TIN module.

The second, and rather extensive, dataset available was an aerial photograph analysis done by EPA's Environmental Photographic Interpretation Center (EPIC) in July 1987. The

analysis provided six enlarged photos from the years 1949, 1960, 1970, 1975, 1980, and 1986, each at different scales ranging from 1:2700 to 1:3700. The first phase of the automation process was to determine registration marks, or tics, for each photograph. Since the site plan already had been digitized, coordinates for building corners, road intersections, and hydrographic features were easily obtained.

The second phase of the automation process involved actual digitizing of several coverages off each photograph. Each coverage fell into one of two categories: dynamic or cumulative. Dynamic coverages were those that changed and had unique forms each year. For example, hydrography, fill lines, and drum and tank areas had to be digitized in their entirety from each photograph. It became apparent when digitizing the lagoons that there was a need to differentiate between cloud reflection, semi-solid wastes, and land. The drum and tank areas were identified by EPIC on mylar overlays as point locations; however, polygons were generated by visually assessing the area and referring to the analysis, which provided approximate drum and tank counts. Cumulative coverages were those that remained constant over the years with some alterations or additions. For example, buildings were enlarged and new roads were added to the coverage.

After all of the layers of information were automated, several analytical tools were provided to the site manager for access, manipulation, and further investigation of the data. The primary tool was a special ARCPLOT (SAP) program developed by Environmental Systems Research Institute (ESRI). SAP provides an interactive user-friendly environment, allowing access to ARCPLOT, the graphics module of ARC/INFO, with relatively little knowledge of the software. Any coverage in the directory can be accessed, displayed, and queried using simple menu-driven commands. SAP offers a spatial and temporal comprehension about the magnitude of the problem that had not been available before. For example, the ability to draw 1949 hydrography, shade rivers and lagoons different colors, then overlay present day locations of monitoring wells becomes a powerful visual tool for determining additional well locations to investigate further areas of concern. Another tool provided was an end-user interface developed in Region I for well-boring analysis. A series of macros were written in the ARC Macro Language (AML) to allow data to be accessed from INFO, the relational database module of ARC/INFO. This program allowed the site manager and other Waste Division personnel to interactively select a well and list data about that well, or draw its core diagram on the screen.

The time required to develop this prototype project in Region I is summarized as follows:

- The Upjohn data automation process took approximately 80 hours of digitizing, 20 hours of editing, 35 hours of coding, 14 hours of processing, and 20 hours of documentation and data dictionary preparation for a total of 170 hours or about 4.5 weeks.

- The Well Boring Analysis program took approximately 40 hours of data entry, 7 hours of coding, 75 hours of programming, and 10 hours of documentation, totaling 132 hours or about 3.5 weeks.

The site manager can use the GIS for support in his discussions with Upjohn concerning plume migration, the validity of sampling locations, and well and boring information. The site manager also has the ability to make updates and corrections to files in a relatively short period of time. Overall, the system has provided the site manager with an efficient and effective data management tool for the site.[5]

3.2.2 Implementation Structure in Region I

In Region I GIS development, the Regional GIS Coordinator must procure resources to accomplish each application from the program where the application originates. Therefore, it is to the advantage of the GIS staff that program staff be educated in GIS capabilities. As a result, GIS staff spend a substantial amount of time marketing/training GIS capabilities to program staff.[18]

Individuals on the GIS technical staff who are familiar with program-specific issues have been essential to the success of the GIS program in Region I. Most GIS staff members have a program area in which they specialize: One staff member is familiar with water programs, two staff members are familiar with waste programs, and one staff member is a "floater" with experience in all program areas.[18]

The GIS infrastructure in Region I is composed of:

- GIS Coordinator - Liaison with program staff;
- GIS Computer Systems Administrator;
- GIS Technical Project Leads; and
- Program Office Project Leads.

The GIS planning and implementation process in Region I is flexible and will vary depending on the size of the task and the availability of program funding.[19] It consists of the following steps:

1. Project initiation;
2. Coordination meeting;
3. Resource procurement;
4. Project plan development;
5. Project implementation; and
6. Data Archival.

The steps are described below.

1. Project Initiation

   Program staff meet with a GIS technical staff member (who will be the Technical Project Lead) to discuss feasibility and requirements. This will ideally occur at the beginning of the fiscal year so that program dollars can be allocated accordingly.

2. Coordination Meeting

   The GIS technical staff member meets with the Region's GIS Coordinator to discuss formal plans and resource requirements.

3. Resource Procurement

   The GIS Coordinator negotiates with the Program Office Project Lead for funding.

> *" The program staff need to be aware of the capabilities of using GIS. Communication between the programs and the GIS technical staff must therefore be encouraged. "*

4. Project Plan Development

   The GIS technical staff member drafts a Project Plan. This Project Plan will be updated, as necessary, in the course of the task. The Project Plan consists of the following elements[19]:

   - Project Name
   - Program
   - Program Office Project Lead
   - GIS Technical Lead
   - Project Goals
   - Geographic Area of Interest
   - Project Summary
   - Data Layers Needed
   - Data Sources
   - Project Plan, Tasks
   - Level of Effort: hours and dollars
   - Comments

5. Data Archival

   When the project is completed, the Project Plan and other relevant information are archived with the data layers and coverages. Data coverage descriptions are added to a data inventory document for future reference.

4.0 COMPONENTS OF THE GIS OPERATION

SUMMARY

The GIS systems at Regions I and III are implemented with Data General workstations using ARC/INFO software. The majority of tasks for a given application are performed using ARC/INFO. There are, however, other software tools that aid GIS technical personnel in data integration tasks. Fundamental to the applications are the actual data items and layers that vary in type and scope from application to application. At the core of the EPA GIS are the technical personnel. The Regions employ five to six staff members who are responsible for the planning, development, and implementation of GIS applications.

EPA Regions I and III agree on a number of factors essential to the successful use and operation of the EPA GIS. In this chapter, data needs and the associated personnel infrastructure used in the Region I and III GIS implementations, both critical to operations, will be described. In addition, traditional technological issues related to hardware and software will be described but will not be discussed in detail. For general information system and data needs, the reader is urged to review other sources of information listed in the Bibliography.

4.1 PERSONNEL

Experienced technical personnel constitute the most critical resource in conducting the EPA GIS programs. The composition of the GIS teams is similar in both regions. The GIS team in Region III is composed of six GIS specialists (three EPA employees and three contractor employees). These specialists have interdisciplinary backgrounds that include training in geology, geography, computer science, and environmental science. The Water Management Division has a GIS Coordinator and a full-time GIS technical specialist. In addition, a contractor performs all hardware support tasks for the Region.[13] Region I has six full time equivalents (FTEs) responsible for GIS work: four GIS specialists who are contractors, one computer systems administrator, and a GIS technical coordinator. The expertise of the GIS technical personnel is varied and includes training in environmental science, geography, and geology. All have excellent analytical skills and computer aptitudes.[18] In addition, the systems administrator has a computer science background and extensive experience.

In both Regions, the GIS technical coordinator usually works with a program office representative who assesses requirements and provides specific data.[13,18] It is vital that the GIS personnel be very familiar with the data and the associated data sources, since the majority of their time will be spent procuring and manipulating the data. These data education efforts also constitute the bulk of the learning curve for a new GIS member.[18]

4.2 HARDWARE/SOFTWARE

Owing to the nature of the source data used in GIS projects and the need for GIS output products, substantial computing performance--including throughput and response time operations--is required. In most of the completed EPA projects, the end products were maps. These products, therefore, required the use of high-end output peripherals such as a plotter or color printer. In both Regions, the platform of choice is the Data General workstation. Because of the rapid advancements in hardware technology, efforts are currently under way to install Rapid Instruction Set Computing (RISC) machines in at least one region.[18] Equipment currently and previously used at both Regions is listed below. Please note that there are numerous other GIS software packages available, which can operate on various hardware platforms.

GIS Computer/Peripheral Equipment for EPA Regions I and III

Equipment in EPA Region I, circa 1992[20]

- Data General Workstation

  5000 Serial Server (one)
  412 Workstations (16GB) (four)
  color thermal printer (one)
  laser printer (one)
  CD ROM reader (one)
  cartridge tape drives (two)
  DOS drives (three)
  Operating System

- Sun Workstations

  4/330 Sparcserver (one)
  Sparcstation (one)
  6250/1600 tape drive
  Sun laser printer (1 GB)

- ARC/INFO Software

  multiseat licenses (two)
  single seat licenses (five)

- Tektronixs X11 (three)

- Tek Terminal Printer (two)

Equipment in EPA Region III, circa 1990

- Prime 2755
- Zeta 8 Plotter
- DEC VT125
- Tektronix 4692
- Tektronix 4207
- Tektronix 4958 Digitizer
- Epson Equity III
- Calcomp 1043 Plotter
- Tektronix 410

Computer memory is at a premium in most systems that utilize large datasets. As the number of projects increases, the need for memory also increases. Because of the dynamic nature of GIS project operations within EPA, datasets cannot be kept online indefinitely and cannot be maintained over a long period of time. Planning for sufficient data storage, therefore, is a requirement that should not be underestimated.[18] For example, USGS's Digital Line Graph files can be at least 0.5 megabytes per quad (USGS 1:24,000 scale) depending on the area chosen. With 30 to 40 quads for a small-sized State, minimum storage requirements would be 15 to 20 megabytes to implement a State base map using this data. For point data, using the Standard File Format of USGS's Geographic Names Information System (GNIS), files can range in size from approximately 9 to 40 megabytes per State (ASCII file format). Thus, maintaining many of these files will consume memory/storage resources quite rapidly.

In addition to disk storage resources, these file sizes also require a sufficient amount of core or random access memory to perform processing. Partly for this reason, the EPA Regions have implemented the GIS software with workstations, rather than PCs, which traditionally have sufficient processing capabilities for all GIS functions. In fact, Daratech estimated that 64.4 percent of 1990 GIS software revenues worldwide were for workstation-based implementations compared to 18.4 percent for PC-based software.[37] EPA's particular selection of hardware alternatives does not preclude using microcomputers as platforms to implement a GIS. Traditional systems implemented on microcomputers have limited georeferencing and attribute-handling capabilities, and are generally used for map entry, editing, and production tasks.[21] Some sacrifices in performance will most likely occur if microcomputers are used, depending on the size and requirements of the application. Rapidly decreasing costs coupled with rapidly advancing hardware and software technologies, however, compel potential GIS users to examine microcomputers as a viable hardware solution for small to medium level applications. To further evaluate the alternative of using a PC or Workstation alternative, the reader should investigate *PCs vs. Workstations - Looking Beyond the Hype* in the June 1992 issue of GIS World.[37]

In addition to the standard operating systems level software used to execute the ARC/INFO GIS applications on EPA's Data General workstations, both Regions use a variety of microcomputer software to aid in data integration tasks. These software packages include, but are not limited to, dBASE III, dBASE IV, and LOTUS 1-2-3.[13,18] Most application-level programming occurs in the ARC Macro Language, or AML, which is used essentially to automate commands in ARC/INFO or to develop interfaces for end-users. Aside from fulfilling minimum requirements, the INFO system generally falls short of more sophisticated entry and reporting capabilities.[18]

4.3 DATA

4.3.1 Data Considerations

Data gathering and editing chores make up most of the effort in any given GIS application. In Region III, approximately 60% of the data used exist in a computer readable format.[13] A higher percentage of Region I's data sources were computer readable because the State and local governments had been performing GIS-related tasks prior to EPA's GIS implementation. Most States in Region I have also adopted quality assurance procedures for their own data. This situation does present some data consistency problems for the regional office in Boston.[18] No formal quality assurance procedures currently exist in Region III because of the variability of the data sources and formats.[13] As with any effort to standardize data and data quality procedures, the more participants and data sources -- and therefore the more diverse the number of requirements, applications, and data collection resources -- the more challenging it becomes to establish a formal set of protocols.

The Office of Information Resources Management (OIRM) group at EPA headquarters in Washington, DC, has established numerous policies[22] in an attempt to establish a set of initial data standards and quality assurance parameters that include:

- Chemical Abstract Service Registry Number Data Standard, EPA Order 2180.1, June 26, 1987
- Data Standards for Electronic Transmission of Laboratory Measurement Results, EPA Order 2180.2, December 10, 1987
- Facility Identification Data Standard, EPA Order 2180.3, April 9, 1990
- IRM Policy Manual, Chapter 13, "Locational Data, Policy" May 17, 1990, revised April 8, 1991
- The Policy on Electronic Reporting, July 30, 1990
- IRM Policy Manual, "State/EPA Data Management"
- IRM Policy Manual, "Data Standards"

EPA's Ground Water Protection Division has established data standards also; these include:

- Minimum Set of Data Elements for Groundwater, EPA Order No. 7500.1, September 11, 1989,[22] subsequently revised in October 1992
- "Definitions for the Minimum Set of Data Elements for Ground Water

Quality," July 1992

EPA Region III promulgated regional locational data standards in 1988:

- Site Location Identification Policy and Responsibilities, Region III Order 5361.5, September 14, 1988

In addition all EPA organizations are required to use Federal Information Processing Standards (FIPS). The spatial data transfer standard, which was not formalized when this document was first drafted will be one of the more significant FIP standards for GIS implementations in the federal government.

In March 1992, OIRM issued an important four-volume set, *Locational Data Policy Implementation Guidance.*[23] The Agency Locational Data Policy (LDP) goal is to achieve 25-meter accuracy for all geographic data. As stated in the Guidance, "All Agency-sponsored data collections and activities that define/describe attributes (environmental characteristics) *about a place* are within the scope of the LDP." Data are to be expressed in latitude/longitude. The policy endorses the use of Global Positioning Systems (GPS) technology. Other locational methods include photogrammetry, map interpolation, photo interpretation, address matching, and ZIP code centroid. Both Regions I and III have used these techniques.

These policies, standards, and technologies, combined with the development and use of detailed project- and program-specific data quality objectives, should assist both Regions in their efforts to establish data standards and quality assurance protocols. With so many organizations developing data for use in GIS applications, the task of detailing the data needed by the Office of Ground Water Protection and related program offices within EPA is challenging. To illustrate the diversity of the data required, Region III's pilot project in New Castle County Delaware, can be used (Table 4-1).[12]

4.3.2 Data Sources

Incorporating base map information is normally the first step in developing a project. These data are usually obtained from USGS Digital Line Graphs (DLG) 7.5- and 15-minute topographic quadrangle series. Thematic categories for these maps include (1) boundaries -- State and county boundaries and federally administered lands; (2) transportation -- roads and trails, railroads, and pipelines and transmission lines; (3) hydrography -- streams and water bodies; and (4) U.S. Public Land Survey System. Each of these categories can be obtained from USGS separately or combined with any other category.[24] [For information on the actual format of DLG files, the reader is urged to review the following reference: USGS Digital Cartographic Data Standards: Digital Line Graphs From 1:2,000,000-Scale Maps.[25]]

Table 4-1. Data Coverages for Region III Pilot Project

CATEGORY	DATA
Base Maps	Political boundaries, transportation, and streams
Water Use	Public water supply wells and intakes, ground water use by county
Hydrogeologic Conditions	DRASTIC Index (Agriculture), Geology, Soils
Land Use	Population, housing, land cover
EPA Regulated Facilities	Underground storage tanks, underground injection control, RCRA sites, CERCLA sites, National Pollutant Discharge Elimination System sites, public water supply system sites
Special Protection Areas	Wellhead protection areas, recharge areas, wetlands
County-specific data	Various data coverages for New Castle County, DE

In the case of the New Castle County pilot project, political boundaries, transportation, and streams were used as base maps. Depending on the scale needed, other data can be obtained from USGS or associated vendors such as Land Use and Land Cover and Associated Maps at 1:250,000 and 1:100,000 scale, or USGS 7.5-Minute Digital Elevation Data. The problem with these data, as was the case with the Region III pilot project and the Region I case study (See Chapters 2 and 3), is that the scales are too small to do substantive analysis. Therefore, much of the information for the New Castle County Pilot project was digitized manually (by the USGS and the NCC Water Resource Authority). Data also can be obtained from sources, such as engineering site maps, at varying scales (e.g., 1:200 - 1:48,000).

As the GIS implementation evolves at a given site, the resolution required by its end users evolves along with it.[26] It is, therefore, important that the information system group obtain as detailed a level of data when doing data procurement as practically possible.[26] For example, in the Region I GIS office, 1:24,000 is the scale at which most projects are performed. The States in Region I, being further advanced in their GIS implementations, are now using 1:5,000 scale data for their projects.[18] State and local governments are increasingly using land use information at the parcel size level, which exists at an even higher level of resolution.[18] This scale requirement further complicates the data procurement and storage process.

In an attempt to centralize data sources for expeditious data procurement, EPA has developed the Geographic Resources Information and Data Systems (GRIDS), which is installed at the National Computing Center in Research Triangle Park, NC. GRIDS contains various data modules, which are listed in Table 4-2 that can be used in conjunction with GIS.[27] Unfortunately, as stated before, most applications in the Regions require larger scale data, which GRIDS does not support at this time.[18]

Table 4-2. Data Modules Available from GRIDS

Module Description	
USGS Hydrography and Transportation	1:100,000, DLG3
USGS Transportation	1:2,000,000, DLG3
USGS DMA Digital Elevation Model, DEM 30 second point topography	
USGS Geographic Names Information System	
USGS Hydrologic Basin Boundaries	
US Bureau of Census/TIGER Line Precensus Files	
US Bureau of Census Master Area Reference File (MARF)	
USEPA Ecoregion Boundaries	

EPA regulatory and support databases include[28]:

- The Facilities Index System (FINDS), index of all facilities regulated/tracked by EPA programs
- The Integrated Risk Information System (IRIS), summaries of health risk and regulatory information on specific chemicals
- The Storage and Retrieval of Water Quality Information (STORET), data on ambient, intensive survey, effluent, and biological water quality monitoring
- The Comprehensive Environmental Response, Compensation and Liability Information System, Version 2 (CERCLIS), Superfund database, covers all aspects of hazardous waste sites from initial discovery to listing on the National Priority List
- The Resource Conservation and Recovery Information System (RCRIS), RCRA database on facilities which generate, transport, and treat, store, or

dispose of hazardous waste

- The EPA Section 305(b) Waterbody System (WBS), biennial State water quality assessment information as required by the Clean Water Act

- The Permit Compliance System (PCS), National Pollutant Discharge Elimination System permit holding facilities

- The Federal Reporting Data System (FRDS), Public Water Supplies database on monitoring compliance, maximum contaminant level regulations and other Safe Drinking Water Act requirements

- The Toxic Release Inventory (TRI), Emergency Planning and Community Right-to-Know Act database on toxic chemical emissions from regulated facilities

Additional databases and data sources produced by Federal, State, and local governments, consulting firms, and other organizations contain data useful for GIS applications. With this in mind, both Regions have continually emphasized the need for **extensive data scouting** to investigate these sources. The resources required to gather, input, and quality assure new data may be much more cost prohibitive when compared with efforts involved in obtaining data through thorough data scouting.[18,29] It should be noted that scouting can be enhanced by using index systems maintained at every Federal agency. At EPA, this index is known as the Information Systems Inventory (ISI), and contains summary information on approximately 700 of the Agency's data systems. It is maintained by the OIRM at EPA.

To further illustrate the potential range of data types and sources refer to Table 4-3, which lists data required for Region III's Lancaster County Agricultural Management and Wellhead Protection Project.[30] (For further information on GIS data and projects for an entire State, see the appendix.[31])

GIS can also employ data from various other sources. The photogrammetry data for Region I's case study on the Upjohn Chemical site is a good example. With increased needs to record information at larger scales, the use of aerial photogrammetry data has become popular. Costs and convenience are possible shortcomings and should be considered when using this method. If the end users require data at greater resolution for a large geographic area, satellite data are available. Examples include the following:

- Earth Observation Satellite Co. (EOSAT) in Lanham, Maryland, offers Landsat 6 (remotely sensed) data at an annual fee of $500,000, which includes Landsat Thematic Mapper products.[32]

- The French Systeme Probatoire d'Observation de la Terre (SPOT) produces

satellite stereoscopic imagery of the Earth's natural resources. These panchromatic images have a ground resolution of 10 meters.[33]

Ultimately, with the completion of the Navigation Satellite Timing and Ranging (NAVSTAR) constellation in 1993, Global Positioning Systems will become an effective means to gather and verify locational data. As mentioned previously, EPA recommended that this method be employed in various capacities to expedite data gathering and verification operations within the Agency to conform to the 25-meter accuracy goal. A GPS primer that describes the GPS technology and includes potential shortcomings such as *multipath* and *selective availability* (S/A) is packaged with the implementation guidance for the Locational Data Policy (March 1992).[34]

Table 4-3. Data Needed for Lancaster County, Pennsylvania Agricultural Management and Wellhead Protection Project [a]

Data	Source
Geomorphological data including geology, hydrogeologic units, hydraulic conductivity, location of sinkholes, springs, caves	USGS collect and automate using literature data PA DER, PGS, EMSL/EPA data
Fracture locations, losing stream sections	EMSL/EPA, USGS, PGS, DER
Geologic and structural mapping information including formational/units type and geographical extent, faults and lineament locations	EMSL/EPA, USGS, PA Geological Survey
Soils	USDA compile and digitize
Well location and construction data for existing wells	USGS (GWSI & State drillers database) and PDA/LCCD local survey
Water quality monitoring for pesticides and nitrates	USGS collect and automate
Populations relying on public and private wells and springs	PDA/LCCD survey; EPA automate
Water table elevation mapping	USGS will collect data and digitize
Dye trace analysis	EMSL/EPA, USGS
Location of public supply wells	USGS, DER & PSC collect and digitize
Property and farm field boundary data from farms to be surveyed	EPA/Temple & Berkeley Universities collect and digitize
Pesticide usage data by property and watershed	Collected by PDA/LCCD; EPA-IRMB will enter into GIS
Current and past crop management practices	PDA/LCCD survey
Land use including crop types	EPIC/EPA
Animal density	USDA-SCS, CES, LCCD/PDA, local officials
Landfills	DER, local officials, EPA
Sewage treatment plants	DER, local officials, EPA
Industry type	DER, local officials, EPA
USTs, other major sources of contamination	DER, local officials, EPA
Areas with manure excesses in relation to land base	USDA-SCS, CES, private vendors

[a] Refer to key on next page for abbreviations

Agency Key for Table 4-3

USGS -	United States Geological Survey
PA DER -	Pennsylvania Department of Environmental Resources
EMSL/EPA -	Environmental Monitoring Systems Laboratory/EPA
EPIC/EPA -	Environmental Photographic Interpretation Center/EPA
USDA -	United States Department of Agriculture
CES -	Cooperative Extension Service
LCCD -	Lancaster County Conservation District
PSC -	Consultant
PGS -	Pennsylvania Geological Survey
PDA -	Pennsylvania Department of Agriculture

5.0 GIS USES AND USERS

SUMMARY

GIS is used to identify sources, receptors, and pathways of ground water and drinking water contamination for regional, State, county and site-specific settings. After contamination sources are identified, GIS may be used to target specific program efforts and focus resources on high-priority areas. Site-specific applications are used to manage pollution source information, site characteristics, and monitoring data to assist in site investigation and remediation activities. GIS also provides information on receptors of ground water contamination, including the population and the ground water resource. This information facilitates pollution prevention initiatives, such as wellhead protection and sole source aquifer protection. In addition, GIS products can be used for public outreach and communication purposes. The majority of the users consist of environmental managers at the regional, State, and local levels.

