REPORT OF THE JOINT SUBCOMMITTEE

STUDYING

THE VIRGINIA RESOURCE INFORMATION SYSTEM

(VARIS)

TO

THE GOVERNOR

AND

THE GENERAL ASSEMBLY OF VIRGINIA

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INTRODUCTION

Legislative and Executive Branches at all levels of government in Virginia and citizens at large have a strong interest in proper management of our resources and the environment.

The 1978 General Assembly, recognizing that effective decisions leading to a desirable balance between economic growth, environmental quality, and the maintenance of adequate resources for future generations are based on readily available and adequate information, created a Joint Subcommittee through House Joint Resolution No. 175 to study the development of a Virginia Resource Information System and to:

1. Investigate systems for effective data sharing by State agencies, regional authorities and other states.

2. Determine effective applications of new technology in obtaining and evaluating natural resource and environmental information.

3. Determine the areas of and conditions necessary to foster coordinated efforts between State agencies, research and education institutions and others in developing and applying resource information.

4. Initiate and monitor demonstration projects using remote sensing technology transfer between federal and State agencies.

5. Recommend legislation required to implement a coordinated resource information system in the Commonwealth.

Based upon preliminary studies on the concept of a comprehensive resource information system, the 1979 General Assembly, through House Joint Resolution No. 225, authorized funds for an Executive Branch Task Force to conduct detailed feasibility studies and to provide other assistance needed by the Joint Subcommittee for the development of this report, its conclusions, recommendations, justifications and support information.

Detailed studies have been completed with the assistance of eighteen executive branch agencies, ten local government agencies, thirteen planning district commission staffs, five universities and colleges and three federal agencies. Although detailed studies have also been conducted in several other states, findings and conclusions in this report are based entirely on resource information needs suggested by State agencies, local government representatives, and planning districts in Virginia.

CONCLUSIONS

As a result of detailed studies on needs in Virginia and on the state of the art in resource information systems development, the Subcommittee has reached the following conclusions:

1. Virginia needs a well developed resource information system. An information system is needed to provide up-to-date and reliable information on the supply, demand, quality and utilization of land, water, air, forest products, minerals and other resources throughout the Commonwealth.

Based on demonstrated experience by State agencies and local governments, with the cooperation of federal agencies and others, information obtained by remote sensing technology from high and low altitude aircraft, Landsat and meteorological satellites, and special ground or water borne devices, is extremely useful and cost-effective in providing additional information needed to inventory, monitor, and evaluate Virginia's resources and environment. It has been clearly indicated that an integrated system to store and access resource information, process data from remote sensing devices, provide up-to-date maps and map overlays, and provide computer based studies on special issues is needed by all levels of government and groups in the private sector.

2. The proposed Virginia Resource Information System can be used by State and local groups. Potential users include:

   a. Executive Branch Agencies, Planning District Commissions, and Local Governments - State agencies have a constant need for statistical information, up-to-date maps, projections and impact studies on resource issues in order to make effective decisions in serving public needs and in carrying out mandated public responsibilities. In managing agency programs there is a need for accurate and up-to-date information on:

   (1) Water resource availability, quality, and use in localities, river basins, and the entire State.

   (2) Atmospheric conditions including air quality, climate, flooding, soil conditions and droughts.

   (3) Land resources including soil capability for crop and forest production, highway and building support, airport and industrial siting, and other development purposes; minerals and energy resources to serve current and future needs; and land use trends and future potentials.

   (4) Farm, forest, wildlife and marine life production, trends and future potentials.

   (5) Man-made resources such as highways, other transportation facilities, water impoundments, recreation facilities, commercial and residential developments.

   (6) Demographic and socio-economic factors relating to the use and management of resources. Local governments and planning district commissions need much of the same information as those required by State agencies and also require assistance in compiling information for resource planning and for decisions affecting community needs.

   b. General Assembly Committees and Commissions–The Legislative Branch has a constant need for timely, up-to-date and accurate information on Virginia's resources in order to make effective policy decisions and to amend laws affecting overall needs of the Commonwealth.

   c. Business Organizations, Special Groups and Individuals in the Private Sector–These have a growing need for resource information in order to make effective decisions on:

   - Site locations for construction and development purposes

   - Potential environmental impact of current or proposed developments

   - Proposals which affect quality of life and economic opportunity

3. Benefits of the proposed Virginia Resource Information System include:

   a. Significant savings in time and costs in gathering information by State agencies, localities, planning districts, and the private sector.

   b. Expertise and capability at a single source to provide greater ease in obtaining desired

resource information for all levels of government and the private sector.

c. Continuously updated and integrated resource data from federal, State, and local sources with standardized output formats for greater ease and effectiveness of use by decision makers.

d. Integrated resource and demographic data on maps and map overlays for greater understanding of impacts from current or anticipated developments.

e. Availability and use of well developed models to make comparisons of causes and effects of alternative proposals and in making predictions for the future.

4. The proposed system should be capable of providing the following services:

a. Correlating data concerning multiple resource factors simultaneously and preparing desired information for decision makers.

b. Preparing maps and map overlays on the latest available resource information requested by users.

c. Preparation and display of statistical information and statistical analyses to accompany maps, map overlays and other reports.

d. Developing simulations and forecasts to aid users in making difficult decisions.

e. Integrating remote sensor data with resource data from other sources in analyses of changes, trends and proposed developments involving Virginia's resources.

f. Providing information to universities, colleges and other educational institutions for use in research and development studies, educational purposes and special advisory needs to General Assembly committees, Executive Branch agencies, planning districts, local government agencies, and the private sector.

Benefit-costs studies on data management, providing land use information services, and on selection of sites for particular developments indicate the proposed system will be capable of achieving a considerable cost savings compared to current manual systems and single agency computerized systems. It appears that as the system is developed and its capabilities become more recognized, there will be a strong demand for services by public agencies, localities and the private sector.

RECOMMENDATIONS

General

Based on detailed studies of current and long-run needs, the Subcommittee recommends development of a comprehensive Virginia Resource Information System (VARIS) within the Office of Commerce and Resources and that a phased approach be used as follows:

1. That the system be initiated concurrent with the 1980-82 fiscal biennium to concentrate on developing programs, plans, and procedures for inititating and controlling comprehensive services. The minimum equipment be purchased and that heavy reliance be placed on established resource information capabilities within the State. That further studies be made on major hardware needs for long term system capability requirements.

2. That the system's hardware and support materials be expanded during the 1982-84 fiscal biennium for broad based geographic information and environmental monitoring systems. That institutions of higher education and State agencies continue active roles in further development and implementation of the system.

3. That the Virginia Resource Information System be fully developed during the 1984-86 fiscal biennium to provide up-to-date resource information that will serve statewide, regional and local needs. That the system have capability for providing environmental, socio-economic and geographic information models for studying impacts and making projections for use by decision makers.

4. That efforts be made to further refine the system during succeeding biennia to meet current needs and to absorb operating costs through user fees.

The following are detailed Recommendations by the Subcommittee:

Scope

It is recommended that:

1. Capabilities listed in Item 4 of the Conclusions be developed in a phased approach based on priorities established and modified according to needs stated by users. The primary goal of the Virginia Resource Information System should be aimed at serving user needs including but not necessarily restricted to:

   a. Collection, storage, networking and retrieval of resource information.

   b. High quality processing services to serve user needs through:

   (1) Standardized analytical software packages.

   (2) Adapting existing models to needs in Virginia for simulations, forecasts and predictions, selecting optimum situations among alternatives, and other analytical services concerning data from multiple sources to provide essential information for decisions.

   (3) Development of new software and models for situations where existing models cannot be adapted to needs in Virginia.

   c. Providing agencies with information relating to the monitoring of regulatory programs and other support services.

2. The System begins by providing services that meet priority needs and which provide positive cost benefits immediately upon implementation. The System Scope should then be expanded only as user needs and demand for services indicate.

Organization and Structure of Varis

It is recommended that:

1. Responsibility for the development and operation of the Information System be assigned to the

Executive Branch, Office of the Secretary of Commerce and Resources.

2. The Executive Branch Task Force be continued to oversee development of the Information System is directed toward meeting user needs as established by the User Needs Survey and as expanded or modified during the life cycle of the system.

3. A small staff of four professionals be established at the beginning of the 1980-82 Biennium and that it be increased to six professionals during the 1982-84 Biennium.

4. Effective use of professional assistance in State institutions of higher education be obtained through contractual arrangements to augment the VARIS professional staff.

5. State agencies cooperate with the VARIS Task Force and the VARIS Staff to minimize duplications of services and to maximize efficient operations for the benefit of the State agencies, localities, planning bodies, private sector, and the taxpayers.

Facilities

It is recommended that:

1. The System be developed and operated in the Richmond area for maximum effectiveness of management and services, and that adequate input/output facilities be established for tie-in with State agencies, institutions of higher education, planning districts, and local governments through lease-line or long distance telephone services.

2. Only minimum equipment be purchased during the first year of the 1980-82 Biennium and that heavy reliance be placed on established capabilities within the State including:

   a. State agency computers for service type data storage and recall programs.

   b. VIMS/W&M for Landsat data analysis using available system hardware and software.

   c. Virginia Tech for Geo-base Information System (GIS) and Environmental Modeling Programs.

3. Purchase of mini-computer in second year to:

   a. Handle date dititizing, storage and recall programs.

   b. Provide computerized mapping services.

   c. Improve tie-ins and economies in working with State agency computers, VIMS/W&M and Virginia Tech in future development and delivery of services.

4. Purchase hardware and software for expanded Landsat capability (assigned to VIMS/W&M) during the 1984-86 Biennium and expand in-house capability to provide computerized services unique to geo-base Information Systems. Continue active roles for Virginia Tech and VIMS/W&M.

Budget

It is recommended that General Funds be appropriated for the 1980-82, 1982-84, and 1984-86 biennia for at least $500,000 each. The individual breakdowns by three biennia are presented in Table I. It is anticipated that in biennia beyond 1982-84, General Fund needs will be stabilized or reduced and that efforts will be made to rely on user fees to cover system operational costs.

Table I - PROPOSED VARIS BUDGET

	80-82 Biennium		82-84 Biennium		84-86 Biennium	
	1	2	1	2	1	2
Staff						
Director, 1	24,500	25,600	26,800	28,000	29,300	30,600
GIS Specialist, 1	18,700	19,600	20,500	21,400	22,400	23,400
Computer Sciences Specialist, 1	-	-	19,600	20,500	21,400	22,400
Cartographer, 1	-	-	17,150	17,900	18,700	19,600
Encoder and Digitizer, 1	-	9,168	9,600	10,032	10,572	10,992
Writer and Editor, 1	10,992	11,472	12,000	12,528	13,128	13,728
Secretary, 1	9,168	9,600	10,032	10,512	10,992	10,992
Benefits	8,870	10,562	16,195	16,922	17,709	18,440
Travel and Training	4,000	5,500	5,500	3,000	2,500	2,500
Data Acquisition						
Landsat Data Tapes	1,000	2,000	2,000	2,000	1,000	1,000
Cooperative Data Programs (w/Localities)	4,000	4,000	8,000	8,000	4,000	4,000
Data Capture and Encode (Student Labor)	800	1,600	1,600	1,600	2,400	2,400
Computer Support Services (State)	10,000	15,000	25,000	-	-	-
Equipment						
Digitizer	15,000	-	-	-	-	-
Input/Output Terminal	10,000	-	15,000	-	-	-
Minicomputer	-	57,000	-	20,000	-	-
Interactive Graphics Unit	-	-	155,000	-	-	-
Chromalin Color Printer	-	-	-	5,000	-	-
Support Equipment	-	-	-	-	23,000	13,000
Maintenance	-	4,000	5,500	5,500	5,000	2,500
Materials	2,500	4,000	6,000	6,000	4,000	2,000

Table I - (concluded)

VPI & SU Development Group						
GIS Development/Env.Modeling	45,000	60,000	50,000	40,000	40,000	40,000
Computer Time	10,000	15,000	10,000	10,000	5,000	5,000
VIMS/W&M Landsat Analysis Group						
ORSER Operation and Interpretation	20,000	15,000	15,000	15,000	10,000	10,000
Tapes, CPU & Connect Time	20,000	15,000	10,000	5,000	5,000	5,000
Yearly Totals	214,530	284,102	440,477	258,894	246,101	237,552
Biennium Totals	498,462		699,371		483,653	
Three Biennium Total			1,681,656			

The phasing of the proposed development program dictates the sequencing of the expenditure of funds. The manner in which the program development relates to expenditure of funds can be observed by examining the following development rationale:

1. First Biennium (1980-82)

a. First year

(1) Minimum staff of four

(2) Staff to concentrate on developing program plans and procedures for initiating and controlling work

(3) Purchase only minimum equipment required to start

(4) Rely heavily on established capabilities within State

- Use State computer for service type data storage and recall programs

- Use VIMS/W&M for Landsat data analysis using ORSER program

- Use VPI & SU for Geo-base Information System (GIS) and Environmental Modeling programs

b. Second year

(1) Continue to rely on State computer for service type operational programs

(2) Continue to rely on VIMS/W&M for Landsat

(3) Continue to rely on VPI & SU for GIS and Environmental modeling

(4) Finalize specifications for major hardware procurements

(5) Initiate purchase of minicomputer compatible with:

- Date dititizing, storage, and recall program

- Computerized mapping requirements

- Upgraded Landsat data processing system to be purchased next biennium

(6) Begin to focus on becoming more self-sufficient

Options:

- Delay second year purchase of minicomputer, thus delaying date of self sufficient in-house capability.

2. Second Biennium (1982-84)

a. First year

(1) Increase staff to seven to accommodate expanded in-house capability

(2) Purchase hardware and software for expanded Landsat capability (assign to VIMS/W&M)

(3) Continue to rely on VIMS/W&M for Landsat programs with expanded interactive graphics and output products capability

(4) Begin doing in-house operational GIS and environmental monitoring programs; VPI &SU to remain prime for development of new GIS and modeling techniques

(5) Begin using own minicomputer for service type operational programs (encode, store, recall, digitize map, etc.)

b. Second year

(1) Self sufficient in-house capability except rely on:

- VPI & SU for GIS and Modeling Research and Development

- VIMS/W&M for Landsat processing

(2) Terminate reliance on State computer for operational support

Options:

- Since have minicomputer, can retain expanded Landsat data processing system and develop in-house capability rather than leave at VIMS/W&M

- Can continue to rely on State computer for portions of the service type operational programs if opted not to purchase minicomputer in second year of previous biennium

3. Third Biennium (1984-86)

(1) Continue in self sufficient mode with VPI & SU and VIMS/W&M with specific responsibilities

(2) Purchase selected items of support equipment needed to improve capability

(3) Operational costs become less as user fees pay more of operational costs

4. Subsequent Biennia

(1) Capital equipment has been purchased

(2) Base data has been captured

(3) User organizations fund operations through user fees

(4) Costs to general fund decrease

SYSTEM NEEDS ASSESSMENT

Background

House Joint Resolution No. 175 (Appendix A) passed by the 1978 General Assembly created a Joint Subcommittee to study a Virginia Resource Information System. At the culmination of the Study, the Executive Branch Task Force submitted a Conceptual Design of an Information System to the Subcommittee which subsequently approved the report. One of the recommendations in the report was that a survey of potential users be conducted to determine if a need does exist for the System and if the need exists, what is the need and how should an Information System be structured to meet the need? The 1979 General Assembly passed House Joint Resolution No. 225 (Appendix A) which directed that an extensive user survey be conducted and authorized State funding of a portion of the effort. The Executive Branch Task Force accepted responsibility to conduct the survey and began the field work in May, 1979.

User Needs Survey

The survey was accomplished through a series of personal visits by members of the Task Force to selected State agencies, planning district commissions, counties, and cities. During each visit, Task Force members presented a briefing on the VARIS concept, objectives, potential uses, and status. Information needs of the organization being visited were discussed relative to how VARIS may be implemented to meet them. Following each meeting, a summary of the key points was made and recorded. In addition, one or more questionnaire survey forms structured to provide specific details on needs were completed by potential users. Three questionnaires were used to gather data. The Document Analysis and Data Sheet Questionnaire was developed to gather details on current data collection and disposition procedures. It was designed primarily for use by State Executive Branch Agencies who routinely gather and distribute natural resource data. State agencies were also asked to complete an Information System Capability Questionnaire. The questionnaire was designed to gather ideas on how VARIS could benefit users and, therefore, how it could be designed to assure user benefit. This questionnaire was the primary one left with the planning district commissions. The Selected Jurisdiction Questionnaire was the third type used. It was designed to gather specific information on the needs of counties and cities. Examples of the three types of questionnaires are contained in Appendix B.

Organizations to be visited were selected to provide representative coverage of urban and rural areas and areas of differing geographical features. An exception to this approach was the selection of State agencies. The intent was to survey all the major State agencies that produce or use natural resource data. A list of State agencies, planning district commissions, counties, and cities surveyed is presented in Table II.

The user survey documented a large number of specific needs for resource data, information, and processing techniques. When reviewed collectively, many of the individual needs were found to be the same or similar, were grouped into major categories and became strong justifications for the implementation of a geo-base information system. Table III lists the seven major need categories identified from the user survey. Commonality of need among the users may be seen by observing the number of users in a need category relative to the number of users surveyed. Arithmetic totals, however, do not necessarily equate to strength of need. An example is the need category of assembling, organizing, and storing an agency's data. Although showing only two users, the need is great and the data to be stored are of major importance to other uses. The major need categories are discussed in more detail in the following paragraphs.

Table II - A LIST OF POTENTIAL USERS VISITED DURING USER NEEDS SURVEY

State Agencies

Commission of Game and Inland Fisheries
Department of Agriculture and Consumer Services
Department of Conservation and Economic Development
Department of Health
Department of Highways and Transportation
Department of Housing and Community Development
Virginia Soil and Water Conservation Commission
Virginia Historic Landmarks Commission
Council on the Environment
State Council of Higher Education
Department of Taxation
Department of Planning and Budget
Division of Industrial Development
Marine Resources Commission
Office of Emergency and Energy Services
State Air Pollution Control Board
State Water Control Board
Virginia Institute of Marine Science

Planning District Commissions

Piedmont
Lenowisco
Accomack-Northampton
Central Shenandoah
Central Virginia
Crater
Fifth
Mount Rogers
Northern Virginia
Rappahannock-Rapidan
Richmond Regional
Southeastern
Southside

Localities

Augusta County
Hampton City
Fairfax County
Fauquier County
Loudoun County
Prince William County
Salem City
Northampton County
Sussex County
Washington County

Table III- USER NEED CATEGORIES IDENTIFIED FROM THE USER SURVEY

Need Category	Number of Users (Number with Need/Number Contacted) State Agencies	Planning District Commissions	Counties and Cities	TOTALS
VARIS to provide:				
° Single Source of Reliable Current Data	10/18	10/13	4/10	24/41
° System to Assemble, Organize & Store an Agency's data	2/18	-	-	2/41
° Access to Other State and Federal Information Systems	5/18	4/13	1/10	10/41
° Land Use/Land Cover Classifications	9/18	10/13	8/10	27/41
° Maps and Map Overlays	7/18	12/13	7/10	26/41
° Geo-base Computerized Studies	6/18	7/13	5/10	18/41
° Environmental & Predictive Modeling	10/18	6/13	5/10	21/41

Single Source of Reliable, Current Data

The concept of an information system that can provide all levels of State and local governments with a central source of current data on the State's resources was of much interest to most organizations. One of the strong needs expressed was to save time expended while trying to gather resource and demographic data to be used in the preparation of planning documents and impact statements. Many of the organizations surveyed stated that they do not always know what data and information are available or from whom to obtain it. VARIS can serve as a central depository of resource data or, in some situations, not actually store and distribute the data but maintain an availability file and refer inquiries to the proper source. Another expressed need was to obtain data in a more uniform format, particularly in reference to mapped data. Distribution through VARIS would help meet this need. Many organizations stated that when they needed access to resource data, they needed the most detailed and most up-to-date data possible. They expressed hope that VARIS will assume the responsibility to provide the broadest data file possible and keep it continually updated. Some quotes from organizations visited to illustrate the above points are as follows:

Accomack-Northampton PDC - "Counties continually need all types of quantity and quality data on land, land use, and natural resources. Finding out what data exist and how it can be obtained is a major time-consuming chore. A central place to get the data, possibly in similar formats and the same scale (if maps are desired) would be of great value and would save tremendous manpower expenditure."

Hampton City - "Hampton needs a single point of contact for natural resource data and would use VARIS for that purpose."

Prince William County - "Our most pressing need is for detailed environmental/natural resource information. I believe – that the State perhaps would be better able to accumulate and store this information than most local jurisdictions."

"It would be helpful to local jurisdictions to know all the date that are available throughout the State. To my knowledge, this information is not presently available."

Division of Mineral Resources - "As a function of the VARIS, one of the most useful State services that could be established is an identification clearing house. This service would be a center to assist the public in determining which State agency could help them with their request."

Marine Resources Commission - "With respect to a statewide resources information system, we are supportive of the concept and can envision circumstances where it would be useful to have a single contact point for water related information."

Specific components of this major need category are listed in Table IV by the potential user group identifying the need. An important observation to be made from the table is that the needs identified are common to State agencies, planning district commissions, and local governments.

System to Assemble, Organize and Store an Agency's Data

The users that will profit from the Single Source of Reliable, Current Data discussed previously are those that need output products from VARIS and from the agencies supplying the data. Some of the agencies supplying data, however, have a need that can be met while preparing data for other users. One State agency and one State educational institution are collecting large quantities of data under specific long term programs without having a formal automated method of tabulating, storing, and disseminating their data. The Historic Landmarks Commission has collected and is still collecting descriptive data on thousands of sites with historic significance. This type of information can be readily encoded into a computerized data base. Computerizing the data places it in a useable and retrievable form which helps both the originator and the user. Of specific significance with these data in a computerized data base is the ability to quickly and accurately recall portions of the data by modifiers. For example, one may want to recall a list of sites in a specific county or group of counties, a list of historic buildings representing a certain type of architecture, etc.

The Agronomy Department of the Virginia Polytechnic Institute and State University in cooperation with the Soil Conservation Service is now undertaking a statewide soils survey by

counties. Ultimately the data collected is distributed in a report, but it takes two to six years after gathering field data to publish and distribute the report. Much of the raw data can be placed into a computerized data base as it is collected. This action will speed up release of the data to users and also increase convenience of handling by the soils survey program staff. A quote from the Historic Landmarks Commission will illustrate the above points:

Historic Landmarks Commission - "Putting some of our data into a computerized base would be very helpful as a way to distribute information to State and local agencies that use the data. Currently, data is stored in file cabinets, and the files must be searched and summarized at each request."

Specific components of this major need category are listed in Table V by the potential user group identifying the need. Although there are only two user groups currently associated with the need category, the significance of meeting the need is great. Data on the location and description of historic sites and the soils survey data are two of the most often used data packages by other State agencies, planning district commissions, and counties. Computerizing these types of data will benefit both originators and users.

Access to Other State and Federal Information Systems

There are numerous information systems now in operation in other states and in federal agencies. These systems, in particular the Federal systems, contain data bases that are useful to Virginia State agencies and local jurisdictions. There are limited scope information systems in operation within State agencies that contain data useful to other agencies and the localities. A VARIS system will provide a convenient point of access to these information systems. The VARIS reference file can maintain a listing of the systems along with a description of their contents. Access to information in the systems will substantially broaden the data base available to decision makers. Some qoutes from organizations visited to illustrate the above points are as follows:

Department of Health - "It would be helpful to have certain socio-economic and demographic data that the Federal Government collects made available through VARIS along with Land Use/Land Cover information."