GIS in EPA Regions I and III is used for the identification, analysis, and management of environmental problems. These applications are directed toward fulfilling various ground water-related program requirements (Figures 5-1 and 5-2) and meeting EPA's mandate. GIS projects are applied on varying geographic scales according to the needs of the particular use. Regional assessments that encompass several States are employed in focusing pollution control efforts. Other projects identify more localized problems on a statewide basis or as countywide assessments. At the largest scale are projects with site-specific scope, that are aimed at performing a risk assessment or assisting in data management of hazardous waste sites.[14] Correspondingly, the users of these applications include regional ground water programs, State ground water/drinking water programs, regional and State hazardous waste programs, and county planning agencies.

An unanticipated use of the EPA GIS has been as a mechanism for building cooperative, interagency (including Federal, State, and local governments) approaches to ground water protection.[14] Due to the characteristics of the data sources for EPA GIS projects, their distributed nature makes cooperative arrangements not only helpful but also necessary to successful GIS projects. In fact, in the second phase of Region III's initial pilot project, cooperative arrangements with both State and local authorities were established as a project objective, with the goal of transferring the GIS technology to the States to make them autonomous.[14] This situation also is true with Region I, which found that cooperative arrangements are necessary for efficient GIS operations.[26]

One of the many uses of GIS is to identify potential hazards to drinking water. This activity involves first identifying ground water contamination sources relative to receptors, and then assessing the vulnerability of potential drinking water supplies to contamination.[12] A more sophisticated use involves geographic targeting. About 30% of Region I's applications are used in prioritization and geographic targeting efforts.[18] With this type of application, existing or potential drinking water supply areas at greatest risk to ground water contamination can be identified. Also, geographic targeting is useful for identifying sites for enforcement action, targeting compliance monitoring resources, or prioritizing other activities, including permits, grants, and wellhead protection programs.[7]

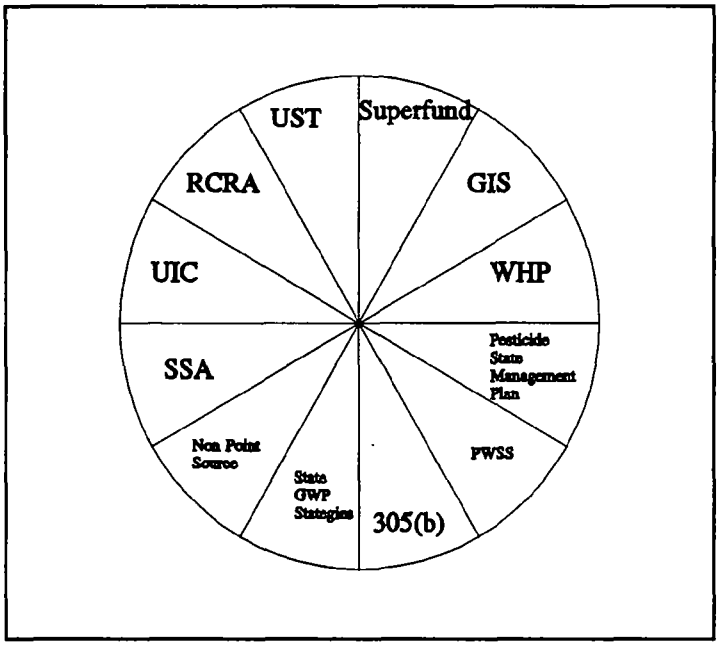

Figure 5-1 - Major Ground Water Related Programs

The fact that GIS can be used effectively as a data visualization tool makes it quite useful for public outreach applications. Specifically it can be used for the following:

- Communicating risk;
- Improving the accuracy and clarity of distributed information;
- Improving public awareness and understanding of environmental problems; and
- Promoting dialogue between regulators and the regulated community.

Many GIS projects overlap in functionality with other projects and are therefore difficult to classify by use. Another approach is to classify GIS projects by the basic questions they answer. Some of the more common questions include the following:

1. Given available data, where are the current source(s) of pollution?
2. Who is at the greatest risk? What area contains the greatest threat to public health or the environment?
3. Are pollution control efforts effective?

4. How does the presence of natural resource areas affect regional ecological values?

The following section lists the applications in Regions I and III according to the questions mentioned above. Each project is referenced in Table 5-1, which follows the text. This table also provides the name of a contact person.

EPA PROGRAMS RELATED TO GROUNDWATER ADDRESSED BY GIS APPLICATIONS

- State Ground Water Protection Strategies
- Public Water Supply Supervision (PWSS) Program, Safe Drinking Water Act
- Sole Source Aquifer (SSA) Program, section 1424(e) of the Safe Drinking Water Act
- Underground Injection Control (UIC) Program, sections 1421 and 1422 of the Safe Drinking Water Act of 1974
- Wellhead Protection Program (WHP), Safe Drinking Water Act 1986 Amendments, section 1428
- Pesticides State Management Plan, Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- Nonpoint Source Pollution Programs, section 319 of the Clean Water Act
- Water Quality Inventory Reports, section 305(b) of the Clean Water Act
- Resource Conservation and Recovery Act (RCRA), Subtitle C
- Comprehensive Environmental Response and Liability Act (CERCLA)

Figure 5-2 - Ground Water Programs

5.1 APPLICATIONS

5.1.1 Where Are the Current Source(s) of Pollution?

- Application: Identify the areas where drinking water supplies are (and potentially will be) most vulnerable to contamination.

  Objective: Identify the location of potential sources of ground water contamination relative to receptors. Employ ground water flow models to delineate Wellhead Protection Areas (WHPAs) for selected wellfields. Employ DRASTIC (or the LeGrand System) to assess the relative vulnerability of designated WHPAs, to ground water contamination. Within the boundaries of designated WHPAs, correlate information on contamination sources with information on receptors. Overlay the Digital Elevation Model (DEM) to indicate the general direction of ground water flow.

  Project Reference: Bucks County Assessment.

  Users: Regional and State ground water programs, county and State planning agencies.

- Application: Conduct a Region-wide assessment of ground water risks and pollution trends.

  Objective: Characterize environmental stress, in the Region, by evaluating such factors as pollution incidence, pesticide usage, the relationship of contamination sources to drinking water supplies, and risk to affected populations. Prioritize the Region's drinking water supplies in terms of vulnerability and risk to affected users.

  Project Reference: Regional Ground Water Risk Assessment, Phase I.

  Users: Regional and State ground water programs.

- Application: Target geographic areas, within a State, where ground water contamination occurs presently, or where it might occur.

  Objective: Assess the causal factors, nature, and spatial extent of the contamination (existing and potential) of drinking water supplies. Develop a mechanism for targeting enforcement actions by identifying the following:

  1. Geographic areas where high levels of contamination are potentially impacting public water supplies; and
  2. Potential violators.

Project Reference: Regional Ground Water Risk Assessment, Phase II.

Users: Regional ground water programs, Regional hazardous waste programs.

- Application: Provide technical assistance to State/local efforts to develop Wellhead Protection Programs.

  Objective: Identify locations of potential sources of ground water contamination. Identify locations of current and potential sources of ground water used for drinking water. Delineate Wellhead Protection Area boundaries.

  Project Reference: Evaluation of Potential Hazards to Drinking Water in New Castle County, Delaware; Anne Arundel County, Maryland, Wellhead Protection Project; Carroll County, Maryland, Wellhead Protection Project.

  Users: Regional ground water programs, State drinking water/ground water programs, county planning agencies.

- Application: Investigate a RCRA Site.

  Objective: Examine in more detail specific questions regarding the corrective action, and communicate these findings to the public and the facility. Manage large volumes of information in an accessible format, and develop interactive links with other data sources. Evaluate the status and effectiveness of cleanup efforts.

  The development of an appropriate RCRA facility investigation under corrective action for UPJOHN Chemical Co. will be performed. The system highlights areas of possible contamination, buried drums, unlined impoundment areas, and other areas for further investigation. Present conditions are analyzed based on past site activities and are used to evaluate the proposed investigation, including locations of boring test pits, sampling areas, and drilling depths.

  Project Reference: Site Management of the Upjohn Chemical Company Fine Chemicals Division, North Haven, Connecticut.

  Users: Regional and State hazardous waste programs.

- Application: Data management of a Superfund site.

  Objective: Utilize GIS technology to develop a digital database of the hydrological components present in the Aberjona River Basin. The database will eventually be used to support soil and water data collection efforts to be completed at a future data.

  Project Reference: Aberjona River Superfund Site.

  Users: Regional and State hazardous waste programs.

- Application: Data management of a chemical hazardous waste site.

  Objective: Utilize GIS technology to develop a digital database containing information on solid waste management units, monitoring wells, and hazardous substance release points at the Pfizer chemical plant and research facility.

  Project Reference: Pfizer Chemical.

  Users: Regional and State hazardous waste programs.

- Application: Identify where hazardous substance releases have occurred.

  Objective: This project explored the use of GIS for identifying those sites, where possible releases of hazardous substances have occurred, for potential inclusion into the National Priority List (NPL).

  Project Reference: Superfund Site Discovery Project.

  Users: Regional hazardous waste managers.

5.1.2 Based on Pollution Sources and Land Characteristics, What Areas Are Potentially Affected or Susceptible to Pollution? Who is at the Greatest Risk? Water Area Contains the Greatest Threat to Public Health of the Environment?

- Application: Inter-Agency Cooperative Projects.

  Objective: Develop Federal/State/local cooperative relationships to identify ground water resources vulnerable to contamination; target "hot spots"; delineate WHPAs, critical aquifers, and recharge areas; and track ground water quality trends.

Project Reference: Evaluation of Potential Hazards to Drinking Water in New Castle County, Anne Arundel County, and Carroll County Wellhead Protection Projects; Pesticides in Ground Water Projects for Lancaster County, Pennsylvania, and Jefferson County, West Virginia (See also: "Option For Focusing Mutual Ground Water Protection Interests and GIS Initiatives in West Virginia").

Users: Regional ground water programs, State drinking water/ground water programs, county planning agencies.

- Application: Assess the impact of pesticide usage and agricultural practices on the quality of ground water. Provide technical assistance to State/local efforts to develop Management Plans.

  Objective: Identify areas where ground water is vulnerable to contamination from pesticides. Identify drinking water wells that are potentially at risk from pesticide contamination.

  Project Reference: Pesticides in Ground Water: GIS Demonstration Projects for Lancaster County and for Jefferson County.

  Users: Regional ground water programs, State drinking water/ground water programs, State Departments of Agriculture, county planning agencies.

- Application: Target and prioritize underground storage tank sites for inspection, enforcement, and cleanup efforts.

  Objective: Identify all high-risk underground storage tank facilities located within a 1/4-mile radius of Wellhead Protection Areas.

  Project Reference: Evaluation of Potential Hazards to Drinking Water in New Castle County, Delaware.

  Users: Regional ground water programs, State drinking water/ground water programs, county planning agencies (e.g., water authorities).

- Application: Predictive Modeling.

  Objective: Construct a dynamic model capable of predicting spatial and temporal trends in land use patterns and associated ground water impacts.

  Project Reference: Bucks County Assessment.

  Users: Regional and State ground water programs, county and State planning

agencies.

- Application: Identify and delineate wellhead protection areas.

  Objective: Use the GIS and PC-based ground water modeling programs to delineate a wellhead protection area in the Annaquatucket Aquifer Wellfield in North Kingstown, Rhode Island.

  Project Reference: GIS Delineation of Wellhead Protection Area and Ground Water Data Management in North Kingstown, Rhode Island.

  Users: State and local planning organizations.

- Application: Environmental Impact Statement Analysis of highway alignment.

  Objective: Develop an automated spatial database for a four-quadrangle area in Connecticut in support of an EIS review of a proposed highway project. The application will be used to analyze proposed and alternative highway upgrade alternatives and alignments to minimize wetland impacts.

  Project Reference: Route 6 (Connecticut) EIS Analysis.

  Users: State and county planning agencies.

- Application: Evaluate potential ground water contamination problems.

  Objective: Identify ground water/drinking water supplies relative to potential sources of ground water contamination. Identify the drinking water supplies most vulnerable to contamination. Assess major ground water-related environmental problems. Employ a risk-based approach to prioritize the drinking water/ground water supplies according the vulnerability to contamination and risk to affected users.

  Project Reference: Evaluation of Potential Hazards to Drinking Water in New Castle County, Delaware.

  Users: Regional ground water programs, State drinking water/ground water programs, county planning agencies (e.g., water authorities).

- Application: Locate high-risk UST facilities.

  Objective: Employ the NETWORK module of ARC/INFO, together with the road network from the (1980) CENSUS DIME file to automate the address matching process for locating high risk underground storage tank facilities.

Project Reference: Evaluation of Potential Hazards to Drinking Water in New Castle County, Delaware.

Users: Regional and State ground water programs; Regional and State hazardous waste programs.

- Application: Identify priority areas at risk from exposure to hazardous chemicals.

  Objective: This project will create a methodology for identifying priority areas at risk from exposure to hazardous chemicals. The result of the model will be a ranked list of towns and a color-coded map for each State in New England. The inputs to the model are population, transportation, certain industries (based on Standard Industrial Classification code), and previous spills. For each town, the model will assign a score for each of the five inputs; each input will be broken down into classes having different scores. The sum of the scores for each of the five inputs will determine the total score for each town. It may be decided to add weights to individual ranges or inputs to make the model more sensitive to specific concerns. The results will be used to prioritize allocation of resources and to educate the Local Area Planning Commissions in each State.

  Project Reference: Title III Emergency Response Project.

  Users: Regional hazardous waste programs, Local Area Planning Commissions.

- Application: Automation of the Superfund Hazard Ranking System (HRS) Scoring Process for the Ground Water Migration Pathway.

  Objective: This project assessed the risk of CERCLA sites to ground water supplies and expedited the HRS scoring process. The location of CERCLA sites relative to Public Water Supply (PWS) wells, Wellhead Protection Areas (WHPAs), aquifers, recharge areas, private wells, and populations at risk was determined.

  Project Reference: Superfund Hazard Ranking Project.

  Users: Regional and State hazardous waste programs, Regional State Ground Water programs.

5.1.3 Are Pollution Control Efforts Effective?

- Application: Investigate sources of storm-induced water pollution.

Objective: Use GIS to select four towns in the Merrimack River Basin for further study/review of stormwater management practices. Selection of the towns was based on the percentage of six landuse categories likely to contribute storm-induced pollution in each of three resource areas. The three resource areas included Wellhead Protection Areas, drainage to Surface Water Intakes, and drainage to the Merrimack River itself.

Project Reference: Assessing Impacts From Stormwater Runoff.

Users: Regional/State water programs.

- Application: Trend Analysis.

  Objective: Measure progress in ground water protection. Evaluate the effectiveness of ground water protection programs. Assess ground water quality trends.

  Project Reference: Regional Ground Water Risk Assessment, Phases I and II and proposed applications.

  Users: Regional and State ground water programs.

5.1.4 How Does the Presence of Natural Resource Areas Affect Regional Ecological Values?

- Application: Assess contribution of wetland areas to wildlife habitat and water quality.

  Objective: Conduct an automated assessment of the wetlands in a portion of the Merrimack River Basin in New Hampshire. Criteria to be examined include predictors of the wetlands' function in terms of wildlife habitat and water quality maintenance. Wetlands are examined in terms of evaluation units -- large, generally contiguous tracts of wetland habitat. Criteria to be examined on a per unit basis, include total area, number of different wetland classes, dominant wetland class, hydrologic connectivity with other units, surrounding landcover, potential function as a wildlife corridor, location within a public water supply Wellhead Protection Area, and proximity to sand and gravel aquifers.

  Project Reference: New Hampshire Advanced Identification Project.

  Users: Local planning and natural resource organizations.

- Application: Assess contribution of wetland areas to wildlife habitat and water

quality.

Objective: Conduct an automated assessment of the wetlands in a portion of the Lake Champlain Basin in Vermont. Criteria to be examined include predictors of the wetlands' function in terms of wildlife habitat and water quality maintenance. Wetlands will be examined in terms of evaluation units large, generally contiguous tracts of wetland habitat. Criteria to be examined on a per unit basis, include total area, number of different wetland classes, dominant wetland class, hydrologic connectivity with other units, surrounding landcover, potential function as a wildlife corridor, location within a public water supply Wellhead Protection Area, and proximity to sand and gravel aquifers.

Project Reference: Vermont Advanced Planning Project.

Users: State planning and natural resource organizations.

5.2 FUTURE EMPHASIS

In Region III, the Hazardous Waste Management Division (HWMD) believes that currently, the most efficient and effective use of GIS technology is as a decision-making tool to assist program managers in determining regional compliance monitoring and enforcement efforts.[11] To this end, the HWMD provided funding to the WMD to implement projects to demonstrate GIS applications that would assist with planning and management decisions in the Superfund program. The following projects were designed and implemented (refer to above projects details):

- The Superfund Hazard Ranking Project
- The Superfund Site Discovery Project

The following additional tasks have been identified as future GIS projects:

5.2.1 Cross-Programmatic Applications

- Application: Problem Identification/Resource Prioritization.
- Objectives: Assess the risks of CERCLA sites to ground water supplies and expedite Hazard Ranking Systems (HRS) scoring, by locating CERCLA sites relative to PWS wells, private wells, WHPAs, recharge areas, population, and land use.

  Establish priorities for the scheduling of future Preliminary Assessments

(PA)/Site Assessments (SAs) or Expanded Site Investigations (ESI), on EPA lead sites, based upon environmental/ecological factors.

Identify the locations of Superfund sites that do not make the National Priority List (NPL), to assess their potential risks in vulnerable areas.

Users: Regional and State hazardous waste program managers.

- Application: Public Water Supply Systems (PWSS)/Emergency Response.

  Objective: Facilitate the Emergency Response process, and construct a regional database in GIS for use in developing local contingency plans. This database would help EPA to coordinate the Federal response to spills by identifying "Trustee Areas", i.e., drinking water sources which would be impacted by a particular release into surface waters. The purpose of the project would be to assist managers and on-scene coordinators in emergency response by identifying drinking water sources potentially impacted by a release to surface water. Additional objectives include identifying, for each State in the Region, the locations of surface water intakes relative to Superfund sites, NPDES major dischargers, and oil storage facilities and transfer points.

  Users: Regional ground water/drinking water programs (PWSS); Regional hazardous waste programs (Superfund Emergency Response); State drinking water and hazardous waste programs; county planning agencies.

- Application: Site Assessments.

  Objectives: Use GIS to identify, analyze, and store information required by Superfund for conducting the Preliminary Assessment/Site Investigation tasks. Specifically, create maps delineating 3-mile buffers around regulated sites, identifying within those areas factors relevant to the evaluation process (e.g., surface water intake and public water supply well locations, population density). In addition to facilitating the PA/SI process, this initiative would also reduce duplicated efforts attendant to data collection and analyses in areas where there are overlapping Superfund sites, or where sites are located in clusters.

  Users: Regional ground water/drinking water programs; Regional hazardous waste programs.

- Application: Data Management.

  Objectives: Undertake efforts to fully aggregate and integrate, within GIS, data that are critical to cross-programmatic (WMD/HWMD) assessment.

Sharing a centralized data system would improve the quality of analyses by (1) making key data, otherwise stored in paper files or separate systems, readily available; and (2) reducing time and effort involved in data collection.

Users: Regional ground water/drinking water and hazardous waste programs.

5.2.2 RCRA/Water Management Division Applications

- Application: Employ GIS to prioritize candidates for RCRA corrective action.

  Objectives: Identify most environmentally significant cases according to environmental health risk criteria. Facilitate the dedication of limited program resources toward ensuring that the treatment, storage, and disposal facilities presenting the greatest environmental risk are addressed through permit or enforcement action.

  Users: Regional ground water and hazardous waste programs.

- Application: Ground water risk assessment from RCRA sites.

  Objectives: Assess the risk of RCRA sites to ground water supplies by locating RCRA sites relative to public water supply wells, private wells, Wellhead Protection Areas, aquifers, recharge areas, and population at risk.

  Users: Regional ground water and hazardous waste programs; State ground water and hazardous waste programs.

- Application: Develop a regional database in GIS for use in evaluating applications for RCRA Part B permits.

  Objectives: This application will assist managers and RCRA staff by identifying areas of sensitive ground water resources, thereby providing an additional tool to help delineate areas where hazardous waste activities should/should not take place.

  Users: Regional ground water and hazardous waste (RCRA) programs.

Table 5-1. GIS Applications in Regions I and III - Reference Table

PROJECT REFERENCE	REGION	CONTACT NAME/PHONE
1. Bucks County Assessment	III	Sumner Crosby/215-597-3424
2. Regional Ground Water Risk Assessment, Phase I	III	Ava Nelson Zandi/215-597-4283
3. Regional Ground Water Risk Assessment, Phase II	III	Pete Weber/215-597-4283
4. Evaluation of Potential Hazards to Drinking Water (In DE and MD)	III	Virginia Thompson/215-597-2786
5. Site Management of the Upjohn Chemical Company, North Haven, Connecticut	I	Amy Hoyt/617-565-4528
6. Aberjona River Superfund Site	I	Jim Fritz/616-565-1435
7. Pfizer Chemical	I	Jim Fritz/616-565-1435
8. Superfund Site Discovery Project	III	Sumner Crosby/215-597-3424
9. Pesticides in Ground Water: GIS Demonstration Projects for Lancaster Co., PA and Jefferson Co., WV	III	Cindy Kranz Greene/215-597-8399
10. GIS Delineation of Wellhead Protection Area and Ground Water Data Management in North Kingstown, RI	I	Marcy Berbrick/617-565-2098
11. Route 6 (Connecticut) Environmental Impact Statement Analysis	I	Greg Charest/617-565-4528
12. Title III Emergency Response Project	I	Deborah Cohen/617-565-3659
13. Superfund Hazard Ranking Project	III	Sumner Crosby/215-597-3424
14. Assessing Impacts From Stormwater Runoff	I	Marcy Berbrick/617-565-2098
15. New Hampshire Advanced Identification Project	I	Marcy Berbrick/617-565-2098
16. Vermont Advanced Planning Project	I	Marcy Berbrick/617-565-2098
17. Multi-Media Targeting of Threatened Environmental Areas	III	Pete Weber/215-597-4283

6.0 GIS BENEFITS & COSTS

SUMMARY

EPA's GIS was implemented as a productivity tool that has enabled both Regions to expand their data, analytical, and regulatory management capabilities. Most benefits realized fall into two main categories: (1) quantifiable efficiencies in current practices, or benefits that reflect improvements to existing practices; and (2) quantifiable expanded capabilities, or benefits that offer added capabilities.[21] To date, there are no comprehensive cost and benefit items for this GIS application. Qualitative benefits are described in this chapter. In addition, some cost items and a portion of a general cost/benefit analysis are provided for illustrative purposes.