Department of Agriculture and Consumer Services - Referring to market analysis activities - "Information from other states could be useful in comparing scope and effectiveness of programs in Virginia with those of other states."

Department of Conservation and Economic Development - "It would be beneficial to access data from other State agencies, federal agencies, and possibly neighboring states."

LENOWISCO Planning District Commission - "Since LENOWISCO borders Tennessee and Kentucky, it would be desirable to access data relative to the border area of these states. Since much of the socio-economic data used by LENOWISCO is collected by Federal agencies, it would be desirable to access their files."

Specific components of this major need category are listed in Table VI by the potential user group identifying the need.

Land Use/Land Cover Classifications

Based on the number or organizations expressing need for land use/land cover data combined with the urgency of the need, this need category is the dominant one. As one user stated, knowing what is currently on the land and what the land is being used for is the beginning of all planning. Most of the users surveyed have some type of current land use/land cover classification map. They vary in sophistication from sketches made from older topographic maps to windshield surveys made by visual inspection from automobiles to topographic map overlays based on color infrared photography of 100 percent of the land area. The first two of these three choices produces products with voids and inaccuracies that must, in some way, impact on the validity of decisions made. The third choice, aerial photography, produces a technically valid product, but it is labor-intensive and expensive when accomplished in detail over a large county or multi-county area. Few of the planning districts and counties can afford to contract for this type of service. Neither can they or the State agencies afford the training and time required to develop the in-house expertise to

interpret or utilize these output products since they are needed on an infrequent basis. Once each three to five years appears to be the average.

An extremely cost beneficial alternative to the three choices described above is to provide, through VARIS, a centralized capability within the State that will supply land use/land cover classifications (maps and tabular data) to agencies, planning districts, and counties as a service. The suggested method of producing the classifications is to utilize Landsat digital data processing techniques for the large rural areas and supplement that classification with details from aerial photography and windshield surveys in urban areas. Under this approach, VARIS will provide the Landsat classifications and possibly the aerial photography as a service. The user can then add the urban area data of choice from his windshield survey or from aerial photographs if he selects to accomplish this in-house rather than buy as a service from VARIS.

Some quotes from organizations visited to illustrate the above points are as follows:

Department of Conservation and Economic Development (Forestry) - "– by examining changes in land use patterns over time, the Virginia Division of Forestry could change priorities regarding forest management programs."

Department of Highways and Transportation (Aeronautics) - A series of written statements that include; "– (we would like) noise exposure information based on current and future activity levels and containing current land use data", "– (graphic products that could be used in fulfilling mission) land use maps", "–(information system could be used to) determine land use around existing airports to protect airports from encroachment."

Department of Housing and Community Development - "– the predominant land use would be the key factor we need to know."

Crater Planning District Commission - "– the rural areas of the district could use the information gained from land cover/land use data and maps (through VARIS)."

Northern Virginia Planning District Commission - "– (we need) land use/land cover, soil, slope maps - all valuable."

Piedmont Planning District Commission - "The PDC has no overall land use/land cover maps. We cannot afford aerial photography. We rely on hand drawn (windshield surveys) base maps which we make as needed."

Augusta County - "How soon could we get land use/land cover information from (VARIS)?"

Fauquier County - "We are especially interested in the land use/land cover mapping capability since many of the County's decisions are based on studies of maps."

Loudoun County - "Trends and projections of land use changes in mapped format would be valuable."

Specific components of this major need category are listed in Table VII by the potential user group identifying the need. Note from the table that the need is common at all levels of government.

There is a specific new technology now available to State and local governments that will meet the above needs in a cost beneficial manner. The spectral image data now collected by NASA's Landsat spacecraft and distributed by the Department of the Interior can be used to develop land use/land cover classifications with resolution elements as small as 1.1 acres. The NASA Regional Applications Program is a formal program aimed at assisting states and local users in developing the in-house capability to process the data. This technology and assistance program will be discussed in more detail in other sections of this report.

Maps and Map Overlays

The most often used form of displaying information among the users visited is the map. Mapping of a resource, or man's planned activity related to a resource, provides the most effective way of

communicating current status and projected future conditions to a group of decision makers. The use of maps and map overlays also provides a way to visually relate resource distribution to demographic data and relate both to a geographic reference. Since these relationships are the key to land use planning, maps and map overlays become a strong need at all levels of government.

The potential users surveyed obtain maps from a number of sources. Most users make some types of maps themselves, then supplement these with maps supplied by other organizations. In particular, counties and planning district commissions make their own base maps to scales of their own choosing. The most frequently used map base is the Geological Survey 7.5 - minute quadrangles purchased at a number of outlets, including the State's Department of Mineral Resources. Other frequently purchased base maps are those produced by the Department of Highways and Transportation from aerial photography and the Tax Maps (land ownership) prepared by the Department of Taxation. All of the planning districts and counties and cities surveyed expressed the need to obtain resource, demographic, historic, and man's activity overlays on one of the above base maps. The computer hardware and software to be included in VARIS provides a mechanism to digitize base maps and produce overlays of a wide variety of types of information. This will provide a significant step towards standardization of map bases and overlays so that a larger percentage of information from all sources can be more conveniently related. There was expressed need for the development of a common base map upon which all overlays would register. It is doubtful that this can be achieved in a manner that will satisfy all conditions to all users; however, one or more of the base maps can be digitized for computer reproductions and overlays of data can be produced at scales to match the base maps. The Rappahannock-Rapidan Planning District Commission has recently undertaken a program in cooperation with the Virginia Commonwealth University to digitize their base maps. These maps would be accessible to the PDC and supporting counties by access through the computer terminal at a local Community College. Another planning district commission, the Northern Virginia PDC, has conducted a study related to computerizing their map and overlay products.

Some quotes from organizations visited that illustrate the needs for maps and map overlays are as follows:

Department of Housing and Community Development - "(It would be useful to) take the population projections of Planning and Budget and develop a series of maps showing changes in population density through time."

Department of Conservation and Economic Development (Mines) - "(It would be useful to) take areas disturbed, mined, graded, and/or vegetated determined from inspectors' progress maps and/or reports and overlay them on county or planning district maps."

"(It would be useful to) take sediment concentrations or pH levels, overlay them on a regional or county stream map, overlay that with mine maps and sediment pond locations."

Department of Health - "The ability to produce maps and graphs routinely using remote sensing information overlayed with this Department's data would be very useful."

"(A typical use that we would make of the VARIS mapping capability is to) locate the public water supplies on a statewide stream map, overlay that with sewerage plant discharge locations, overlay that with the locations of oyster beds, and overlay that with industrial plant locations. This type of information would be useful in determining the location of a new sewerage plant or in helping to find the cause of contaminated water."

Commission of Game and Inland Fisheries - "(It would be useful to) map private and public outdoor recreation areas and facilities; map private, public, commercial forest land with overlays showing timber types and agricultural land use."

LENOWISCO Planning District Commission - "Maps showing change over time or the same information at two or more points in time would be useful."

Mt. Rogers Planning District Commission - "(We would like to map and overlay) commuting patterns, employment, and population data."

Richmond Regional Planning District Commission - "There is a need for a statewide reference

base map with a uniform grid size based on the State Plane Coordinate System. (The State needs) such a uniform base map for two reasons: 1.) It would save thelocalities and PDC's tremendous amounts of money since they all produce their own, and 2.) the grid lines between the different localities would match up."

Fairfax County - "(We need maps of) vegetation, land use, population trends, micro climate, detailed hydrology, air quality, highway noise contours, aircraft noise contours, wildlife habitat."

Fauquier County - "(We are interested in the VARIS mapping capability) since many of the County's decisions are based on studies of maps. County personnel want to see what the decision alternatives are rather than to hear about them."

Specific components of this major need category are listed in Table VIII by the potential user group identifying the need. The needs are at all levels of government, they are strong needs, and they are varied in scope and content. The needs associated with maps and map overlays are predominantly needs that will not be fulfilled without a centralized, computerized mapping and overlay capability such as the one planned for the proposed VARIS System.

No single government unit can independently afford the resources to develop or operate the capability.

Geo-base Computerized Studies

The most unique capability of a geo-base information system is its ability to assemble a large quantity of data, reference it to a geographic base of selection, and overlay that with other layers of data in such a manner that computer hardware and software can be employed to study impact of decisions. Ability to study the impact of a decision and decision alternative on a resource management problem before the decision has been implemented will be a most valuable tool to State agencies and local governments.

Most potential user groups visited expressed a need to conduct computerized studies relating the synergistic effect of considering two or more resources or resources overlaid with demographic data when seeking answers to resource management or planning actions. These needs include ability to make comparisons (changes with time, two or more methods), determine impacts of decisions, and identify alternatives to the primary decisions. Some quotes from organizations visited illustrate the above points as follows:

Department of Conservation and Economic Development (Mines) - "(We can use VARIS to) determine environmental impacts based on cumulative impacts of other mines within the same region."

Department of Agriculture and Consumer Services (Markets) - "If quantities of various agricultural commodities produced in the geographical units were entered into the system, marketing personnel could gain valuable insight as to quantities produced and what portion of the production is being reached by marketing activities. In other words, such information could be used to plan marketing activities and then evaluate their effectiveness."

Department of Agriculture and Consumer Services (Plant Pests) - "As time goes on, the delivery of our program histories, from the first report of, to the last control effort against a pest could be encoded in hopes of being able to make predictions about its reappearance. Patterns might be recognized in the interaction of pest and host populations and other natural or physical factors which are not detectable without access to broad base data."

Soil and Water Conservation Commission - "Using this data (geo-base encoded), we could determine for each construction site such factors as soil erodibility due to texture and slope, soil suitability for different plant materials, and drainage patterns."

Piedmont Planning District Commission - "(We) are in the process of establishing an intercounty mass transit system to meet the needs of people with poor mobility. We need to overlay population density data with the current road systems and then study their relationships."

Specific components of this major need category are listed in Table IX by the potential user

group identifying the need. At least two of the planning district commissions currently use a geo-base information system for conducting impact assessment studies and trend predictions. These two commissions are the Richmond Regional and the Crater. At least one other commission, the Central Virginia, has conducted a feasibility study and concluded that one is needed. It was suggested that a rapid development of the VARIS geo-base information system could reduce the scope of their system thus keeping costs down.

Environmental and Predictive Modeling

In addition to computerized studies related to the geo-base data package, other data processing capabilities using generalized models are needed. Without appropriate models for processing some data, much relevant information that could be developed from the data will be lost. The user survey has identified the need for data processing models in the subject areas of urban expansion, county zoning, flood plain management, growth planning, route location, energy planning, facility siting, airport siting, and emergency situations. With most of these models, the need is to be able to make predictions based on changes that occur in environmental or demographic conditions in the area of interest. Some quotes from organizations visited illustrate the above points as follows:

LENOWISCO Planning District Commission - "The predictive capability of assessing the impact of one change, such as increased deep coal mining activity, on population increases or decreases and needs generated and the locations of the facilities to meet those needs — recognizing constraints — would be very useful. The speed with which such impact assessments could be made with electronic assistance and with both graphic as well as statistical documentation would be fantastic."

Fairfax County - "Resource information is needed relating to development plans and to environmental impact statement reviews. Predictive modeling may be very useful if VARIS is developed. At this time, Fairfax County has not engaged in this kind of work."

Loudoun County - "(We) would like to be able to assess impacts of planning decisions on the environment and on the community."

Specific components of this major need category are listed in Table X by the potential user group identifying the need. Consistency of need is implied by the significant number of agencies expressing need. Taken collectively, the needs reflected by the list of users on Tables IX and X also show that users need a system with more capibility than data storage and retrieval. Agencies need the capability to apply data in computerized programs and models to produce new levels of information for decision making.

Table IV - MAJOR NEED CATEGORY: SINGLE SOURCE OF RELIABLE, CURRENT DATA

Component of Major Need Category	User Group Identifying Need		
	State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Save Time Gathering Information	° Department of Health ° Department of Industrial Development ° Department of Taxation	° Accomack/ Northampton	° Sussex County
° Know Where and How to Obtain Specific Information	° Department of Conservation and Economic Development ° State Water Control Board	° Accomack/ Northampton	° Prince William County
° Have Greater Ease of Accessibility to Information	° Department of Taxation ° Department of Agriculture and Consumer Services	° Accomack/ Northampton ° Southeastern	
° Have Standardized Output Formats	° Department of Taxation ° Department of Agriculture and Consumer Services	° Accomack/ Northampton ° Southeastern	
° Maintain A Broader and More Detailed Data Base	° Department of Taxation ° Department of Agriculture and Consumer Services ° Department of Conservation and Economic Development ° Department of Health ° Department of Highways and Transportation	° Central Shenandoah ° Piedmont ° Rappahannock/ Rapidan ° LENOWISCO ° Richmond Regional ° Southeastern	° Washington County ° Prince William County ° Salem City ° Fairfax County

Table IV - MAJOR NEED CATEGORY: SINGLE SOURCE OF RELIABLE, CURRENT DATA
(Continued)

° Maintain Continually Updated Data Base	° Department of Health ° Division of Industrial Dev. ° Department of Taxation	° Southeastern ° Accomack/ Northampton	
° Have Additional Resources for Gathering and Organizing Data (Personnel, Hardware, Software)	° Department of Housing and Community Development ° State Water Control Board ° Department of Highways and Transportation ° Department of Taxation ° Department of Energy and Emergency Services	° Accomack/ Northampton ° Central Virginia ° Piedmont ° Rappahannock/ Rapidan	° Prince William County ° Salem City

Table V - MAJOR NEED CATEGORY: SYSTEM TO ASSEMBLE, ORGANIZE, AND STORE AGENCY'S DATA

Component of Major Need Category	User Group Identifying Need: State Agencies	Planning District Commissions	Counties & Cities
need to:			
Computerize Storage and Print Out of Descriptive Data	° Historic Landmarks Commission ° VPI & SU Agronomy Dept. (Statewide Soils Survey)		

Table VI - MAJOR NEED CATEGORY: ACCESS TO OTHER STATE AND FEDERAL INFORMATION SYSTEMS

Component of Major Need Category	User Group Identifying Need		
	State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Access to Other States	° Air Pollution Control Board	° LENOWISCO	
° Access to Federal Systems	° Department of Agriculture and Consumer Services ° Air Pollution Control Board ° Department of Taxation	° LENOWISCO ° Northern Virginia ° Rappahannock/Rapidan	
° Access to Systems within State	° Department of Planning and Budget ° Department of Agriculture and Consumer Services ° Department of Taxation	° Mt. Rogers	° Salem City

Table VII - MAJOR NEED CATEGORY: LAND USE/LAND COVER CLASSIFICATIONS

Component of Major Need Category	User Group Identifying Need: State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Obtain Land Use/Land Cover Classifications and Reference to USGS	° Department of Conservation and Economic Development ° Department of Highways and Transportation ° Department of Housing and Community Development ° State Water Control Board	° Central Shenandoah ° Fifth ° Piedmont ° Rappahannock/ Rapidan	° Washington
° Obtain Land Use/Land Cover Classifications and Reference to Unspecified Map Bases	° Commission of Game and Inland Fisheries ° Commission on Outdoor Recreation ° Department of Agriculture and Consumer Services ° Virginia Institute of Marine Sciences ° State Air Pollution Control Board	° LENOWISCO ° Crater ° Mt. Rogers ° Northern Virginia ° Richmond Regional ° Southeastern	° Augusta ° Hampton City ° Fairfax ° Fauquier ° Loudoun ° Prince William ° Salem City

Table VIII - MAJOR NEED CATEGORY: MAPS AND MAP OVERLAYS

Component of Major Need Category	User Group Identifying Need: State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Develop Uniform Map Base	° Department of Housing and Community Development ° State Water Control Board	° Piedmont ° Richmond Regional	
° Map Resources and/or Demographic Data	° Department of Taxation ° Commission of Game and Inland Fisheries ° Department of Agriculture and Consumer Services ° Department of Conservation and Economic Development ° Department of Housing and Community Development ° State Air Pollution Control Board	° Southeastern ° Richmond Regional ° Piedmont ° Southside ° Central Shenandoah ° Rappahannock/ Rapidan ° Northern Virginia ° Fifth ° LENOWISCO ° Mt. Rogers ° Accomack/ Northampton	° Fairfax ° Loudoun ° Sussex ° Washington ° Prince William ° Salem City

Table IX - MAJOR NEED CATEGORY: GEO-BASE COMPUTERIZED STUDIES

Component of Major Need Category	User Group Identifying Need		
	State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Study Cause & Effects (Impact of Decisions)	° Department of Health ° State Water Control Board ° Department of Agriculture and Consumer Services ° Department of Highways and Transportation ° Department of Conservation and Economic Development ° Commission of Game and Inland Fisheries		° Salem City
° Identify Alternatives	° Department of Health ° Department of Highways and Transportation	° Rappahannock/ Rapidan ° Northern Virginia	° Prince William ° Fauquier ° Salem City
° Make Comparisons	° Department of Agriculture and Consumer Services ° Department of Highways and Transportation	° Mt. Rogers ° Richmond Regional ° Piedmont ° Southeastern ° Northern Virginia ° Rappahannock/Rapidan ° LENOWISCO	

Table X - MAJOR NEED CATEGORY: ENVIRONMENTAL AND PREDICTIVE MODELING

Component of Major Need Category	User Group Identifying Need: State Agencies	Planning District Commissions	Counties and Cities
need to:			
° Develop Resource and Demographic Models	° State Air Pollution Control Board ° Department of Agriculture and Consumer Services ° Department of Highways and Transportation ° Department of Conservation and Economic Development ° State Water Control Board	° Southeastern ° Northern Virginia ° LENOWISCO ° Rappahannock/ Rapidan ° Mt. Rogers ° Richmond Regional	° Fairfax ° Loudoun ° Fauquier ° Prince William
° Make Predictions (Future Trends)	° Department of Health ° Department of Agriculture and Consumer Services ° Department of Taxation ° Soil & Water Conservation Commission ° Department of Highways and Transportation ° Marine Resources Commission ° Commission of Game and Inland Fisheries	° LENOWISCO ° Northern Virginia ° Rappahannock/ Rapidan ° Mt. Rogers ° Richmond Regional	° Fauquier ° Prince William ° Loudoun ° Fairfax ° Salem City

Findings From Information Systems in Other States

In order to complete the study to determine the feasibility of a statewide resource information system, the VARIS Task Force considered it necessary to critically evaluate information systems already in place in other states by visiting their cognizant agencies. Visits were made by Task Force members to six of the nineteen states which have geo-base information systems in operation or in various stages of development. The states visited are: Florida, Georgia, Maryland, Minnesota, North Carolina and South Carolina. A description of each state's information system is provided in Appendix C.

As a result of the visits to overview these systems, six specific findings were discerned as factors to be considered in Virginia's development of its own information system. These six findings are:

1. Based on experiences of the Florida, Maryland and Minnesota systems, it is recommended that the Virginia system start small and expand as needed.

2. The Maryland and Minnesota systems advocate the use of State universities as they offer established computer facilities, portions of the data base, student labor and technical expertise to an information system.

3. The South Carolina, North Carolina and Minnesota systems suggest that Virginia give careful consideration to its choice between grid-based or polygon-based geographic cells for its system. They argue in favor of polygon cells due to the resulting accuracy and precision that polygons afford a geo-base information system.

4. The Minnesota, Georgia and Maryland systems indicate that digitized maps prove to be one of the most useful capabilities of an information system and recommend that Virginia also provide this function.

5. All six states' information systems have experienced expanding requests for services and recommend that Virginia provide for the future growth of its information system. Care should be taken to design a modular system capable of handling an expanding work load.

6. The Maryland, Georgia and Minnesota systems advocate using data derived from remote sensing (Landsat) for land use/land cover mapping.

In consideration of these findings, the Task Force has recommended that VARIS:

1. start small and expand as needed

2. use state universities

3. study the choice between polygon and grid cells

4. provide digitized maps

5. design a modular system and

6. use Landsat data for land use/land cover mapping.

Applications of VARIS

At least twenty State agencies and eight federal agencies routinely assemble resource data, maps and other information which may, if desirable, become more readily available through the proposed Virginia Resource Information System. Virginia's planning district commissions and local planning commissions assemble additional data which may be available to the System where mutually beneficial. Table XI provides a partial list of potential sources of resource data. The section on Economic Evaluation of VARIS indicates some of the information/data desired by State, regional and local agencies and a cost summary relating to alternative methods of assembling and using such data. A brief summary is also provided on systems in selected states and their costs which may be compared to budget recommendations in this report. It is anticipated that evaluation procedures will be adapted in order to improve decisions on hardware, systems data resources, and services to be provided by the proposed system in Virginia.

Collection, Storage, Networking and Retrieval of Information

As discussed elsewhere in this report, it is anticipated that the proposed system will reduce cost and/or improve the availability of data, maps and other information to user agencies at the State, regional and local levels and to the private sector. Anticipated data sources, which may be further improved, included the following:

Table XI - SOURCES OF RESOURCE DATA THAT MAY BE MADE AVAILABLE AS THE SYSTEM IS DEVELOPED (PARTIAL LIST)

Type of Information	Source: Virginia	Source: Federal
Lithosphere (land)		
Soils	VPI&SU	U.S. Department of Agriculture
Topography, Geology, Minerals	Conservation and Economic Development	U.S. Geological Survey
Land Use/Cover	Housing and Community Devel. Regional and Local Planning Commissions Taxation	Earth Resources Information Center U. S. Geological Survey
Hydrosphere (water)		
Marine, Coastal	Water Control Board Marine Resources Commission Institute of Marine Science Health	U. S. Geological Survey
Fresh Water	Water Control Board Health	U. S. Geological Survey
Atmosphere (air)		
Atmospheric Constituents	Air Pollution Control Board VPI&SU	U. S. Weather Service
Metrological Factors	VPI&SU	U. S. Weather Service
Biological		
Fisheries	Marine Resources Commission Institute of Marine Science Health	
Wildlife	VPI&SU Game and Inland Fisheries	U. S. Department of Agriculture
Insects	VPI&SU Agriculture and Consumer Services	U. S. Department of Agriculture

TABLE XI (concluded)

Type of Information	Source: Virginia	Source: Federal
Biological (continued)		
Agriculture	Agriculture and Consumer Services	U. S. Department of Agriculture
Forestry	Conservation and Economic Development	
Mans Activities		
Transportation: Highways, Railways, Airports	Highways and Transportation	U.S. Department of Transportation
Marine Ports	Ports Authority	
Utilities		
Electric, Gas, Petroleum Pipelines	Corporation Commission	
Water and Sewer	Regional and Local Planning District Commissions; Health	
Water Impoundments	Soil and Water Conservation Commission; Regional and Local Planning Dist. Commissions	U.S. Corps of Engineers
Mines	Conservation and Economic Development	U. S. Geological Survey
Industries	Industrial Development Division	
Socio-economic Factors		
Commerce	Industrial Development; Tayloe Murphy Institute; Planning and Budget	
Government	Planning and Budget	
Archaeological and Historical Sites	Historic Landmarks Commission	
Demographic	Tayloe Murphy Institute	

Soils Data

State and local governments together with the federal Soil Conservation Service are carrying out a master plan to complete surveys and mappings of all soils throughout the Commonwealth by 1990. As a result of this accelerated project, surveys have been completed in thirty-six counties and cities, are underway in twenty localities and are scheduled for forty additional local jurisdictions. It is anticipated that as VARIS develops, arrangements can be made to capture soils data as they are assembled from the field in order to reduce time in publication and to make data, maps and overlays more readily available for numerous user agencies and others. It is also anticipated that, as user needs arise, steps will be taken to encode other soils data from existing survey and mapping reports.

Historical Landmarks Data

The Virginia Historical Landmarks Commission is developing and maintaining a statewide inventory of historic resources including historic districts, historic site complexes and archaeological sites. These data require detailed information on street plans, road systems, growth patterns, environmental conditions and a variety of preservation threats. Much of the data is sent to the National Register of Historic Places, Department of Interior and is made available to State agencies, localities and individuals who are concerned with changes in land use. The Commission has expressed a desire to store these data in the proposed Resource Information System to facilitate easy retrieval and use by all concerned.

Data Generated And/Or Used by State Agencies

Many State agencies assemble and use resource related data as a normal part of service programs and special projects. Commerce and Resource Agencies which generate and use considerable resource information include the following:

The Department of Agriculture and Consumer Services routinely collects information related to Virginia farms, production of livestock, poultry and crops, marketing, disease and pest control, and on resource use related to this sector of the economy. Much of the data has been captured in machine readable form and, with restrictions for the protection of privacy, can be made available to the proposed system.

The Air Pollution Control Board assembles and interprets data on emission density; point source air pollution; locations of industrial, commercial, and residential concentrations; transportation systems and other factors affecting air quality in Virginia. These data are made available to the federal Environmental Protection Agency and other agencies for data banks such as the National Emission Data System (NEDS) and the Storage and Retrieval of Atmospheric Data Systems (SAROAD). The Commission has expressed an interest in storing such data in VARIS and in the development of systems to acquire additional data relating to air quality which are being collected incidentally by other agencies and institutions throughout the Commonwealth.

The Department of Conservation and Economic Development generates considerable resource data including the following divisions:

1. The Division of Forestry, with local services throughout the State assembles data on forest production, fires, disease and pest control, and timber regeneration. These data are assembled manually for use by the National Forest Service and can be made available to other users. Demonstration work described in Appendix D indicates that Landsat digital data and other new technology will improve data resources.

2. The Division of Mined Land Reclamation has responsibility for administration of all laws requiring the reclamation of lands disturbed by surface mining of coal and minerals other than coal. Considerable data relating to land use, land disturbance and land reclamation are developed. A demonstration project using Landsat and other technology is further described in Appendix D.

3. The Division of Mineral Resources serves as the official map distribution service for the Commonwealth and develops a number of maps cooperatively with the U.S. Geological Survey. The Division maintains contact with about twenty-five State agencies, twenty-two planning district commissions, some localities and a large number of private firms. In this cooperative project maps

are constructed which include: a statewide grid coverage at a scale of 1 to 24,000; broad overview maps at a scale of 1 to 250,000; State overview maps at a scale of 1 to 1,000,000; and an all metric measuring map at a scale of 1 to 1,000,000. Further work is being carried out to update grid coordinated maps through the use of high altitude photographic images and to develop ortho-photo quads. A series of geological maps are under development and interpretations on mineral resources are completed for about twenty percent of the State (similar to the soil survey map described above). Investigations of direct tie-in of data to the proposed Resource Information System have not been conducted.

4. The Division of Parks develops and maintains site information on State parks and other parks throughout the Commonwealth. Some interest has been expressed on the inclusion of these data and other related outdoor recreation site data in the proposed system.

The Commission of Game and Inland Fisheries routinely collects data on fish and game harvest throughout the State together with data related to land use, soils, water resources and demographic trends. These data are made available to the Federal Fish and Wildlife Service and to other agencies and individuals as needed. The Commission has indicated the fish and wildlife harvest data and stream classification surveys can be made readily available to the proposed system.

The Department of Housing and Community Development assembles data relating to residential building construction, fire marshal enforcement, and loan activities relating to residential development. The Department also assists planning district commissions and local planning commissions in comprehensive planning and related studies. Much of the planning related data, however, is likely to become available through districts and localities rather than through this department.

The Marine Resources Commission provides data and analysis on the status of Virginia's fisheries, including the availability and harvest of marine finfish and shellfish. The Commission also has responsibility for wetlands management. Although no definite commitments on providing information for the proposed system have been made, the Commission has expressed an interest in cooperating with the proposed system.

The State Water Control Board routinely conducts surveys and field studies on water resource availability, water quality on stream gauge records, well data and other water related information. The Board completed a Comprehensive River Basin Study in 1972 with considerable detailed information relating to rivers and streams, water needs and water uses. Data produced in machine readable form include inputs to the National Pollutant Discharge and Elimination System (NPDES), Discharge Monitoring Report (NPDMS), permit condition file, well water completion report, chlorophyll data (on streams, ponds and lakes), Kepone data, and water quality data. The Board is also working with several other agencies in the development of a statewide Water Use Inventory System. Although details have not been developed, it appears that some of the above data will be effectively used in the proposed Resource Information System.

Other State agencies and institutions outside the Office of Commerce and Resources include:

The Department of Health has data relating to shellfish sanitation, sewerage plants, septic systems, and water systems. Water related data are provided to the Federal STORET System and can be made available to other agencies and users. The Department has expressed an interest in working with the proposed system by providing machine readable information and in using information from other agencies for health management related decisions.

The Department of Highways and Transportation has a comprehensive resource data system based on ground surveys, aerial photography and engineering studies relating to existing and proposed transportation systems. Division of Aeronautics is now working with VPI & SU on a comprehensive study relating to airport site locations. (Details are referred to in this report under System's Needs Assessment/Economic Evaluation of VARIS). Although details of data exchange were not addressed in the survey, there appears to be a considerable potential for effective cooperative use of current data and in the further development of additional data as the proposed system evolves.

The Department of Planning and Budget develops considerable research data for counties, planning districts and other groups. Of particular interest to resources are data related to projections

and economic analysis, and other data summaries. Potentials for tie-in with the proposed system have not been investigated.

The Office of Emergency and Energy Services assembles damage assessment information relating to urban and suburban areas, business and industry, agriculture and public property. The Office also assembles considerable information on energy resources and energy needs. Although specific details have not been discussed, the Office has expressed an interest in data exchange with the proposed system.

The Virignia Polytechnic Institute and State University has developed a broad based State Information System within the Research Division and the School of Forestry and Wildlife Resources. Other resource related data are assembled in the statewide Soil Survey and Mapping Project (described above), the Agro-Environmental Information System now under development and in special studies relating to the Virginia Water Resource Research Center. Additional work is prepared for the development of a broad base system relating to insect and other plant pests. The University has expressed considerable interest in working with the proposed project and further details are outlined in the Recommendations, Preliminary Design and Appendix D.

The College of William and Mary and its associated subsidiary, Virginia Institute of Marine Science, have installed a system (ORSER) to analyze, interpret and print information derived from Landsat satellite data stored on computer compatible tapes. It is anticipated that this system and its data processing capability will be made available as an integral part of the proposed system. Other data that may be made available include shoreline condition maps, beach profiles, wetlands maps, tidal basis studies and circulation and biological data relating to marine resources.

Land Use/Land Cover Data

Several State agencies and the National Aeronautic and Space Administration are cooperating in several demonstration projects using Landsat satellite data and aerial photographs to develop and interpret information on land use and land cover. These are discussed in Appendix D. The U.S. Geological Survey is developing a nationwide land use/land cover map. Some other states have arranged contracts with the Geological Survey to encode such data and there appears to be potential for such work in Virginia. The Department of Taxation, Real Estate Appraisal and Mapping Division includes a Cartographic Section which produces property maps for most of the counties in Virginia. This Section has expressed considerable interest in cooperating with the proposed Resource Information System in order to update its cadastral record system and to use computerized techniques to reduce the number of steps needed in producing and updating property maps from tax records. There appears to be a potential of integrating this service with other map related services to improve and to reduce duplication in services.

Regional Planning Districts and Local Planning Offices contacted during the VARIS Task Force survey indicated considerable interest in data exchange. Details relating to these interests are reported in the section on System Needs Assessment.

Access To Other Information Systems

Demographic Data

The Department of Planning and Budget obtains census track tapes from the Bureau of Census, Department of Interior for general use by State agencies. It appears that these tapes will be of considerable importance to the proposed Resource Information System as it is further developed particularly in relation to computer studies referred to in the Preliminary Design.

The Tayloe Murphy Institute, associated with the University of Virgina, regularly conducts studies and prepares reports on a number of demographic topics and is the official source of population estimates in Virginia. Although some planning districts and localities have expressed a concern regarding the need for more rapidly available data where changes are occurring, it appears that the Institute has considerable data that may be useful to the proposed system.

The Department of Taxation is developing a statewide Econometric Model to project impacts of trends, changes and proposals on Virginia's economy and on State revenues. Initial contacts indicate the potential for cooperative efforts to improva data availability and use.

Reference File

Use of the proposed Resource Information System as a reference file for information and data from federal agencies and other sources, appears to be a likely course of action in development of the system. It has been suggested that VARIS be a principal reference file for resource information. It has also been suggested that the system acquire tapes and records from other sources and incorporate the data into a comprehensive system where steps will be cost-effective in developing information for user decisions.

Data Compilation and Manipulation and Outputs by VARIS

Based on the User Needs Survey, it appears that the proposed Virgina Resource Information System can best serve the Commonwealth by restricting its initial operations to clearly identify the user needs and to expand operations based on decisions relating to additional demands for services on a priority basis. As explained further in the Preliminary Design, it appears that foreseeable needs can be met by a system with four distinctly separate capabilities including:

1. Data management services including:

   a. Storage, indexing and recall of data

   b. Plotting and display of data

   c. Lists and inventories of data that can be made available

   d. Statistics which may be compiled from many sources within the system

   e. Access to other state and federal information systems

2. Remote sensor data processing and display to include:

   a. Aircraft data in the form of black and white, true color and color infra-red photography; imagery from multi-spectral scanners; and possibly output data from radar systems and microwave radiometers.

   b. Landsat satellite reflected radiance data in the form of digital tapes.

   c. Data from fixed points including data from the VPI & SU Agro-Environmental Monitoring System, Air Pollution Control Board sensing devices, Institute of Marine Science sensing devices and others.

   NOTE: These data from multiple sources may be brought together within the system to develop land use/land cover classifications and data analysis using inter-active graphic displays and false color output products.

3. Maps and map overlays to base maps now in use or available to agencies, localities and the private sector.

4. Computerized studies including:

   a. Statewide geo-base grid and/or polygon systems

   b. Software for statistical analysis

   c. The use of sophisticated computer software packages for routine and special studies to meet user needs.

Studies by the Task Force indicate a large body of expertise resides in the institutions of higher education which can be made available in systems development and improvement. A partial list of capabilities include:

1. Virginia Commonwealth University which has been working with the Rappahannock-Rapidan

Planning District Commission in developing a simplified computer mapping system which can be operated by planners with a relatively small level of computer technology expertise. This system has adapted software from other sources to serve regional and local needs and further development is anticipated.

2. Old Dominion University has conducted a number of research projects relating remote sensing including demonstration projects relating to land use/land cover on the Eastern Shore of Virginia and to identification of specific forest and agriculture management practices over large areas. The ODU is also cooperating with the State Air Pollution Control Board to develop a methodology of determining the total mass of vegetation over a large area that may be contributing to the hydrocarbon concentration in the environment.

The College of William and Mary/Virginia Institute of Marine Science has adapted the Pennsylvania State College ORSER software system for the analysis and interpretation of Landsat tapes. Other remote sensing work includes pollution measurement of particulates and chlorophyll bearing organisms in rivers, lakes and ponds.

4. The University of Virginia has considerable research background in shoreline erosion measurement and shoreline erosion factors. Further research using remote sensing and other technology is under way.

5. Virginia Polytechnic Institute and State University has the largest and most sophisticated computer system in state government and has considerable research expertise relating to a geo-base State information system, water resource research, development of the agro-environmental crop management model, and the State federal cooperative soil survey and mapping project. Other resource information systems research is now at the proposal stage.

As discussed elsewhere in this report, it appears that effective use of considerable expertise can be made available on a contractual basis in developing and improving the proposed system. Proposals for services by Virginia Polytechnic Institute and State University and by William and Mary College/Virginia Institute of Marine Science are listed in the Recommendations and in the Preliminary Design sections. Further details on projects anticipated in the system are listed in Recommendations and elsewhere in this Section. Diagrams of typical potentials for data assembly, interpretation and users are shown in Appendix E.

Economic Evaluation of VARIS

In our rapidly changing society, constant reappraisal of resource management is needed as increasingly complex choices have to be made on a rapid basis. Although the social cost of mismanaging Virginia's natural resources cannot be calculated in monetary terms, the cost to society of faulty decisions becomes enormous as society becomes increasingly concerned with environmental impacts. It is clear that the identification of social costs and benefits is difficult and evaluation often impossible. Because of this often lack of adequate information, the resource decision-maker is placed in an unfortunate position.

The traditional, seemingly reliable, "quick fix" technological solutions of the past are increasingly being called into question by a broadening base of vocal opinion, both informed and uninformed. Yet the complex demands which a modern society makes upon its resources require speedy, accurate judgment with minimum undesirable side effects. (Bradley-Journal of Environmental Management-1973)

Present information about the effects of man's increasing interaction with the environment is usually fractional, if available at all, and decision-makers rarely have the time to collect such information or the ability to compute it.

A complete economic evaluation on obtaining and utilizing the proposed resource information system (VARIS) is not practical at this time. However, based on past experience one should expect the costs associated with use of a much more sophistocated system for handling a given body of data in terms of meeting current objective levels to be greater than the current cost of handling that data. Yet the system can provide substantial increased benefits in terms of saving personnel time, greater accessibility of data, more accurate data and, therefore, will provide for better decisions. Furthermore, an appropriate evaluation of the need for VARIS is its ability to provide specialized information needs which are not presently available through approaches to State agencies, regional and/or local units of decision-making. This report provides a limited evaluation mostly by a survey and interview procedure plus specific case examples of the economic value of VARIS compared to available alternatives in providing needed special information that is not now available to decision-makers.

This evaluation is constrained by the six basic tenets on the economics of information:

1. Market prices generally do not exist for information.

2. Information is not a physical good and therefore lacks concreteness.

3. The impact of having information is generally not observable.

4. The values of information differ among parties.

5. After a certain level of information accessibility is reached, the marginal cost of obtaining additional information increases while the marginal benefit of obtaining an excess decreases.

6. The level of system needed is directly related to risk associated with that decision. Risk may be low, outcome unimportant but information cost high; or risk may be high, outcome very important and information cost low. As risk increases, value of the information system increases.

A system of sending questionnaire surveys followed by one or more personal interviews with a sample of potential users of the information system was the procedure followed to objectively identify important areas where VARIS could be utilized in the decision-making process and to determine its value to specific aspects of the decision-making process. The sample of potential users included 18 State agencies, 13 planning district commissions, 8 counties and 2 cities.

Table XII provides a summary of open-ended responses from potential users on types of information needed for their decision-making process. Of those responses, apparatus by which resource information can be gathered, a broader data base in the form of more detailed and additional information, and an availability of up-to-date information were identified as the most needed aids in the decision-making process. Time saving in information analysis, greater accessibility of information and adequate information on a continual basis were also identified as highly needed system capabilities.

Table XII - DESCRIPTION OF BENEFITS OF VARIS

AS IDENTIFIED BY POTENTIAL USERS

	Most Needed	Highly Needed	Moderately Needed
Save Time		6	
Info-Gathering Apparatus[1]	9		
Greater Accessibility of Info		7	
Broader Data Base[2]	10		
Standardized Format			3
Know How to Obtain Data			1
Know What Data Exists			1
Up-to-Date Info	12		
Info on Continual Basis		5	
More Accurate Info			2
Better Info[3]			1

Numbers indicate respondents in each category.

[1] Many agencies lack the necessary apparatus (personnel, hardware, technology) by which to gather and process information.

[2] Includes more detailed information and additional information.

[3] A broad category which includes more accurate, up-to-date and easier to understand information.

TABLE III, in the "User Needs Survey" section of this report, provides summation of number of users in each user category who indicated a need for each major need categories. Need categories included: (1) single source of reliable current data, (2) system to assemble, organize, and store an agency's date, (3) access to other State and federal information systems, (4) and land use/land cover classifications, (5) maps and map overlays, (6) geo-base computerized studies, and (7) environmental and predictive modeling. Over half, a very significant number of the survey users had a need for a single course of data, land use/ land cover classifications, maps and map overlays, and a computerized studies system.

In addition to the summarized responses, specific comments on potential value of a VARIS system were as follows:

State Agencies

Information on preservation and development of the oyster industry needs to be more readily available for decisions by the Department of Health. That agency can also use VARIS information in determining water supply potential. VARIS can be used to graphically present trends and changes in coliform levels.

Improved information relative to crop estimates, storm and flood damage would aid decision-making in the Department of Agriculture and Consumer Services. The Plant Pest Section needs automated printouts and graphic displays of plant pest information. The Co-op Crop Reporting Service can use the system to update their basic area sampling frame. The Division of Markets can utilize highway and rail lines location data in their marketing activities. The Planning and Development Division can use VARIS in the management of prime agriculture land and waste management activities.

In the Department of Conservation and Economic Development, the Division of Mineral Resources needs an automated system to update its mineral resources maps on a periodic basis. The system can be useful to the Division of Forestry in providing assistance (timberland examinations) to forest landowners and in control of forest fires. The Division of Mined Land Reclamation can use system to check accuracy of mining operation plans and suitability of area for mining.

The Marine Resources Commission can use computer enhanced images to monitor water quality for marine resource preservation. It can be used in preparation of condemned shellfish patrol reports.

The Department of Housing and Community Development can use the VARIS system to aid the counties and districts in use of land-use information. It now often costs more to make a single county land-use data base map than total printouts of county maps of the information from VARIS now projected to cost.

The VARIS approach will allow a tremendous expansion of the use of basic tax maps and data produced by the Department of Taxation. The system can reduce the number of steps now needed to introduce the Department's map numbering system back into the local record system. Access to an available library of cartography is needed. A map check and plotting system will allow for better use of such data as highway plans and housing data. Geodetic Survey data will be extremely useful in gridding counties into map sections.

The State Water Control Board has a need for continuous land use and land cover information to provide an up-to-date land use classification for more accurate non-point source modeling. Also, VARIS can provide needed data on permit compliance in order to effectively monitor that work and make the best use of personnel in monitoring programs.

Planning District Commissions

The collection, analysis and use of resource information varies considerably among the planning district commissions. For instance, most PDC's do not have the capital or processing knowledge to individually obtain and effectively utilize Landsat data. Those who do use Landsat data use a manual method of interpreting the data. By providing a system for automated processing of Landsat digital data, time and money are saved by reducing the use of labor intensive interpretation of aerial photographs and accuracy is improved relative to the limited coverage possible during windshield

surveys.

Likewise those few PDC's which use geo-base data for decision-making use non-automated data storage and manipulation and manual mapping processes. VARIS can provide tremendous savings in terms of cost-effectiveness and accuracy through use of computerized systems.

Specific responses from selected PDC's include:

Accomack-Northampton – A central place to get data, possibily in similar formats and the same scale would be of "great value" and will save tremendous manpower expenditures. VARIS will extend staff capability. Capability of detecting changes is needed.

Central Virginia – In 1977, the PDC Board and county supervisors were in favor of establishing an information system but implementation money was not available. With VARIS, that system scope can be reduced, thereby keeping costs reasonable for implementation.

Central Shenandoah – Land cover/land use maps are done from windshield surveys and therefore are not accurate away from roads. The counties still use soil survey data from the 1930's and recent surveys should be speeded up by use of the VARIS system.

Mount Rogers – They have a high interest in land use/land cover data and in the prospect of manipulating data across a broad range of issues.

LENOWISCO – The commission staff has been looking for some form of computerized information system for at least two years. Land use data is generated using aerial photographs and windshield surveys. Maps are prepared manually and photographically. Socio-economic analysis is now very slow and incomplete due to time constraints. Analysis and comparisons could be made rapidly with a VARIS system.

Northern Virginia – Land use/land cover, soil and slope maps would be very valuable. Currently maps are produced by hand from aerial photography. The PDC is in the process of developing a base map system. Also, they would use VARIS output for selection of sites for land application of wastewater.

Rappahannock-Rapidan – They would use VARIS output to analyze cost-effectiveness of alternative courses of action. Rural agencies and local units of government are not sophisticated enough to denote the desired correlations and analysis available to solve problems. Nor do they have the staff to utilize the information. By assessing data from other sources as supplied by VARIS, the PDC could greatly reduce data collection costs.

Piedmont – The VARIS computer capability could interface data needs from different reference bases. In updating their land use plans, the PDC has a Landsat photo but lacks the technical knowledge or terminal to assimilate the imformation from tapes. Currently they have no land cover/land use maps and must rely on hand-drawn maps which they make as they are needed. VARIS output could help select best routes for an inter-county mass transit system.

Richmond-Regional – Although they have their own computerized information system, they would use VARIS to make comparative analyses, financial models and impact assessments. They would like to see centralized statewide data. A statewide reference base map which VARIS could provide would save the localities and PDC's tremendous amounts of money by eliminating duplication of effort as each unit produces its own map.

Southside – The PDC has a need for good maps. The major advantage of VARIS would be a data system to supply impacts of various projects and developments. VARIS would allow the PDC to provide adequate data to the counties.

Southeastern – This PDC uses aerial photos and must get new ones every five years with added cost of enlarging and scaling each photo. This information has been very valuable but also very expensive. They need access to State agency data which VARIS could provide.

Counties and Cities

Northampton County – They need statewide soils survey data and VARIS could speed up the process of their obtaining it.

Augusta County – They need land use/land cover data that VARIS could provide.

City of Hampton – The City of Hampton would use VARIS as a single point of contact for natural resource data. They have land use classification on computer tapes but it is not very current and they desperately need to update that data from a VARIS system.

Fairfax County – They have not engaged in predictive modeling work but would use VARIS to do so.

Fauquier County –Fauquier County recently completed a comprehensive plan at a substantial cost. They need VARIS for use in refining and updating the plan, particularly the land use/land cover mapping capability.

Loudoun County – Mapping is carried out manually and they need VARIS's capability to provide maps.

Prince William County – They would like to have information available in map form with the use of false colors. Their most pressing need is for detailed environmental/natural resource information. The State would be better able to accumulate and store this information than would local jurisdictions. VARIS could do some of the jobs that they had envisioned but could not afford. They are particularly interested in the capability to perform sensitivity testing via a computer terminal hook-up.

City of Salem – Time restraints involved with collecting necessary data from many different sources has not allowed them time to utilize the data in graph or map form. They would definitely like data in this form from VARIS. More complete and accurate staff recommendations to the policy and decision-makers would result from VARIS availability.

Sussex County – Land use/land cover maps would be very useful. VARIS would allow them to save time in accomplishing statutory duties since much of the present legwork could be eliminated.