Effective GIS implementation, like most successful information system implementations, starts with a defined set of requirements from which designs and specifications, and ultimately, system functionality are derived. Quantitative benefits, resulting from decreased labor hours associated with system-related tasks and improved efficiency resulting from higher quality information, can be calculated from this type of system.[21] The EPA GIS was implemented as a general productivity tool to assist in the management and operation of various environmental programs including ground water. Therefore, the tasks accomplished with the EPA GIS are dynamic (i.e., they were not wholly defined prior to its implementation). In fact, ongoing improvements in hardware and software technologies are enhancing system functionality and making the EPA GIS a more powerful decision support tool.

6.1 BENEFITS

In their book entitled *Geographic Information Systems: A Guide to the Technology*, John Antenucci, et al. present five potential benefit types resulting from GIS implementation[21]:

- **Type 1** - Quantifiable efficiencies in current practices, or benefits that reflect improvements to existing practices.
- **Type 2** - Quantifiable expanded capabilities, or benefits that offer added capabilities.
- **Type 3** - Quantifiable unpredictable events, or benefits that result from unpredictable events.

- **Type 4** - Intangible benefits, or benefits that produce intangible advantages.

- **Type 5** - Quantifiable sale of information, or benefits that result from the sale of information services.

GIS was implemented in Regions I and III as a resource tool with the specific goal of enhancing current operations. The majority of the quantifiable benefits to the EPA GIS program can therefore be classified as Type 1 and Type 2. Specifically, the GIS has resulted in improved efficiencies in data collection, data management, and data use by:

- Reducing redundancies involved with repeatedly collecting the same data (e.g., Public Water Supply well locations) for various analyses by creating a centralized on-line data management system;

- Improving the accuracy of data by facilitating both identification of errors or error gaps in existing databases and the correction of databases, where needed; and by being able to incorporate such technologies as GPS and photogrammetry into locational data acquisition;

- Increasing data availability by accelerating the distribution and access of relevant information to affected parties;

- Augmenting data completeness by being able to consolidate data from heterogeneous sources into a database, and;

- Establishing a more efficient data management system by streamlining corrections, updates, and modifications to environmental information used for decision making.[4,29]

In addition to enhanced activities, GIS bestows the following[7]:

- Increases analytical capabilities, in terms of both spatial and temporal parameters, and with regard to analytical complexity;

- Permits effective geographic targeting of limited program resources to focus on most salient problems;

- Enables documentation of trends to assess overall environmental condition, and otherwise to monitor environmental quality in quantitative terms; and

- Provides a mechanism for undertaking preventive planning measures by using the GIS as a forecasting tool to anticipate environmental problems.

In addition to the benefits associated with data management, there is the expected

cost savings associated with using an automated system instead of manual means for map production. The joint Ground Water/Underground Storage Tank program pilot project performed in Region III demonstrated that without the benefit of an automated system, manual mapping processes were prohibitively expensive.[7]

The regional GIS organizations also have profited by Type 4 (intangible) benefits, that cannot be expressed in terms of cost. Type 4 benefits include:

- Enhancing regulatory decision-making abilities by improving the quality of analyses conducted;
- Creating a technical assistance or technology transfer mechanism to aid States and local governments in programs where Federal resources are limited (such as Wellhead Protection and Pesticides);
- Promoting inter-agency, inter-program coordination (both internally and externally, among State, local, and Federal agencies, and with universities) on ground water matters;

Most evident in the list of this type of benefit is the development of cooperative (inter-governmental) relationships through information sharing (via GIS projects), which result in the improved quality of environmental databases. In both Regions these information exchanges among EPA, State, and local entities have greatly improved EPA's knowledge of the Region's environmental concerns.

6.2 COSTS

6.2.1 Personnel

The most critical costs that the EPA GIS programs incur are related to staffing with experienced technical personnel. Region I has six employees (Full-Time Equivalents, FTEs) responsible for GIS work: four GIS specialists who are contractors; one computer systems administrator; and a GIS technical coordinator. Region has six FTEs (see Chapter 4, GIS Components). Furthermore, the programs require managers and staff to be familiar with GIS and its capabilities. In addition, the Region III Water Management Division has hired an employee proficient in GIS programming and technical project development.

6.2.2 Hardware and Software

The inventory of computer hardware (including cost) and software is presented here for Region I. This should be considered a "snapshot" of EPA's capabilities, recognizing that advances in computer technology are ongoing and the tools for both Regions are being upgraded. Additional fixed and variable cost-category items to be considered in GIS implementations are also included.

FIXED COSTS: GIS HARDWARE

Equipment for EPA Region I[20]

- Data General Workstation (Total Cost $100,000):

  1 5000 Serier Server
  4 412 Workstations (16 GB)
  1 color thermal printer
  1 laser printer
  1 CD ROM reader
  2 cartridge tape drives
  3 DOS drives
  Operating System

- Sun Workstations (Total Cost: $40,000):

  1 4/330 Sparcserver
  1 Sparcstation
  6250/1600 tape drive
  Sun laser printer (1 GB)

- ARC/INFO Software (Total Cost: $30,000)

  2 multiseat licenses
  5 single seat licenses

- Tektronix X11 - 3 (Replacement Cost $20,000)

- Tek Terminal Printer - 2 (Total Cost: $10,000)

FIXED COSTS: GIS SOFTWARE

- Operating System Software
  (i.e., software provided with computer, and other basic "host-specific" software [e.g., FORTRAN], as well as "special performance routines")

  - initial costs
  - annual maintenance fee

- Core Geographic Information Management Software

  - initial costs
  - annual maintenance costs

- Application Software
  (software capable of performing specialized processes; e.g., ARC/INFO's NETWORK module)

  - initial costs
  - annual maintenance costs

- Device Software
  (software programs used for communicating between systems and for operating peripheral equipment)

  - licensing fees
  - annual maintenance fees

GIS: VARIABLE COSTS

- Database Development (locational information)
  - Database Construction
    - -- Reconstruction or Data Conversion
      - * Digitizing (manually encoding analog maps into computer readable format)
      - * Scanning (automated process of converting analog information into digital representation)
    - -- Photogrammetric Mapping
  - Acquisition of Digital Data Files
    - -- Direct Purchase
    - -- Data Exchanges via cooperative arrangements
- Database Development (qualitative information)
- Quality Assurance/Quality Control procedures
- Operating Cost Components
  - Personnel
  - Overhead
  - Maintenance Fees
  - Supplies
  - Data Base Maintenance
  - Software Development

6.2.3 Data

The EPA GIS operations have variable project-specific costs because of the dynamic nature of the GIS applications that have been implemented at both Regions. Consideration should be given to the development of reusable data layers, which is an ongoing process at all geographic scales. These data development efforts initially may expend a substantial amount of resources in data gathering, capture, integration, edit, and quality assurance tasks, but will ultimately make up for initial cost outlays with repeated use, even while considering maintenance costs (see Chapter 4, GIS Components). Also, data scouting efforts, with the objective of obtaining data that have already been developed, are crucial to control labor costs associated with data-specific tasks.[26]

When GIS was installed in the Regions, $250,000 was initially budgeted to support each Region for its operation; a national budget of $1 million was allocated to purchase data digitized by other Federal agencies.[35] The EPA Headquarters GIS Program continues to work toward developing Memoranda of Understanding with other Federal agencies to promote data sharing.

6.3 COST/BENEFIT

The Type 1 labor-saving benefits (quantifiable efficiencies) associated with EPA's GIS implementations are savings related to the automation or computerization of tasks. These savings have resulted from the facilitation and improvement of the data collection, management, and use benefits. Specific illustration of cost savings for the Region I and III ground water projects would require a before/after analysis. Such an exercise is not being performed in this report.

The enhanced functionality that the GIS gives to EPA's technical employees and management (Type 2 benefits) constitutes the bulk of benefits. Quantifying these advantages also would require more specific information than is available. From a qualitative standpoint however, technical personnel believe that GIS enables them to perform better quality analyses, and gives them greater capability to perform the various tasks presented by EPA.[13,18,26,27] Region III did complete a general cost/benefit analysis when initially assessing GIS applications. A portion of this analysis is included for review in Tables 6-1 and 6-2.

TABLE 6-1 - Cost/Benefit Analysis of Specific GIS Applications in Region III[7]

		UST-1		UST-2		UST-3		UST-4		UIC-1		UIC-2		UIC-3		PW-1		PW-2	
	Multiplier	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score
BENEFITS																			
Fiscal Savings:																			
Q1. FTE Savings	3	3	9	1	3	1	3	1	3	3	9	3	9	1	3	2	6	2	6
Q2. Direct Cost Savings	3	3	9	1	3	1	3	1	3	3	9	3	9	2	6	2	6	2	6
Q3. Time Savings	3	1	3	0	0	1	3	0	0	1	3	1	3	0	0	1	3	1	3
Q4. Benefits to Other Agencies	2	3	6	2	4	1	2	2	4	2	4	1	2	2	4	3	6	3	6
Program Need:																			
Q5. Immediate Use to Programs	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3
Cross-Media Impact																			
Q6. More Efficient Cross-Media Management	2	2	4	1	2	2	4	1	2	3	6	3	6	3	6	2	4	3	6
Q7. Programs served	2	2	4	2	4	4	8	3	6	3	6	3	6	4	8	3	6	7	14
ENVIRONMENTAL BENEFIT																			
Q8. Focus Regulatory Efforts	2	0	0	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Q9. Improve QA/QC Processes	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q10. Improve Tech Basis--Decisions	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Q11. Facilitate Decisions	3	2	6	1	3	3	9	3	9	3	9	3	9	3	9	3	9	3	9

TABLE 6-1 - Cost/Benefit Analysis of Specific GIS Applications in Region III[7]

		UST-1		UST-2		UST-3		UST-4		UIC-1		UIC-2		UIC-3		PW-1		PW-2	
	Multiplier	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score
Q12. Develop Proactive	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Q13. Environmental Results	3	3	9	1	3	2	6	2	6	3	9	3	9	2	6	2	6	3	9
Q14. Assist in Dir/Oversee Activities	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Q15. Develop State/Local Program	2	1	2	1	2	1	2	1	2	1	2	0	0	1	2	1	2	1	2
Q16. Accountability System	3	1	3	0	0	1	3	0	0	1	3	1	3	0	0	1	3	1	3
Q17. Direct Benefits in Managing Water	2	2	4	1	2	3	6	2	4	3	6	3	6	2	4	2	4	3	6
Q18. Consistency in Management of Groundwater	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Q19. Trends in Regional GW Programs	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	0	0
EXTENT OF BENEFITS																			
Q20. Geographic Area	2	4	8	3	6	3	6	3	6	3	6	4	8	3	6	4	8	4	8
TOTAL BENEFITS			32.1		18.9		28.8		24.7		35.4		34.6		28.4		31.7		37.9
COSTS																			
Q21. Operating Costs	3	3	9	3	9	3	9	3	9	1	3	1	3	2	6	2	6	2	6
Q22. Production Time--Application	3	0	0	3	9	2	6	0	0	0	0	2	6	0	0	0	0	0	0
Q23. Costs--Data into GIS-Usable Form	3	0	0	3	9	2	6	1	3	0	0	3	9	1	3	0	0	0	0

TABLE 6-1 - Cost/Benefit Analysis of Specific GIS Applications in Region III[7]

		UST-1		UST-2		UST-3		UST-4		UIC-1		UIC-2		UIC-3		PW-1		PW-2	
	Multiplier	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score	Score	Decision Score
TOTAL COSTS			13.3		40		31.1		17.7		4.44		26.6		13.3		8.88		8.88
FEASIBILITY																			
Q24. Necessary Data Available	3	1	3	3	9	1	3	1	3	2	6	2	6	1	3	2	6	2	6
ACTION/DECISION FEASIBILITY																			
Q25. Action Decision 09/20/88	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q26. Feasibility by Certain Date	0	B		B		C		C		B		B		C		B		B	
TOTAL FEASIBILITY			3.15		9.47		3.15		3.15		6.31		6.31		3.15		6.31		6.31
GRAND TOTAL			48.6		68.4		63.1		45.6		46.2		67.6		44.9		46.9		53.1
RANK			13		3		5		17		16		4		18		15		9

TABLE 6-2 - Methodology for Scoring Categories in Region III GIS Cost/Benefit Analysis[3]	
Factor/Question	Scoring
1. What is the potential net FTE savings, to the Agency, as a result of this application?	3 = > 3 FTE's, 2 = 1-3 FTE's, 1 = .5-1 FTEs, 0 = none
2. To what extent is this application expected to result in direct cost savings (in terms of absolute dollars)	3 = significant, 2 = moderate, 1 = nominal, 0 = none
3. Would this application enable significant time-savings in one or more resource-limited programs?	1 = yes, 2 = no
4. What is the anticipated benefit, of this application, to other agencies?	3 = significant, 2 = moderate, 1 = nominal
5. Would this application be of immediate use to one or more programs?	1 = yes, 2 = no
6. To what extent would this application result in more efficient cross-media program management?	3 = significant, 2 = moderate, 1 = nominal, 0 = none
7. How many programs would be served by this application?	assign 1 point per program
8. Would this application help to focus regulatory efforts on undermanaged or poorly defined environmental problems?	1 = yes, 0 = no
9. Would the application improve the quality assurance/quality control processes for environmental data?	1 = yes, 0 no
10. Would this application improve the technical basis for decision making?	1 = yes, 0 = no
11. Would this application facilitate decisions in the following areas: (a) Targeting enforcement actions; (b) permitting; (c) compliance monitoring and inspection prioritization; (d) undertaking cleanup or remedial actions; (e) facilitating problem identification and risk assessment; (f) protecting priority areas and targeting outreach initiatives; (g) facilitating program evaluations	3 = 5-7 areas, 2 = 3-4 areas, 1 = 1-2 areas, 0 = none
12. Would this application enable managers to develop proactive (preventative) mechanisms to reduce risks?	1 = yes, 0 = no
13. What are the anticipated environmental results of this application?	3 = significant, 2 = moderate, 1 = nominal, 0 = uncertain
14. Would this application assist in directing or overseeing activities in a Federally-funded or delegated program?	1 = yes, 0 = no
15. Would this application facilitate the development of State/local programs?	1 = yes, 0 = no
16. Would this application assist program managers in directly satisfying accountability system measures?	1 = yes, 0 = no
17. Would this application have direct benefits in managing water programs?	3 = significant, 2 = moderate, 1 = nominal, 0 = none

TABLE 6-2 - Methodology for Scoring Categories in Region III GIS Cost/Benefit Analysis[3]	
Factor/Question	Scoring
18. Would this application promote consistency in management approaches among Agency programs dealing with ground water?	1 = yes, 0 = no
19. Would this application enable the identification of trends and/or progress occurring in Regional ground water programs?	1 = yes, 0 = no
20. What is the geographic area benefitting from this application?	4 = Region-wide, 3 = 2 or more states, 2 = State-wide, 1 = sub-state
21. What operating costs (data-related procurement) will be involved?	3 = No additional, 2 = Nominal (less than $500), 1 = moderate ($500 - $1000), 0 = significant (exceeds $1000)
22. What is the production time required to complete this application?	3 = 2-4 weeks, 2 = 5-8 weeks, 1 = 9-12 weeks, 0 = 13-24 weeks
23. What are the costs involved in collecting data required and translating it into a GIS-usable form?	3 = less than .1 man-years, 2 = .1-.5 man-years, 1 = .5-1 man-years, 0 = 1 or more man-years (1 man-year = $80,000)
24. To what extent is necessary data available?	3 = necessary data available, 2 = additional data available, timely acquisition probable, 1 = additional data required, timely acquisition possible, 0 = additional data required, timely acquisition unlikely.
25. What is the probability of a manager being able to make an action decision, using the results of this application, by 09/30/88?	5 = Probable, 3 = Possible, 0 = Unlikely
26. What is the feasibility of completing the application?	not scored

In evaluating the benefit of using GIS for environmental protection, consideration must be given to the following items:

1. To perform truly comprehensive environmental analyses, data from multiple media must be considered.

2. All relevant physical characteristics and all pathways to resources that may be impacted also must be considered.

3. Contaminants or potential contaminants must then be accurately quantified, with sufficient locational information, to make the analysis practical and applicable.

To perform this magnitude of information assimilation *without* a GIS would result either in exorbitant sacrifices in time and cost, or lead ultimately to failure. This in turn, would compromise the ultimate benefit for the EPA GIS: protection of the ground water resource for the public welfare and environmental benefit.

> "Organizations are directing more attention to the risks of not proceeding with GIS development."[36]

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APPENDIX

Vermont Chapter, from
"Catalogue and Directory of New England
States and Regional GIS Organizations
and Activities, And an Assessment
of their Future GIS Needs,"

January 1992

VERMONT

This section describes the organizational structure of GIS activities in Vermont and summarizes the GIS activities of the organizations which partook in the study.

8.1 ORGANIZATIONAL STRUCTURE

Figure 8-1 is a generalized chart of organizations within the state of Vermont which are or may be involved in GIS activities which could have a bearing on environmental protection. This Figure is intended to help orient the reader with respect to which organizations were interviewed for this project and why; and also as a reference for the organizational information included in the survey responses.

In addition to the structure of organizations noted on Figure 8-1, the Vermont Geographic Information System (VGIS), which is the entity that oversees GIS in Vermont, has a substructure of its own. As defined in the Annual Report to the Vermont General Assembly (March 1991), the VGIS consists of five major groups:

1. VGIS Advisory Board - a fifteen member board whose historical responsibilities have included policy, standards and budget review; public discussion of projects affecting VGIS; and commissioning of subcommittees on data priorities, pricing and public access.

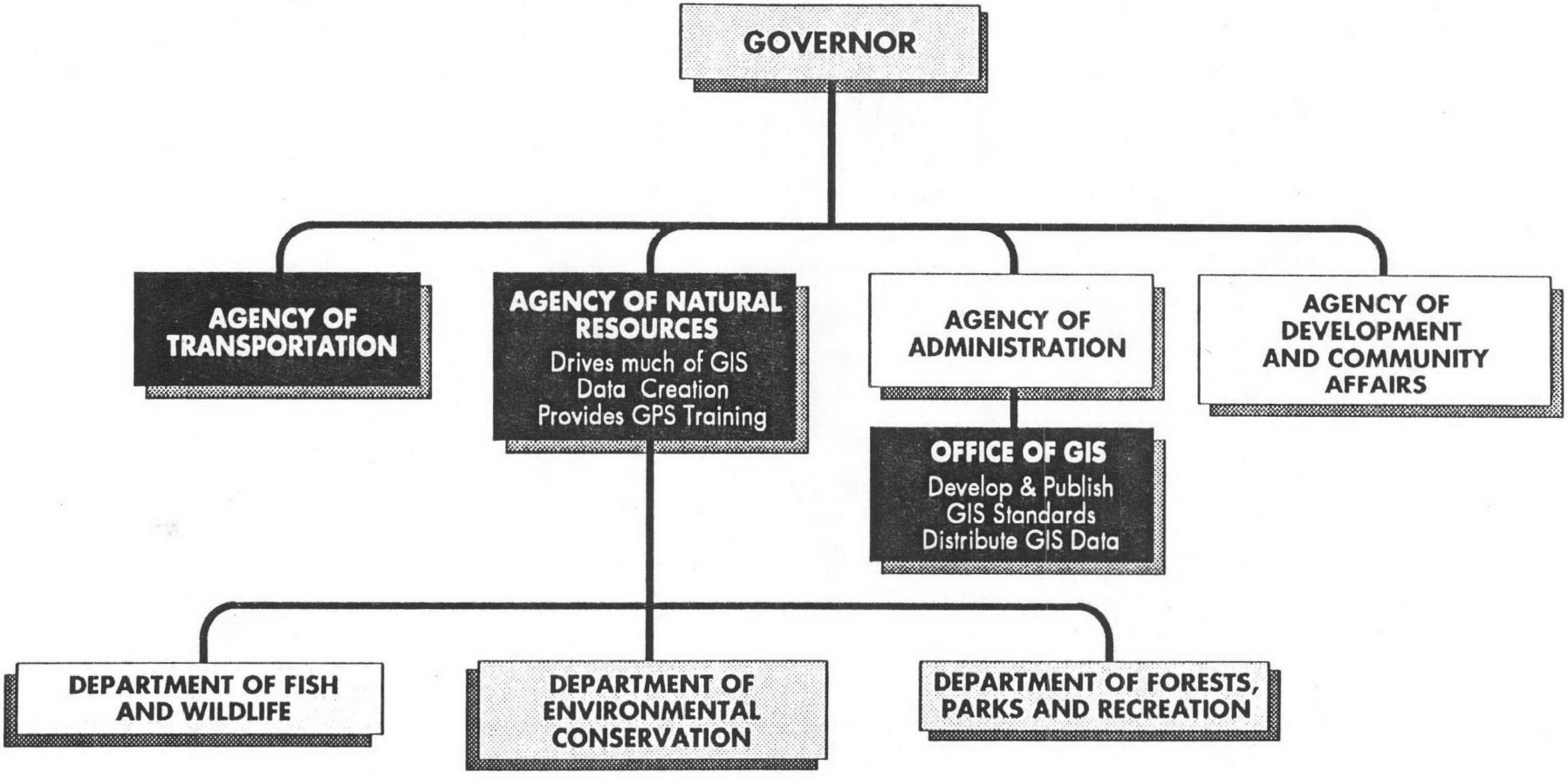
2. Office of GIS (OGIS) - which falls under the Agency of Administration and is responsible for development of data, standards and applications and for support of a decentralized, multi-governmental, multi-program GIS. Additional information regarding OGIS may be found in Section 8.2.

3. Other State and Federal Agencies - with which OGIS collaborates in an effort to most effectively utilize GIS resources.

4. Regional Planning Commissions (RPC) - which number 12 and which are working toward the capabilities to provide GIS service to every Vermont town. In general, data which exists at RPCs includes local parcels, refined wetlands delineations and zoning.

5. VGIS Network - an informal voluntary organization whose purpose is to facilitate access to and dissemination of GIS information.

GIS ORGANIZATIONAL CHART OF VERMONT



Source: Adapted From Warneke, Unpublished Data, 1991

= PARTICIPATING ORGANIZATION

CATALOGUE AND DIRECTORY OF NEW ENGLAND STATES AND GIS ORGANIZATIONS AND ACTIVITIES, AND AN ASSESSMENT OF THEIR GIS NEEDS

Camp Dresser & McKee Inc.	January 1992	FIGURE 8-1

8.1.1 ENVIRONMENTAL AGENCIES

The primary environmental agency in Vermont that contributes to GIS is the Agency of Natural Resources (ANR). Regional Planning Commissions' (RPC) activities are often based on EPA grants to the ANR. The ANR has instituted an unofficial GIS Coordinating Committee to address GIS policy decisions within the Agency.

8.1.2 INTER-AGENCY AND INTER-STATE COORDINATION

Vermont GIS has achieved a high level of coordination both between agencies in the state and with surrounding states. VGIS policies, standards, data applications and concepts have been well documented in three separate manuals, one of which is called GIS for Vermont Communities: Applications and Concepts (1990). This manual contains guidelines for communities that wish to investigate GIS solutions and refers to examples of GIS applications implemented in Vermont. Regional Planning Commission and local government roles in the development of GIS are also documented extensively in the Policies, Standards, Guidelines and Procedures Handbook (April 1991). As a result GIS work will be directed to the appropriate organization and there will be little duplication of effort. The aforementioned manuals are available to anyone upon request at a cost of approximately $50 each.