Washington County – They have a particular interest in obtaining land use/land cover maps for use in completion of a comprehensive plan.

As a result of the responses from State agencies, planning district commissions, counties and cities four system capabilities were selected for initial inclusion in VARIS. They are: 1) data collection, storage, index and recall; 2) geo-base data system with aggregation/manipulative capacity; 3) land use/land cover mapping capability; and 4) common base mapping with overlays. Each of the capabilities was selected for initial inclusion in VARIS because of the strength of user need and because their inclusion would proide early positive cost benefits. Specific examples of some of these proposed capabilities were subjected to economic evaluation. Use of a geo-base data system to select new airport sites was evaluated. Also, a comparison among three planning districts of their land use/land cover mapping techniques and their need for increased capabilities was evaluated. A third example compares a county's present manual processing capabilities with an automated geo-base system such as VARIS.

Example 1. – Airport Site Evaluation

The first example is use of a limited geo-base data system to select sites for new airports. The airport selection is a State level responsibility which has significant implications for regional and local areas. The general area location of twenty future airports to be built by 1990 were included in the Virginia Air Transportation (VAT) System Plan. The average cost to develop each of these new airports has been estimated to be two million of today's dollars. Not only would a geo-base system (such as VARIS) be useful in the selection of the general area location of airports, it is significantly less expensive in terms of the actual airport site selection process. Thus, this comparison of cost is between the use of a geo-base system which was developed by Dr. Robert Giles (VPI&SU) and which is proposed to be a component of VARIS and the alternative of continuing with the past selection procedure. A final on-site verification is needed for either system. Our assumption for this

analysis is that either system will give an acceptable set of alternatives, although we expect a better evaluation with use of the geo-base system.

Dr. Giles' Geo-Base System: This project will provide a procedure for making a computer application of geo-base data and provide analysis of site evaluations for ten of the twenty VAT general area locations. Through use of aerial photos and map data the system will eliminate infeasible areas and then identify a set of best sites.

The system was developed at a cost of more than $300,000 over a period of several years with annual operation, maintenance and repair in excess of $15,000. Amortization of those costs for this specific project is impossible because that system has been used to provide limited analysis for several other projects.

This system will provide an analysis and set of best sites for ten areas for a cost of $56,700 which does not include any of the previous system development cost but does include specific costs of developing the procedure for making this computer application. The most important point is that additional site solutions can be provided for an estimated cost of only $500-$1000 if procedures are established which will allow further development and maintenance of that geo-base system.

The only alternative is to continue to use the present system of hiring outside consultants to do most of the work manually and to continue to require at least one day inspections by each of fifteen State agencies. Use of the geo-base system would save approximately $25,000 per site evaluation. Of course, those savings are based on the assumption that a geo-base system is maintained. If not, maintenance of an individual system solely for airport site evaluations is probably not a feasible alternative.

Example 2 – Land Use/Land Cover Mapping

Windshield Surveys

The second example was a comparison of the current windshield survey procedures used in land cover mapping and of the need for additional mapping capability among three planning district commissions and their associated counties. The three areas selected for intensive interviews were the Piedmont Planning District Commission, the Mount Rogers Planning District Commission, and the Central Shenandoah Planning District Commission.

Piedmont: This commission has completed a comprehensive land-use plan for only one of seven counties. A lack of necessary resources has prevented the development of plans for the other counties. Their efforts are currently limited to windshield surveys and available topographic type maps. (A windshield survey is the process of traveling each road and making notations of land use in near road areas on maps.) If resources are available, the estimated cost of developing a land-use plan for each county with this procedure is about $8,015 plus additional cost of supervisory time. After development, each of these plans will require a periodic (1-5 years) update.

Budget Estimate for Plan Development Using Windshield Survey Technique*

	Average Cost per County	Average Cost per Square Mile
Survey and Inventory	$5,732	$14.33
Tabulation and Analysis	1,283	3.28
Transportation	1,000	2.50
TOTAL	$8,015	$20.11

* Estimates derived from personal interview with planning district commission personnel.

The Piedmont Planning District has seven counties with an average of 400 square miles of land area per county.

Mount Rogers: This commission has developed a land use plan for each of its six counties. Those plans were developed manually with the use of windshield surveys and basic topography maps. Each plan includes map overlays for slope, watersheds, soils, existing land use, water and sewer systems, traffic and highways, future land uses, plus a few others. The estimated cost of developing each county plan was about $7,900 plus additional supervisory time. The estimated cost of an annual update for each county plan is approximately $2,230. Mileage for traveling each road for each update is a significant part of the update cost.

Budget Estimate for Plan Development Using Windshield Survey Technique*

	Average Cost per County	Average Cost per Square Mile
Survey and Inventory	$4,800	$10.32
Tabulation and Analysis	1,400	3.01
Transportation	1,700	3.65
TOTAL	$7,900	$16.98

* Estimates derived from personal interview with planning district commission personnel.

The Mount Rogers Planning District has six counties with an average of 466 square miles of land area per county.

Central Shenandoah : This commission has developed fairly detailed land use plans for each of its five counties. The plans were developed manually with use of windshield surveys and topographic maps using a square mile grid and starting with the U.S.G.S. base map. These plans provide the traditional maps on slope, soils, existing land uses, water and sewer systems, roadways, utilities plus detailed information on location of present and future land uses and housing densities for each square mile grid. The estimated cost of developing each county plan ranged from $4,185 to $9,909 with an average cost of $7,539 plus additional supervisory time. The estimated cost of an update every two or three years for each county plan is approximately $240 in personnel cost and $45 in transportation. That update would be limited to areas with significant activity and changes.

Budget Estimate for Plan Development Using Windshield Survey Techniques*

	Average Cost per County	Average Cost per Square Mile
Survey and Inventory	$4,195	$6.15
Tabulation and Analysis	2,663	3.91
Transportation	781	1.00
TOTAL	$7,539	$11.06

* Estimates derived from personal interview with planning district commission personnel.

The Central Shenandoah District has 5 counties with an average of 688 square miles of land area per county.

The type of decisions which can be made from each of these three sets of county capabilities varies considerably. However, an average for the three provides a basis for comparison to other procedures.

Average County Budget Estimate for Plan Development Using Windshield Survey Techniques*

	Average Cost per County	Average per Square Mile
Survey and Inventory	$4,909	$10.27
Tabulation and Analysis	1,782	3.40
Transportation	1,127	2.38
TOTAL	$7,818	$16.05

* Estimates derived by averaging cost information for the three planning district commissions.

These windshield surveys are limited to information on the small number of land cover categories which could be obtained by traveling every road in the county. This procedure places a major constraint on the type of decision which can be made. The information which is provided by these windshield surveys and manually constructed topographic type maps allows for only the very basic and minimal necessary decisions at this time. The very minimum next step which is needed by most counties is to obtain sufficient capability to provide decision-making information which can only come from a complete walk and drive survey of the area or from systems such as aerial photography or Landsat capability.

Complete Ground Survey

Costs data for a complete walk and drive survey was not found to exist in Virginia but has been estimated for a three county area in Illinois. That complete ground survey included 40 land cover categories which is significantly more categories than were included in any of the Virginia PDC plans.

Average County Budget Estimate for Plan Development Using a Complete Ground Survey Technique*

	Average Cost per County	Average per Square Mile
Survey and Inventory	$18,333	$30.78
Tabulation and Analysis	16,877	28.34
Transportation	191	.11
TOTAL	$35,401	$59.23

* Estimates were derived from an Illinois survey of three counties. Those counties had an average of 595 square miles of land per county.

Cost estimates were also derived for obtaining aerial photography and Landsat capability. Of course, the use of aerial photography and/or Landsat capabilities will not totally eliminate the need for windshield survey work and other on-site verification procedures, however, it will eliminate much of the basic personnel field work. The major advantage, however, is in the additional information it provides for the decision-making process.

Aerial Photography

A second alternative for providing sufficient information for the next level of decision making is to utilize aerial photography. In the past a limited number of counties have used this practice. Some have used the services of Virginia Department of Highways and Transportation. The Department can handle only a limited number of counties per year and then must steer requests to commercial firms. Estimates for three counties are provided for comparative purposes. Use of commercial services would be higher than these estimates.

Average County Budget Estimate Plan Development Using Aerial Photography Techniques*

	Average Cost per County	Average per Square Mile
Survey and Inventory (Photos and Flight Cost)	$ 2,463	$ 4.30
Tabulation and Interpretation (Photo Interpretation)	23,900	41.71
Transportation (Ground Truth)	750	.20
TOTAL	$27,113	$46.21

* Estimates derived from information obtained from Virginia Department of Highways and Transportation and Private Consultants who did some of the photo interpretation. This work was accomplished for the counties of Accomack, Northampton, Bedford and Campbell.

Landsat

The other alternative is to use the available capabilities of Landsat. These same capabilities can be available to Virginia counties at this time. Estimated costs were based on land cover mapping by previous Landsat experience. These are the costs to the local area to get Landsat output products. The average county size in the sample ws 542 square miles of land area.

Average County Budget Estimate for Plan Development Using Landsat Capability*

	Average Cost per County	Average per Square Mile
Survey and Inventory (data tapes and ground truth)	$ 157	$ .30
Tabulation and analysis (computer classification and statistics, map preparation, supplies)	2,015	3.77
Transportation (ground truth)	750	.20
TOTAL	$2,922	$4.27

* Estimates were derived from information contained in a document entitled, "A Legislators Guide

to Landsat" published by the National Conference of State Legislatures (NCSL). The information is based on a case history of a project conducted by the Southwestern Illinois Metropolitan Regional Planning Commission.

Information in the following table is presented for the purpose of comparing the cost per square mile of land area of various types of information. These figures are based on costs to the county to get that information and, as indicated, may not include total cost of the system development. For instance, much of the cost for development of Landsat was provided by the federal government and is a fixed cost of that system. Also, the start-up cost for VARIS has not been included in these cost figures.

Comparison of Alternative for Land Use/Land Cover Analysis in Estimated Cost Per Square Mile

	Windshield Survey	Complete Ground Survey	Aerial Photo-graphy	Landsat Classi-fication
Survey and Inventory	$10.27	$30.78	$ 4.30	$ .30
Tabulation and Analysis	3.40	28.34	41.71	3.77
Transportation	2.38	.11	.20	.20
TOTAL	$16.02	$59.23	$46.21	$4.27

The cost figures for the windshield survey techniques are included as an example of current cost for plan development. These are the current costs to localities for obtaining information for th very limited level of decisions which are being made at this time. The other three alternatives wi provide for the much greater level of decision-making ability which all planning officials indicate is needed for adequate management of natural resources. We did not attempt to evaluate the value of making those additional levels of decisions or the opportunity cost (damage) of not making them.

A complete ground survey is obviously much more expensive ($59.23/sq. mile) than the windshield survey ($16.05 sq. mile). In using the same basic procedure it covers more ground and a larger number of categories. In comparison with the ground survey, aerial photography eliminates much of the manual work in survey and analysis but demands considerably more analysis. Overall, use of aerial photogaraphy ($46.21/sq. mile) is expensive but is a less expensive alternative than a complete ground survey ($59.23/sq. mile). The previously referenced National Conference of State Legislatures document quotes a cost of aerial photograaphy of $20.18/sq. mile. While this is approximately half the cost experienced in the Virginia example, it is still a factor of 5 more expensive than the Landsat technique. Landsat ($4.27/sq. mile) clearly provides a much less expensive alternative than any of the others. However, Landsat capability is not a sufficient planning tool by itself and planning must depend on other sources of information such as limited aerial photography in urban areas where Landsat lacks sufficient resolution to produce desired detail and limited ground survey data for calibrating the Landsat classifications.

These data clearly indicates the advantages of a computer based automated system over the manual approach. As stated previously, the start-up cost of an automated system has not been included in use of Landsat or aerial photography. However, as those costs are spread over a large number of square miles, the incremental cost to each square mile becomes relatively small. Most likely, the cost of an automated system using both Landsat and aerial photography would be comparable to the expenditures which are being made now for the current windshield survey techniques. But the important point is that one or a small number of counties cannot justify such a sophisticated system and these economies can be gained only through development of a larger statewide system.

Example 3. – A County Level Geo-Base System

A third example evaluates the costs and benefits of a county-level geo-base data system which uses several data sets with aggregation, manipulation and productive capabilities. Prince William County was selected for this study because they have established a need for these capabilities and were prepared to develop some cost projections comparing their present manual system with an automated one such as VARIS. The comparison involves their present approach of encoding five sets of geo-base referenced data and manually producing output products versus using an automated system which would automatically produce a similar product and would therefore produce information for making the same set of decisions.

Lloyd Grooms and Mike Kevany of the Prince William County Planning Office provided a case study of the economies of a county level geo-base system in which they outline their present approach, their typical uses of environmental data, the automation of data, and the cost estimates of implementing an automated system.

PRINCE WILLIAM COUNTY: A CASE STUDY

Of the Economies Of A County Level Geo-Base System

At present Prince William County utilizes natural resource information for several purposes including the preparation of comprehensive plans, evaluation of requests for development permission (rezoning, subdivision, site plans, etc.), administrative and policy studies and response to Federal and State regulation requirements. All natural resource and environmental data manipulation and analysis is currently performed manually. However, the county is preparing plans to convert the data processing to a computer-based method. The new method will include conversion and storage of several elements of environmental data in a computer-processable form on the basis of 4-acre grid cells.

This paper presents information on the present approach, the uses of environmental data in Prince William County, a description of an automated approach and an estimate of the costs of implementing such a system.

Present Approach

A set of maps containing five types of environmental data is utilized. The data include: soil, slope, vegetation, hydrology and flood hazard. The maps are at the USGS scale of 1″ = 2,000′. The data from each of these maps are manually overlayed on each other in succession (i.e., factor 1 and 2 combined, factor 3 added, etc.).

The overlaying process results in a five-factor environmental constraints map. In addition, land in the flood hazard areas and with excessive slope (25%+) are identified as lying outside the analysis. The constraints map is produced by manual drafting methods. Next an environmental sensitivity map is produced by weighing the environmental variables on the basis of their importance in the ecological planning process. Each combination of factors in the constraints map results in a polygon which is assigned a sensitivity value and a map color code. A new map of these color-coded polygons is produced manually.

The final step involves the overlaying of the sensitivity map on a parcel boundary map. The amount of land in each sensitivity class in each parcel is measured manually using a planimeter. The resulting area measure is then multiplied by a factor for the amount of permissable development to compute the allowable development for each parcel. The resulting land use/permissable map is used in the comprehensive planning process.

The present process is being conducted for planning study areas of the county. There are 25 such areas averaging approximately 25,000 acres each. To date about 20% of the county has been thus mapped. These maps have been used for the Study Area Comprehensive Plan and are now available to support other Planning Office functions. The next planning area is being mapped now and the Office plans to continue the program through the remainder of the county.

Uses of Environmental Data

Natural resource and environmental data have become a very important aspect of Planning Office operations and they are used to support several of the office's activities. In the comprehensive planning process, these data are used to establish the basic capacity of the land to support development. An extensive effort is employed to acquire, organize and analyze environmental data to determine the maximum level of development which will be allowed. This information is then passed to the plan preparation process. It is also referenced in that process to assist in decision making.

The environmental data are also used in the Planning Office's development administration operations. Development administration processes are requests for rezoning, subdivision and site plans approval and other development authorities. The environmental data are to be responded to in a short time. In these cases rough estimates must suffice or environmental issues are left unresolved. In some cases these insufficiencies generate more serious problems which must be dealt with at a later date.

Automation of Natural Resource and Environmental Data

The main problem encountered in automating environmental data is its geographic irregularity. Most phenomena cover a geographic area represented by an irregular polygon rather than a parcel boundary or city block. In addition, the polygons of the different types of data are almost never the same. This presents a problem in storing and comparing the data. To resolve this problem, many users have resorted to the use of uniform grid cells as a common base to store and compare data. With the grid cell, the data are fitted into a uniform geographic unit within which the different data types can be compared and machine storage and manipulation are facilitated. The grid cell approach has the disadvantage of compromising accuracy as the values of irregular polygons are assigned to regular cells. Because of this, effective use requires careful selection of the cell size which optimizes efficiency while maintaining an acceptable level of accuracy. An investigation of this issue in Prince William County has resulted in the selection of an approximately 4-acre cell as the desirable size for their county's purposes.

The assignment of data values to grid cells may be accomplished in two ways. The simplest approach is to lay a transparent grid cell sheet over an environmental data map and assign one or more of the underlying environmental values to the cell. This can be encoded by cell and entered into a computerized data base. A more complex approach is to digitize the boundaries of the irregular polygons and their environmental data value and utilize the computer to assign these values to grid cells based on the coordinates of the polygon and grid cell boundaries. This method has the advantage of being able to recover a computer readable version of the actual polygons whenever needed for a precise analysis or response.

Once in grid cell form in a data base, the data can be retrieved, overlayed and otherwise analyzed, utilizing the speedy and flexible capabilities of the computer.

Cost Estimates

Estimating the costs of the present method and an automated alternative to preparing and utilizing environmental data is somewhat difficult due to the lack of information available, the wide variance in complexity across Prince William County and the intangible value of the greater speed and flexibility afforded by an automated approach. The following information and estimates are offered as representing a reasonable accuracy achieved in a relatively short time.

An estimate of the present effort can be made based on experience to date. The most recent experience is in the Lake Manassas Planning Area of approximately 25,000 acres where it took approximately 9 man-months of a Planning Technician II's (salary: $12,400) time to prepare the set of environmental data and to analyze maps manually. A cost of approximately $9,300 per planning area or $232,500 for the entire county was estimated.

Prior experience with three other planning areas required a similar level of effort. Consideration of expansion of the data base to include additional factors indicates that that would be a desirable action but it was estimated that one additional factor would add three man-months of effort and more factors would increase the required effort exponentially.

To the present manual effort must also be added the cost of responding to development

administration, special studies and requests. While these requirements vary greatly, it is estimated that approximately two or three administrative tasks and two significant special issues are dealt with each month. Each of these requires an estimated one-half man-month of effort or a total of six man-months per year.

In addition to these costs, it should be recognized that there are opportunity costs incurred where the availabile manpower is engaged primarily in data acquisition rather than in analysis, only extremely limited analysis of alternatives is possible and time available limits the quality of information which can be organized to support a decision.

Cost estimates for automation cover both the direct encoding of grid cells and the encoding of polygons and conversion to grid cells. Using the present analytical methodology as a guide and developing a grid cell data base to support it, an estimated 60,000 four acre grid cells would be required for Prince William County. With the direct encoding approach of overlaying grid cell boundaries on each of the basic data maps, it would take an average of approximately one-half minute per cell, totaling 500 man-hours or 12 1/2 man weeks per data type. The one-half minute average considers a range from the very complex and time-consuming soil maps to the very simple vegetation and flood plain maps. Assuming a $5.00 hourly rate, each environmental factor would cost $2,500. The present five-factor base would therefore cost approximately $12,500 for the county.

In addition to the above costs, it would cost approximately $10,000 to set up the operation and implement the necessary software programs. All this would take about one month to do. Subsequent to the encoding, another $12,000 to $15,000 and one month's time would be spend processing and editing the data. So the entire system could be implemented for $37,500 in about 35 weeks.

The polygon digitizing approach, which is more desirable, is also estimated to be more costly. The cost estimate is based on an estimate of the number of polygons which would require encoding and a factor for the cost per polygon. A rough estimate of the number of polygons for the five factors being used in approximately 150,000. While digitizing costs vary greatly depending on the complexity and quality of the maps, a factor of $.50 per polygon is a reasonable average. This would result in an estimated cost for data input at $75,000. In addition, it would be necessary to convert the polygons to a grid cell format costing approximately $2,000 in computer time for a total of $77,000.

Once implemented, the automated system would be a relatively inexpensive operation. The extraction of data could be done at a nominal fee and an individual map could be produced for between $25 and $50 depending on area covered and means used (i.e., printer or plotter).

The resulting system would not necessarily allow the Planning Office to perform any new functions. However, the strength of the automated system lies in its ability to facilitate quick response to both administrative and policy questions and the capability it affords the staff to perform repeated analyses of alternative scenarios with different combinations of environmental factors and different weighings of factors. Also, the system is designed to better accommodate the inclusion of additional factors in the base and subsequent analyses. As such, the system would be both more efficient and productive than the manual system presently used.

(End, Prince William County Case Study)

Additional Considerations for Economic Analysis

Subsequent to implementation of the initial VARIS system capabilities and services which promise positive cost benefits, economic analysis should be used to determine desirability of additions to the system and what the ultimate size of the system should be. An evaluation of the benefits of higher levels of decisions relative to the cost of getting those decisions is needed. Likewise, we need to determine the opportunity cost (damage) of not making those decisions. Relevant variables for evaluation of adding additional components to the system are the probability of certain events occurring (scenario) and the cost of gathering information relative to the outcome function or payoff. Several approaches are available:

1. Decision theory approach - Rests on assumption that several outcomes are possible and likelihood or probability of each sitution is known. Uses a rational approach and relies heavily upon

implicit statements of goods. Based on utility of decisions and expected outcome. Utilizes cost, probability of events occurring and value of payoff. Essentially a choice among alternatives and permits computation of liklihood of a certain situation coming true as the result of an improved information system.

2. Net Social Benefit Approach - Value of the information system is the difference between measurement of net social benefit of old and new systems. Perfect information maximizes net social benefit. Lack of information or wrong information shifting supply and demand curves for goods or services. Can use programming model approach for maximization of net social benefits at each level of information system.

3. Scoring Approach - Key evaluators express their evaluation of various information systems by weighing criteria as to their importance. Less scientific than others, but provides a simple procedure to formulize choice of a system. This approach is not inexpensive , as it requires much time input from very expensive and scarce talent.

Only through evaluation of benefits to be derived from expansion of the system or through evaluation of the opportunity cost (that is, what happens if certain decisions cannot be made) of not including certain data in the system, can the optimum size and capability of the system be determined.

PRELIMINARY DESIGN

Design Approach - There are many ways to approach the preliminary design of a new Information System. Ideally one would like to know precisely what data are available and what information is needed from the data, who the users are to be, what are their needs now and in the future, and in what format are the output products to be produced. This situation of knowledge, however, is not likely to be available during the infancy of a new program. The other extreme is to attempt the design of a system based entirely on supposition and on what the system designer "thinks" the users need and want. Certainly this procedure is foolhardy and may lead to a large number of expensive mistakes. In planning the preliminary design of the VARIS system the Task Force concluded that; although a 100 percent user survey gathering all available data was not practical, neither was it practical to prepare a preliminary design without having surveyed a significant portion of the user community. The system design must be based on a user needs survey sufficient in scope to identify needs representative of those of all users and indicative of those present now and in the near future. Therefore, the System Needs Assessment was accomplished, and the preliminary system design is based on the needs assessment. There were two ground rules that evolved gradually during the user survey that contributed to the proposed preliminary design approach. A statement of those ground rules and a short discussion of each follows:

Start Small/Expand as Needed - This ground rule is a result of two influences. One is the technical influence previously discussed of knowing that in the beginning of a system design, the designer cannot possible foresee all the future system requirements and, therefore, must save some available development resources and design flexibility for bringing in new technology and for accomodating future user needs. The other influence is the practical one of knowing that funding resources are going to be available in a series of small sums rather than in a large lump sum, particularly true in the proposed development of a new system offering unproven benefits. The start small/expand as needed ground rule also coincides with the desire to assure a cost beneficial system development. The proposed VARIS plan begins with development and implementation of select individual projects whose accomplishment through VARIS can be proven cost beneficial.

Use Existing Facilities and Expertise Available Within the Commonwealth - This ground rule also evolves from the consideration of two influences. The first influence is the need to keep development and implementation costs as low as possible. Existing State operated computer hardware and software are available to support a large portion of the data storage, retrieval, and display capability of the system. Hardware and data processing programs are also available at several educational institutions - VIMS/W&M, ODU, VPI &SU, UVa - for the processing of remote sensing data including Landsat digital data. There is also a large geographically referenced data base complete with software programs available at the Virginia Polytechnic Institute and State University to serve as an early nucleus for a statewide geo-base information system. A second influence is the need to utilize the technical skills and experience available at some of the State educational institutions. Utilization of these talents will contribute to an early VARIS operational capability.

Incorporation of the facilities and personal expertise into the VARIS system would certainly be cost effective to the system development. It would also provide a mechanism for continual updating of the technology base upon which VARIS develops and operates.

System Design - The User Survey identified seven broad user need categories that dictate the preliminary design of the VARIS system. An analysis of the seven broad categories concluded that the needs could only be met by a system with four distinctly separate capabilities. A discussion of the four capabilities follows:

Data Management Services - Under this capability, the system will perform a variety of computerized services. Some of the needed services identified during the user survey include:

Store, Index, Recall Data - This service will benefit both the supplier and user of data. Suppliers of data can use the system to organize data, store it electronically (saving space), index it by different subject indices, standardize storage and output formats, and make it accessible without repetitive manual searching and gathering. Users of data can use the system to search by subject area, recall by selectable descriptors, and perhaps choose the format of the output. This data management service is likely to be the most often used service provided by the system.

Plot and Display Data - Data are often stored and used in tabular form. Information,

however, is often a result of composite data properly massaged and displayed in a visual form. Most users want the service of computerized graphics; receiving the information in bar chart, two axis curves, shaded density plots, and possibly three dimenisional representations.

Lists and Inventories - The system will be self-documenting and will provide potential users with lists and inventories of its contents. The lists and inventories will relate to data, reports, software programs, environmental models, aerial photographs and maps, projects complete, etc. At least three different types must be present: (1) data and information available, (2) system capabilities and services available, and (3) projects completed or under way.

Compile Occurrences - Routine data compiled over a period of time often becomes useful information as occurrence patterns become evident. Typical examples, but not a comprehensive list of possiblities, include the number of fires per structural age of buildings, fires per income bracket, crime events by city zones, frequency and location of water or air quality parameters being over set limits, and frequency and location of the occurrence of agricultural pests. There is an unlimited number of subject areas that can be included within the scope of this system service. As users experience the need or recognize the value of compiling occurrences on their subject of interest, VARIS should have the capability of responding. This type of service can be integrated with the computerized mapping and overlay capability to further enhance the utility of the resulting output information.

Packaged Statistical Analyses - Data gathered as a result of an experimental program or a program to observe conditions that change as a function of changing variables are more meaningful when qualified by statistical analyses techniques. The long range scope of VARIS must include capabilities to support statistical analyses of data. Examples include calculations of means, standard deviations, analysis of variance, regression analyses, etc. The exact selection of capability and sequence for implementation of statistical analyses capability will be a function of need. One subject area of statistical analysis capability will be implemented as an inherent part of another system capability; the Landsat digital processing capability. The software packages for the digital processing routinely produces statistical analysis to accompany the classifications.

Access Other State Federal Information Systems - The adjoining States of Maryland and North Carolina are known to have Geo-base Information Systems. It is expected that West Virginia and Kentucky will have systems or some type of computerized data base. It is planned that VARIS would have the capability of accessing some of the data and information from those systems. This capability will be particularly valuable when working boundary and adjacency problems shared with adjoining states. Federal organizations also have data base information systems that contain data useful to Virginia organizations. It will be useful to access information such as that present in the Demographic Information Display System (DIDS) developed by the Census Bureau. Other systems and data bases are also available.

Remote Sensor Data Processing and Display - Under this capability, the system will contain the software and hardware for processing remote sensing data from aircraft and spacecraft platforms. The aircraft data will be in the form of black and white, true color, and color infrared photographs of the resource or geographic area of interest. Utilization of the photographic data does not require digital processing capability. It does, however, require some standard equipment used for photographic interpretation, and it also requires personal expertise in interpretation techniques. Much of the required equipment and skill is available within the State Department of Highways and selected educational institutions such as the Remote Sensing Laboratory at Old Dominion University. These skills will be used as much as possible.

The utilization of data from the Landsat spacecraft does require digital data processing capability. There are two levels of this processing capability. The initial VARIS capability will be provided by the ORSER system in operation at the Virginia Institute of Marine Scinces/William and Mary complex. This capability will support data analysis at VIMS/W&M or at remote stations equipped with dial-up terminals. The primary output from this initial system capability will be black and white line printer classifications supported with the statistics of the classifications. The most useful form of classification will be a geometrically corrected map. Outputs from the ORSER mapping software programs (NMAP, UMAP, CLASS, MAXCLASS, etc.) can be produced to overlay a map base of choice. In the initial VARIS system, the base map for Landsat overlays will be the U.S. Geological Survey 7.5 - minute topographic quadrangles.

The longer term outlook for Landsat data processing capability includes hardware and software that will support uses of Landsat in addition to land use/land cover analysis. It will include interactive graphic hardware and software that will allow the investigator to apply experience and judgment during the analysis procedure. The hardware needed to arrive at this capability is commercially available. The software needed has recently been developed by the NASA Earth Resources Laboratory and is available through the Government sponsored Computer Software Management and Information Center (COSMIC) at the University of Georgia.

The VARIS system design is to include the capability to integrate Landsat digital data analysis with manual photo interpretation to produce the desired output products. The use of Landsat for large rural area clasifications is technically acceptable and is a cost effective way of accomplishing the classification. Thus, the major area of a county or group of counties could be evaluated with Landsat data. Complementing this evaluation, photographic interpretation can provide detail for the urban and core city areas where the Landsat resolution is not adequate and not cost effective. In order to assist State agency personnel in developing an in-house capability for using remote sensor data, eight joint State/NASA technology demonstration projects are under way. Two of the projects relate to aircraft remote sensor platforms and six relate to the Landsat spacecraft platform. A discussion of each demonstration is included in Appendix D.

Maps and Map Overlays - the user survey established that maps and map overlays are the most useful output product of the system. There are at least three different base maps now used by State and local levels. They include the variable scale maps (1:6,000 to 1:7,200) produced by the Department of Highways and Transportation, the 1:6,000 cadastral maps produced by the Department of Taxation, and the 1:24,000 scale 7.5-minute quadrangle topographic maps produced by the U.S. Geological Survey and distributed by the Virginia Division of Mineral Resources. Of these three, a most frequently used base is the 7.5-minute quadrangle. The entire state is mapped at the 1:24,000 scale in the form of 805 separate quadrangles. If only the one scale and geographic referencing technique can be accomodated with an initial set of equipment and methods, the USGS 7.5-minute quadrangles will be used as a base map for overlays. Subsequently, the capability for overlaying data on the tax maps and Highway Department maps could be developed. Variable scaling of overlays over different map bases may not be a complex technical capability to develop but accurate geographical referencing may be. User needs will drive the decision to develop or not develop this capability. An alternative that appears attractive for the long term scope of VARIS is to work with user agencies and agencies with current mapping responsibilities in an attempt to develop a statewide, standardized base map. Perhaps it could be standardized at least to the extent that geographic referencing of overlays could be accomplished on the standardized base and then up and down scaling of the base and overlays could be accomplished to suit user agencies and needs. One capability known to be required in the initial development of VARIS is that of digitizing data for recall as a map overlay. The funds for a digitizer are requested in the proposed budget.

The user needs survey identified a number of natural resource, man-made resource, demographic data, environmental factors, and regional planning factors that are used in the format of map overlays. The VARIS design must consider each for inclusion in the list of services to provide. The ones identified include:

a. Natural Resources - streams, forest lands, prime agricultural lands, coal and mineral deposits, game distributions, ground water distributions, watersheds, soil classifications.

b. Man Made Resources - water reservoirs, highways and utility right-of-ways.

c. Demographic Data - population distributions, income distributions and land parcel ownerships.

d. Environmental Factors - Rainfall patterns, water and air pollution plumes (area and quantity), flood plains and noise contours.

e. Regional Planning Factors - political boundaries, land slope and relief, utility services, zoning categories, parks and recreation facilities, commuter patterns, emergency and fire protection routes and school bus routes.

Other factors that may need to be mapped but not easily categorized were identified by users and by consultants to the VARIS study include: airport zoning, health related factors, pest occurrences and predictions, waste disposal areas, and crime patterns.

Upon analysis of the above information needs, Dr. Robert Giles, Information System Consultant from the VPI & SU, states that VARIS must be capable of mapping spots, lines, areas, and layers and shade them in black and white or in color to produce images for some form of reproduction. Based on the user survey, it may also be stated that the most useful form of these products will be as overlays to selected base maps.

Computerized Studies - There are many ways of categorizing the system capabilities for doing computerized studies. Based on the user needs survey, two distinctly different capability needs can be defined. They are environmental modeling and geo-base studies. The VARIS system must be developed with the capability to conduct each of these or else a valuable new tool for situation assessment and decision making has been lost. A further discussion of the two categories of computerized studies follows:

Environmental Modeling - In reviewing the returns from the user needs survey, Dr. Robert Giles identified the generalized models needed for processing data to produce the maximum amount and usefulness of information. They include: urban expansion, county zoning, flood plain management, growth planning, route location, energy planning, facility siting, industrial development, forest management, airport siting and zoning, emergencies (road, rail, fire, toxic release, flood, tornado), and solar radiation. In addition, the Agro-Environmental Crop Management Model now being developed by the VPI and SU College of Agriculture and Life Sciences is needed. It provides timely local information to guide the agriculture community in making decisions related to pest control, hydrological considerations and crop production. Many of the models have been developed and need only be brought to an operational status on the available computer facility. Not all of the models need to be brought to operational status in the initial phase of VARIS implementation. The proposed criteria for making the early selection for implementation is to choose the one currently near implementation (Crop Management Model) and those that are integral parts of the two geo-base studies selected for early implementation (airport site evaluation and Prince William County studies).

Geo-Base Studies - The most unique capability to be provided by VARIS is the computer program for manipulation of a geographically referenced data base for accomplishing impact assessment, prediction of results, and evaluation of alternatives. The greatest benefit of having this capability is that a decision maker can evaluate the effect of a decision upon a factor or multiple of factors before the decision is implemented. Thus, the potential for making wrong decisions leading to costly mistakes can be reduced.

To be responsive to all user needs, VARIS must develop the capability to support three different levels of geo-base system studies. Studies need to be conducted at statewide, regional (several counties), and local levels. If a square grid is used for area coverage where a single square of predetermined size is used as the geographic base unit, each of the three levels will probably require a different size grid. This is a practical consideration rather than a technical decision. A grid system with geo-base units small enough to give adequate detail for local (county or city) use may be impractical for regional use and most certainly impractical for state level studies because of the large number of base units involved. One reasonable approach to this problem is to begin with a statewide grid system which ties in with an established set of coordinates such as the State Plane Coordinate System (English Units) or Universal Transverse Mercator System (Metric Units) and design regional and local level grid systems to be subdivisions of larger units. In this type of design based on square grids, each lower level grid would need to be one-fourth the size of the next larger unit. Another reasonable approach is to use polygon base units for statewide capture of data and then overlay with a grid system of choice for computerized studies. Additional study will be needed before the selection of a geo-base unit or units for use in VARIS can be made. One size geo-base unit for use in VARIS has, however, been made from a practical consideration. In order to utilize the operational capability and expertise already available in Virginia, the geo-base unit system developed at the VPI & SU containing 1.1 million grid cells covering a large section of Virginia will be included in the initial scope of VARIS. This grid cell system is based on a 27-acre unit. This geo-base package is not being applied to the airport site evaluation study under way in the Department of Highways and Transportation, Division of Aeronautics. Inclusion in VARIS will permit this program to be continued for further use by the Division and by other State agencies and regional organizations.

A second geo-base computerized study package proposed for the initial VARIS scope is one to be conducted in cooperation with Prince William County. During the user needs survey it was

discovered that the County was planning to develop a geo-base system for aid in managing county development within the comprehensive planning process. Inclusion of this effort in the initial scope of VARIS will be of service to the County and will provide VARIS with a first local level application of the geo-base computerized system concept. Other counties in the State choosing this option for local planning in the future could also benefit from experiences gained during the VARIS - Prince William County program. Additional details of the proposed county program are contained in the economic evaluation section of this report.

Upon evaluation of the design approach and system design considerations discussed above, a design approach for the initial scope of VARIS has been selected. The contents of this design are proposed for implementation in the first biennium. The design is responsive to the most pressing needs as concluded by the user survey. It is also known that implementation of the design features, more correctly titled system capabilities, will be cost effective in that they will return dollar savings to the users or provide the users with additional information that has been declared to be of greater value than the dollar resources required to produce the end products. The proposed initial scope of the VARIS design is presented in outline form on Table XIII. A design approach to the long range scope of VARIS has been defined. The long range scope builds upon the contents of the initial system scope and does not negate the utility of the initial capabilities. The proposed long range scope is presented in outline form in Table XIV. The primary criterion for selection of the contents was to be responsive to the user needs.

Table XIII. PROPOSED INITIAL SCOPE OF THE VARIS DESIGN

Data Management Services	Remote Sensor Data Processing and Display	Maps and Map Overlays	Computerized Studies
° Develop reference file of data available at State agencies	° Land Use/Land Cover classifications using Landsat data (by ORSER System)	° Digital overlay of resource and demographic data on USGS 7.5-minute quadrangle maps	° Incorporate Dept. of Highways and Transportation (Aeronautics) Airport Site Evaluation System into VARIS
° Store Historic Landmarks Commission Data	- with line printer output products		° Develop and implement geo-base system for Prince William County
			° Incorporate operational aspects of the VPI&SU Agro-Environmental Crop Management model

Table XIV. PROPOSED LONG RANGE SCOPE OF THE VARIS DESIGN

Data Management Services	Remote Sensor Data Processing and Display	Maps and Map Overlays	Computerized Studies
° Store data from State agencies (Resource data)	° Photo interpretation of aerial photography	° Develop & distribute standardized statewide base maps	° Develop statewide geo-base grid or polygon system for studies at State level: * Approx. 1 sq. mile
° Develop reference file of State agency data not in VARIS file	° Land Use/Land Cover classifications using Landsat data (by interactive graphics system)	° Produce & distribute resource and demographic data overlays of the base maps - USGS 7.5 minute quads - Tax maps - New statewide base map	° Develop regional geo-base grid or polygon system for studies at regional level: * Approx. 25-40 acres
° Store demographic data related to resources	- with selectable scale color output products	° Produce & distribute Landsat LU/LC classification overlays of base maps	° Develop local area geo-base grid for studies at PDC and county level * Approx. 4-10 acres
° Store soils survey data	- with software referencing Landsat classifications to the geo-base data		° Develop environmental, socio-economic, and geographic resource models for studying impacts and making predictions
° Develop reference file and procedures for access to other State and Federal information systems			
° Software for statistical analysis (mean, mode, range, standard deviation, regression analysis, analysis of variance)			

* the size of geo-base grid cells is used for illustrative purposes only. Additional study is needed before final selections are made.

DISCUSSION OF ALTERNATIVES

During the study several alternatives to the proposed design approach, implementation plan, system management and operational functions, and proposed budget and staffing have been identified and evaluated. Some of the more seriously considered alternatives and the reasons for their rejection are presented in the following paragraphs.

Design Approach

The definition of a system scope and design approach offers the greatest number of alternatives of all the tasks requiring a decision. As a general statement, but not lacking importance because of being a generalization, it can be stated that any design approach other than the one proposed is not sufficiently resonsive to user needs. The definition of user needs and conclusions on how those needs can best be met were the dominant considerations in selecting the design approach. Alternatives considered included:

Limit Study to Storing, Indexing, and Recall Functions - This alternative would reduce the scope of the system and thus reduce its development and operational costs. It would, however, produce a system only partially responsive to user needs. It would also reduce the system to essentially a library function and preclude the development of the new technological tools available within the computerized mapping and computerized studies functions.

Limit Subject Content of System to Natural Resources - This alternative would reduce the quantity of data to be handled by the system and would reduce crossing of organizational lines in the data gathering and processing operations. This alternative was found to be impractical during the user survey. Most all the planners in the regional districts and counties presented conclusive evidence that the management of natural resources cannot be separated from considerations of the people who use them and who, in the final analysis, are responsible for their conservation or misuse.

Exclude Remote Sensor Data Processing Capability From System Design - This alternative would reduce the scope of the system and thus reduce its development and operational costs. Its elimination, however, would deprive the system of a cost effective tool for producing complete and accurate land use/land cover classifications of large areas at low costs. The ability to produce these classifications are one of the strongest user needs.

Implementation Plan

Alternatives to the proposed implementation plan do not affect the final system scope but they do affect the efficiencies of the management and monetary steps taken to develop the final scope. Alternatives considered include:

Contract System Design and Implementation to An Outside Systems Firm - This alternative is attractive because of the feeling of security in having technical experts carry the load of early decisions during a period when a trained staff is not available. It should also produce a system encompassing the latest state-of-the-art since the business firms remain constantly aware of the technology in their field of expertise. This alternative is not considered necessary in development of VARIS since it is believed that the necessary technical expertise for system development is available within the federal and State agencies and educational institutions of the State. It appears both cost effective and professionally ethical to utilize these skills. in addition, questions on proprietary rights of software and techniques will not become an issue. A "turn-key" contract to an outside systems contractor is not consistent with the accepted ground rule of "start small - expand as needed."

Develop Total Capability Within VARIS Staff From Beginning of Implementation - This alternative is attractive because of the ease of managing the total program and the convenience of having all personnel and facilities centrally located. These advantages are offset, however, by the facts that the VARIS program cannot justify the staff required to do the job alone and even if the required number of personnel could be obtained, the necessary technical skills and experience is not likely to be present in the early years of operation. In order to develop the desired capability within the proposed six-year period, the expertise outside the VARIS staff but within the State must be utilized. A secondary reason for planning participation by professionals outside the VARIS staff is that many of these experts were responsible for bringing the technologies to be used in VARIS to a development level that spurred the proposed implementation of the system.

Buy All Equipment and Attempt Operational Status In One Step - The obvious attractive feature of this alternative is the anticipated result of having an early operational capability for the entire system. This attractive feature is, however, artificial since there is no practical way for it to materialize. The first reality is that a sufficient lump sum of money is not likely to be appropriated on the basis of promised expectations. VARIS will have to prove its continued worth as funds are requested and made available. A second consideration negating the selection of this alternative is that the VARIS Staff and Advisors collectively cannot foresee all of the hardware, software, and support equipment needs in sufficient detail to permit a one shot procurement. The staff must gain experience by working through a six year program of incremental growth while being responsive to user needs. During visits to other states who have Information Systems in operation, it was repeatedly observed that systems that evolved gradually as staff experience was gained and as the system demonstrated its progressive worth were the systems most widely used and supported by the user community.

System Location

The proposed location for the administration and management of the VARIS system is the Executive Branch, Office of Commerce and Resources in Richmond, Virginia. Alternatives considered included:

Location Other than Richmond - Since VARIS is to be a program in which the Executive Branch of the State government is to provide services to all branches of the government, to regional planning offices, and to localities, it needs to be located in Richmond where it will be perceived as a service organization of the State government. Any other geographic location would weaken this perception. Since VARIS is going to make use of the existing computer hardware and software expertise within the State system, it must be located in Richmond where that capability exists. The single largest concentration of potential users, the Executive Branch Agencies, are also in Richmond. Any other location may lead to loss of users because of remoteness. Throughout the VARIS program, there will always be a need for personal contact between VARIS staff members and users attempting to secure services.

Office or Agency Other than Commerce and Resources - The Office of Commerce and Resources is the only logical location for VARIS. Most of the Agencies that will be supplying the resource data for much of the data base are currently under the Commerce and Resources organizational structure. In addition, the State Agency coordinating activities of a large potential user group, the Planning Districts, is administered within the Office of Commerce and Resources. The Executive Branch Task Force that conducted the user needs survey and prepared conclusions and recommendations based on the survey and other study material has been under the direction of the Secretary of Commerce and Resources. Since this Task Force is to be re-established and charged with the responsibility to oversee development of an operational VARIS, it can be most effective in its role if VARIS is also operated under the same Cabinet Secretary. It also appears desirable to have Cabinet level participation and support for VARIS to assure that the System maintains its orientation towards being a service type system for all Agencies and Departments.

Proposed Budget and Staffing

The dollar quantities and personnel numbers presented in the proposed budget and staffing section of this report are based on identifying the minimum resources required to produce a system responsive to user needs. Any reduction in available resources, dollars or personnel, will result in a loss of needed capability. The Task Force has recommended that the General Fund be used to pay the six year development cost and that user fees be collected to pay a major portion of operating costs. Two alternatives to this approach are to be considered:

Charge Development Costs to Users - A decision to charge development costs to potential users or prorate development costs over user projects would defeat the System in concept and defeat its acceptance by the potential user community. The potential users simply do not have the funds available for a development of this type. The cost of doing business would be prohibitive.

Do Not Charge Any Costs to Users - This alternative is impractical for two reasons. It would require that all funds come from the General Fund. With Virginia's proper concern for fiscal restraint, this is not likely to occur. Users should, however, be expected to pay fairly for services rendered. Most users contacted during the user needs survey expressed willingness to "buy services"

from the System. By having to buy the services, the user will screen his requests. Projects are not likely to be undertaken unless the products meet a need and unless buying it from VARIS is cost beneficial. If services were free, users may "shotgun" requests just to "see what happens". Many projects that should not be undertaken may well use up a significant portion of available resources.

APPENDICIES

Appendix A

House Joint Resolutions 175 and 225

HJR 175 created a Joint Subcommittee to study the feasibility of developing a Virginia Resource Information System (VARIS). A copy of HJR 175 is included and is followed by HJR 225 which authorized a portion of the funding for the user needs survey and preliminary design.

HOUSE JOINT RESOLUTION NO. 175

Creating a joint subcommittee to study the development of a Virginia Resource Information System.