The following are some examples that illustrate coordination of GIS efforts between Vermont agencies and surrounding states:

1. Interstate River Corridor Project - management of the area surrounding the Connecticut River running from Canada to Long Island Sound.

2. Air Quality Project - a cooperative effort with the state of New Hampshire to track the effects of acid rain on vegetation quality over time.

3. Lake Champlain Management Conference - a cooperative effort involving the use of GIS to properly manage the Lake Champlain environment. The project involves the states of Vermont and New York, the U.S. Geological Survey, and EPA.

8.1.3 ORGANIZATIONS INTERVIEWED

The Vermont organizations interviewed for this project are the Office of GIS and the Agency of Natural Resources. Salient aspects of our discussions and summaries of each organization's response to the written survey are presented below.

As a result of scheduling difficulties, no personal interview was conducted with the Agency of Transportation, however, some survey responses are reflected in the appendices.

8.2 OFFICE OF GIS

8.2.1 MISSION

The mission of the Office of GIS (OGIS) is to facilitate the development of GIS in the state of Vermont. It does so by providing GIS services and support to regional planning commissions, local and state agencies, and the public; establishing GIS standards; collecting, creating and distributing GIS data; ensuring that all data for distribution meet the established standards; and delegating GIS responsibilities to the appropriate agencies. A detailed account of the duties of the OGIS can be found in GIS for Vermont Communities; Applications and Concepts (1990).

8.2.2 STAFFING

The OGIS currently employs five staff members dedicated to GIS. Responsibilities of those staff include GIS program management, GIS project management, database administration and technical specialization. Allocation of staff is itemized in Appendix C.

8.2.3 FUNDING

Funding for GIS development work is provided largely under Act 200 Special Municipal Planning Grants (1988). Act 200 established an initial $4.75 million, five year appropriation to develop priority data layers. Costs

beyond that appropriation are defrayed by cooperative agreements with local governments and the private sector, and by additional appropriations from programs such as the Housing and Conservation Trust Fund, Vermont Community Development Program, and the Federal Land and Water Conservation Fund.

OGIS is authorized by state to chance a fee for the distribution of GIS data, products and services. The VGIS Data Catalog (July 1991), discussed in Section 8.2.6 contains a complete listing of available items, and describes the fee structure associated with each.

8.2.4 DATA MAINTENANCE/DISTRIBUTION

As part of its mission, OGIS is responsible for collecting and organizing periodic data layer updates, and distributing them to organizations and individuals that request them. Custodianship of particular data layers is usually delegated by OGIS to a specific agency or organization, but there are some coverages that are maintained by OGIS. OGIS generally determines which organizations to delegate to based on need for and use of the particular data layer being delegated. Before OGIS will accept data into the VGIS system (for distribution), however, the OGIS must ensure that it meets the standards established for the state. Finally, the OGIS must be able to track ongoing GIS development well enough to be able to coordinate data criteria and maintenance efforts between agencies.

8.2.5 GIS STANDARDS

The OGIS is the organization that has the primary responsibility for developing and publishing VGIS standards and policies. The Policies, Standards, Guidelines and Procedures Handbook (April 1991) outlines standards for digital data conversion, map coordinate systems and data layer documentation. In addition, it contains guidelines for functions such as maintaining an SML library, exchanging data and configuring hardware and software.

8.2.6 DATA LAYERS AND COVERAGES

Data layers used, maintained or distributed by OGIS are summarized in Appendix D. A detailed account of available data is also presented in the VGIS Data Catalogue (July 1991). This Data Catalog is available on a paid subscription basis, and is updated regularly.

Since the OGIS plays the role of data distribution center for Vermont, it has possession of a wide range of data layers available for distribution at scales of generally 1:24,000 or smaller. Data layers of note include statewide coverages of endangered species, broken down into plants, vertebrates, invertebrates and natural communities; and statewide coverages of wellhead protection areas and watersheds. In addition, OGIS has been coordinating the authorization of town assessing maps at a scale of 1:5,000. Approximately 35 town assessors maps, showing parcel boundaries and identification, are available through OGIS. Many more are available through RPCs and communities. Data are available in a variety of quad and orhtophoto based tile structures which are documented in the VGIS Data Catalog (July 1991).

8.2.7 RESOURCES

Resources in use at the OGIS are summarized in Appendix C. These resources consist primarily of two copies of PC ARC/INFO operating on two 386 PCs, a copy of workstation ARC/INFO, an E size pen plotter and a D size digitizer. These resources must meet both the internal data development needs of the OGIS as well as the needs of agencies and communities requesting GIS services.

8.2.8 ENVIRONMENTAL APPLICATIONS

While the function of the OGIS is primarily as statewide GIS data and service facilitator, it does manage some applications for various end users. These applications include, among others, community growth planning, wildlife management, stormwater management and watershed/wellhead protection.

8.2.9 FUTURE NEEDS

Future needs as indicated by OGIS staff are itemized in the Appendices. Presented below are particular needs as discussed during the interview process.

8.2.9.1 Data, Applications and Resources

In an effort to continue the development of the VGIS, the OGIS has indicated a need to expand their resources in terms of hardware, software and personnel specifically in the case of database management capability, network access, plotting capabilities and GIS technical talent.

In terms of environmental applications, the OGIS has expressed a need to invest in a number of air pollution-related applications including, among others, emissions tracking, industrial facility siting, pesticide studies and air quality studies.

8.2.9.2 Regional Cooperative Efforts & EPA's Role

The primary issue that the OGIS would like to see addressed by EPA is the full integration of states as data partners when deciding matters of policy and finance. It is essential that parties involved in determining GIS policy review that determination process and be sure that the resources, program needs and time frames of all participating states are taken into consideration. Individual states have different data and application needs than perhaps the EPA or federal government, but by addressing those differences, it may be possible to devise solutions to meet everyone's needs.

8.3 AGENCY OF NATURAL RESOURCES GEOGRAPHIC INFORMATION SYSTEM

8.3.1 MISSION

The Agency of Natural Resources Geographic Information System (ANR/GIS) is responsible for providing GIS applications and services to all of the

Departments within the Agency of Natural Resources (ANR), and also for providing ANR data to the OGIS for distribution in formats meeting VGIS standards. The ANR itself is the state's environmental agency, included within which are both regulatory and non-regulatory environmental and Natural Resource Management Departments.

8.3.2 STAFFING AND FUNDING

GIS staff at ANR/GIS consists of a GIS program manager whose other duties include Agency automation coordination; and one full-time technical specialist. There are several staff with ANR Departments that have knowledge and limited GIS experience. These individuals have been trained by ANR/GIS staff to perform project-specific GIS tasks. The current plan is for the GIS program manager to devote 100% of his time to GIS by the end of 1991.

ANR/GIS currently has no formal funding mechanism for GIS efforts. At this time, ANR/GIS receives funding from the general fund and from grants by other state departments. It is anticipated that in November of 1991, ANR/GIS will become part of the State Geologists Office.

8.3.3 DATA MAINTENANCE/DISTRIBUTION

ANR/GIS is responsible for maintaining data layers specific to that agency. This includes keeping the appropriate coverages up to date, making sure that they comply with the standards outlined in the Policies, Standards, Guidelines & Procedures Handbook (April 1991), and periodically sending updated coverages to OGIS. ANR/GIS also possesses a number of data layers which do not yet meet VGIS standards. These data are used internally only and are not sent to OGIS for distribution.

8.3.4 GIS STANDARDS

Vermont GIS standards are determined by the OGIS, with input from other agencies including ANR/GIS, and are outlined in the Policies, Standards, Guidelines & Procedures Handbook (April 1991). This manual outlines

standards for such tasks as digital data conversion, map coordinate systems and data layer documentation. In addition, it contains guidelines for functions such as maintaining an SML library, exchanging data and configuring hardware and software.

8.3.5 DATA LAYERS AND COVERAGES

Data layers used, maintained or distributed by ANR/GIS are summarized in Appendix D. Data currently in use at ANR/GIS consist primarily of earth and water information such as hydrography, soils, surface water and wellhead protection areas, digitized at scales ranging from 1:5,000 to 1:100,000.

8.3.6 RESOURCES

Resources in use at ANR/GIS are summarized in Appendix C. These include three copies of PC ARC/INFO running on three 386 personal computers as well as additional database management, drafting, digitizing and plotting resources. The agency uses Auto/CAD and the Foxpro database management system extensively.

Several data layers of point sources of pollution and/or EPA-regulated facilities either exist or are in development. Global positioning systems (GPS) units are being used to collect these data.

8.3.7 ENVIRONMENTAL APPLICATIONS OF GIS

Environmental applications of GIS in use at ANR/GIS are summarized in Appendix E. At this time, ANR/GIS considers itself to be primarily a map making shop, with little or no data analyses incorporated in their final products. The Agency has developed a standard map-making application which is utilized by several Agency Departments. This SML-driven application will create a paper map, at any specified scale, of all data currently residing on the ANR/GIS system, for a buffered area about any user-selected point.

ANR/GIS is preparing to develop GIS analytical routines for wellhead protection and watershed protection.

8.3.8 FUTURE NEEDS

Future GIS needs for ANR/GIS are itemized in the Appendices. Presented below are specific needs discussed during the interview process.

8.3.8.1 Data

ANR/GIS has performed its own data needs analysis and developed a prioritized list of data layers. The analysis identifies needed data layers, the current status of the data layers (3-complete and meets VGIS standards, 2-complete but doesn't meet VGIS standards, 1 in progress, 0-wishlist) and the Agency Departments that have a need for the data. This information has been processed and the result is a matrix of data layers prioritized by the number of agencies that need them. This matrix is included here as Table 8-1. An additional data priority discussed during the interview process is the need for data for low level radioactive waste siting.

8.3.8.2 Applications

There are a number of application needs that have had an impact on the type and priority of data required. One such application is the zoning of lakeshore recreational lands in an effort to control boating traffic and decrease risk as a result of high speed boating. Other applications include buffering wetlands to extend protection limits and tracking public land offerings and determining the potential effect on adjoining recreational lands.

8.3.8.3 Resources

In order to meet the data and application needs discussed above, ANR/GIS will need to expand it resources, largely by hiring additional GIS talent. It would also like to add to its GIS and database capabilities through the

AGENCY OF NATURAL RESOURCES
GEOGRAPHIC INFORMATION SYSTEM
NEEDS ANALYSIS SUMMARY TABLE

HIGHEST PRIORITY — SCORE 26-25 — SCORE 16-19 — SCORE 15 OR BELOW

DATA LAYER	SCORE	STATUS	CENTRAL OFFICES: PLAN	GEOL	LOW LEVEL	ENFORC	FISH AND WILDLIFE: FISH	WILD-LIFE	NON GAME	E BOARD: ENVIR BOARD	FORESTS, PARKS, AND RECREATION: FOREST	RECR	STATE LANDS	STATE PARKS	CONSERV EDUC	ENVIRONMENTAL CONSERVATION: AGENCY FACIL	HAZ MAT	AIR QUAN	SOLID WASTE	PUBLIC FACIL	WATER QUALITY: LAKES PONDS	SPECIAL STUDIES	LAB	RIVERS	WETLANDS	ENGINRG	FLOOD PLAIN	WATER SUPPLY	ENVIR PROT
COUNTY BOUNDARIES	27	3																											
BLG POWERLINES	27	3																											
BLG RAILROADS	27	3																											
BLG ROADS	27	3																											
BLG TRANS LINES	27	3																											
GEOGRAPHIC NAMES	27	3																											
ORTHOPHOTO GRID	27	3																											
REGIONAL PLANNING COMMISSIONS	27	3																											
TOWNS	27	3																											
USGS QUADRANGLE GRID	27	3																											
LAKES & PONDS	27	2																											
AGENCY AUTOMATION COORDINATION	27	1																											
GLOBAL POSITIONING SYSTEM	27	1																											
RIVERS & STREAMS	27	1																											
ROADS	27	1																											
STATE LAND BOUNDARIES	27	1																											
SURFACE WATERS	27	1																											
TOPOGRAPHY	27	0																											
USGS REFERENCE MARKS	27	0																											
WETLANDS	25	1																											
WASTEWATER TREATMENT FACILITIES	25	0																											
SOILS	24	1																											
HAZARDOUS WASTE SITES	23	3																											
SOURCE PROTECTION AREA	22	2																											
CULTURAL FEATURES	22	1																											
MINERAL RESOURCES	21	3																											
RIVER DRAINAGE BASINS	21	2																											
FISHERIES	21	1																											
POLLUTION SOURCE INVENTORY	21	1																											
AQUIFERS	20	2																											
LAKE/POND DRAINAGE BASIN	20	2																											
EROSION HAZARDS	20	0																											
STATE LAND ROADS	20	0																											
RCRA SITES	19	1																											
UNDERGROUND STORAGE TANKS	19	1																											
ENFORCEMENT ACTION TRACKING	19	0																											
PERMIT TRACKING SYS	19	0																											
SOLID WASTE	19	0																											
BAN LOCATIONS	18	2																											
FLOODPLAIN MAPPING	18	0																											
RADIOACTIVITY	18	0																											
SURFICIAL GEOLOGY	18	0																											
AIR QUALITY	17	2																											
NATURAL HERITAGE	17	2																											
BEDROCK GEOLOGY	17	1																											
LANDSLIDE SUSCEPTIBILITY	17	1																											
PETROLEUM PROBLEM SITES	17	1																											
RECREATIONAL ACCESS	17	1																											
BRIDGE LOCATIONS	17	0																											
USGS GAGING STATIONS	17	0																											
BOATING ACCESS AREAS	16	1																											
OUTSTANDING WATERS	16	1																											
LAKE SHORE ZONING SUPPORT	16	0																											
TIMBER STANDS	15	0																											
OPEN SPACES	14	1																											
UNDERGROUND INJECTION CONTROL	14	1																											
MACROINVERTEBRATES	14	0																											
OUTSTANDING FEATURES	14	0																											
DEER YARDS	13	2																											
PRIVATE WATER WELLS	13	1																											
TRAILS AND GREENWAYS	13	1																											
CONTOURS - 2500 FOOT	12	3																											
FOREST PEST TRACKING	12	2																											
BEAR HABITAT	12	0																											
INJECTION WELLS	12	0																											
STORET STATIONS	10	0																											
MONITORED WELLS	5	0																											
TOTAL DIVISION DEMAND			67	49	58	56	54	41	52	66	39	68	57	35	47	49	48	38	48	26	54	47	38	58	61	33	47	58	64

NOTES: FROM STUDY COMPILED IN FOXPRO, AUGUST 1991

purchase of additional ARC/INFO licenses, database management systems, 386 personal computers, and plotting devices. Finally, ANR/GIS feels that in order for data analysis to become widely used, they will need to implement a data distribution network and a user friendly data access system such as ArcView.

8.3.8.4 Regional Cooperative Efforts and EPA's Role

During the interview with a representative from ANR/GIS, the following suggestions were made as to hov EPA might direct its efforts to help the development of GIS in Vermont and throughout the northeast.

1. EPA could compile a catalogue of data available throughout Region I and make that catalogue available for viewing through a computerized bulletin board. In addition, the bulletin boards could also include almanac updates and satellite availability.

2. EPA could facilitate communication between agencies in Region I and Region II. Communication between Vermont and New York regarding Lake Champlain is essential.

3. EPA could institute a regional GPS training center. Currently, although ANR/GIS provides GPS training, the demand for such training exceeds its capabilities to provide it.

4. The New England Governors' Conference could be used as a vehicle for communication regarding GIS efforts and resources.

Table B-1:Participating Organizations

CONNECTICUT

Organization Name	Organiztion Abbreviation		Function/Comments
Connecticut Bureau of Air Management	CT-BAM	P	Division of the Connecticut DEP.
Connecticut Bureau of Environmental Services	CT-BES	T	Division of the Connecticut DEP.
Connecticut Bureau of Waste Management	CT-BWM	P	Division of Connecticut DEP.
Connecticut Department of Environmental Protection	CT-DEP	T	State environmental regulatory agency
*Connecticut - Natural Resources Center	CT-NRC	P	Division of the DEP. Responsible for distribution of Connecticut GIS data.

MASSACHUSETTS

Organization Name	Organiztion Abbreviation		Function/Comments
CZM Buzzards Bay Project	MA-BBP	T	A project of Mass. Coastal Zone Management.
Cape Cod Commission	MA-CCC	N	Regional planning commission for Cape Cod.
Mass Department of Environmental Protection	MA-DEP	P	State environmental regulatory agency under EOEA.
Mass Department of Food and Agriculture	MA-DFA	T	Provides support to the agricultural industry/community; administers programs for agricultural preservation, land use planning and regulatory actions. Under EOEA.
*Mass Executive Office of Environmental Affairs	MA-EOEA	T	Umbrella agency for all state environ agencies. Manages MassGIS from Research and Data Systems office, which handles all information technology for EOEA
Mass EOEA Data Center	MA-EOEAD	P	Under EOEA. Maintains and distributes many state environmental data layers. MassGIS located in Data Center.
CZM Massachusetts Bay Project	MA-MBP	T	A project of Mass. Coastal Zone Management.
Mass Water Resources Authority	MA-MWRA	P	Water and sewer authority serving 60 communities in the Boston Metro area.
Mass Office of USGS, Water Resources Division	MA-USGS	T	Federal agency engaged in hydrologic research

MAINE

Organization Name	Organiztion Abbreviation		Function/Comments
Maine Bureau of Health	ME-BOH	T	
Maine Board of Pesticides Control	ME-BOPC	T	
Maine Department of Environmental Protection	ME-DEP	P	Project specific GIS applications
Maine Geological Survey	ME-GS	P	
Maine State Office of GIS	ME-OGIS	P	Resource center, distribution of GIS data, training and

. - Personal interview conducted
T - Telephone interview conducted
N - No survey materials returned
* - Organization to which primary contact belongs

Organization Name	Organiztion Abbreviation		Function/Comments
			resource center, owner of multi-use data layers.

NEW HAMPSHIRE

Organization Name	Organiztion Abbreviation		Function/Comments
University of NH, Complex Systems Research Center	NH-CSRC	P	Houses and manages GRANIT database. Provides technical expertise for state and regional GIS projects.
New Hampshire Department of Environmental Services	NH-DES	P	State environmental regulatory agency.
*New Hampshire Office of State Planning	NH-OSP	P	State's GIS coordinating agency. Manages state growth and development by monitoring land use planning.

RHODE ISLAND

Organization Name	Organiztion Abbreviation		Function/Comments
*Rhode Island Dept. of Admin., Divison of Planning	RI-DADP	T	State's central planning agency and GIS coordinating agency. Licenses RIGIS data.
RI DEM, Groundwater Section of ISDS	RI-DEMGW	T	Under RI DEM. Responsible for protecting state's groundwater.
Rhode Island Environmental Data Center	RI-EDC	P	Within URI's Department of Natural Resources Science. Houses and maintains RIGIS database.
RI DEM Environmental Regulatory Information Center	RI-ERIC	T	
Rhode Island Narragansett Bay Project	RI-NBP	T	Monitor and protect Narragansett Bay. Under RI-DEM, primary funding from EPA. Nearing project completion.
RI DEM Office of Environmental Coordination	RI-OEC	T	Under RI DEM. Responsible for non-point source program.
RI Office of Soil Conservation Service	RI-SCS	N	Federal agency. Maps country's soild, provides assistance to farmers.
RI Office of USGS, Water Resources Division	RI-USGS	N	Federal agency engaged in hydrologic research.

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Organization Name	Organiztion Abbreviation		Function/Comments
*Environmental Protection Agency - Region I	US-EPAI	N	

VERMONT

Organization Name	Organiztion Abbreviation		Function/Comments
Vermont Agency of Development & Community Affairs	VT-ADCA	N	
Vermont Agency of Natural Resources	VT-ANR	P	Maintenance of data layers and applications specific to ANR.

P - Personal interview conducted
T - Telephone interview conducted
N - No survey materials returned
* - Organization to which primary contact belongs

Organization Name	Organiztion Abbreviation		Function/Comments
.mont Agency of Transportation	VT-AOT		
*Vermont State Office of GIS	VT-OGIS	T	1) Develop data - state & local level. 2) Data maint & dist, develop standards & docs. 3) Develop applications. 4) Public education, training, support for decentralz, mulitgovt GIS.
University of VT - School of Natural Resources	VT-UVM	N	GIS training and education resources.