WHEREAS, the demand for, and utilization of, land, water, forest products, minerals, energy and other resources is constantly increasing as a result of increased population and an increased rate of consumption per individual; and

WHEREAS, the supply and quality of natural resources throughout the Commonwealth of Virginia is finite; and

WHEREAS, the conversion of lands from farm, forest and water absorption uses to highways, utility rights of way, commercial, residential or industrial developments is continuing at an unprecedented rate; and

WHEREAS, mandatory standards for water resource, air resource and other environmental issues must be met throughout Virginia in the near future; and

WHEREAS, several districts in the Commonwealth are facing significant shortages in water resources; and

WHEREAS, many districts of the Commonwealth are experiencing rapid population growth and development; and

WHEREAS, the legislative and executive branches of the Commonwealth and the citizens at large have taken a strong interest in the proper management of resources and the environment in Virginia and have indentified specific recommendations directed toward its growth with a desirable balance between economic growth, environmental quality, and future resource needs; and

WHEREAS, there is a keen awareness by the legislative and executive branches of the Commonwealth, and by local government and citizens, of the significance, increasing complexity and lasting impact of decisions which are made relative to the use of resources throughout the Commonwealth; and

WHEREAS, members of the General Assembly recognize the need for an up-to-date, accurate and consistent information base in order to make intelligent decisions on resource management throughout the Commonwealth; and

WHEREAS, members of the General Assembly strongly believe that coordinated efforts of State agencies, research and educational institutions and cooperating federal agencies will result in greater accuracy and improved effectiveness of work relating to resource information in relation to costs; and

WHEREAS, members of the General Assembly strongly believe, on the basis of demonstrated experience, that the types of information obtained by remote sensing technology from high and low altitude aircraft, Landsat and meteorological satellites, and special ground or waterborne devices is extremely useful and cost effective in providing additional information that is necessary for inventorying, monitoring and evaluating Virginia's resources and environment; and

WHEREAS, members of the General Assembly have indicated a strong interest and intention to support the use of remote sensing to assist in resource and environmental management programs within the Commonwealth, while supporting the expansion of technology transfer capacity from NASA's Earth Resources Laboratory and from other cost effective sources; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the General Assembly of Virginia hereby endorses the continuation and improvement of remote sensing systems through the implementation of the Landsat follow-on program and other available remote sensing capabilities together with coordinated technology transfer efforts by agencies, research and educational institutions of the Commonwealth as steps in the development of a Virginia Resource Information System that will provide accurate and up-to-date information for management decisions related to natural and other resources of the Commonwealth. In carrying out the purpose specified herein, a

joint subcommittee to study the development of a Virginia Resource Information System is hereby created. The joint subcommittee shall study the most cost effective applications of remote sensing technology to resource and environmental information needs of the State, investigate areas for coordinated efforts between State agencies and by research and educational institutions, initiate demonstration remote sensing and technology transfer projects with Federal agencies, initiate systems for sharing data banks with other states and other regions, and provide guidance on recommended legislation required to implement a coordinated Virginia Resource Information System.

The joint subcommittee shall be composed of nine legislative members to be appointed as follows: two persons shall be appointed from the membership of the House of Delegates' Agricultural Committee by the Chairman thereof; one person shall be appointed from the membership of the House of Delegates' Conservation and Natural Resources Committee by the Chairman thereof; one person shall be appointed from the membership of the House of Delegates' Mining and Mineral Resources Committee by the Chairman thereof; one person shall be appointed from the membership of the House of Delegates' Chesapeake and Its Tributaries Committee by the Chairman thereof; three persons shall be appointed from the membership of the Senate's Agriculture, Conservation and Natural Resources Committee by the chairman thereof; and one person shall be chosen from the membership of the Senate by the Senate Committee on Privileges and Elections.

The members of the joint subcommittee shall elect a Chairman and Vice-Chairman from the membership thereof. If a vacancy occurs for any reason, successors shall be appointed by the appropriate person or Committee designated herein to make the appointment. All agencies of the Commonwealth shall assist the joint subcommittee upon request.

The joint subcommittee shall make an interim report to the Governor and the General Assembly not later than December one, nineteen hundred seventy-eight and shall make a final report not later than December one, nineteen hundred seventy-nine.

HOUSE JOINT RESOLUTION NO 225

Authorizing the Virginia Resource Information System Joint Subcommittee to participate with the Virginia Resource Information System Task Force to continue the study to determine the feasibility of such a system and allocating funds therefor.

WHEREAS, House Joint Resolution No. 175 passed by the 1978 General Assembly created a Joint Subcommittee to study a Virginia Resource Information System; and

WHEREAS, the Virginia Resource Information System Joint Subcommittee in the first year of the study has approved a conceptual design of a Statewide information system; and

WHEREAS, it is necessary to assess the feasibility, both economical and technical, of a Statewide information system to take advantage of latest advances of technology and economies of scale; and

WHEREAS, questions necessary to assess feasibility require a repetitive process with considerable personal contact with potential users; and

WHEREAS, it is necessary to have the conceptual design professionally analyzed to assure that concept and data are complementary; and

WHEREAS, it is desirable to conduct field demonstrations to show the utility of selected information subsystems; and

WHEREAS, it is necessary to critically evaluate information systems already in place with other states by visiting the cognizant agencies; and

WHEREAS, other groups have agreed or will be solicited to participate in the funding of the additional study noted above to the extent of about nineteen per centum by Virginia State agencies, twenty-four per centum by the National Aeronautics and Space Administration and thirty-eight per centum being sought from federal agencies; and

WHEREAS, it is necessary for the Virginia General Assembly to participate in the funding in order that all benefactors be contributors; and

WHEREAS, it is necessary that the project be funded so that the best possible judgment can be made of the feasibility of developing a Statewide information system; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Virginia Resource Information System Joint Subcommittee, as hitherto constituted, with any vacancies being filled in the same manner as the original appointments, is authorized to participate in the proposed study for which there is hereby allocated from the contingency fund of the General Assembly a sum sufficient estimated at twenty-five thousand dollars.

Appendix B

User Survey Questionnaire Forms

Examples of the user survey questionnaires used by Task Force members in collecting data from potential system users are shown.

INFORMATION SYSTEM CAPABILITY QUESTIONNAIRE

A properly designed Information System can do much more than store and recall "records." In some unpublished correspondence, Dr. Robert H. Giles, Jr. of Virginia Polytechnic Institute and State University states, "It is easy to imagine VARIS as a conventional library that stores numbers, not books. If this concept persists, cost-effectiveness will not be achieved and the promise and potential of this exciting system will be lost."

The VARIS Task Force foresees developing the Information System as a broad capability, data manipulation and information producing system that will provide all users with information that could not be obtained cost effectively by other methods. We propose to use data that you now collect, add it to data from other sources, and present it to you as information in a variety of optional formats. You may choose to receive information in the form of raw lists, lists categorized or reduced by excluding modifiers, graphs, and charts, maps, overlays over existing maps, photographic products, and other forms. The point is: an Information System can provide you with more information from current data or new information from past, current, or projected data. You still make the decisions, but you make them from a broader base of knowledge.

In order to incorporate the above type considerations in our justification and design efforts, it is vital to get your inputs on desired system capability. Please think "freely" and attempt to answer the following questions.

1. a. Do you normally produce graphic products* or maps from your data? Please specify. If you do not but would like them produced routinely from your data, can you specify what you would like produced?

b. Could you use graphic products or map data from other users in fulfilli your mission? Are there data other than curves and maps produced by other users that would be useful to you? Please specify.

*Graphic products include plotted curves, graphs, bar charts, etc.

2. Does any of your data go into any type of State or Federal Information System? What are they? Would you like to access data from other States or Federal agencies through a VARIS?

3. What type of large scale (watershed, planning district commission, county, statewide) compilation, plotting, mapping, statistical analysis would be useful to you using your data, with and without other resource data?

Example: Take the heavy metals concentrations determined from monthly stream surveys, overlay* them on a statewide stream map, overlay* that with industrial plant locations, overlay* with sewage treatment plant locations.

* Information System does

4. It is envisioned that VARIS would contain a data base of natural and physical resource data. The State would be organized into geographical units of 5, 10, 27, 40, or 100-acre blocks (or some other subdivision not yet chosen). An almost unlimited number of characteristics describing each block could be encoded into the system. Assuming this was done and data such as soil type, slope, aspect, cover-type, rainfall, agricultural potential, presence of historic sites, presence of protected streams, presence of endangered species, etc. ---were encoded into the data base, how could you use the Information System? (Some detailed thinking here may pay great dividends!)

   Example: State wants to develop a new highway, power line, or pipeline corridor from point "a" to point "b". Using data encoded by the geographic units through which the corridor passes what is the corridor of: least construction cost, least environmental impact, least impact on agriculture, or least impact with above factors weighted?

5. What data do you now collect that could be added to a statewide geo-base Information System (data that helps describe natural and physical resources of the geographical units mentioned in question 4)? If none at the present time, what type of data could you best help a VARIS project team collect and encode at a future date?

   Example: We know that the V. P. I. Agronomy Department and the Soil Conservation Service are now conducting a state-wide soils survey. These data would be vital to the Information System base.

6. Do you have a feel for what size geo-base unit would be most suitable for your use in an Information System? Why is this unit best for you?

Example: A geo-base unit based on a Landsat scene could be any multiple of 1.1 acres. The V. P. I. system currently uses 27 acres. The Maryland Information System uses a 2,000 x 2,000 feet square which is a sub unit of a larger unit defined by the State Plane Coordinate System. The selection of the geo-base unit shape and size is one of the most important design features to be determined.

7. Some of the examples mentioned in questions 1-6 illustrate possible uses of an Information System. Many others are possible. Can you name other uses related to your operation? Don't worry about how "far out" they may appear. During the early design phases, we can and should "blue sky" a little.

8. <u>This is not another question to answer!</u> This is a statement of fact.

The Task Force must depend on getting good inputs from potential users. Without your input, we cannot design a system tailored to user needs and wants. If it is not designed to be useful to the users that it is to serve, it need not be designed at all.

Thank you for your help.

RESOURCE INFORMATION SYSTEM QUESTIONNAIRE
(selected jurisdictions)

The attached Information System Capability questionnaire is to gather some ideas on how VARIS can benefit users in counties and cities throughout the Commonwealth in order that the system can be designed to meet information needs for local decisions.

There is no way we can be all knowledgeable on what questions to ask and how to ask them. Please feel a free license to make comments, suggestions, ask questions of us, or make follow-up contact that you feel appropriate.

The VARIS Task Force foresees a good System that will provide all users with information that could not be obtained cost effectively by other methods. We propose to use data that you now have available, add it to resource data from other sources, and present it to you as information in a variety of optional formats. You may choose to receive information in the form of raw lists, lists categorized or reduced by excluding modifiers; graphs, and charts; maps and overlays over existing maps; photographic products; and other forms. The point is: an Information System can provide you with more information from current data or new information from past, current, or projected data. You and the people you work with still make the decisions, but you make them from a broader base of knowledge.

In order to incorporate the above type considerations in our justification and design efforts, it is vital to get your inputs on desired system capability. Please think "freely" and attempt to answer the following questions:

I. Please check (✓) whether the following types of resource data or information is used by your office (or other local government units in your county or city), If used, please list the source; if not now available, please check (✓) whether or not it will be helpful in local government decisions for other purposes.

Check (✓) Appropriate items:

A. Land

	Used	Needed	Would be helpful if available Yes	No		Source of Data
1.	( )	( )	( )	( )	Soil (types, capabilities, suitabilities, for various kinds of uses and locations)	_____
2.	( )	( )	( )	( )	Topography (elevations, slopes, and drainage patterns)	_____
3.	( )	( )	( )	( )	Geology (minerals, sub-surface materials availability, special situations and locations)	_____
4.	( )	( )	( )	( )	Other land related data or information (describe: _____ _____)	_____

B. Water and Marine

1.	( )	( )	( )	( )	Surface Water (quantity, quality, contaminants, special factors, availability for impoundment and use, and locations)	_____
2.	( )	( )	( )	( )	Groundwater (quantity, quality, contaminants, special factors, availability for use and locations)	_____
3.	( )	( )	( )	( )	Rivers & Lakes (locations, size, flow, water quality, special factors, seasonal characteristics and flooding problems)	_____
4.	( )	( )	( )	( )	Marine (tidal waters, wetlands, circulation patterns, depth, water quality, special factors and locations)	_____
5.	( )	( )	( )	( )	Other water related information (describe: _____ _____)	_____

	Used	Needed	Would be helpful if available: Yes	Would be helpful if available: No		Source of Data
C. Atmosphere						
1.	( )	( )	( )	( )	Atmospheric Conditions (air contaminants, pollution levels, special factors, and impacts of proposed developments)	_____
2.	( )	( )	( )	( )	Climatic Data (temperature, rainfall, storm data, special and problems)	_____
3.	( )	( )	( )	( )	Other Atmospheric related information: (describe: _____ _____)	_____
D. Biological						
1.	( )	( )	( )	( )	Agriculture (crops,livestock, poultry, special issues, acres, yields, locations)	_____
2.	( )	( )	( )	( )	Forestry (acres, characteristics, yield, special issues, and location)	_____
3.	( )	( )	( )	( )	Wildlife (types, numbers, habitats, special issues, locations)	_____
4.	( )	( )	( )	( )	Fish (types, estimates, special issues, locations)	_____
5.	( )	( )	( )	( )	Insects (infestations, special issues, locations)	_____
6.	( )	( )	( )	( )	Other Biological related information (describe: _____ _____)	_____
E. Man's Activities						
1.	( )	( )	( )	( )	Transportation (highways, rail lines, airports, special issues and locations)	_____
2.	( )	( )	( )	( )	Commercial Utilities (electric and telephone rights of way, pipelines, special issues and locations)	_____
3.	( )	( )	( )	( )	Public Utilities (water systems, sewer systems, water impoundments, special issues and locations)	_____
4.	( )	( )	( )	( )	Mining (deep mines, surface mines, quarries, sand, gravel, and locations)	_____
5.	( )	( )	( )	( )	Other Industries (types, special issues, locations)	_____

	Used	Needed	Would be helpful if available: Yes	Would be helpful if available: No		Source of Data
6.	( )	( )	( )	( )	Other man made and related resources (describe: _____ _____)	_____

F. Socio-Economic

1.	( )	( )	( )	( )	Archeological and Historic Sites (Public owned, dedicated, special situations and locations)	_____
2.	( )	( )	( )	( )	Public Facilities (schools, public buildings, other public property and locations)	_____
3.	( )	( )	( )	( )	Recreation Facilities (parks, sports facilities, private clubs, special situations and locations)	_____
4.	( )	( )	( )	( )	Other socio-economic factors (describe: _____ _____)	_____

G. Other

Please comment on any other specific types of resource or related information that you think would be helpful for your county or city.

II. Please comment on the need or desirability of resource information being made available to your county or city in the following forms. These may be made available in hard copy by the VARIS central office or through input/output terminals in your locality. Indicate your needs in relation to the types you checked in Question #1.

A. Maps (black and white; overlays; false colors)

B. Data Listings (showing statistics and comparisons)

C. Trends and Projections (using bar graphs, plotted curves and listings)

D. Special Correlations and Analyses (through special techniques or computer models using several types of resource data to indicate likely effects of changes or decisions on particular issues.)

III. Assuming a State Geo-Based Resource Information System is developed, please check (✓) below the sizes of information units that will likely be most useful for your county or city. (Check (✓) the most likely level to serve your needs.)

Unit Size	1 Will be satisfactory for most levels	2 Of some use but not always necessary	3 Will be needed for special purposes	4 No particular need
One acre or less	( )	( )	( )	( )
Approx. 5 acre units	( )	( )	( )	( )
Approx. 10 acre units	( )	( )	( )	( )
25 - 30 acre units	( )	( )	( )	( )
40 - 50 acre units	( )	( )	( )	( )
90 - 100 acre units	( )	( )	( )	( )
County wide	( )	( )	( )	( )
Larger than county wide	( )	( )	( )	( )
Other non-source good units (i.e. watershed, tax maps, magisterial district, etc.)				

IV. Would you like someone to visit your county or city to further discuss your needs for resource information that may be made available through the proposed system? If so, who should he or she contact?

V. Other Comments or Suggestions:

CURRENT DATA AND USE QUESTIONNAIRE

PROCEDURE - How to Complete the Document Analysis & Data Sheet.

Source Input-0: Place an "X" in the square if the attached form is a "Source Input" document. The form will be initiated without the use of backup data. EXAMPLES: A customer order, a voter registration application or a personnel job application.

Basic Record-1: is a document that is up-dated from a Source Input-0 document or a turn around document. It is a master record type document. EXAMPLES: A stock record card, a pay record or an accounting record.

Intermediate Output-2: is a document that is partially complete. It is sent to another activity for additional information and is then returned to the originator for further action. EXAMPLES: A Time and Attendance Card containing a person's name and social security number is placed in a visible file near a time clock. Each individual employee pulls his card every morning and the time clock stamps the time he reported for work each morning. He will also use the time clock to stamp the time he departed at the end of the day. At the end of the pay period the Time and Attendance Card is returned to the payroll section to determine the hours worked by each employee to be used in the preparation of the payroll.

Final Output-3: is a document that represents a final action. The Document Analysis and Data Sheet will always have a "Backup Data" entry and will never have a "Document originating from this and being updated by this document" entry. EXAMPLES: A pay check, a shipment order or a student's report card. (See Enclosure Number 6).

Identification: Enter the name of the document or form.

Number of Pages: Enter the number of pages making up the form or document.

Frequency: Enter the form or document preparation frequency time element. EXAMPLES: 2 times per day, daily, weekly, biweekly, semi-monthly, monthly, quarterly, semi-annually, annualy, etc. are all possible entries.

Volume Average: Enter the average volume of the form or document being reported in relation to the "Frequency" field above.

Number of Copies Received: Enter the number of copies received (prepared).

Number of Copies Forwarded: Enter the number of copies forwarded.

Source: Enter where the information came from to complete this document.

Destination: Enter the name of place where the form or document is forwarded after completion.

Use of This Document: Enter a short explanation on how this form or document is used. (See Enclosures 3 through 7 for examples).

Disposition: Enter an "X" in the appropriate square(s). More than one entry is possible. A completed form could be forwarded and filed if there were 2 or more copies of the form.

How Prepared: Possible entries include typewriter, keypunched, computer, manually, etc.

Media: Possible entries include hard copy, magnetic tape, punched card, or magnetic disk.

No. Items: The number of document entries can be taken from the back of the Document Analysis and Data Sheet.

Documents Originating From This and Being Updated by This Document: This area will always be blank if Final Output-3 of the Document Analysis and Data Sheet is checked. This area will always contain an entry if Source Input-0 is checked. For instance, a time card will result in a payroll check being written; a requisition in the Commonwealth should result in a purchase order being prepared.

Sequenced by: Enter the sequence this document is filed, printed or maintained on magnetic tape or disk media.

Access Requirements: Enter the average number of times this record (document) is pulled from a file during a particular period of time for some reason. Entry examples may be, daily, two times per day, weekly, two times per month, etc.

Retention Characteristics: Enter how long this document must be retained. Sometimes the retention period is specified by Virginia or Federal laws.

Backup Data: Enter the names of the forms or documents that caused the preparation of this particular type document. This area will always contain an entry is this a Final Output-3 document. This field will always be blank if this is a Source Input-0 type document.

Is This Form Used in Conjunction With A Map? Check the appropriate answer. If the answer is yes, please check the kind of map(s) that are used.

Remarks: Please indicate in this area any additional information about this document that will help clarify its use.

Date and Prepared By: Enter the date this Document Analysis and Data Sheet was prepared for this document and sign your name.

Back of Document Analysis and Data Sheet: The back of the Document Analysis and Data Sheet will begin to describe the characteristics of the data (information) that is entered in the document or form being analyzed. Many of the documents or forms to be analyzed will require more than one Document Analysis and Data Sheet (back side only) to enter all of the fields of data (information).

Item No.: Each entry in this column is numbered sequentially beginning with one.

Sub No.: Certain data fields may be broken down into sub numbers. For instance, a data field is broken down into sub number "a" for a two digit month number from "01" through "12"; "b" for a two digit day from "01" through "31", and "c" for a two digit year "79", "80", etc.

Description: The name of the data field is entered, i.e. today's date, payroll date, batch date, the date the form is prepared, etc. Date examples are used since a date used on one document or form does not necessarily have the same meaning as a date used on another form. Please describe the date entry as precisely as you can.

Average Number of Characters: Enter the average number of characters in this data field, i.e. the month field could be "2" characters if the numeric month code is used but the entry would be "6" if the month were spelled out.

Alphabetic/Numeric (A/N): Enter an "A" if the data field is always alphabetic, an "N" if it is always numeric and "A/N" if it contains both alphabetic and numeric characters.

Number of Decimal Positions: Enter the appropriate number to indicate the number of decimal positions for a numeric data field, if applicable. Enter a "1" if the data field contains one decimal position, a "2" if two decimal positions, etc.

Total Characters of Information: Enter the sum of all Average Number of Character columns for all data fields.

DISPOSITION:

Attach one copy of the form or document to the applicable Document Analysis and Data Sheet. Forward the Document Analysis and Data Sheet with the attached form, the second form or document to your VARIS Task Force representative. If you have any questions, please contact the VARIS Task Force representative assigned to your agency, university, planning district or local government.

DOCUMENT ANALYSIS & DATA SHEET

SOURCE INPUT - 0	X	Identification of Document			No of Pages
BASIC RECORD - 1		TIME REPORT			1
INTERMEDIATE O/P - 2		Frequency	Average Volume	No copies received	No copies forwarded
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Is this form used in conjunction with a map? Yes ☐ No ☐

If above answer is yes, please check the kind of map(s) that are used:

- ☐ High-resolution aerial photographs.
- ☐ Hydrologic maps.
- ☐ Vegetation maps.
- ☐ 7½-minute topographic quadrangles.
- ☐ Floodplain delineation.
- ☐ Current land use.
- ☐ Soil maps
- ☐ Wetland delineation.
- ☐ Geologic maps.
- ☐ Wildlife habitat delineation.

Remarks SECTION CHIEF MAINTAINS TIME REPORT DAILY. FORWARDED TO DEPARTMENT OR KEY OFFICE FOR CHECKING EACH MONDAY A.M. USED EVERY 2 WEEKS TO UPDATE LAST PAY PERIOD'S PAY REGISTER

Date MARCH 9, 1979	Prepared by JOHN A. ANALYST

Item No.	Sub. No.	Description	Ave. No. Charac.	A/N	No of Dec. Positions
1	.	ENDING DATE			
	A	MONTH	6	A	
	B	DAY	2	N	
	C	YEAR	2	N	
2		SUNDAY	10	N	2
3		MONDAY	18	N	2
4		TUESDAY	18	N	2
5		WEDNESDAY	18	N	2
6		THURSDAY	18	N	2
7		FRIDAY	18	N	2
8		SATURDAY	18	N	2
9		TOTAL HOURS WORKED	4	N	2
10		SIGNATURE	22	A	
11		REGULAR HOURS WORKED	4	N	2
12		OVERTIME HOURS WORKED	4	N	2
Total Characters of Information			162		

Appendix C

Information Systems in Other States

A description of each state's information system is provided.

Florida

The South Florida Water Management District

The visit to Florida's computer system consisted of a demonstration of land and water use relationships in two specific localities. The demonstration showed the system's rapid manipulation of its data base (which consists of 235 layers of data) and its practicality. Specific information about a specific point is available immediately and almost any desired resolution is possible.

The Florida system is primarily water based, although it also utilizes data on soils, mineral geology, and other data from comprehensive land use plans. The system provides data printouts and depicts isometric pitcure projections on water use through the use of a digitizer. With the digitizer, information for specific locations can be combined at will with 3-D ploy displays.

The Florida system cost $150,000 to develop and it provides a complete turnkey access point for $50,000 in hardware costs.

Based on Florida's experiences, these suggestions were made for Virginia's consideration:

1.) Have limited application at first, in a use essentially assured of success.

2.) Hire a software consultant - do not try to do it yourself.

3.) Keep staff requirements to a minimum.