P - Personal interview conducted
T - Telephone interview conducted
N - No survey materials returned
* - Organization to which primary contact belongs

Table B-2:Organizational Contacts Summary

CONNECTICUT

Contact Name	Position Title	Organization Name
Chris Mulcahy	Project Manager	Connecticut Bureau of Air Management
Richard Hyde	Assistant Director	Connecticut Bureau of Environmental Services
Hugo Thomas	Director	Connecticut Bureau of Environmental Services
Beth Doran	Project Manager	Connecticut Bureau of Waste Management
Sandy Prisloe	Supervising Environmental Analyst	Connecticut - Natural Resources Center

MASSACHUSETTS

Contact Name	Position Title	Organization Name
Neil MacGaffey		CZM Buzzards Bay Project
Christina Dirker		Cape Cod Commission
Donovan Bowley	GIS PRogram Manager	Mass Department of Environmental Protection
Steve Travis	GIS Technical Manager	Mass Department of Environmental Protection
Lee Corte-Real		Mass Department of Food and Agriculture
Barbara Hopson	GIS Coordinator	Mass Department of Food and Agriculture
Rick Taupier	Assistant Secretary	Mass Executive Office of Environmental Affairs
Christian Jacqz	MassGIS Data Manager	Mass EOEA Data Center
Dillon Scott	Data Manager	CZM Massachusetts Bay Project
Stephen Estes-Smargiassi	GIS Coordinator	Mass Water Resources Authority
Daniel Nvule	GIS Project Manager	Mass Water Resources Authority
Peter Steeves	Cartographer	Mass Office of USGS, Water Resources Division
Michael Yurewicz	Massachusetts Office Chief	Mass Office of USGS, Water Resources Division

MAINE

tact Name	Position Title	Organization Name
Terry Mingo		Maine Bureau of Health
Tammy Gould		Maine Board of Pesticides Control
Christopher Kroot	GIS Specialist	Maine Department of Environmental Protection
Robert Marvinney	Physical Geologist	Maine Geological Survey
Dan Walters	Director - Office of GIS	Maine State Office of GIS

NEW HAMPSHIRE

Contact Name	Position Title	Organization Name
Fay Rubin	GIS Coordinator	University of NH, Complex Systems Research Center
Hastings George	GIS Coordinator	New Hampshire Department of Environmental Services
Chris Simmers	Senior Planner	New Hampshire Department of Environmental Services
J s McLaughlin	Senior Planner	New Hampshire Office of State Planning

RHODE ISLAND

Contact Name	Position Title	Organization Name
John Stachelhaus	RIGIS Coordinator	Rhode Island Dept. of Admin., Divison of Planning
Ernest Panciera	Senior Environmental Planner	RI DEM, Groundwater Section of ISDS
Peter August	Director	Rhode Island Environmental Data Center
Charles LaBash	Database Manager	Rhode Island Environmental Data Center
Pam Annarumo		RI DEM Environmental Regulatory Information Center
Andrew MacLachlan		Rhode Island Narragansett Bay Project
Lynn Carlson		RI DEM Office of Environmental Coordination
Jackie Pashnik		RI Office of Soil Conservation Service
Virginia DeLima	Rhode Island Office Chief	RI Office of USGS, Water Resources Division
Jack Kliever	Hydrologist	RI Office of USGS, Water Resources Division

TED STATES - FEDERAL

Contact Name	Position Title	Organization Name
Greg Charest	GIS Program Manager	Environmental Protection Agency - Region I

VERMONT

Contact Name	Position Title	Organization Name
Bill Shouldice	Deputy Secretary	Vermont Agency of Development & Community Affairs
John Dudley		Vermont Agency of Natural Resources
Lloyd Robinson	Deputy Secretary	Vermont Agency of Transportation
Bruce Wescott	Director	Vermont State Office of GIS
Gary Smith	GIS Program Coordinator	University of VT - School of Natural Resources

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UNITED STATES - FEDERAL

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VERMONT

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Fax:

John Dudley
GIS Office - Agency of Natural Resources
Center Building, Waterbury Complex
Waterbury, VT 05671-0301
Tel: (802) 244-8747
Fax: (802) 244-1102

Lloyd Robinson
Deputy Secretary
Agency of Transportation
133 State St.
Montpelier, VT 05633
Tel: (802) 828-2658

Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
		Mainframe ARC/INFO GIS	1.0			

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Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
US-EPAI	Expenditures	Hardware		150,000.00	Total	
		Personnel		360,000.00	Annual	
		Software		60,000.00	Total	
		System Maintenance		30,000.00	Annual	
	Hardware	D size digitizer	1.0			Not currently in use.
		Data General workstations	5.0			One is a server.
		E size color electrostatic plotr	1.0			
		E size pen plotter	1.0			
		Graphic terminal	8.0			Three X-terminals, three 4207, one 4107, one 4125, several PCs with Tek emulation software.
		Miscellaneous big digitizer	1.0			Backlit 48" by 62".
		Prime minicomputer	1.0			Will be phased out over the next year.
		Screen dump plotter	5.0			
		SUN workstation	2.0			
		Tek workstation	1.0			
		Trimble low-res GPS	8.0			Seven Pathfinders and one 4000 series base stations.
	Personnel	GIS project manager	1.0			
		GIS technical specialist	4.0			
		System manager	1.0			
	Software	ARC/INFO's TIN model	7.0			
		Minicomputer ARC/INFO	1.0			Prime minicomputer
		Trimble global postioning	2.0			Once copy at GIS center and one copy at Environmental Services Division.
		Workstation ARC/INFO GIS	8.0			

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Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
VT-ANR	Expenditures	Data development and maintenance		50,000.00	Total	
		General operations		5,000.00	Total	
		Hardware		80,000.00	Total	
		Personnel		65,000.00	Total	
		Software		20,000.00	Total	
	Hardware	386 chip PC	3.0			
		Digitizer smaller then D size	2.0			
		E size digitizer	1.0			
		E size pen plotter	1.0			
		Trimble low-res GPS	3.0			

Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
	Personnel	GIS program manager	1.0			Manager half-time until 11/1/91
		GIS technical specialist	1.0			
	Software	AutoCAD drafting	1.0			
		DCA contour/3D modelling	1.0			
		FoxPro Database Management Sys	2.0			With FOXBASE+
		PC ARC/INFO GIS	3.0			
		Quatro Pro	2.0			
		Trimble global postioning	3.0			
VT-AOT	Hardware	386 chip PC	2.0			Used sparingly for GIS.
		D size digitizer	1.0			
		Graphic terminal	2.0			Color
		Miscellaneous workstation	2.0			
		VAX mainframe	1.0			
	Personnel	Database Administrator	1.0			
		System manager	1.0			
	Software	Intergraph drafting	1.0			Int 250, Int 380 and workstations. Only Int 250 workstations are used for GIS as this equipment is not the standard GIS platform.
		Mainframe ARC/INFO GIS	1.0			
		PC ARC/INFO GIS	2.0			Currently used only for training and some elementary prototyping. Not on dedicated equipment - all equipment has other primary uses.
VT-OGIS	Expenditures	Data development and maintenance		100,000.00	Annual	
		General operations		40,000.00	Annual	
		Hardware		20,000.00	Annual	
		Marketing and public relations		10,000.00	Annual	
		Personnel		180,000.00	Annual	
		Research and development		20,000.00	Annual	
		Software		10,000.00	Annual	
		System Maintenance		20,000.00	Annual	
		User support and training		20,000.00	Annual	
	Hardware	386 chip PC	2.0			
		D size digitizer	1.0			
		E size pen plotter	1.0			
		Screen dump plotter	1.0			
	Personnel	Database Administrator	1.0			
		GIS program manager	1.0			
		GIS project manager	1.0			
		GIS technical specialist	2.0			
	Software	FoxPro Database Management Sys	2.0			
		PC ARC/INFO GIS	2.0			
		Workstation ARC/INFO GIS	1.0			

RHODE ISLAND

Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
RI-DADP	Expenditures	Data development and maintenance		25,000.00	Total	
		General operations		2,000.00	Annual	
		Hardware		5,000.00	Annual	
		Personnel		65,000.00	Annual	For 1.5 full time employees.
		Software		5,000.00	Annual	
		System Maintenance		6,500.00	Annual	6K for maintenance contracts.
		User support and training		3,000.00	Annual	
RI-EDC	Software	ARC/INFO's TIN model	2.0			2 TIN modules ordered for workstation ARC/INFO.
		Workstation ARC/INFO GIS	2.0			These will replace ARC/INFO on the Prime. Each will be a single-user license.
RI-ERIC	Hardware	D size color electrostatic plotr	1.0			Agricultural Division
		SUN workstation	1.0			On-order by Division of Agriculture.
		Trimble low-res GPS	1.0			Division of Agriculture - I believe they ordered low-resolution.
	Personnel	GIS program manager	1.0			Attempting to hire 1 position for administration and some technical, for immediate future need 1 technical person MINIMUM, but have enough work for 2 people.
	Software	Trimble global postioning	1.0			On-order by Division of Agriculture.
		Workstation ARC/INFO GIS	1.0			On-order for the Division of Agriculture.

UNITED STATES - FEDERAL

Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
US-EPAI	Software	AutoCAD drafting	1.0			Unix workstation release 11

VERMONT

Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
VT-ANR	Expenditures	Hardware		30,000.00	Total	
		Software		5,000.00	Total	
VT-OGIS	Hardware	E size digitizer	1.0			
		E size pen plotter	1.0			
	Personnel	Database Administrator	2.0			
		GIS program manager	1.0			
		GIS project manager	1.5			
		GIS technical specialist	3.0			
		System manager	1.0			

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Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
US-EPAI	Expenditures	Hardware		500,000.00	Total	
		Personnel		60,000.00	Annual	
		Software		100,000.00	Total	
		System Maintenance		100,000.00	Annual	
	Hardware	386 chip PC	1.0			
	Personnel	Database Administrator	1.0			
	Software	Oracle Database Management Sys	1.0			

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Organization Reference	Resource Type	Resource	How Many?	Total Cost	Annually or Total	Additional Comments
VT-ANR	Expenditures	Data development and maintenance		25,000.00	Total	
		General operations		5,000.00	Total	
		Hardware		100,000.00	Total	
		Personnel		40,000.00	Total	
		Software		30,000.00	Total	Upgrade from PC versions to host Arc/INFO.
		System Maintenance		2,500.00	Total	
		User support and training		5,000.00	Total	
	Hardware	386 chip PC	1.0			
		E size color electrostatic plotr	1.0			
		E size digitizer	1.0			
		PC Server	1.0			
		Screen dump plotter	1.0			
		Trimble low-res GPS	3.0			
		Unspecified scanner	1.0			
	Personnel	GIS technical specialist	0.5			
	Software	FoxPro Database Management Sys	1.0			
		Mainframe ARC/INFO GIS	1.0			
		PC ARC/INFO GIS	1.0			
		Quatro Pro	1.0			
VT-AOT	Personnel	GIS program manager	1.0			No staff dedicated to GIS works. Still in process of establishing direction and defining needs.
		GIS project manager	1.0			
		GIS technical specialist	1.0			
VT-OGIS	Expenditures	Data development and maintenance		250,000.00	Annual	VT operates under a 5 year data development plan. If avail, could spend 400 - 600 thousand/ year responsibly w/ good control, direction & application.
		General operations		60,000.00	Annual	
		Hardware		40,000.00	Annual	
		Marketing and public relations		20,000.00	Annual	
		Personnel		300,000.00	Annual	

Organization Reference	Resource Type	Resource	How Many?	Total Annually Cost or Total	Additional Comments
		Research and development		20,000.00 Annual	
		Software		20,000.00 Annual	
		System Maintenance		30,000.00 Annual	
		User support and training		30,000.00 Annual	
	Hardware	386 chip PC	3.0		
		E size b/w electrostatic plotter	1.0		
		E size color electrostatic plotr	1.0		
		Screen dump plotter	1.0		
		SUN workstation	1.0		Multi-user, networked
	Personnel	Database Administrator	2.0		
		GIS program manager	1.0		
		GIS project manager	2.0		
		GIS technical specialist	6.0		
		System manager	1.0		
	Software	ARC/INFO's TIN model	1.0		
		ARC/VIEW end user interface	1.0		Multi-user, public walk-in and dial-up access
		FoxPro Database Management Sys	3.0		
		Oracle Database Management Sys	1.0		
		PC ARC/INFO GIS	3.0		
		Workstation ARC/INFO GIS	4.0		

Table C-4:Existing GIS Resources by Resource

Resource Type	Resource	Organization Reference	How Many?	Total Cost	Annually or Total
Expenditures	Data development and maintenance	MA-EOEAD		100,000.00	Annual
		MA-MWRA		895,000.00	Total
		NH-CSRC		40,000.00	Annual
		NH-OSP		150,000.00	Annual
		VT-ANR		50,000.00	Total
		VT-OGIS		100,000.00	Annual
	General operations	RI-DADP		2,000.00	Annual
		VT-ANR		5,000.00	Total
		VT-OGIS		40,000.00	Annual
	Hardware	MA-BBP		15,000.00	Total
		MA-DFA	1.0		
		MA-EOEAD		10,000.00	Annual
		MA-MWRA		200,000.00	Total
		ME-DEP		60,000.00	Total
		ME-GS		50,000.00	Total
		ME-OGIS		200,000.00	Total
		NH-OSP		16,000.00	Total
		RI-DADP		2,000.00	Annual
		US-EPAI		150,000.00	Total
		VT-ANR		80,000.00	Total
		VT-OGIS		20,000.00	Annual
	Marketing and public relations	VT-OGIS		10,000.00	Annual
	Personnel	MA-BBP		45,000.00	Annual
		MA-DFA	2.0		
		MA-EOEAD		180,000.00	Annual
		MA-MWRA		200,000.00	Annual
		ME-OGIS		94,000.00	Annual
		NH-CSRC		80,000.00	Annual
		NH-OSP		100,000.00	Annual
		RI-DADP		65,000.00	Annual
		RI-EDC	5.0		
		US-EPAI		360,000.00	Annual
		VT-ANR		65,000.00	Total
		VT-OGIS		180,000.00	Annual
	Research and development	VT-OGIS		20,000.00	Annual
	Software	MA-BBP		11,200.00	Total
		MA-DFA	1.0		
		MA-MWRA		100,000.00	Total
		ME-DEP		20,000.00	Total
		ME-GS		15,000.00	Total
		ME-OGIS		127,000.00	Total
		NH-OSP		7,500.00	Total
		RI-DADP		4,000.00	Annual
		US-EPAI		60,000.00	Total
		VT-ANR		20,000.00	Total
		VT-OGIS		10,000.00	Annual
	System Maintenance	MA-BBP	1.0		
		MA-EOEAD		30,000.00	Annual
		ME-DEP		8,000.00	Total
		ME-OGIS		27,000.00	Annual
		NH-OSP		1,000.00	Annual
		RI-DADP		500.00	Annual
		US-EPAI		30,000.00	Annual
		VT-OGIS		20,000.00	Annual
	User support and training	MA-DFA	4.0		
		RI-DADP		2,000.00	Annual
		VT-OGIS		20,000.00	Annual
Hardware	286 chip PC	CT-NRC	6.0		
		ME-GS	1.0		
		RI-EDC	2.0		
	386 chip PC	CT-NRC	5.0		
		MA-BBP	1.0		
		MA-MBP	?		
		MA-MWRA	1.0		
		ME-BOPC	1.0		
		ME-GS	2.0		
		NH-CSRC	1.0		
		NH-OSP	1.0		
		RI-DADP	1.0		
		RI-EDC	14.0		
		VT-ANR	3.0		

Resource Type	Resource	Organization Reference	How Many?	Total Annually Cost or Total
		VT-AOT	2.0	
		VT-OGIS	2.0	
	Avilon workstation	CT-NRC	1.0	
		RI-EDC	2.0	
	D size color electrostatic plotr	RI-EDC	1.0	
	D size digitizer	CT-NRC	1.0	
		ME-GS	2.0	
		RI-DADP	1.0	
		US-EPAI	1.0	
		VT-AOT	1.0	
		VT-OGIS	1.0	
	Data General mainframe	CT-NRC	1.0	
	Data General workstations	US-EPAI	5.0	
	Digitizer 44 x 60	CT-NRC	1.0	
	Digitizer smaller then D size	CT-NRC	2.0	
		VT-ANR	2.0	
	E size color electrostatic plotr	CT-NRC	2.0	
		MA-EOEAD	1.0	
		MA-MWRA	1.0	
		US-EPAI	1.0	
	E size digitizer	CT-NRC	2.0	
		MA-BBP	1.0	
		MA-EOEAD	2.0	
		MA-MWRA	2.0	
		MA-USGS	2.0	
		ME-DEP	1.0	
		ME-GS	1.0	
		ME-OGIS	2.0	
		NH-CSRC	1.0	
		NH-DES	2.0	
		NH-OSP	1.0	
		RI-EDC	2.0	
		VT-ANR	1.0	
	E size pen plotter	CT-NRC	2.0	
		MA-EOEAD	2.0	
		MA-MWRA	1.0	
		MA-USGS	1.0	
		ME-DEP	1.0	
		ME-GS	2.0	
		ME-OGIS	1.0	
		NH-CSRC	1.0	
		NH-DES	2.0	
		NH-OSP	1.0	
		RI-DADP	1.0	
		RI-DEMGW	1.0	
		RI-EDC	1.0	
		RI-ERIC	1.0	
		RI-NBP	1.0	
		RI-OEC	1.0	
		US-EPAI	1.0	
		VT-ANR	1.0	
		VT-OGIS	1.0	
	Graphic terminal	CT-NRC	4.0	
		MA-DFA	1.0	
		MA-EOEAD	13.0	
		MA-MWRA	4.0	
		ME-OGIS	2.0	
		NH-CSRC	5.0	
		NH-DES	2.0	
		NH-OSP	1.0	
		RI-DEMGW	2.0	
		RI-EDC	5.0	
		RI-ERIC	2.0	
		RI-NBP	2.0	
		RI-OEC	2.0	
		US-EPAI	8.0	
		VT-AOT	2.0	
	Hewlett-Packard Scanjet Plus	ME-BOPC	1.0	
	IBM workstation	ME-DEP	1.0	
		NH-DES	1.0	
	Miscellaneous big digitizer	US-EPAI	1.0	
	Miscellaneous workstation	MA-USGS	1.0	
		VT-AOT	2.0	

Resource Type	Resource	Organization Reference	How Many?	Total Annually Cost or Total
	Pen plotter smaller than D size	CT-NRC	1.0	
		MA-BBP	1.0	
		MA-USGS	3.0	
		ME-GS	1.0	
	Prime mainframe	NH-CSRC	1.0	
		RI-DEMGW	1.0	
		RI-EDC	1.0	
		RI-OEC	1.0	
	Prime minicomputer	US-EPAI	1.0	
	Screen dump plotter	CT-NRC	1.0	
		MA-MWRA	1.0	
		MA-USGS	1.0	
		ME-OGIS	1.0	
		NH-CSRC	1.0	
		NH-DES	1.0	
		RI-DADP	1.0	
		RI-DEMGW	1.0	
		RI-EDC	1.0	
		RI-ERIC	1.0	
		RI-NBP	1.0	
		RI-OEC	1.0	
		US-EPAI	5.0	
		VT-OGIS	1.0	
	Sun Sparcserver	ME-OGIS	1.0	
	SUN workstation	CT-NRC	5.0	
		ME-GS	1.0	
		ME-OGIS	3.0	
		NH-CSRC	1.5	
		NH-DES	1.0	
		RI-DADP	1.0	
		US-EPAI	2.0	
	Tek workstation	ME-DEP	1.0	
		US-EPAI	1.0	
	Trimble low-res GPS	CT-NRC	2.0	
		RI-EDC	1.0	
		US-EPAI	8.0	
		VT-ANR	3.0	
	Unspecified scanner	ME-BOH	1.0	
	VAX mainframe	MA-BBP	1.0	
		MA-DFA	1.0	
		MA-EOEAD	1.0	
		MA-MWRA	1.0	
		VT-AOT	1.0	
Personnel	Active trained users	MA-MWRA	4.0	
	Cartographer/Database Administr	MA-EOEAD	1.0	
	Database Administrator	RI-DADP	0.3	
		RI-EDC	1.0	
		VT-AOT	1.0	
		VT-OGIS	1.0	
	GIS Administrator	ME-OGIS	1.0	
	GIS coordinator	MA-DFA	1.0	
		ME-OGIS	1.0	
		NH-DES	1.0	
	GIS program manager	CT-NRC	1.0	
		MA-EOEAD	1.0	
		MA-MWRA	1.0	
		ME-DEP	1.0	
		NH-CSRC	1.0	
		NH-OSP	1.0	
		RI-DADP	0.3	
		RI-EDC	1.0	
		RI-NBP	1.0	
		VT-ANR	1.0	
		VT-OGIS	1.0	
	GIS project manager	MA-BBP	1.0	
		MA-NBP	1.0	
		MA-MWRA	1.0	
		MA-USGS	1.0	
		ME-BOH	1.0	
		NH-OSP	1.0	
		RI-DADP	1.0	
		RI-EDC	4.0	
		US-EPAI	1.0	

Resource Type	Resource	Organization Reference	How Many?	Total Annually Cost or Total
		VT-OGIS	1.0	
	GIS technical specialist	CT-NRC	4.0	
		MA-DFA	2.0	
		MA-EOEAD	1.0	
		MA-MWRA	3.0	
		MA-USGS	1.0	
		NH-CSRC	2.0	
		NH-DES	1.0	
		RI-DADP	1.0	
		RI-DEMGW	1.0	
		RI-EDC	1.0	
		RI-ERIC	1.0	
		RI-OEC	1.0	
		US-EPAI	4.0	
		VT-ANR	1.0	
		VT-OGIS	2.0	
	Interns	MA-MWRA	1.0	
	Programmer/Analyst	MA-EOEAD	1.0	
	System manager	CT-NRC	1.0	
		NH-CSRC	1.0	
		RI-DADP	0.3	
		RI-EDC	2.0	
		US-EPAI	1.0	
		VT-AOT	1.0	
Software	ARC/INFO's NETWORK module	ME-OGIS	1.0	
	ARC/INFO's TIN model	CT-NRC	3.0	
		MA-BBP	1.0	
		MA-DFA	1.0	
		MA-EOEAD	1.0	
		MA-MBP	1.0	
		MA-MWRA	1.0	
		MA-USGS	1.0	
		ME-DEP	1.0	
		ME-GS	1.0	
		ME-OGIS	1.0	
		NH-CSRC	1.0	
		RI-DEMGW	1.0	
		RI-EDC	1.0	
		RI-ERIC	1.0	
		RI-NBP	1.0	
		RI-OEC	1.0	
		US-EPAI	7.0	
	AutoCAD drafting	CT-NRC	1.0	
		MA-MWRA	4.0	
		MA-USGS	1.0	
		RI-ERIC	1.0	
		VT-ANR	1.0	
	Contouring software	RI-ERIC	1.0	
	DCA contour/3D modelling	VT-ANR	1.0	
	ERDAS Satellite Imaging	NH-CSRC	1.0	
		RI-EDC	1.0	
	FoxPro Database Management Sys	VT-ANR	2.0	
		VT-OGIS	2.0	
	Grafpoint software	NH-DES	1.0	
	Ingres DBMS	MA-USGS	1.0	
	Intergraph drafting	RI-EDC	10.0	
		VT-AOT	1.0	
	Mainframe ARC/INFO GIS	CT-NRC	1.0	
		MA-BBP	1.0	
		MA-DFA	1.0	
		MA-EOEAD	1.0	
		MA-MBP	1.0	
		MA-MWRA	1.0	
		ME-OGIS	1.0	
		NH-CSRC	1.0	
		RI-DEMGW	1.0	
		RI-ERIC	1.0	
		RI-NBP	1.0	
		RI-OEC	1.0	
		VT-AOT	1.0	
	MapInfo GIS	CT-NRC	1.0	
	McDonnel/Douglas drafting	MA-MWRA	25.0	
	Minicomputer ARC/INFO	US-EPAI	1.0	

Resource Type	Resource	Organization Reference	How Many?	Total Annually Cost or Total
	Oracle Database Management Sys	MA-BBP	1.0	
		MA-EOEAD	1.0	
		MA-MBP	1.0	
		MA-MWRA	1.0	
		ME-DEP	1.0	
	Oracle RDBI	ME-OGIS	1.0	
	PC ARC/INFO GIS	CT-NRC	5.0	
		MA-BBP	1.0	
		MA-EOEAD	1.0	
		MA-MWRA	1.0	
		ME-GS	3.0	
		NH-CSRC	1.0	
		NH-DES	1.0	
		NH-OSP	1.0	
		RI-DADP	1.0	
		RI-EDC	10.0	
		VT-ANR	3.0	
		VT-AOT	2.0	
		VT-OGIS	2.0	
	PC ERDAS Satellite Imaging	NH-CSRC	2.0	
	PC ORACLE	MA-BBP	1.0	
	Quatro Pro	VT-ANR	2.0	
	Surfer contour/3D modelling	CT-NRC	1.0	
		NH-CSRC	1.0	
		RI-EDC	1.0	
	Trimble global postioning	CT-NRC	2.0	
		RI-EDC	2.0	
		US-EPAI	2.0	
		VT-ANR	3.0	
	Workstation ARC/INFO GIS	CT-NRC	4.0	
		MA-USGS	1.0	
		ME-DEP	1.0	
		ME-GS	1.0	
		ME-OGIS	3.0	
		NH-DES	1.0	
		RI-DADP	1.0	
		US-EPAI	8.0	
		VT-OGIS	1.0	

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
			1:24,000	unknown		State of CT	From CT-DEP. Includes name, utility name.
		Wells (community)	POINT	good		CT	From CT DEP. Includes name, supply code, aquifer.
			POINT	excellent		MA	From MAGIS. Includes pwsid, usgs id, name.
			POINT	good		NH 16 quads	From WGP, R1.
		Wells (non-community)	POINT	good		NH, 16 quads	From WGP, R1.
		Wells (private)	POINT	good		ME, 2 quads	From EPA Region I. Includes nitrate concentration.
		Wetlands	1:24,000	Good		Rhode Island	Wetlands which were mapped and digitized by IEP.
			1:24,000	good		VT, 18 quads	From VT/ANR.
	Wildlife	Rare and endangered species	?			VT, 31 quads	From VT/ANR. Includes Nat'l Her. Code.

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Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
VT-ANR	Earth	Bedrock geology	1:24,000			limited	
		Hydrography	1:100,000			State	USGS-DLG
			1:20,000			Limited areas	UVM
			1:5,000			Limited areas	UVM
		Soils	1:20,000		COUNTY	7 Counties	UVM
	Infra	Roads	1:100,000			State	USGS-DLG
	Land Use	Population or pop density					Default census data
	Pol Bound	County boundaries	1:24,000			State	EPA Region I - enhanced here
		State boundaries	1:24,000			State	EPA Region I - enhanced here
		Town boundaries	1:24,000			State	EPA Region I - enhanced here
	Water	Drainage basins	1:24,000			Limited	
		Reservoirs	1:24,000			State	
		River basins	1:100,000			State	
		Surface water (ponds,streams)	1:100,000			State	USGS-DLG
			1:20,000			Limited areas	
			1:5,000			Limited areas	
		Surface water classifications	1:100,000			Winooski River basin only	
		Wellhead protection areas	1:24,000			State	
		Wells (community)					
		Wetlands	1:80,000			70% of state	National Wetlands Complexes only
	Wildlife	Rare and endangered species	1:24,000			State	
		Wildlife habitats	1:24,000			30% of state	
VT-OGIS	Backgroun	7.5' quad boundaries	?		STATE	State	
		DLG tile boundaries	?		STATE	State	
		Orthophoto boundaries	1:5,000		STATE	State	
	Earth	Elevation - DEM	1:5,000		VT-OP4	Chittenden county except along borders	
		Hydrography	1:100,000		VT-DLG	State	
			1:20,000		V 16	Chittenden,	Single line surface waters (no lake or po oundaries),

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
						Passamodquoddy/Town	
			1:24,000	poor		ME, Passamoquoddy/PP	From EPA.
		Population		good		Region I	From U.S. Census. Includes pop 90, town, density.
			POINT			Region I	From MARF U.S. Census. Includes population 70 through 85, fips.
		Postal carrier routes					
		State boundaries	1:2,000,000	good		Region I	From USGS/EPA. Includes fips, county, state.
		Town boundaries	1:125,000	good		NH	From UNH. Includes name, fips, rpa.
			1:24,000	good		16 quads NH	From UNH. Includes name.
			1:24,000	good		CT	From CT DEP. Includes name, county.
			1:24,000	good		ME, 2 quads	From USGS/EPA.
			1:24,000	good		RI	From URI. Includes name, fips, county.
			1:24,000	good		VT,31	From EPA.
			1:25,000	good		MA	From MAGIS. Includes name, fips, county.
			1:250,000	poor		VT31 Q	From VT/ANR. Inlcudes townname.
		Zip code centroids	POINT	poor		Region I	From GDT/EPA HQ. Includes zip.
	Sample	Ozone monitoring stations	POINT	fair		Region I & II	From Airs. Includes id, 1987, 1988 data.
		Precipitation monitoring	POINT	good		CT	From CT DEP. Includes name, number, status.
	Water	Aquifers	1:24,000	good		2 quads, ME	From ME USGS. Includes <,> 50 gpm.
			1:24,000	good		Plymouth, MA	From EPA.
			1:24,000	good		State of RI	From RIGIS. Includes name.
			1:48,000	accurate		MA	From MA EOEA. Includes type, yield.
			1:62,500	fair		2 quads Maine	From ME USGS.
		Coastline	1:25,000	Fair	?	Mass. Bay and Portland, ME	NOAA coastline for Mass. Bay area and Portland, ME area.
		Dams	1:2,000,000	good		Region I	From USGS/EPA. Includes name.
			1:24,000	good		RI 12 quads	From URI.
			1:24,000	draft		VT 31 quads	From VT/ANR. Includes dam name, town.
		Hydrologic Unit Codes	1:2,000,000		?	EPA Region I	Hydrologic Unit Code boundaries coded with HUC ID number.
		Monitoring wells	POINT	good		NH, 16 quads	From WGP, R1. Includes many.
			POINT	good		RI 2 quads	From EPA.
		Public water supply	1:24,000	Good	?	Connecticut	Surface water supplies in Connecticut.
			POINT	good		NH, 16 quads	Location of intakes. Source WGP, RI. Includes many attributes.
		River basins	1:100,000	Generally?	?	Mass.	Major basins and subbasins for Massachusetts coded with basin names.
			1:125,000		?	Connecticut	Major basins and subbasins for Connecticut coded with basin number.
			1:125,000	Fair	?	New Hampshire	Major basins for New Hampshire coded with basin names.
			1:24,000	Poor	?	Lake Champlain, VT	Major basins and subbasins in the Lake Champlain area coded with basin name and basin number?
			1:24,000	Good	?	Rhode Island	Major basins and subbasins for Rhode Island coded with basin code number.
		Supply wells	POINT	good		NH, 16 quads	From WGP, R1.
			POINT	good		States of RI, NH	GPS collected. Includes PWSID number.
		Water supply watersheds	1:24,000	Good	?	New Hampshire	Watersheds for New Hampshire coded with Hydrologic Uni

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
						Franklin, Grand Isle	from 1:20,000 orthophotos.
			1:5,000		VT-OP12	Addison, Orange, Rutland, Windham	
		Hypsography (elevation contours)	1:5,000		VT-OP4	Chittenden County except along boundar	
		Lakes	1:100,000		STATE	State	
		Soils	1:20,000		VT-OP16	Addison, Orage, Rutland, Windham cty	
	Haz	Hazardous waste sites	1:25,000		STATE	State	
		Pollutions sources	1:63,360		STATE	State	
	Infra	Railroads	1:100,000		VT-DLG	State	
		Roads	1:100,000		VT-DLG	State	
		Transmission lines	1:100,000		VT-DLG	State	
		Transportation	1:20,000		VT-OP16	Chittenden, Franklin, Grand Isle	
	Land Use	Managed areas	?		STATE	State	
	Pol Bound	County boundaries	1:250,000		STATE	State	
		Regional environmental districts	1:250,000		STATE	State	
		Regional Planning Commission	1:250,000		STATE	State	
		Town boundaries	1:24,000		STATE	Addison, Orange, Rutland, Windham	
			1:250,000		STATE	State	
			1:62,500		STATE	State	
	Water	Buffered wellhead prot areas	1:25,000		STATE	State	
		Lake/pond drainage basins	1:25,000		STATE	State	Pre-release of lakes and ponds drainage basins.
		River drainage basins	?		STATE	State	
		Water supply watersheds	1:25,000		STATE	State	
		Wellhead protection areas	1:25,000		STATE	State	
		Wells (community)	1:25,000		STATE	State	For delineated wellhead protection areas
		Wetlands	1:24,000		VT-DLG	QUAD16 tiles 11-15,21,23,24,31-33	
	Wildlife	Endangered invertebrate species	1:25,000		STATE	State	Subset of endangered species coverage.
		Endangered natural communities	1:25,000		STATE	State	Subset of endangered species coverage.
		Endangered plant species	1:25,000		STATE	State	Subset of endangered species coverage.
		Endangered vertebrate species	1:25,000		STATE	State	Subset of endangered species coverage.
		Rare and endangered species	1:25,000		STATE	State	

VERMONT

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
VT-ANR	Infra	Roads	1:5,000			State	Orthophoto - from OGIS
	Land Use	Publically owned lands					
		Recreation facilities	1:24,000			State	Part of SCORP effort (due 1993)
	Pol Bound	TIGER (reprocessed)					

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
							recompiled before digitizing.

NEW HAMPSHIRE

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
NH-CSRC	Air	Forest cover; forest type	1:24,000		QUAD7.5	State	Current project in Coos County is developing this data, however future funding to increase coverage does not exist
	Earth	Elevation - DEM	1:24,000	NMAS	QUAD7.5	State	Statewide coverage needed, however not all quads are available.
	Land Use	Land cover	1:24,000		QUAD7.5	State	
		Land use	1:24,000	NMAS	QUAD7.5		
	Water	Aquifers	1:24,000	NMAS	QUAD7.5	State	
NH-DES	Infra	Sewer service areas	1:24,000		?	None	This layer will contain the extent of areas served by publi sewer as well as the collection system and treatment facili ies. Data on population served, etc. will be included.
	Water	Aquifers	1:24,000		QUAD7.5	State	Completed statewide aquifer data layer.
		Wetlands	1:24,000	?	?	None	Wetlands mapping has been completed for entire State by the US Fish and Wildlife Service. It is being considered for automation.
NH-OSP	Land Use	Zoning			QUAD7.5	None	Regional Planning Agencies may contribute zoning districts.

RHODE ISLAND

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
RI-EDC	Backgroun	Orthophoto images				State	Would like orthophoto images as background to ARC/INFO data.
	Land Use	Land use	1:24,000			State	Would like updated land use - current land use is from 1988 aerial photos.
	Pol Bound	TIGER (reprocessed)				State	Would like complete address-matched roads for the state.
RI-NBP	Earth	Bathymetry					
	Sample	Marine sediment sampling					
	Wildlife	Marine finfish					Updates beyond the first base line data will be needed.
		Marine invertebrates					Updates beyond the first base line data will be needed.
		Marine macrophytes					Updates beyond the first base line data will ne needed.
RI-OEC	Land Use	Land use	1:24,000			State	Need updated land use for Non-point source program.

UNITED STATES - FEDERAL

VERMONT

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
VT-ANR	Air	Air quality					
		Forest cover; forest type					
	Backgroun	USGS reference marks					Priority 27, status 0 on Needs Analysis Summary Table.
	Earth	Hydrography					Priority 27, status 1 on Needs Analysis Summary Table.
		Surficial geology					

Organization Reference	Data Type	Data Layer	Source Scale	Data Accuracy	Tile Unit	Data Extent	Additional Comments
	Haz	Landfills					
		Underground storage tanks	1:5,000			State	Using GPS; conversion to GIS not funded.
	Infra	Drainage					NPDES, CSO's
		Roads					Priority 27, status 1 on Needs Analysis Summary Table.
	Land Use	Archaeoligical sites					
		Historic sites					
		Land cover					
		Land use					
		Protected areas					
		State owned lands					Priority 27, status 1 on Needs Analysis Summary Table.
	Pol Bound	Census tracts					
		Zip code boundaries					
	Sample	Stream gaging					
	Water	Aquifers					
		Floodplains					
		Groundwater classifications					
		Surface water classifications				Other than Winooski River basin	
		Water supply watersheds					
		Wells (private)					

Table D-4:Existing GIS Data by Data Layer

Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
Air	Aeroradioactivity	CT-NRC	1:250,000			State
		RI-EDC	1:250,000	NMAS	STATE	State
	Emissions source	CT-NRC	POINT			State
	Forest cover; forest type	NH-CSRC	1:24,000		QUAD7.5	Coos County
		NH-OSP			COUNTY	State
		RI-EDC	1:24,000	NMAS	QUAD7.5	State
	Pesticides	MA-USGS	1:250,000	NMAS		National
		ME-GS	1:24,000	12m	QUAD7.5	Few quads, Presque Isle area
		NH-CSRC	1:24,000	NMAS	QUAD7.5	State
		NH-DES	1:24,000	?	QUAD7.5	State
		US-EPAI	1:24,000	questionable	?	16 quads in New Hampshire
	Radon	CT-NRC	1:24,000			State
Backgroun	7.5' quad boundaries	CT-NRC				State
		MA-EOEAD	1:25,000		STATE	state
		RI-NBP				
		US-EPAI	1:24,000	good		NH, 16 quads
		US-EPAI	1:24,000	excellent		CT
		US-EPAI	1:24,000	good		VT
		US-EPAI	1:24,000	gbod		RI
		VT-OGIS	?		STATE	State
	Census tracts	MA-EOEAD	1:100,000			2 halves of state
		MA-EOEAD	1:250,000			3 250k quads
	DLG tile boundaries	VT-OGIS	?		STATE	State
	Geodetic survey benchmarks	RI-NBP	POINT			state
	Geographic names	RI-NBP				
	Land base map	CT-NRC	1:100,000			Long Island Sound
	Orthophoto boundaries	VT-OGIS	1:5,000		STATE	State
	State plane grid (10000 ft)	MA-EOEAD	1:25,000		STATE	state
:arth	Areas of high elevation	ME-OGIS	1:100,000			State
	Bathymetry	MA-BBP	POINT			Buzzards Bay
		MA-EOEA				
		MA-EOEAD	1:25,000		QUAD7.5	selected quads
		MA-MWRA		NMA	HARBOR	Boston Harbor
		ME-GS	1:250,000	125m	QUAD250	One quad
		NH-CSRC	1:24,000	?		Bathymetry for 2 waterbodies in NH
		RI-EDC	POINT			Narragansett Bay
	Bedrock geology	CT-NRC	1:24,000			10% of state
		CT-NRC	1:125,000			10% of state
		MA-MWRA	1:25,000	NMA		Four quadrangle area
		ME-BOPC				
		ME-GS	1:62,500	32m	QUAD15	Few quads completed
		ME-GS	1:24,000	12m	QUAD7.5	Few quads completed
		ME-OGIS	1:500,000			State
		NH-CSRC	1:250,000		STATE	State
		NH-OSP	1:250,000		STATE	100% of State
		RI-EDC	1:125,000	NMAS	?	State
		US-EPAI	1:250,000	Generalized	?	Mass.
		US-EPAI	1:250,000	accurate		MA
		VT-ANR	1:24,000			limited
	Bedrock outcrops	US-EPAI	1:62,500	poor		ME 2 quads
	Coastal zones	CT-NRC	1:24,000			State
		MA-EOEA	1:25,000			
		ME-GS	1:62,500	32m	QUAD15	Several quads
	Earthquake epicenters	ME-GS	POINT	10,000m	REGION	Regional
		US-EPAI	POINT	good		Region I,II & Eastern Canada
	Elevation - DEM	CT-NRC	1:24,000			State
		MA-EOEAD	1:250,000	NMA		state
		MA-EOEAD	1:25,000			189 25k quads
		MA-EOEAD	1:250,000			28 unique grid
		MA-MWRA	1:250,000	NMA		State
		ME-DEP	1:24,000			Fore River watershed - in progress
		ME-OGIS	1:24,000			
		NH-CSRC	1:24,000	NMAS	QUAD7.5	
		NH-OSP	1:24,000	NMAS	QUAD7.5	15 quadrangles
		RI-EDC	1:24,000	NMAS	QUAD7.5	5 partial quads
		RI-OEC				
		US-EPAI	1:24,000	good		CT
		VT-OGIS	1:5,000		VT-OP4	Chittenden county except along borders
	Generalized bedrock	US-EPAI	1:150,000	poor		CT
		US-EPAI	1:1,000,000	fair		Region I
	Geologic terrains	CT-NRC	1:250,000			State

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	Glacial deposits	US-EPAI	1:24,000	draft		RI 12 quads
	Hydrography	MA-EOEAD	1:100,000			5 panels
		MA-MWRA	1:100,000	NMA	BASIN	State
		MA-USGS	1:24,000	NMAS		Cape-wide
		ME-BOPC				
		ME-OGIS	1:100,000			State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	60% of state
		RI-EDC	1:24,000	NMAS	QUAD7.5	State
		RI-OEC				
		US-EPAI	1:24,000	good		CT, 30 quads
		US-EPAI	1:24,000	good		ME, 2 quads
		US-EPAI	1:24,000	good		RI
		US-EPAI	1:100,000	good		Region I
		US-EPAI	1:2,000,000	good		Region I
		VT-ANR	1:100,000			State
		VT-ANR	1:20,000			Limited areas
		VT-ANR	1:5,000			Limited areas
		VT-OGIS	1:20,000		VT-OP16	Chittenden, Franklin, Grand Isle
		VT-OGIS	1:100,000		VT-DLG	State
		VT-OGIS	1:5,000		VT-OP12	Addison, Orange, Rutland, Windham
	Hydrography (detailed)	CT-NRC	1:100,000			State
		CT-NRC	1:24,000			State
	Hydrography (subset)	CT-NRC	1:24,000			State
	Hypsography (elevation contours)	CT-NRC	1:24,000			2% of state (Bound Brook, Ellington)
		MA-EOEAD	1:25,000			189 25k quads
		MA-USGS	1:250,000			Cape Cod
		ME-BOH			QUAD15	
		US-EPAI	1:2,000,000	fair		Region I
		US-EPAI	1:24,000	good		ME, 2 quads
		VT-OGIS	1:5,000		VT-OP4	Chittenden County except along boundary
	Lakes	VT-OGIS	1:100,000		STATE	State
	Metamorphic geology	ME-OGIS	1:1,000,000			State
	Mineral resources	US-EPAI	1:24,000	good		VT 31 quads
	Photo-lineament	ME-GS	1:100,000	50m	QUAD100	Lincoln, Lewiston
	Quaternary geology	CT-NRC	1:80,000			State
	Sand dunes	ME-GS	1:4,800	5m	TOWN	Sand beaches
	Slope	NH-CSRC	1:24,000		QUAD7.5	Same extent as DEM data
		RI-EDC	1:24,000		QUAD7.5	
	Soils	CT-NRC	1:250,000			State
		MA-MWRA	1:25,000	NMA		Four quadrangle area
		ME-BOPC				
		ME-DEP	1:24,000			Fore River watershed - in progress
		ME-OGIS	1:24,000			Approximately 10% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	Carroll,Grafton,Rockingham,Strafford Co.
		NH-OSP	1:24,000		QUAD7.5	About 2/5 of the State
		RI-EDC	1:15,840		QUAD7.5	State
		RI-OEC				
		US-EPAI	1:24,000	good		24 quads in Vermont
		US-EPAI	1:24,000	good		ME, 2 quads
		VT-ANR	1:20,000		COUNTY	7 Counties
		VT-OGIS	1:20,000		VT-OP16	Addison, Orage, Rutland, Windham ctys
	Stratified drift	CT-NRC	1:125,000			State
		US-EPAI	1:125,000	Generalized	?	Connecticut
	Surficial geology	CT-NRC	1:125,000			State
		CT-NRC	1:24,000			75% of state
		MA-EOEAD	1:125,000			3 250K quads
		MA-EOEAD	1:250,000			3 panels, statewide
		MA-MWRA	1:25,000	NMA		Four quadrangle area
		ME-BOPC				
		ME-OGIS	1:250,000		QUAD250	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	6 quads
		NH-OSP	1:24,000		QUAD7.5	6 quadrangles
		RI-EDC	1:24,000	NMAS	?	State
		US-EPAI	1:24,000	good		ME 2 quads
	Tidal flats	MA-EOEA				
Haz	Above ground storage tanks	RI-DEMGW	1:24,000		QUAD7.5	state
	Ash disposal sites	CT-NRC	1:24,000			State
	CERCLIS sites	RI-OEC				
	Dry cleaning facilities	RI-DEMGW	1:24,000		QUAD7.5	state
	Hazardous waste sites	US-EPAI	?			VT, 31 quads
		VT-OGIS	1:25,000		STATE	State
	Landfills	CT-NRC	1:24,000			State

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
		MA-MWRA				
		ME-DEP	POINT			Fore River watershed
		ME-GS	1:24,000	12m	QUAD7.5	10% of state
		NH-DES	1:24,000	+- 200 ft.	?	90% of State
		RI-DEMGW	1:24,000		QUAD7.5	state
		RI-OEC				
		US-EPAI	POINT	fair		CT
		US-EPAI	POINT	fair		Conn.
		US-EPAI	POINT	fair		RI
		US-EPAI	POINT	fair		States of CT, RI
	Leaking USTs	RI-DEMGW	1:24,000		QUAD7.5	state
	Marine fisheries sanitary survey	MA-BBP				
	Misc. hazardous waste site	RI-DEMGW	1:24,000		QUAD7.5	state
	NPDES outfalls	MA-BBP	POINT	unknown		Buzzards Bay
		US-EPAI	POINT	good		NH, 16 quads
		US-EPAI	POINT	good		Blackstone Basin
	Oil spill sites	RI-NBP				
	Polluted wells	CT-NRC	1:48,000			State
	Pollutions sources	CT-NRC	1:50,000			State
		NH-DES	1:24,000	+- 200 ft.	?	90% of State
		US-EPAI	?	poor		VT, 31 quads
		VT-OGIS	1:63,360		STATE	State
	RCRA facilities	US-EPAI		Fair	?	EPA Region I
	RCRA generators	US-EPAI		Fair	?	EPA Region I
	RCRA storage facailities	US-EPAI		Fair	?	EPA Region I
	RCRA treatment,storage,disposal	US-EPAI		Varied	STATE	EPA Region I
	Sand/salt piles	ME-GS	1:24,000	12m	QUAD7.5	10% of state
		RI-DEMGW	1:24,000		QUAD7.5	state
	Spill sites	RI-OEC				
	Surface impoundments	RI-DEMGW	1:24,000		QUAD7.5	state
	Undergrnd injection control site	RI-DEMGW	1:24,000		QUAD7.5	state
	Underground storage tanks	CT-NRC	POINT			State
		MA-MWRA				Watersheds
		ME-DEP	POINT			Fore River watershed
		NH-DES	1:24,000	+- 200 ft.	?	90% of State
		RI-DEMGW	1:24,000		QUAD7.5	state (except Block Island)
		RI-OEC				
		US-EPAI		Fair	?	Connecticut
Infra	"Segments" data	MA-BBP	1:25,000	NMA		Buzzards Bay
	Aqueducts	MA-EOEAD	1:100,000		STATE	state
	Buildings	ME-DEP	1:2,400			Camp Ellis
		RI-EDC			?	University of Rhode Island campus
	Combined Sewer Overflows	MA-BBP		unknown		New Bedford Harbor
	Dredged channels	RI-NBP				
	Electric	RI-EDC	1:24,000	NMAS		State
	Gas	RI-EDC	1:24,000	NMAS		State
	Pipelines	MA-EOEAD	1:100,000		STATE	state
		ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		NH-OSP	1:24,000	NMAS	QUAD7.5	41 quads
	Power generating facilities	CT-NRC	1:24,000			State
	Railroads	MA-EOEAD	1:100,000		STATE	state
		ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		NH-OSP	1:24,000	NMAS	QUAD7.5	41 quads
		US-EPAI	1:100,000	good		Region I
		US-EPAI	1:25,000	good		MA, 4 quads
		VT-OGIS	1:100,000		VT-DLG	State
	Rights of Way	MA-DFA	1:25,000	+- 100 ft.		Part of Plymouth/Barnstable counties
	Roads	CT-NRC	1:100,000			State
		MA-EOEAD	1:100,000			189 25k quads
		MA-EOEAD	1:100,000		STATE	state
		MA-MWRA	1:100,000	NMA	QUAD7.5	State
		ME-BOH				
		ME-BOPC				
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		ME-OGIS	1:100,000		QUAD100	State
		NH-CSRC	1:100,000	NMAS	QUAD7.5	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	60% of state
		NH-OSP	1:24,000	NMAS	QUAD7.5	41 quads
		RI-EDC	1:24,000	NMAS	QUAD7.5	State
		RI-OEC				
		US-EPAI	1:2,000,000	good		Region I