Department of Natural Resources

The visit to Georgia's information system consisted of a slide-discussion on the work done by the Department of Natural Resources, Environmental Protection Division with support of the Georgia Tech Engineering Experiment Station. The work carried out is the result of a project begun in 1975 as a "technology transfer" with NASA to analyze use of Landsat digital data. From this data, Georgia has produced statistics and maps on land cover by counties and other geographic divisions.

The users of the George system are:

Envirnmental Protection Division

Soil Conservation Service

U. S. Corps of Engineers

U. S. Army

Georgia Forestry Commission

Office of Planning and Budget

Department of Community Affairs

The Georgia system has a staff of two Natural Resource Unit Supervisors and ten hourly payroll workers. The staff has experienced a growing demand for their work and are currently experiencing the maximum work load that they can handle.

The projects undertaken by this system are negotiated on a one-to-one basis. Funds from these projects average $100,000/year. In additon, they receive a $500,000/year budget allowance through the Department of Natural Resources.

The Maryland Geographic Information Project (MAGI)

The visit to the Maryland Department of Planning consisted of a discussion which led to these findings:

MAGI was initiated to assist in fulfilling a statutory requirement that the Department of Planning determine land uses throughout the State. Under development since 1974, the system took approximately 1.5 years to complete the system design and to capture the initial data for land use studies. The project was planned to provide capabilities to serve the needs of other agencies. The system was designed to enlarge its capabilities as the needs and demands of the agencies justified the expansion.

Cost of the system development has been approximately $80,000 per year or a total of $214,000 to date. Annual cost has been approximately $60,000 for personnel (mostly geographers and planners), $15,000 for computer time and $5,000 for miscellaneous expenditures. Operations have been on a subscription fee basis contractual arrangement since 1976. Most of the updating and improvement of the system results from contractual arrangements.

The Minnesota Land Management Information System

The Minnesota Land Management Information System (MLMIS) was developed and implemented at the State University in 1967. It remained at the University until 1977 when it became a separate unit in the State Planning Agency.

The most useful products of the System are data and interpretative maps for the whole State. They use aerial photography, soils maps and topography maps on land use, zoning, land ownership, bedrock geology, mineral potential, soils, forest cover, and water and highway orientation. Each agency collects and retains its owns data. They are mandated, however, to collect and store data in a format that can be accessed by MLMIS. About one half of the State's regions have requested MLMIS services.

The estimated cost of system development was $1.3 million through 1977. The projected FY/1980 budget was $310,000 plus an $80,000 revolving fund. User fees for this fund are based on cost of direct services. A mini-computer and processing equipment are being purchased at a cost of $300,000. Aerial photos for the entire State cost $450,000.

The North Carolina Land Resources Information System

The North Carolina Land Resources Information System (LRIS) had its inception in the Land Policy Act of 1974. The legislature recognized a need for assistance to be provided to local governments, State and regional agencies, and citizens in their obtaining information pertaining to land use.

The system's objectives are (1) to minimize the cost of collecting and processing information, (2) to increase the information's usefulness, accessibility and quality and (3) to facilitate in land use decisions.

The system provides for the integration of a geo-base system and interactive graphic displays. The interactive graphics package provides four color maps of land use and other characteristics, digitized maps, drawings, aerial photographs, and other display devices. The automation of the system allows for the collection of data in a computer readable form, the computer storage and manipulation of the data, and the retrieval of data in plotted, printed or tabular form. User agencies supply the data used and maintain updates. Digitizing of the data is provided by USGS on a contractual arrangement.

Typical LRIS applications to date have relied heavily on the data compositing, or the data overlay capability, of the system. For example, a recent project with the Soil Conservation Service (SCS) involved identifying areas which because of land use, soil type, and nearness to streams, had a high probability of contributing to nonpoint source water pollution. Specifically, the objective of the study was to:

* Isolate areas with high potential for having agricultural-related water problems resulting from erosion and sedimentation.

* Calculate soil loss for these areas in terms of tons/acres/year by applying the Universal Soil Loss Equation.

* Identify the best management and treatment practices and associated costs of applications.

* Graphically and tabularly summarize the results.

Along with the actual outputs of this study, an additional result of the project was the demonstration that land resource decision-making can be facilitated by ready access to pertinent information and can incorporate creative techniques for analysis and display of alternatives.

LRIS is a mechanism for facilitating communication among the collectors and users of land resource information at all levels: federal, state and local. It provides a means by which to mesh numerous sets of State resources. it also provides more data at a lower cost to individual users.

The system costs $150,000 to initiate with continued development on a cost-recovery basis.

Department of Research and Statistics

Work in South Carolina is carried out with support of a computer center at the University which is tied to equipment at the State's Computer Services Divisions/Graphics. The System has been developed over the past five years and has provided services primarily to State agencies.

Inputs into the System include data on soils, topographic maps, geologic maps and geodetic maps of the coastal zone. The System provides interpretation of Landsat data, multi-spectral tapes, digitizing equipment and graphic maps. Greatest emphasis at this time is placed on digitizing polymetric information and computer controlled plotting from the digitized statistics. The System is also now involved in establishing polygon parameters for encoding its data.

The estimated cost of the System has been $75,000 for hardware, $250,000 for software and $200,000 for annual operational and maintenance expenses. Most of these monies have been provided by State funds supplemented by federal grants from NASA, USGS and the Coastal Plains Regional Commission.

Appendix D

Remote Sensing Demonstration Projects

Concurrent with the VARIS user needs survey and preliminary design study mandated by House Joint Resolutions 175 and 225, there were eights projects being undertaken within Virginia to demonstrate the applicability of remote sensing technology to monitoring of natural resources and to geo-base referenced information systems. Two of the projects were oriented towards aircraft remote sensor platforms and six were oriented towards the Landsat spacecraft remote sensor platform. The two aircraft related projects were accomplished under standard NASA experimental research programmatic structure. The six Landsat related projects are being accomplished in cooperative efforts between State Agencies and the Eastern Regional Remote Sensing Applications Center (ERRSAC) at the NASA Goddard Space Flight Center, Beltsville, Maryland. The Regional Applications program is specifically organized to transfer Landsat data processing capability to State and local government levels by the accomplishment of projects in which State agency personnel work directly with Landsat data under tutelage of NASA discipline scientists.

The eight remote sensor demonstration projects are discussed in the following paragraphs. The discussion of results contain only written descriptions due to practical considerations of reproduction of visual output products; however, visual products are available for each project which has produced results to date.

Thermal Plume Detection and Quantification

Remote Sensor and Platform:

Bendix Multispectral Scanner aboard NASA, P-3, Earth Resources aircraft.

Location:

James River between Fort Eustis and Hopewell, Virginia.

Participants:

NASA Langley Research Center and Virginia State Water Control Board, Piedmont Region.

Objective:

The objective of the project is to demonstrate that an aircraft borne remote sensor can map the thermal structure of a large section of river at a sufficient level of resolution to permit its use as a routine monitoring tool.

Project Description:

The P-3 aircraft with an 11-band multispectral scanner flew six flight lines along the James River from Fort Eustis to Hopewell, Virginia. The 9:00, 10:00 and 11:00 A.M. flight lines were accomplished during an outgoing tide and the 3:00, 4:00 and 5:00 P.M. flight lines were accomplished during an incoming tide. All flight lines were flown at an altitude of 10,800 feet. At this altitude, the width of the scan is approximately 16,200 feet (1-1/2 x altitude).

Bands 1-10 of the multispectral scanner measure radiance (reflected sunlight) in the visible portion of the spectrum between the wave lengths of 380 and 1060 nanometers (10-9 meters). The data from these bands were used for other scientific experiments. Band 11 of the scanner measures radiance in the thermal portion of the spectrum between the wavelengths of 8,00 and 13,000 nanometers. The data from Band 11 were analyzed with computerized algorithms supported by 14 ground truth stations to produce a thermal map of the river surface.

Results:

Data are available that permit the thermal structure of the river to be mapped at the time of the six flight lines. Specific maps of the Hog Island and Hopewell areas have been produced from the 9:00 A.M. and 3:00 P.M. flight lines. Thermal plumes from industrial plants can be seen in each area and the movement of the plume due to tidal changes can be seen. In the Hopewell area, the effect of day long sunlight can be seen by the presence of warmer water bodies over shallows. The data show that the mapping of temperature variations of 1° C will produce computer generated maps showing significant thermal boundaries within a water body.

Contact:

Mr. Ted Talay, NASA Langley Research Center, Hampton, Virginia.

Land Use/Land Cover Classifications

Remote Sensor and Platform:

Zeiss mapping camera with color infra-red film.

Location:

Virginia Eastern Shore (Accomack/Northampton Counties).

Participants:

Old Dominion University, Northampton-Accomack Planning District Commission and NASA Langley Research Center.

Objective:

The objective of the project is to demonstrate that aerial photography and manual photographic interpretation techniques can be used to produce Land Use/Land Cover classifications for use in regional planning activities.

Project Description:

The C-130 aircraft equipped with a Zeiss mapping camera flew three flight lines along the length of the eastern shore. All flight lines were flown at an altitude of 20,000 feet. At this altitude, the width of the photographic coverage was 30,000 feet. This combination of number of flight lines, altitude, and single flight line coverage resulted in a 100 percent coverage of the two counties. The Land Use/Land Cover mapping is a staged process that includes making a mylar copy of the 7.5-minute USGS Quadrangle, hand drawing road changes and political boundaries on the mylar, tracing water-land boundaries on the mylar from enlarged photography, and hand drawing the Land Use/Land Cover classifications as interpretated from the enlarged photography. Acreages of each Land Use/Land Cover classification are then calculated.

Results:

The reulting products are mylar overlays of the 7.5-minute quadrangle sheets. The overlays include number coded classifications down to 1-acre parcels, highways and roads, water-land boundaries, and political boundaries.

Preparation of Land Use/Land Cover classifications with as much detail as present on these overlays is labor intensive. It is planned that this technique be used only in urban areas to supplement large rural area classifications derived from digital processing of Landsat data.

Contact:

Mr. Ben Drake, Remote Sensing Laboratory, Old Dominion University, Norfolk, Virginia.

Forest Classification Using Landsat

Remote Sensor and Platform:

Spectral Radiometer aboard Landsat spacecraft.

Location:

James City County, Virginia.

Participants:

Virginia Division of Forestry and NASA/ERRSAC.

Objective:

The objective of the project is to demonstrate the use of Landsat digital data processing techniques to produce a Level II forest classifiction of a large area (entire County). Assuming success of the classification techniques, classification in subsequent years can produce a method of locating and quantifying changes.

Project Description:

A computer compatible tape of a Landsat scene recorded on April 28, 1978 was obtained and entered into the ORSER[1] data processing System at the Pennsylvania State University. The project engineer from the Virginia Division of Forestry then conducted a forest classification of James City County using a teleprinter terminal located in the Charlottesville office and connected to the ORSER system by a leased telephone line. Simultaneously, a NASA discipline scientist at ERRSAC conducted a similar classification of the same area using the IDIMS[2] system at the NASA Center. The classifications were then compared, validated with aerial photography and field trips, and finalized for calculation of statistics. The County boundary was then digitized and overlaid on the classifications. Acreage statistics for each land cover class were calculated with special attention being given to the three forest classifications.

Results:

A Level 1 Land Use/Land Cover classification was made of the entire county supplemented with a Level II classification of the forested areas. Classifications included Commercial/Residential, Agricultural, Water, Marsh Land, Forest (Hardwood, Pine, Mixed Hardwood/Pine), and Unclassified. Acreage calculations of the three forest classifications were compared with the 1975 U. S. Forest Service inventory of the county. The acreage calculations made with the Landsat data were within 4 percent of the values calculated from the Forest Service Inventory.

Contact:

Mr. James Copony, Virginia Division of Forestry, Charlottesville, Virginia.

[1] ORSER (Office for Remote Sensing of Earth Resources) - this acronym refers to a computer program developed by the Pennsylvania State University to process digital multispectral sensor images stored on computer compatible tapes.

[2] IDIMS (Interactive Digital Image Manipulation System) - this acronym refers to a mini-computer based system designed for processing Landsat digital data. The IDIMS System is located at the NASA Goddard Space Flight Center and was developed under contract with the Electromagnetic Systems Laboratory, Sunnyvale, California.

Coniferous Biomass Assessment

Remote Sensor and Platform:

Sepctral Radiometer aboard Landsat spacecraft.

Location:

Tidewater Region of Virginia including the counties of Southamption, Isle of Wight, Sussex, York and the cities of Chesapeake, Franklin, Norfolk, Portsmouth, Virginia Beach, Hampton, Newport News and Poquoson.

Participants:

Virginia State Air Pollution Control Board, Tidewater Region, Norfolk, Virginia; Old Dominion University Remote Sensing Laboratory, Norfolk, Virginia; and NASA/ERRSAC.

Objective:

The objective of the project is to demonstrate the capability to produce a vegetative classification inventory of a regional area with special emphasis on the inventory of coniferous vegetation. The Air Pollution Control Board has a need for a vegetation inventory for the Tidewater Region for input into a model that estimates total hydrocarbon contributions to the atmosphere by vegetation categories.

Project Description:

Computer compatible tapes of Landsat scenes recorded on April 28 and June 11, 1978 were obtained and entered into the ORSER system at the Pennsylvania State University and the IDIMS System at NASA/ERRSAC. Unsupervised classification of the area is being conducted in a joint effort between a NASA discipline scientist and ODU project engineer on the IDIMS System. Five major classes are being established. They include water, wetlands, agriculture, forests, and other land categories. The forest classification is being further divided into subclasses to distinguish between conifers and deciduous types. The IDIMS classifications are being validated by extensive ground truth, and area statistics are being developed on the ORSER System at the remote terminal at Old Dominion University.

Results:

Project under way, results not finalized.

Contact:

Mr. John Salop, Virginia State Air Pollution Control Board, Tidewater Region, Norfolk, Virginia.

Watershed Change Detection

Remote Sensor and Platform:

Spectral Radiometer aboard Landsat spacecraft.

Location:

Swift Creek Reservoir watershed, Chesterfield County.

Participants:

Virginia State Water Control Board; Chesterfield County, Virginia; and NASA/ERRSAC.

Objective:

The objective of the project is to produce a Level I land cover map for the watershed and to provide land cover data that, when combined with soils and other descriptive data, can be used to explain or predict threats to water quality.

Project Description:

Project being defined.

Results:

Project being defined, results not available.

Contact:

Mr. Steve Williams, State Water Control Board, Richmond, Virginia.

Agrigulatural and Forestry Management Practices

Remote Sensor and Platform:

Spectral Radiometer aboard Landsat spacecraft.

Location:

Virginia Eastern Shore/Accomack-Northampton Counties.

Participants:

Old Dominion University Remote Sensing Laboratory, Norfolk, Virginia and NASA/ERRSAC.

Objective:

The objective of the project is to produce a Level I land cover map of the two counties on the Eastern Shore that are included in the Accomack-Northampton Regional Planning District. In addition, a Level II land cover map of forest and agriculture classifications will be done on selected areas of the Eastern Shore. It is also planned to perform an accuracy assessment of the Landsat classifications by comparing them with the classifications produced by the aircraft remote sensor project.

Results:

A Level I classification of the two counties has been completed using the IDIMS system at ERRSAC. The ODU Laboratory is now conducting supervised classifications (with ground truth) of three 7.5-minute quads using the ORSER System remote terminal at Old Dominion University. The ORSER classifications are for adding detail to the agriculture and forestry classifications and to produce acreage statistics to complement both the IDIMS and ORSER classifications.

Contact:

Mr. Ben Drake, Old Dominion University, Department of Geophysical Sciences, Norfolk, Virginia.

Mined Land Reclamation Assessment

Remote Sensor and Platform:

Spectral radiometer aboard Landsat spacecraft.

Location:

Seven coal producing counties in southwestern Virginia.

Participants:

Virginia Division of Mined Land Reclamation and NASA/ERRSAC.

Objective:

The objectives of the project are to produce (1) a land cover map for two study areas as well as the entire reclamation region for the 1974 data, (2) a land cover map for the two study areas for the 1978 data, (3) acreages for items (1) and (2), and (4) a change detection map for the two study areas showing land cover changes which occurred between 1974 and 1978. These classification mapping techniques, especially change detection mapping, will be evaluated for use in applied reclamation efforts.

Project Description:

Computer compatible tapes of the area recorded in 1974 and 1978 were obtained and portions of the data were entered into the ORSER data processing System at the Pennsylvania State University and the IDIMS System at NASA/ERRSAC. The project engineer from the Division of Mined Land Reclamation and the NASA discipline scientist then performed separate land cover classifications for both years on two 7.5-minute quad size test areas within the reclamation jurisdiction using both the ORSER and IDIMS System.

Six Level I land cover classes were developed including two strip mine classes. Acreages for each land cover classes were determined for the study areas. In addition, the classification was extended over the entire reclamation district for the 1974 data set. The strip mine classes will be divided into subclasses of active, abandoned reclaimed, and abandoned unreclaimed based on differences in vegetative cover between the two years. The entire technique will be evaluated for use as a reclamation monitoring tool.

Results:

Project under way, results not finalized.

Contact:

Mr. David Cress, Southwest Virginia Community Colege, Richlands, Virginia; Mr. Robert Cumbrow and Mr. Brad Simmons, Virginia Division of Mined Land Reclamation, Big Stone Gap, Virginia.

Integration of Landsat Data

and

Geo-Base Information System

Participants:

Virginia Polytechnic Institute and State University, Department of Fisheries and Wildlife Sciences, Blacksburg, Virginia; Division of Mined Land Reclamation, Big Stone Gap, Virginia; and NASA/ERRSAC.

Objective:

The objective of the project is to accomplish the integration of Landsat data with another geo-base data set and to demonstrate that tedious, expensive manual activity can be automated using the combined Landsat and Information System data base.

Project Description:

Landsat classifications of Southwestern Virginia developed under the Mined Land Reclamation assessment project will be used in this project. A six division land use classification of Tazewell County, Virginia will be entered into the Tazewell County data set for the VPI and SU State Information System. A boundary will be displayed as well as the cells in a computer generated gray scale map. The data will be aggregated and computer processed to produce a predominant land use classification of each 27-acre cell of the county. Other cell data such as elevation, slope, aspect, and cultural sites may be displayed in map form. The results will provide an example of a system that can save thousands of dollars in mapping and planning report preparation as well as provide a working tool for efforts to improve environmental quality.

Results:

Project under way, results unavailable.

Contact:

Dr. Robert H. Giles, Jr., Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Appendix E

Resource Information Systems Development

Based on the 1979 User Survey and its evaluation it appears that the proposed Virginia Resource Information System should be designed to eventually support users by providing the following:

1. Assistance to managers in formulating and improving goals and objectives relating to resource issues and problems.

2. Assistance in colleciton, storage, networking and retrieval of resource and related information.

3. Assistance in providing high qaulity, appropriate processing services in statistical analysis, supplying canned analytical software packages, developing new software and models, locating existing models and assisting in adapting these to Virginia conditions and Virginia projects.

4. Assistance relating to inspection services, monitoring and providing feedback on programs served by various Virginia agencies.

5. Assistance in making projections.

Chart #1 is a graphic illustration of services for which the proposed System can be developed to provide to serve identified user needs. A priority need in further planning and developing the proposed System is clarification of broad goals based on specific user needs. Task Force surveys of State agencies, planning district commissions and local jurisdictions in 1979 identified four broad types of user needs as follows:

1. Collection, storage, networking and retrieval of information.

2. Classification and inventory of land use/land cover information.

3. Providing maps and map overlays tailored to specific needs.

4. Providing geo-based computerized studies on resource issues including environmental and predictive modeling.

Further work will be needed with potential users to clarify more specific goals relating to resource information from the standpoint of each potential user in relation to their individual problems and needs. These may relate to State agency goals and objectives with relative ease. In many cases, it may be that planning districts and local government agencies may need more help unless their programs of work have been defined clearly.

After user goals are clarified sufficiently for mutual understanding, the next step will be to establish specific objectives for particular resource information outputs which will, at least in part, support individual user's goals. These can be expressed as specific information system outputs which may include any or all of the above types of resource information needs.

After the initial user goals and systems output objectives are clarified, consistent decisions can be made on specific data needs, priority on data to be acquired, and generalized models required to produce the desired outputs.

In addition to the generalized models, there will also be a need of service or utility computer software to develop and implement the overall system. Generalized models that have been identified as a result of the user survey are included in Chart #2. Service packages or utility programs to support these models are listed in Chart #3.

Generalized models listed in Chart #2, while somewhat conceptual in nature, are necessary for effective decisions in the selection, development and/or adaptation of service packages and utility programs. Generalized models will usually be developed with the particular user, or group of users, in order to assure the most effective data inputs and system outputs. Service packages and utility programs will be assembled by the staff and/or other professional assistance. At this level users will be concerned primarily with data inputs and approval of the resource information outputs.

In addition to data and systems development for resource information, there will also be a need for utility packages to handle acconting, billing, records of available models, and the availability of data to the system.

Although detailed work on generalized models has not been developed for the proposed system, the attached charts Nos. 4 through 11 are inital concepts for further modification and development. These concepts indicate some potential sources, data elements, data interpretations, and anticipated users of different types of information and may serve as a basis for early work in developing generalized models. It appears that considerable effort and lost time can be saved if the generalized models are developed relatively well before heavy investments are made on data resources, service packages, and utility programs. Models will also help serve as tools in selecting priorities that will assure effective information for immediate use in early stages of program development.