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
		US-EPAI	1:24,000	good		RI
		US-EPAI	1:24,000	good		ME, 2 quads
		US-EPAI	1:100,000	good		Region I
		VT-ANR	1:100,000			State
		VT-OGIS	1:100,000		VT-DLG	State
	Roads and trails	CT-NRC	1:24,000			State
	Sewage treatment plants	CT-NRC	1:24,000			State
	Sewer	MA-MWRA				
		MA-USGS	1:100,000	NMAS		Cape-wide
		RI-EDC		NMAS	QUAD7.5	State
		RI-OEC				
	Sewer service areas	CT-NRC	1:24,000			State
		MA-MWRA				
		MA-USGS	1:100,000	NMAS		Cape-wide
		ME-DEP	POINT	95%		Portland, South Portland, Westbrook
		NH-CSRC	1:125,000		STATE	State
		NH-DES	1:125,000	?	?	State
	Trails	ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
	Transmission lines	ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		VT-OGIS	1:100,000		VT-DLG	State
	Transportation	VT-OGIS	1:20,000		VT-OP16	Chittenden, Franklin, Grand Isle
	Water	MA-MWRA				
		RI-OEC				
	Water service areas	CT-NRC	1:24,000			State
		MA-MWRA			STATE	MWRA Service Area
		NH-CSRC	1:125,000		STATE	State
		NH-DES	1:125,000		?	State
		NH-DES	1:24,000	?	?	Very limited
Land Use	Archaeoligical sites	NH-OSP	1:24,000			Very limited
		RI-EDC	1:24,000	NMAS	STATE	State
	Areas of critcal env. concern	MA-EOEAD	1:25,000		STATE	state
	Farmland	CT-NRC	1:24,000			80% of state
		US-EPAI	1:24,000	fair		ME, 2 quads
	Golf courses	CT-NRC	1:24,000			State
	Historic sites	RI-EDC	1:24,000	NMAS	STATE	State
	Land cover	NH-CSRC	1:24,000		QUAD7.5	Coos County
		RI-OEC				
	Land use	CT-NRC	1:24,000			3% of state (4 quads at level 3 detail)
		MA-EOEAD	1:25,000		TOWN	351 towns
		MA-MBP	1:25,000			
		MA-MWRA	1:25,000		TOWN	
		NH-CSRC	1:24,000	NMAS	QUAD7.5	very partial coverage
		NH-OSP	1:24,000	?	QUAD7.5	7 full quads, 24 partial quads
		RI-EDC	1:24,000	NMAS	QUAD7.5	State
		RI-OEC				
		US-EPAI		?	?	Most of Rhode Island
		US-EPAI	1:24,000	Good	?	2 quads in Connecticut?
	Land use/land/cover	US-EPAI	30M	unknown		24 quads in NH
		US-EPAI	1:24,000	good		State of MA
	Managed areas	VT-OGIS	?		STATE	State
	Municipally owned lands	CT-NRC	1:24,000			15% of state
	Open space	US-EPAI	1:24,000	unknown		State of RI
	Population or pop density	MA-USGS				Nation
		VT-ANR				
	Privately owned land	ME-OGIS	1:100,000		QUAD100	State
	Protected areas	MA-EOEAD	1:25,000		GRPCNTY	6 panels
		MA-USGS	1:24,000			Cape-wide
		RI-OEC				
		US-EPAI	1:62,500	poor		NH
		US-EPAI	1:25,000	accurate		MA
	Publically owned lands	MA-MWRA	1:25,000		BASIN	
		ME-OGIS	1:100,000		QUAD100	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	partial coverage of Coos County
		RI-EDC	1:24,000	NMAS		State
		RI-OEC				
	Recreation facilities	RI-EDC				Some towns
	State owned lands	CT-NRC	1:24,000			State
		US-EPAI	1:24,000	unknown		State of CT
	TIGER data	MA-EOEAD	1:100,000		TOWN	351 towns
		MA-EOEAD	1:100,000		COUNTY	14 counties
	Zoning	CT-NRC				50% of state

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
		MA-MWRA				
Pol Bound	Census tracts	NH-CSRC	1:100,000	NMAS	QUAD7.5	Raw TIGER for entire State.
		RI-EDC	1:100,000	NMAS		Partial coverage
	County boundaries	CT-NRC	1:250,000			State
		MA-EOEAD	1:25,000		STATE	state
		MA-MWRA	1:25,000	NMA	STATE	State
		ME-BOH			QUAD7.5	
		ME-BOPC				
		ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	60% of state
		US-EPAI	1:2,000,000	good		Region I
		VT-ANR	1:24,000			State
		VT-OGIS	1:250,000		STATE	State
	Indian reservations	US-EPAI	1:24,000	poor		ME, Houlton Malisett
		US-EPAI	1:24,000	poor		CT, Mashantucket Pequot
		US-EPAI	1:24,000	poor		ME, Passamoquoddy/PP
		US-EPAI	1:24,000	poor		ME, Passamodquoddy/Town
		US-EPAI	1:24,000	good		MA, Wampanoag
	Political boundaries	ME-OGIS	1:500,000			
	Political districts	NH-CSRC	1:24,000	NMAS	QUAD7.5	60% of state
		NH-OSP	1:24,000	NMAS	QUAD7.5	41 quads
	Population	US-EPAI	POINT			Region I
		US-EPAI		good		Region I
	Postal carrier routes	US-EPAI				
	Regional environmental districts	VT-OGIS	1:250,000		STATE	State
	Regional Planning Commission	CT-NRC	1:250,000			State
		MA-EOEAD	1:25,000		STATE	state
		VT-OGIS	1:250,000		STATE	State
	Senate districts	MA-EOEAD	1:25,000		STATE	state
	State boundaries	MA-MWRA	1:25,000	NMA	STATE	State
		ME-BOH			QUAD7.5	
		ME-BOPC				
		ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:24,000		QUAD7.5	35-50% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	60% of state
		RI-EDC	1:24,000	NMAS	STATE	State
		RI-OEC				
		US-EPAI	1:2,000,000	good		Region I
		VT-ANR	1:24,000			State
	TIGER (reprocessed)	MA-MWRA	1:100,000	NMA		Service area
		RI-EDC	1:100,000	NMAS		partial coverage
	Town boundaries	CT-NRC	1:24,000			State
		CT-NRC	1:250,000			State
		MA-EOEAD	1:25,000		STATE	state
		MA-MWRA	1:25,000	NMA	STATE	State
		ME-BOH			QUAD7.5	
		ME-BOPC				
		ME-OGIS	1:24,000		QUAD7.5	30-50% of state
		ME-OGIS	1:100,000		QUAD100	State
		RI-EDC	1:24,000	NMAS	STATE	State
		RI-OEC				
		US-EPAI	1:24,000	good		VT,31
		US-EPAI	1:250,000	poor		VT31 Q
		US-EPAI	1:125,000	good		NH
		US-EPAI	1:25,000	good		MA
		US-EPAI	1:24,000	good		ME, 2 quads
		US-EPAI	1:24,000	good		16 quads NH
		US-EPAI	1:24,000	good		CT
		US-EPAI	1:24,000	good		RI
		VT-ANR	1:24,000			State
		VT-OGIS	1:250,000		STATE	State
		VT-OGIS	1:62,500		STATE	State
		VT-OGIS	1:24,000		STATE	Addison, Orange, Rutland, Windham
	Zip code boundaries	MA-EOEAD	1:2,000,000		STATE	state
	Zip code centroids	US-EPAI	POINT	poor		Region I
e	Marine sediment sampling	ME-GS	1:24,000	12m	QUAD7.5	5% of coast
		RI-EDC	POINT			Narragansett Bay
	Ozone monitoring stations	US-EPAI	POINT	fair		Region I & II
	Precipitation monitoring	CT-NRC				
		US-EPAI	POINT	good		CT
	Sediment Chemistry	MA-EOEA				
	Soil boring sampling	RI-EDC	1:15,840	NMAS	QUAD7.5	State

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	Stream gaging	MA-MWRA	POINT		STATE	Service area watershed
		MA-USGS		NMAS		State
		NH-DES			STATE	State
	SWUDS	MA-USGS		NMAS		State
	Water quality	MA-BBP	POINT	unknown		Buzzards Bay
		MA-USGS		NMAS		State
	Water quality monitoring network	CT-NRC	1:24,000			State
Water	Aquifer protection areas	CT-NRC	1:24,000			10% of state
	Aquifers	CT-NRC	1:125,000			State
		MA-EOEAD	1:48,000		BASIN	25 panels
		MA-MWRA			BASIN	
		ME-BOPC				
		ME-GS	1:24,000	12m	QUAD7.5	10% of state
		ME-OGIS	1:50,000		QUAD50	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	Nashua, Lamprey, Exeter
		NH-DES	1:24,000	?	QUAD7.5	27 quadrangles
		US-EPAI	1:62,500	fair		2 quads Maine
		US-EPAI	1:24,000	good		2 quads, ME
		US-EPAI	1:24,000	good		Plymouth, MA
		US-EPAI	1:48,000	accurate		MA
		US-EPAI	1:24,000	good		State of RI
	Buffered wellhead prot areas	RI-EDC	1:24,000		?	State
		VT-OGIS	1:25,000		STATE	State
	Coastal water use	RI-NBP				
	Coastal wetlands	NH-OSP	1:24,000	?	QUAD7.5	About 4 quads on coast
	Coastline	US-EPAI	1:25,000	Fair	?	Mass. Bay and Portland, ME
	Dams	NH-DES	1:24,000	+- 100 ft.	STATE	State
		US-EPAI	1:2,000,000	good		Region I
		US-EPAI	1:24,000	good		RI 12 quads
		US-EPAI	1:24,000	draft		VT 31 quads
	Drainage basins	CT-NRC	1:250,000			State
		CT-NRC	1:24,000			State
		MA-BBP	1:25,000	unknown		Buzzards Bay drainage basin
		MA-EOEAD	1:25,000		STATE	state
		MA-MBP	1:25,000			Cape Code Bay watershed
		MA-MWRA				
		ME-GS	1:24,000	12m	QUAD7.5	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	State
		NH-DES	1:24,000	?	BASIN	100% of State
		RI-NBP	1:24,000	140ft		Narragansett Bay
		VT-ANR	1:24,000			Limited
	Drainage sub-basins	MA-EOEAD	1:25,000		GRPBASIN	4 panels
	Floodplains	ME-BOPC				
		ME-DEP	1:2,400			Camp Ellis
		RI-EDC	?			
	Groundwater classifications	RI-DEMGW	1:24,000			
	Groundwater recharge areas	RI-EDC	1:24,000	NMAS	STATE	State
	Groundwater reservoirs	RI-EDC	1:24,000	NMAS	STATE	State
	Hydrologic Unit Codes	US-EPAI	1:2,000,000		?	EPA Region I
	Lake/pond drainage basins	VT-OGIS	1:25,000		STATE	State
	Major drainage basins	RI-EDC	1:24,000	NMAS		State
	Monitoring wells	MA-USGS		NMAS		State
		US-EPAI	POINT	good		RI 2 quads
		US-EPAI	POINT	good		NH, 16 quads
	Ponds	MA-EOEAD	1:100,000		GRPBASIN	5 panels
	Public water supply	CT-NRC	1:250,000			State
		NH-DES	1:24,000	?	QUAD7.5	More than half of State
		US-EPAI	1:24,000	Good	?	Connecticut
		US-EPAI	POINT	good		NH, 16 quads
	Reservoirs	CT-NRC	1:24,000			State
		MA-MWRA				
		MA-USGS	1:250,000			Nation
		RI-OEC				
		VT-ANR	1:24,000			State
	River basins	MA-MWRA				
		ME-GS	1:500,000	250m	STATE	State
		RI-OEC				
		US-EPAI	1:125,000		?	Connecticut
		US-EPAI	1:125,000	Fair	?	New Hampshire
		US-EPAI	1:100,000	Generally?	?	Mass.
		US-EPAI	1:24,000	Good	?	Rhode Island
		US-EPAI	1:24,000	Poor	?	Lake Champlain, VT
		VT-ANR	1:100,000			State

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	River drainage basins	VT-OGIS	?		STATE	State
	Snow survey results	ME-GS		50m	STATE	State
	Sole source aquifers	MA-EOEAD	1:25,000		STATE	state
		MA-USGS	1:24,000			
		RI-EDC	1:24,000			State
	Streams	CT-NRC	1:250,000			State
		MA-EOEAD	1:100,000		GRPBASIN	5 panels
	Sub-drainage basins	RI-EDC	1:24,000	NMAS	?	State
	Supply wells	MA-EOEAD	1:25,000		STATE	state
		MA-USGS		NMAS		State
		US-EPAI	POINT	good		NH, 16 quads
		US-EPAI	POINT	good		States of RI, NH
	Surface water (ponds,streams)	ME-BOH			QUAD7.5	
		ME-BOPC				
		VT-ANR	1:100,000			State
		VT-ANR	1:20,000			Limited areas
		VT-ANR	1:5,000			Limited areas
	Surface water classifications	VT-ANR	1:100,000			Winooski River basin only
	Water diversions	CT-NRC	1:24,000			25% of state
	Water quality classifications	CT-NRC	1:24,000			20% of state
	Water supply watersheds	CT-NRC	1:24,000			State
		MA-MWRA				
		ME-OGIS	1:24,000		QUAD7.5	State
		RI-EDC	1:24,000	NMAS		State
		RI-OEC				
		US-EPAI	1:24,000	Good	?	New Hampshire
		US-EPAI	1:24,000	unknown		State of CT
		VT-OGIS	1:25,000		STATE	State
	Wellhead protection areas	MA-EOEAD	1:25,000		STATE	state
		MA-MWRA				
		MA-USGS	1:24,000			
		VT-ANR	1:24,000			State
		VT-OGIS	1:25,000		STATE	State
	Wells (community)	CT-NRC	1:24,000			State
		MA-MWRA	POINT		STATE	State
		MA-USGS	1:24,000			Southeast Mass.
		ME-GS	POINT	100m	TOWN	10% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	50% of state
		RI-EDC	1:24,000	NMAS	?	State
		US-EPAI	POINT	good		NH 16 quads
		US-EPAI	POINT	good		CT
		US-EPAI	POINT	excellent		MA
		VT-ANR				
		VT-OGIS	1:25,000		STATE	State
	Wells (Ind, Ag, Commer)	MA-MWRA				
		ME-GS	POINT	100m	TOWN	10% of state
	Wells (non-community)	MA-MWRA				
		ME-GS	POINT	100m	TOWN	10% of state
		NH-CSRC	1:24,000	NMAS	QUAD7.5	50% of state
		RI-EDC	1:24,000	NMAS	QUAD7.5	1 town
		US-EPAI	POINT	good		NH, 16 quads
	Wells (private)	MA-MWRA				
		MA-USGS	1:24,000			Eastham
		ME-GS	POINT	100m	TOWN	10% of state
		US-EPAI	POINT	good		ME, 2 quads
	Wetlands	CT-NRC	1:24,000			State
		MA-EOEAD	1:100,000		STATE	state
		ME-BOPC				
		ME-DEP	1:24,000			York - in progress
		ME-OGIS	1:100,000		QUAD100	State
		ME-OGIS	1:250,000		QUAD250	State
		NH-CSRC	1:24,000	NMAS	QUAD7.5	24 quadrangles
		NH-OSP	1:24,000	30m pixel sz	QUAD7.5	24 quadrangles
		RI-EDC	1:24,000	NMAS	QUAD7.5	State
		RI-OEC				
		US-EPAI	1:24,000	good		VT, 18 quads
		US-EPAI	1:24,000	Good	?	Rhode Island
		VT-ANR	1:80,000			70% of state
		VT-OGIS	1:24,000		VT-DLG	QUAD16 tiles 11-15,21,23,24,31-33
ildlife	Eelgrass beds	MA-BBP	1:25,000	very poor		Buzzards Bay
	Endangered invertebrate species	VT-OGIS	1:25,000		STATE	State
	Endangered natural communities	VT-OGIS	1:25,000		STATE	State
	Endangered plant species	VT-OGIS	1:25,000		STATE	State

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	Endangered vertebrate species	VT-OGIS	1:25,000		STATE	State
	Rare and endangered species	CT-NRC	1:24,000			80% of state
		ME-DEP	POINT			Casco Bay watershed
		NH-OSP	1:24,000		QUAD7.5	State
		RI-EDC	1:24,000	NMAS	STATE	State
		US-EPAI	?			VT, 31 quads
		VT-ANR	1:24,000			State
		VT-OGIS	1:25,000		STATE	State
	Shellfish areas	CT-NRC	1:24,000			20% of state
		MA-BBP	1:25,000	NMA		Buzzards Bay
	Wildlife habitats	ME-DEP	POINT			Casco Bay watershed
		RI-NBP	1:4,800			
		VT-ANR	1:24,000			30% of state

Table D-5:Planned GIS Data by Data Layer

	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
Air	Forest cover; forest type	NH-CSRC	1:24,000		QUAD7.5	Coos County
	Ozone study	ME-DEP				
Earth	Bathymetry	MA-MBP				MA & Cape Cod Bays, Merrimack Embayment
		ME-GS	1:250,000	123m	QUAD7.5	
	Bedrock geology	ME-GS	1:62,500	32M	QUAD7.5	
		ME-GS	1:24,000	12m	QUAD7.5	
	Coastal segmentation	MA-MBP				From NH border to Provincetown
	Coastal zones	ME-GS	1:62,500	32m	QUAD7.5	
	Earthquake epicenters	ME-GS	POINT	10,000m	REGION	Regional
	Hydrography	ME-GS	1:24,000	12m	QUAD7.5	
		NH-CSRC	1:24,000	NMAS	QUAD7.5	40% of State
	Hydrography (network)	CT-NRC	1:24,000		QUAD7.5	
	Hypsography (elevation contours)	ME-BOH			QUAD7.5	
	Soils	CT-NRC	1:15,840			None completed
		NH-CSRC	1:24,000	NMAS	QUAD7.5	Hillsborough, Coos, Cheshire Counties
Haz	CERCLIS sites	CT-NRC	1:24,000			
	Landfills	ME-GS	1:24,000	12m	QUAD7.5	
	NPDES outfalls	MA-MBP				Selected embayments only
	Pollutions sources	NH-DES	1:24,000	+- 100 ft.	QUAD7.5	None
	RCRA facilities	CT-NRC	1:24,000			
	Sand/salt piles	ME-GS	1:24,000	12m	QUAD7.5	
	SARA sites	CT-NRC	1:24,000			
	Spill sites	CT-NRC	1:24,000			
	Underground storage tanks	CT-NRC	1:24,000			
		ME-DEP	POINT			Fore River watershed
Infra	Combined Sewer Overflows	MA-MBP				Selected embayments only
	Roads	ME-GS	1:24,000	12m	QUAD7.5	
		NH-CSRC	1:24,000	NMAS	QUAD7.5	40% of state
		VT-ANR	1:5,000			State
	Stormdrains	MA-MBP				Selected embayments only
Land Use	Farmland	ME-BOPC			QUAD7.5	4 quads in Aroostook County
	Historic sites	NH-OSP	1:24,000			None
	Land cover	ME-DEP	1:24,000			Fore River watershed
		NH-CSRC	1:24,000		QUAD7.5	
		NH-OSP	1:24,000		QUAD7.5	None
	Land use	CT-NRC		30 meters		State
		ME-DEP	1:24,000			Fore River watershed
	Population or pop density	MA-MWRA				
	Publically owned lands	NH-CSRC	1:24,000	NMAS	QUAD7.5	
		NH-OSP	1:24,000		QUAD7.5	None
		VT-ANR				
	Recreation facilities	NH-OSP	1:24,000			None
		VT-ANR	1:24,000			State
	Zoning	ME-DEP	1:2,400			Fore River watershed, Harspwell
Miscellan	Miscellaneous comment	ME-OGIS				
Pol Bound	County boundaries	CT-NRC	1:24,000			
		NH-CSRC	1:24,000	NMAS	QUAD7.5	40% of state
	Political districts	NH-CSRC	1:24,000	NMAS	QUAD7.5	40% of state
	Regional Planning Commission	CT-NRC	1:24,000			
	State boundaries	NH-CSRC	1:24,000	NMAS	QUAD7.5	40% of state
	TIGER (reprocessed)	VT-ANR				
	Town boundaries	CT-NRC	1:24,000			
		ME-GS	1:24,000	12m	QUAD7.5	
Sample	Marine sediment sampling	CT-NRC	1:80,000			
		MA-MBP				
		ME-DEP				
		ME-GS	1:24,000	12m	QUAD7.5	
	Water quality	MA-BBP	POINT	unknown		Buzzards Bay
Water	Aquifers	ME-GS	1:24,000	12m	QUAD7.5	
	Drainage sub-basins	MA-MBP				Selected embayments only
	NPDES sites	CT-NRC	1:24,000			
	Public water supply	CT-NRC	1:24,000			
	Water quality and circulation	MA-MBP				Mass and Cape Cod Bays
	Wellhead protection areas	ME-BOPC				
		RI-EDC	1:24,000	NMAS		
	Wells (community)	ME-BOH	POINT	GPS		
		ME-GS	POINT	100m	TOWN	
	Wells (Ind, Ag, Commer)	ME-GS	POINT	100m	TOWN	
	Wells (non-community)	ME-BOH	POINT	GPS		
		ME-GS	POINT	100m	TOWN	
	Wells (private)	ME-GS	POINT	100m	TOWN	

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	Wetlands	NH-CSRC	1:24,000	NMAS	QUAD7.5	State
Wildlife	Living resources	MA-MBP				Selected embayments only
	Rare and endangered species	ME-BOPC				
		ME-DEP	POINT			Casco Bay watershed
	Wildlife habitats	ME-DEP				Casco Bay watershed
		NH-OSP	1:24,000		QUAD7.5	None

Table D-6:Needed GIS Data by Data Layer

	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
Air	Air quality	VT-ANR				
	Forest cover; forest type	NH-CSRC	1:24,000		QUAD7.5	State
		VT-ANR				
	Pesticides	ME-BOPC				
Backgroun	Land base map	MA-MBP	1:5,000			
	Orthophoto images	RI-EDC				State
	USGS reference marks	VT-ANR				
Earth	Bathymetry	MA-MWRA				Gulf of Maine
		ME-OGIS	POINT	1:24,000		
		RI-NBP				
	Elevation - DEM	MA-MWRA				MWRA Service Area
		ME-DEP				All but North Central Maine
		ME-OGIS	POINT	1:24,000		
		NH-CSRC	1:24,000	NMAS	QUAD7.5	State
	Hydrography	MA-BBP	1:25,000			Buzzards Bay watershed
		VT-ANR				
	Soils	MA-DFA				State
		MA-EOEAD				
		ME-OGIS				
	Surficial geology	VT-ANR				
az	CERCLIS sites	ME-BOH				
	Landfills	ME-BOH				
		VT-ANR				
	Non-point pollution sources	MA-MBP				
	Pesticide areas	CT-NRC				
	RCRA facilities	ME-BOH				
	Sand/salt piles	ME-BOH				
	Sewage disposal type	MA-MBP				
	Sewage lagoons	ME-BOH				
	Spill sites	ME-BOH				
		ME-BOPC				
	Underground storage tanks	ME-BOH				
		ME-DEP	POINT			Fore River watershed
		VT-ANR	1:5,000			State
nfra	Drainage	VT-ANR				
	Railroads	ME-BOPC				
	Rights of Way	ME-BOPC				
	Roads	MA-MWRA				MWRA Service Area
		VT-ANR				
	Sewer service areas	NH-DES	1:24,000			None
Land Use	Archaeoligical sites	VT-ANR				
	Golf courses	ME-BOPC				
	Historic sites	VT-ANR				
	Land cover	NH-CSRC	1:24,000		QUAD7.5	State
		VT-ANR				
	Land use	MA-BBP	1:25,000			Buzzards Bay watershed
		MA-DFA	1:25,000			State
		MA-MBP				
		MA-MWRA	1:25,000			MWRA Service Area
		NH-CSRC	1:24,000	NMAS	QUAD7.5	
		RI-EDC	1:24,000			State
		RI-OEC	1:24,000			State
		VT-ANR				
	Land use/land/cover	ME-OGIS		1:24,000		
	Population or pop density	MA-MBP				
	Protected areas	VT-ANR				
	State owned lands	VT-ANR				
	Zoning	NH-OSP			QUAD7.5	None
Pol Bound	Census tracts	VT-ANR				
	TIGER (reprocessed)	RI-EDC				State
	Zip code boundaries	VT-ANR				
ple	Marine sediment sampling	MA-BBP	POINT			Buzzards Bay
		MA-MBP				
		RI-NBP				
	Sediment Chemistry	MA-EOEA				
	Stream gaging	VT-ANR				
	Water quality	MA-BBP	POINT			Buzzards Bay
Water	Aquifers	NH-CSRC	1:24,000	NMAS	QUAD7.5	State
		NH-DES	1:24,000		QUAD7.5	State
		VT-ANR				
	Coastal features	MA-MBP				

Data Type	Data Layer	Org Reference	Source Scale	Data Accuracy	Tile Unit	Data Extent
	Coastline	MA-MBP	1:5,000			
	Dams	MA-MBP				
	Drainage basins	ME-BOH				
	Floodplains	MA-MBP				Coast and rivers
		VT-ANR				
	Groundwater classifications	VT-ANR				
	NPDES sites	MA-MBP				
	Offshore base map	MA-MBP				State
	Reservoirs	ME-BOH				
	River basins	ME-BOH				
	Saltwater intrusion	MA-MBP				Estuaries
	Surface water classifications	VT-ANR				Other than Winooski River basin
	Volume of water flow	MA-MBP				Rivers
	Water supply watersheds	ME-BOH				
		VT-ANR				
	Wellhead protection areas	ME-BOH				
	Wells (private)	ME-BOPC				
		VT-ANR				
	Wetlands	CT-NRC				
		MA-MBP	1:5,000			
		ME-OGIS		1:24,000		
		NH-DES	1:24,000	?		None
Wildlife	Anadromous fish runs	MA-MBP				
	Living resources	MA-MBP				
	Marine Finfish	RI-NBP				
	Marine Invertebrates	RI-NBP				
	Marine macrophytes	RI-NBP				
	Shellfish areas	MA-DBP				Buzzards Bay
		MA-MBP				

Organization Reference	Application Type	Application	End User	Additional Comments

VERMONT

Organization Reference	Application Type	Application	End User	Additional Comments
VT-ANR	Air Pollution	Air pollution emissions tracking		Preliminary version; un-verified
	Miscellaneous	Data storage and transfer		
		Map products		
		Wildlife management		
	Waste Management	Hazardous waste		
	Water Management	Water permit/license/registratn		
		Watershed/wellhead protection		
		Wetland studies		
VT-OGIS	Miscellaneous	Community growth mgmt planning	Town government	
		Data storage and transfer		VT OGIS fills role as data distributor and archive.
		Wildlife management	State game authorities	
	Waste Management	Municipal solid waste management	Several regional waste authorities	
	Water Management	Stormwater management	City government	
		Watershed/wellhead protection	State & local government	

Organization Reference	Application Type	Application	End User	Additional Comments
ME-DEP	Air Pollution	Air pollution emissions tracking	AIR Bureau	The facility and mobil emissions are currently stored in the EPA AIRS computer system and are spatially referenced.
		Ozone study	AIR Bureau	This study is just beginning.
	Miscellaneous	Oil spill preparedness	State of Maine	Focused on marine oil spill.
		Wildlife management	State of Maine	To be incorporated with oil spill preparedness.
	Water Management	Marine studies	Casco Bay National Estuary Program	
		Stormwater management	Casco Bay National Estuary Program	
		Water pollution control	Casco Bay National Estuary Program	
ME-GS	Miscellaneous	Oil spill preparedness	Maine DEP	Provide various data for multi-agency effort.
	Water Management	Aquifer mapping	State agencies, municipalities	
		Groundwater resrc characterizatn	State agencies, municipalities	Characterize quality, quantity, availability of groundwater resources.

NEW HAMPSHIRE

Organization Reference	Application Type	Application	End User	Additional Comments
NH-OSP	Miscellaneous	Community growth mgmt planning	Municipal planners	
	Water Management	Watershed planning	Community/watershed groups	

RHODE ISLAND

Organization Reference	Application Type	Application	End User	Additional Comments
RI-ERIC	Air Pollution	Air pollution pesticide studies	Division of Agriculture	Awaiting hardware delivery, project with EPA, coordinate with Groundwater and Air & Hazardous Divisions, Water Resources.
	Miscellaneous	Agricultural studies	Division of Agriculture	Awaiting hardware delivery, project with EPA, coordinate with Groundwater, Air & Hazardous Divisions, Water Resources
RI-NBP	Miscellaneous	Community growth mgmt planning	Municpal planners, state planning divs	
		Land use planning	Project staff, state planning divisions	

UNITED STATES - FEDERAL

Organization Reference	Application Type	Application	End User	Additional Comments
US-EPAI	Waste Management	Municipal solid waste management	Superfund Program	
	Water Management	Non-point source pollution	Non-point Source Program	

VERMONT

Organization Reference	Application Type	Application	End User	Additional Comments
VT-ANR	Miscellaneous	Data storage and transfer		
VT-OGIS	Miscellaneous	Forestry planning	State	Northern Forest Lands Council
		Socio-economic factors	Legislation	Reappointment
		Transportation	Municipality & state government	Road mapping and planning
	Waste Management	Hazardous waste	State authority	Low level radioactive waste

Table E-2:Planned GIS Applications by Organization

CONNECTICUT

Organization Reference	Application Type	Application	End User	Additional Comments
CT-NRC	Air Pollution	Air pol. fate/transport analysis	DEP, EPA	Ozone studies/ models with NY, NJ.
		Air quality studies	DEP, EPA	Ozone studies/ models with NY, NJ.
	Miscellaneous	Risk assessments	DEP, EPA, towns, applicators	Pesticides/EPA ground water protection program.
	Waste Management	Hazardous waste	DEP, EPA	Part of EPA/LT core grant GIS add-on.
		Waste facility siting	DEP, EPA	Part of EPA/LT core grant add-on.
		Waste generation studys/analysis	DEP,EPA	Part of EPS/LT core grant GIS add-on.
		Waste permit/license/registratn	DEP, EPA	Part of EPA/LT core grant add-on.
	Water Management	Wetland studies	DEP, towns	Awaiting UNIX ARC/INFO - application/database defined, parts in place.

MASSACHUSETTS

Organization Reference	Application Type	Application	End User	Additional Comments
MA-BBP	Miscellaneous	Oil spill preparedness		Have plans to develop a series of maps to support oil spill response. Maps would show sensitive resources.
	Water Management	Marine studies	Buzz. Bay Program office	
MA-EOEAD	Water Management	Water pollution control		3056 reporting.
MA-MBP	Water Management	Marine studies	CZM, MBP Office, MWRA, communities	Show location and results of offshore (bay) circulation studies.
		Water pollution control	CZM, MBP office, MWRA, communities	Show location of NPDES discharges, shellfish areas, nonpoint source (through landuse).
		Wetland studies		Through grants program, analyze wetland acreage around a bay
MA-MWRA	Waste Management	Waste facility siting	Sewerage Division	
MA-USGS	Water Management	Inland water quality	State, USGS	Applications at a local and national scale are being programmed and tested.
		Non-point source pollution	State, USGS	Applications at a local and national scale are being programmed and tested.
		Stormwater management	State, USGS	Buzzard Bay potential.
		Water facility siting	State, USGS	Applications at a local and national scale are being programmed and tested.
		Water pollution control	State, USGS	
		Water supply and demand	State, USGS	A statistical package thru AMC has been put together.
		Watershed/wellhead protection	Cape Cod, USGS	Modeling on Cape Cod has and is being done extensively for water quality and quantity.
		Wetland studies	State	

MAINE

Organization Reference	Application Type	Application	End User	Additional Comments
ME-BOPC	Water Management	Water pollution pesticide study	State, municipal	Evaluate vulnerability of gw to pesticide contamination. Need current farmland and crop maps.
		Watershed/wellhead protection		Planned by Department of Human Services - Drinking Water Division.

Organization Reference	Application Type	Application	End User	Additional Comments
	Water Management	Wetland studies	State & local government	

Organization Reference	Application Type	Application	End User	Additional Comments
US-EPAI	Air Pollution	Air quality studies	Air Division	Mobile source emissions tracking.
	Miscellaneous	On-line data catalog	Various programs and states	On-line data catalog with interface.
	Water Management	Wetlands permit tracking	Wetlands Protection Section	

VERMONT

Organization Reference	Application Type	Application	End User	Additional Comments
VT-ANR	Air Pollution	Air pol. permit/licence/registr		
		Air pollution facility siting		
		Air quality studies		
	Miscellaneous	Acid Rain		
		Demographics		
		Forestry planning		
		Land use planning		
		Socio-economic factors		
	Waste Management	Industrial waste management		
		Municipal solid waste management		
		Waste permit/license/registratn		
	Water Management	Aquifer mapping		
		Non-point source pollution		
		Water pollution control		
VT-OGIS	Air Pollution	Air pol. fate/transport analysis		
		Air pol. permit/licence/registr		Proposals made, some funded.
		Air pollution emissions tracking		
		Air pollution facility siting	State environmental quality authorities	Proposals made, some funded.
		Air pollution pesticide studies		
		Air quality studies		
	Waste Management	Industrial waste management		
		Recycling and waste minimization		
		Waste generation studys/analysis		
		Waste Hauling		

Table E-3: Needed GIS Applications by Organization

Table E-4:Existing GIS Applications by Application

ication	Application	Organization Reference	End User
Air Pollution	Air pol. fate/transport analysis	NH-OSP	OSP
	Air pollution emissions tracking	US-EPAI	Air and Environ Services Divisions
		VT-ANR	
	Air pollution pesticide studies	MA-EOEAD	DPH, DFA, DEP tech serv branch
		NH-CSRC	NH Dept. of Agriculture
Miscellaneous	Acid Rain	MA-EOEAD	UMASS/ARM (acid rain monitoring)
	Address to coordinate matching	MA-EOEAD	
	Agricultural studies	MA-DFA	DFA, EOEA, Farming community
	Basin delineation	MA-USGS	State, USGS
	Chemical spill preparedness	US-EPAI	Enforcement and Preparedness Section
	Community growth mgmt planning	ME-GS	Municipalities
		RI-DADP	RI cities and towns
		RI-NBP	Municipal planners, state planning divs
		VT-OGIS	Town government
	Data storage and transfer	CT-NRC	Govt agencies, business, individuals
		MA-MWRA	
		NH-CSRC	Multiple users
		VT-ANR	
		VT-OGIS	
	Demographics	MA-EOEAD	
		MA-MWRA	
		MA-MWRA	
		ME-BOH	
	Epidemiologic studies	MA-EOEAD	DPH
		MA-MWRA	
		ME-BOH	
	Forestry planning	MA-MWRA	
		NH-CSRC	NH Dept of Resources and Economic Devt
	Global warming/climate change	MA-MWRA	
	Land use planning	MA-BBP	Buzz. Bay Program office
		MA-DFA	DFA, Farmers
		MA-MWRA	
		ME-GS	State planning agencies, municipalities
		NH-CSRC	OSP, and US Forest Service
		NH-OSP	OSP, municipalities
		RI-DADP	RI DEM, State planning
		RI-ERIC	Division of Planning
		RI-NBP	Project staff, state planning divisions
	Map products	CT-NRC	DEP
		MA-BBP	Many users
		MA-EOEAD	public + private
		MA-NBP	CZM, EPA, RPAs, MiniBays
		MA-MWRA	
		MA-USGS	Cape Cod
		ME-DEP	Anyone who requests maps
		ME-GS	State & federal agencies, public
		NH-CSRC	Multiple users
		RI-NBP	Municipal & state agencies, public
		VT-ANR	
	Marine Oil Spill Response	ME-OGIS	DEP, Marine Resources...
	Multi-media initiatives	US-EPAI	Various programs
	Northern Forest Lands Study	ME-OGIS	Conservation, State Planning...
	Oil spill preparedness	ME-DEP	State of Maine
		RI-ERIC	Groundwater Division
	Radon	CT-NRC	DEP, health dept, towns
	Risk assessments	MA-MWRA	
	Socio-economic factors	ME-BOH	
		NH-CSRC	US Forest Service
	Wildlife management	ME-DEP	State of Maine
		RI-ERIC	Natural Heritage Program
		VT-ANR	
		VT-OGIS	State game authorities
Waste Management	Fate/transport/dispersion model	MA-MWRA	Harbor studies
	Hazardous waste	MA-EOEAD	DEP/DUSC (div of waste site cleanup)
		RI-ERIC	Hazardous Materials Division
		VT-ANR	
	Industrial waste management	US-EPAI	RCRA and Superfund Programs
	Municipal solid waste management	MA-EOEAD	DEP/DSW
		VT-OGIS	Several regional waste authorities
	Waste facility prioritization	US-EPAI	RCRA and Superfund Programs
	Waste facility siting	MA-MWRA	Sewerage Division

Application Type	Application	Organization Reference	End User
		ME-GS	ME Low Level Radioactive Waste Auth.
		RI-ERIC	Hazardous Materials Division
	Waste permit/license/registratn	RI-ERIC	Hazardous Materials Inventory
Water Management	Aquifer mapping	CT-NRC	DEP, water companies, towns
		MA-EOEAD	DEP/DWS (div of water supply)
		MA-MBP	
		MA-MWRA	
		MA-USGS	State, USGS
		ME-BOPC	
		ME-GS	State agencies, municipalities
		NH-CSRC	Municipalities
		RI-DEMGW	DEM GW
		RI-ERIC	Groundwater Division
	Facility inventory	RI-DEMGW	
	Groundwater class mapping	RI-DEMGW	
	Groundwater resrc characterizatn	ME-GS	State agencies, municipalities
	Inland water quality	RI-ERIC	Water Resources Division
	Marine studies	CT-NRC	USGS, DEP, UConn, Univ. New Haven, SCS
		MA-BBP	Buzz. Bay Program office
		MA-EOEAD	CZM (coastal zone management)
		MA-MWRA	
		ME-GS	MGS, Federal agencies
		RI-ERIC	Water Resources Division
		RI-NBP	Project staff, public education
	Non-point source pollution	CT-NRC	DEP, EPA, towns, businesses
		MA-DFA	DFA
		MA-EOEAD	
		MA-MBP	CZM, MBP
		MA-MWRA	
		NH-DES	DES
		RI-ERIC	Office of Environmental Coordination
		RI-NBP	Proj staff, pub educ, state planning div
		RI-OEC	DEM NPS Program, Muni & State Agencies
	Stormwater management	ME-DEP	Casco Bay National Estuary Program
		RI-NBP	state reg agencies, public education
		RI-OEC	DEM NPS Program, Muni & State Agencies
		US-EPAI	Non-point source Program, Merrimack Init
		VT-OGIS	City government
	Water permit/license/registratn	VT-ANR	
	Water pollution control	MA-MWRA	
		ME-DEP	Casco Bay National Estuary Program
		RI-ERIC	Water Resources Division
		RI-NBP	Muni, state reg agencies, pub education
		RI-OEC	DEM NPS Progam, Muni & State Agencies
	Water supply and demand	MA-MWRA	Waterworks Division
		RI-ERIC	Groundwater Div., Air & Haz. Mater. Div
	Watershed/wellhead protection	CT-NRC	DEP, water companies, towns
		MA-BBP	private non-profit
		MA-DFA	DFA, EOEA, Farmers
		MA-EOEAD	
		MA-MWRA	
		MA-USGS	Cape Cod, USGS
		NH-DES	DES
		RI-ERIC	Groundwater Div., and OEC
		US-EPAI	Various programs
		VT-ANR	
		VT-OGIS	State & local government
	Wellhead protection	RI-DEMGW	DEM GW
	Wetland studies	MA-EOEAD	DEP/DWW (div of wetlands & waterways)
		MA-USGS	State
		ME-DEP	Town of York
		NH-CSRC	Municipalities
		RI-ERIC	Wetlands Division
		US-EPAI	Wetlands Protection Section
		VT-ANR	

Table E-5:Planned GIS Applications by Application

cation Type	Application	Organization Reference	End User
Air Pollution	Air pol. fate/transport analysis	CT-NRC	DEP, EPA
	Air pollution emissions tracking	ME-DEP	AIR Bureau
	Air pollution pesticide studies	RI-ERIC	Division of Agriculture
	Air quality studies	CT-NRC	DEP, EPA
	Ozone study	ME-DEP	AIR Bureau
Miscellaneous	Agricultural studies	RI-ERIC	Division of Agriculture
	Community growth mgmt planning	NH-OSP	Municipal planners
		RI-NBP	Municpal planners, state planning divs
	Data storage and transfer	VT-ANR	
	Forestry planning	VT-OGIS	State
	Land use planning	RI-NBP	Project staff, state planning divisions
	Oil spill preparedness	MA-BBP	
		ME-DEP	State of Maine
		ME-GS	Maine DEP
	Risk assessments	CT-NRC	DEP, EPA, towns, applicators
	Socio-economic factors	VT-OGIS	Legislation
	Transportation	VT-OGIS	Municipality & state government
	Wildlife management	ME-DEP	State of Maine
Waste Management	Hazardous waste	CT-NRC	DEP, EPA
		VT-OGIS	State authority
	Municipal solid waste management	US-EPAI	Superfund Program
	Waste facility siting	CT-NRC	DEP, EPA
		MA-MWRA	Sewerage Division
	Waste generation studys/analysis	CT-NRC	DEP,EPA
	Waste permit/license/registratn	CT-NRC	DEP, EPA
Water Management	Aquifer mapping	ME-GS	State agencies, municipalities
	Groundwater resrc characterizatn	ME-GS	State agencies, municipalities
	Inland water quality	MA-USGS	State, USGS
	Marine studies	MA-BBP	Buzz. Bay Program office
		MA-MBP	CZM, MBP Office, MWRA, communities
		ME-DEP	Casco Bay National Estuary Program
	Non-point source pollution	MA-USGS	State, USGS
		US-EPAI	Non-point Source Program
	Stormwater management	MA-USGS	State, USGS
		ME-DEP	Casco Bay National Estuary Program
	Water facility siting	MA-USGS	State, USGS
	Water pollution control	MA-EOEAD	
		MA-MBP	CZM, MBP office, MWRA, communities
		MA-USGS	State, USGS
		ME-DEP	Casco Bay National Estuary Program
	Water pollution pesticide study	ME-BOPC	State, municipal
	Water supply and demand	MA-USGS	State, USGS
	Watershed planning	NH-OSP	Community/watershed groups
	Watershed/wellhead protection	MA-USGS	Cape Cod, USGS
		ME-BOPC	
	Wetland studies	CT-NRC	DEP, towns
		MA-MBP	
		MA-USGS	State
		VT-OGIS	State & local government

Table E-6:Needed GIS Applications by Application

cation	Application	Organization Reference	End User
Air Pollution	Air pol. fate/transport analysis	VT-OGIS	
	Air pol. permit/licence/registr	VT-ANR	
		VT-OGIS	
	Air pollution emissions tracking	CT-NRC	DEP
		VT-OGIS	
	Air pollution facility siting	VT-ANR	
		VT-OGIS	State environmental quality authorities
	Air pollution pesticide studies	VT-OGIS	
	Air quality studies	US-EPAI	Air Division
		VT-ANR	
		VT-OGIS	
	SARA Title III	CT-NRC	DEP, EPA, towns
Miscellaneous	Acid Rain	VT-ANR	
	Address to coordinate matching	CT-NRC	DEP
		MA-MWRA	
		RI-ERIC	Regulatory Divisions
	Community growth mgmt planning	ME-BOH	
		RI-NBP	Municipal planners, state planning divs
	Demographics	MA-MWRA	
		VT-ANR	
	Epidemiologic studies	NH-CSRC	NH Div. of Public Health Services
	Forestry planning	CT-NRC	DEP
		RI-ERIC	
		VT-ANR	
	Land use planning	CT-NRC	DEP, OPM, towns
		ME-BOH	
		RI-NBP	Project staff, state planning divisions
		VT-ANR	
	Oil spill preparedness	CT-NRC	
		ME-BOH	
	On-line data catalog	US-EPAI	Various programs and states
	Radon	ME-BOH	
	Risk assessments	ME-BOH	
	Socio-economic factors	VT-ANR	
	Transportation	NH-CSRC	NH Dept. of Transportation
	Wildlife management	RI-ERIC	Division of Fish & Wildlife
Waste Management	Hazardous waste	ME-BOH	
	Industrial waste management	ME-BOH	
		VT-ANR	
		VT-OGIS	
	Municipal solid waste management	ME-BOH	
		VT-ANR	
	Recycling and waste minimization	CT-NRC	DEP, recycling regions
		ME-BOH	
		VT-OGIS	
	Waste facility siting	ME-BOH	
	Waste generation studys/analysis	ME-BOH	
		VT-OGIS	
	Waste Hauling	VT-OGIS	
	Waste permit/license/registratn	VT-ANR	
Water Management	Aquifer mapping	ME-BOH	
		VT-ANR	
	Groundwater management	ME-OGIS	DOT, DOC, DEP, MGS, DOA, SPO
	Inland water quality	RI-ERIC	WRD, and GW & ISDS Divisions
	Marine studies	RI-ERIC	Water Resources Division
	Non-point source pollution	MA-BBP	
		MA-MBP	
		RI-ERIC	Office of Environmental Coordination
		VT-ANR	
	Stormwater management	MA-MWRA	
		ME-DEP	Casco Bay National Estuary Program
		RI-ERIC	WRD and OEC
	Water facility siting	CT-NRC	DEP, business
	Water permit/license/registratn	CT-NRC	DEP, business
	Water pollution control	CT-NRC	DEP, businesses
		ME-BOH	
		ME-BOPC	
		ME-DEP	Casco Bay National Estuary Program
		RI-ERIC	Water Resources Division
		VT-ANR	
	Water supply and demand	CT-NRC	DEP, water companies

Application Type	Application	Organization Reference	End User
		ME-GS	
	Watershed/wellhead protection	ME-BOH	
		NH-DES	DES
	Wetland studies	ME-DEP	National Estuary Program
		ME-GS	
		RI-ERIC	Wetlands Division
	Wetlands permit tracking	US-EPAI	Wetlands Protection Section