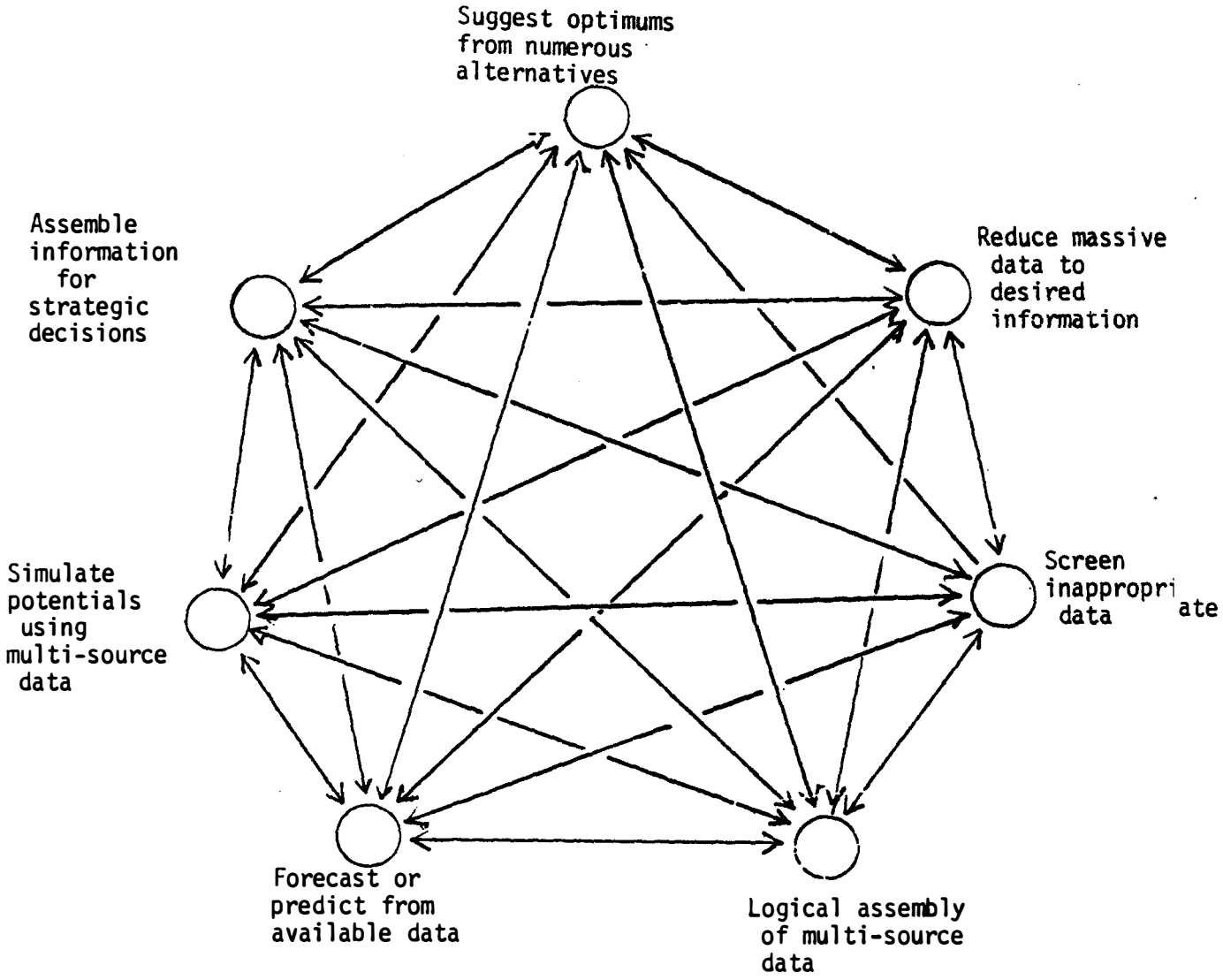


Chart #1 Integrated Service Potentials for the Virginia Resource Information System

Chart #2 - GENERALIZED MODELS

(For discussion in systems planning)

1. Growth planning
2. Urban expansion
3. County zoning
4. Facility siting
5. Industrial development
6. Comprehensive planning
7. Buildings near airports and airport zoning
8. Flood plain management
9. Route location
10. Energy planning
11. Solar radiation relationships
12. Forest management
13. Wildlife and wetlands
14. Emergency planning and services
    1. road or rail
    b. fire
    c. toxicant release
    d. flood
    e. tornado
    f. wars

Chart #3 - SERVICE PACKAGES AND UTILITY PROGRAMS

1. Standard statistics
2. Plot all (bar graphs, etc.)
3. Commuter analyses
4. Population projections
5. Grid-to-grid transformation
6. Noise contours
7. Air pollution plume
8. Flood plain mapper
9. Health-related subsystems
10. Pest problem predictions
11. Soil analyses (erodability etc.)
12. Solar
13. Transportaiton analyses (county and urban)
14. Satellite and land use
15. Searches for lost people and aircraft (aids)
16. Ground water analysis
17. Coal mine analyses
18. County comprehensive planning aid (Dynaplan)
19. Power line package
20. Inventory of available aerial photos
21. Inventory of available aerial maps
22. Links with Archives
23. Solve boundary and adjacency problems (out-of-state) through shared programs
24. Vegetation site selection (trees, landscaping)
25. Energy conservation potentials
26. Foreign ownership of lands
27. Land fill for solid waste disposal
28. Network - where to go in what sequence to make visits, inspections so as to minimize costs, travel time, etc. (map and number)
29. Generalized permit compliance system
30. Agricultural decision aids

31. Master plan for a new park

32. Fire analyses (county)
    fires/x income
    fires/x structural age

33. How to map vertical space
    leased air space
    mine (mineral rights)
    water (ground)
    subadjacent (oil)
    superjacent interests (solar)

CHART # 4

LAND RESOURCES AND LAND USE

(A CONCEPT

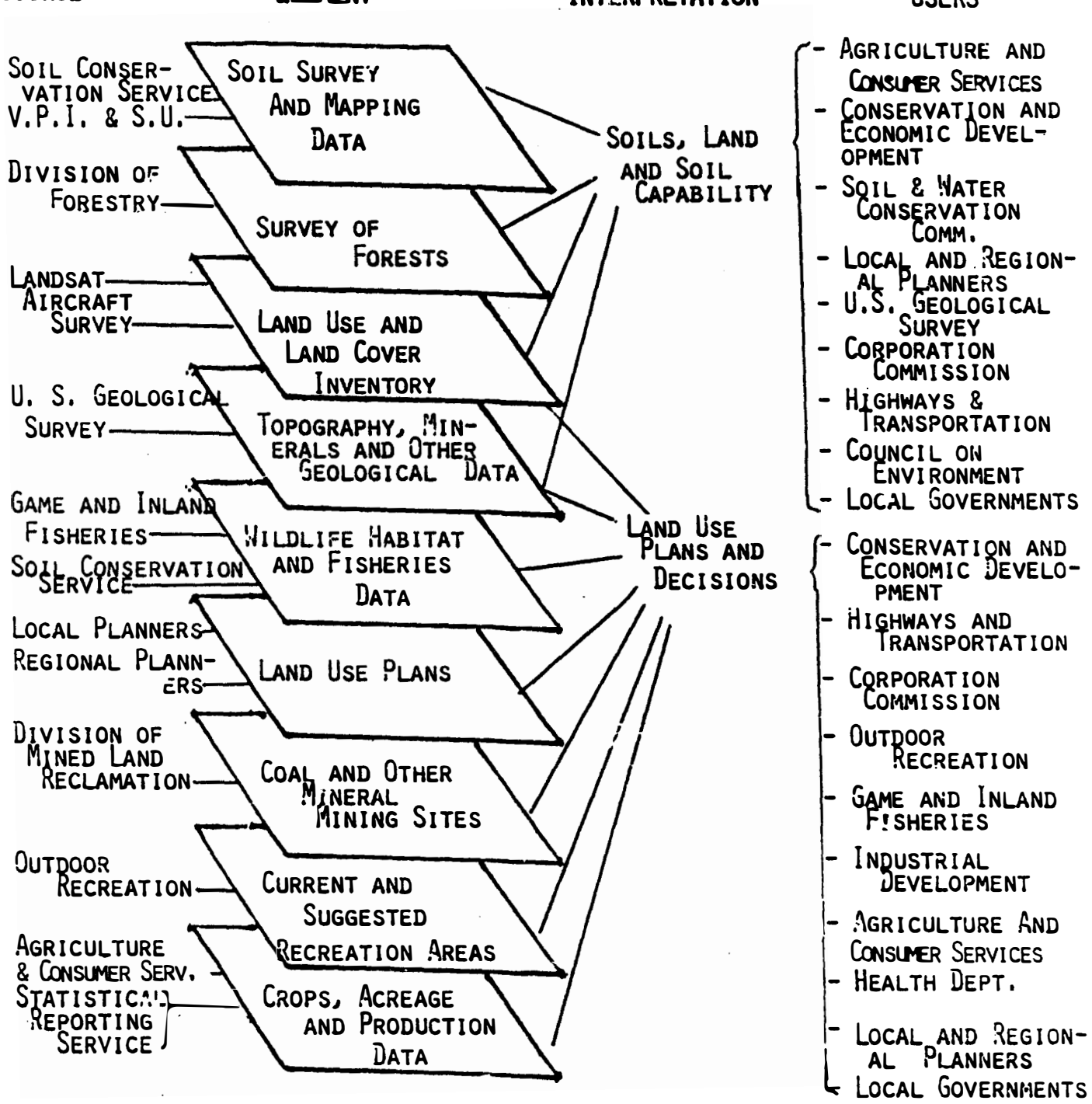


CHART # 5

MONITORING - WETLANDS AND STREAMLINE CONDITIONS AND MARINE RESOURCES

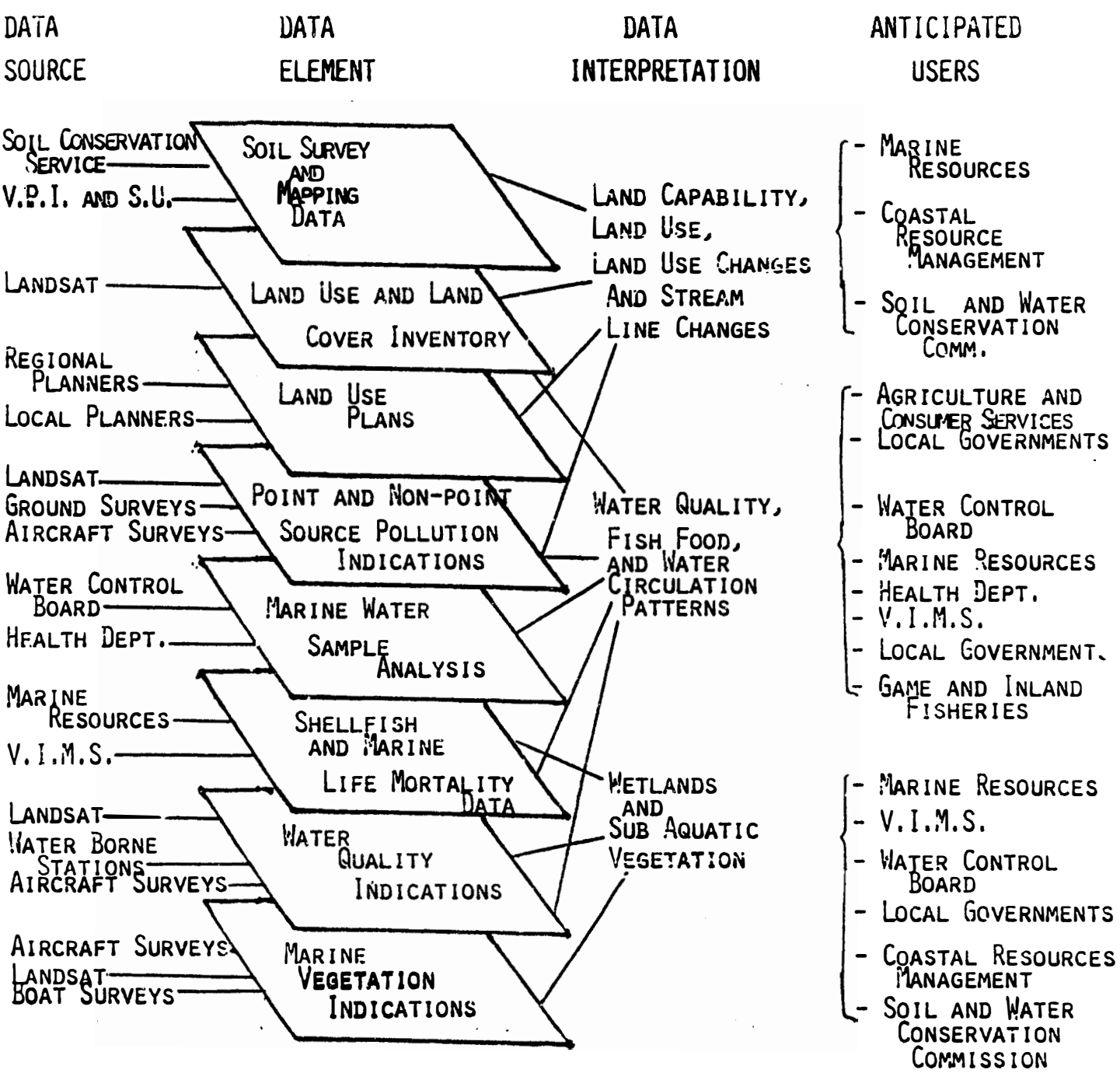


CHART # 6

WATER RESOURCES INVENTORY SYSTEM

(A CONCEPT)

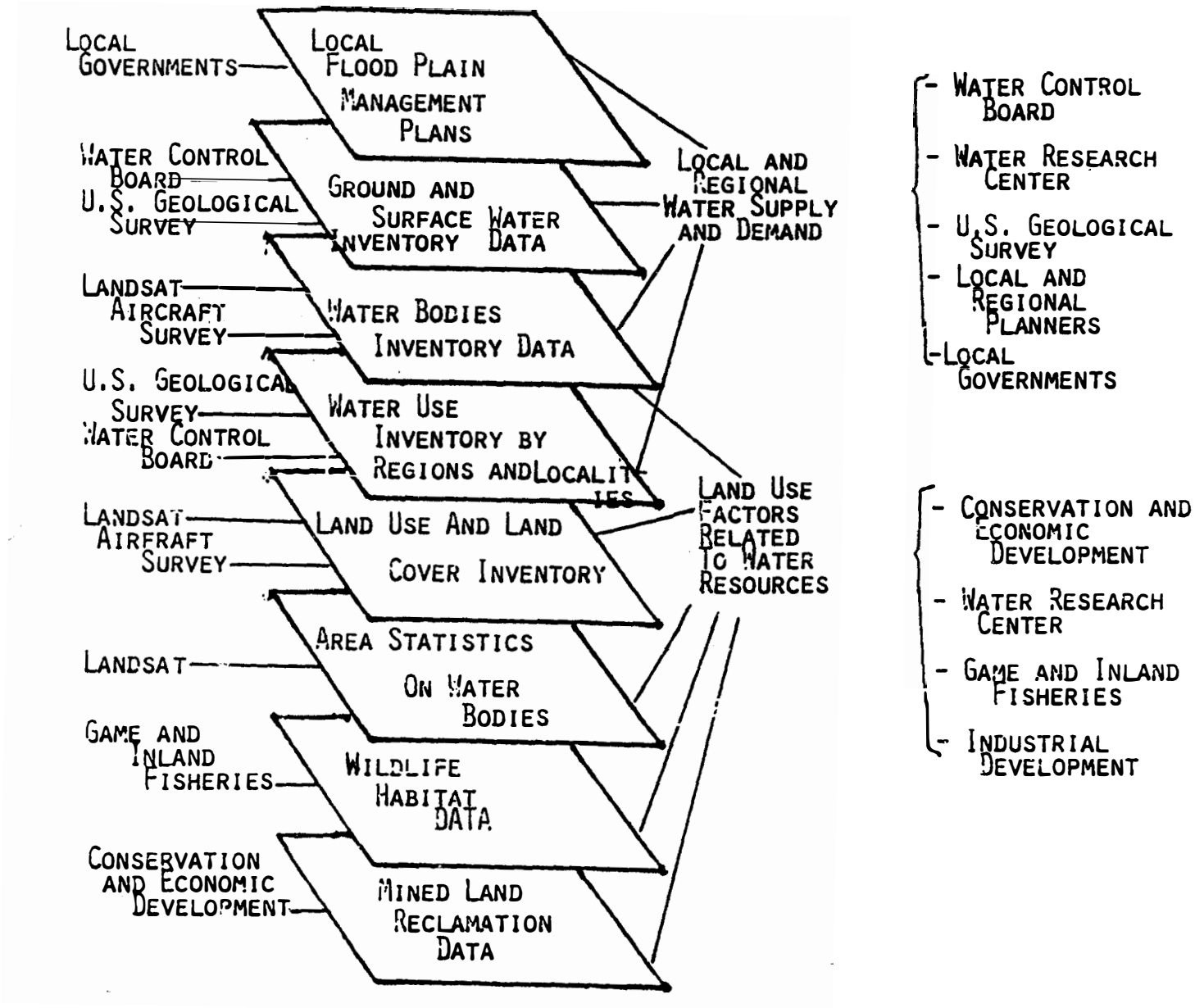


CHART # 7

WATER QUALITY INVENTORY AND MONITORING SYSTEM

(A Concept)

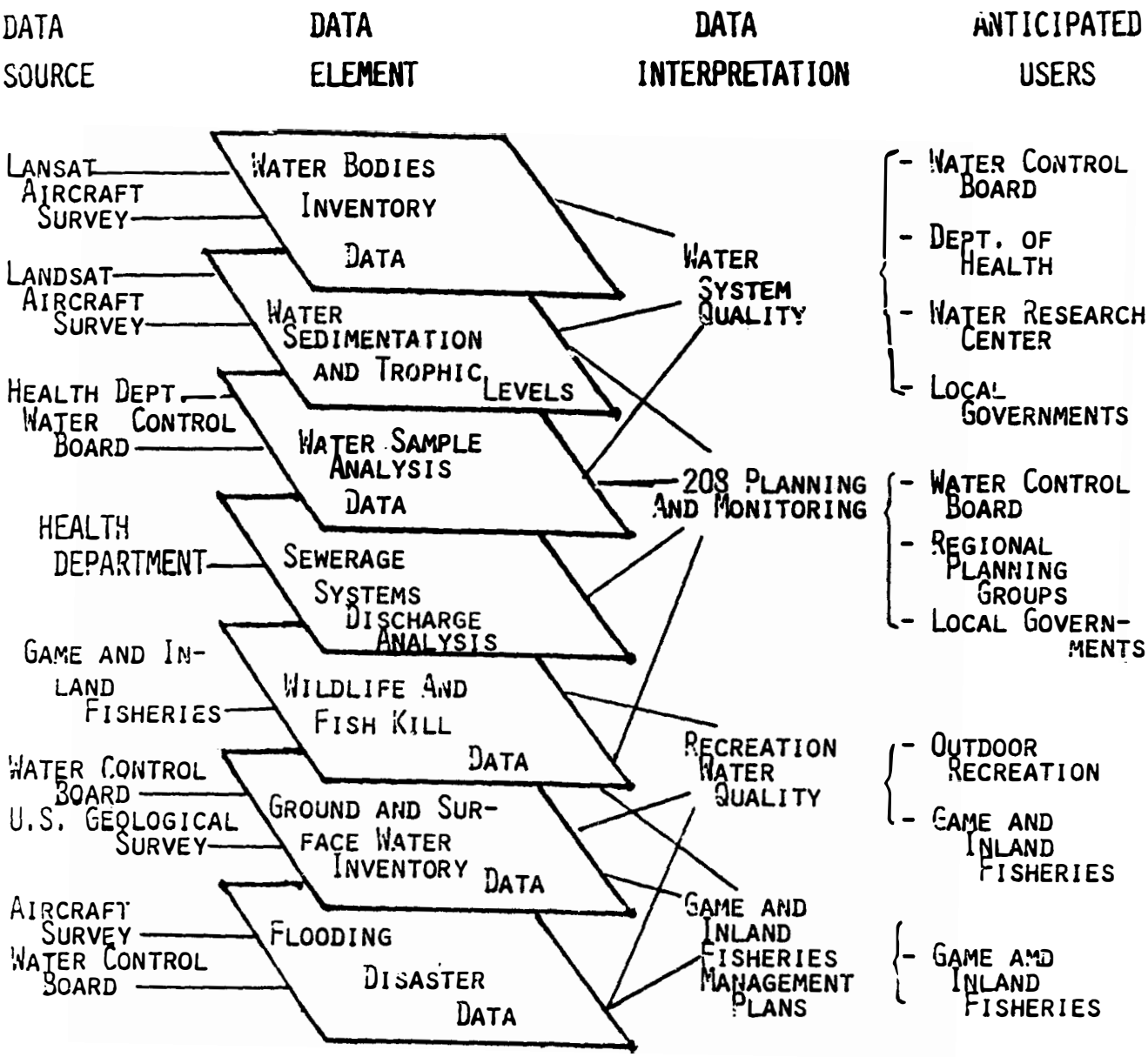


CHART # 8

MONITORING -- WEATHER, SOIL MOISURE AND GROUND WATER
(CONCEPT)

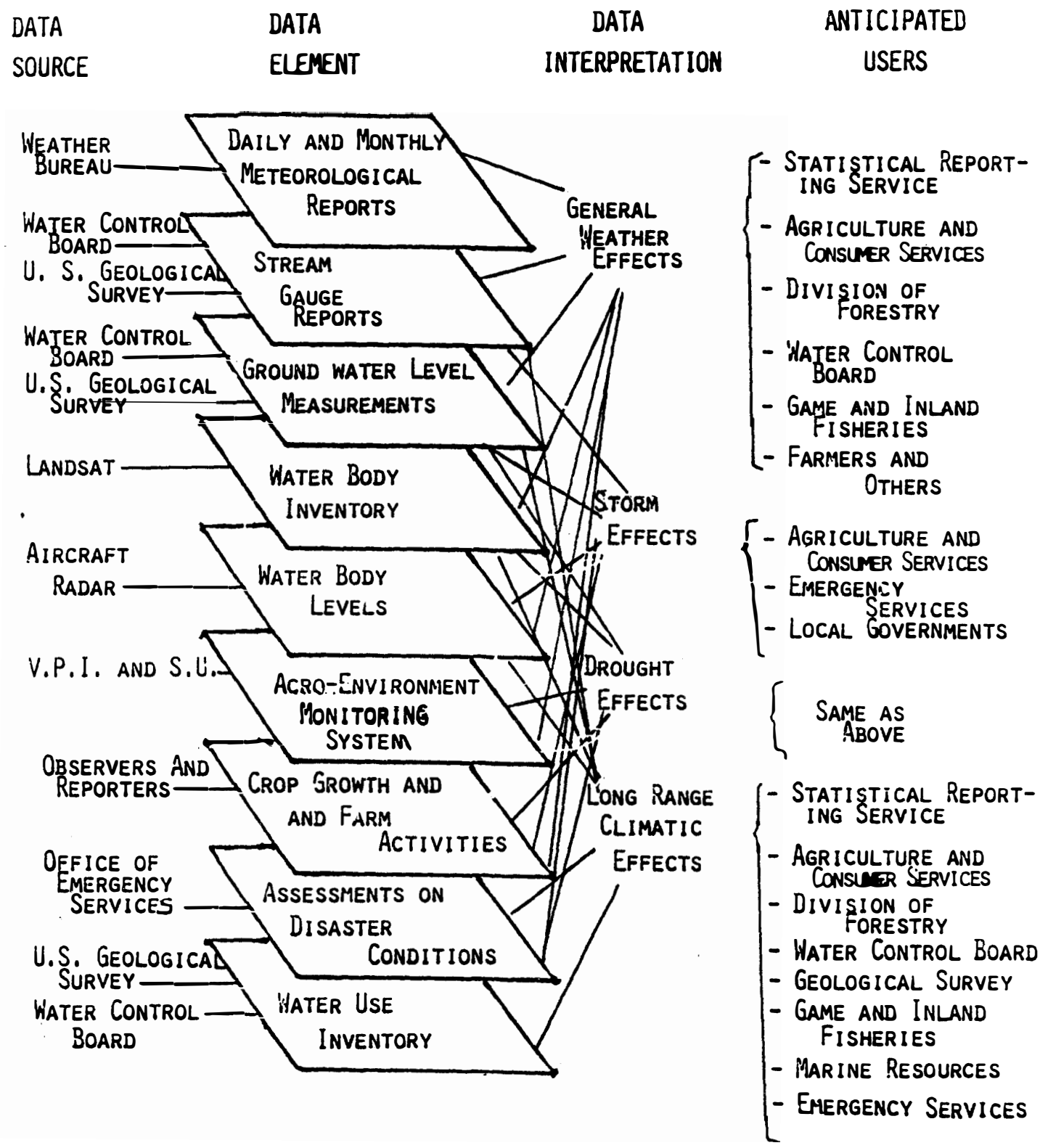


CHART # 9

MONITORING CROPS, FOREST AND PRODUCTION CONDITIONS
(A CONCEPT)

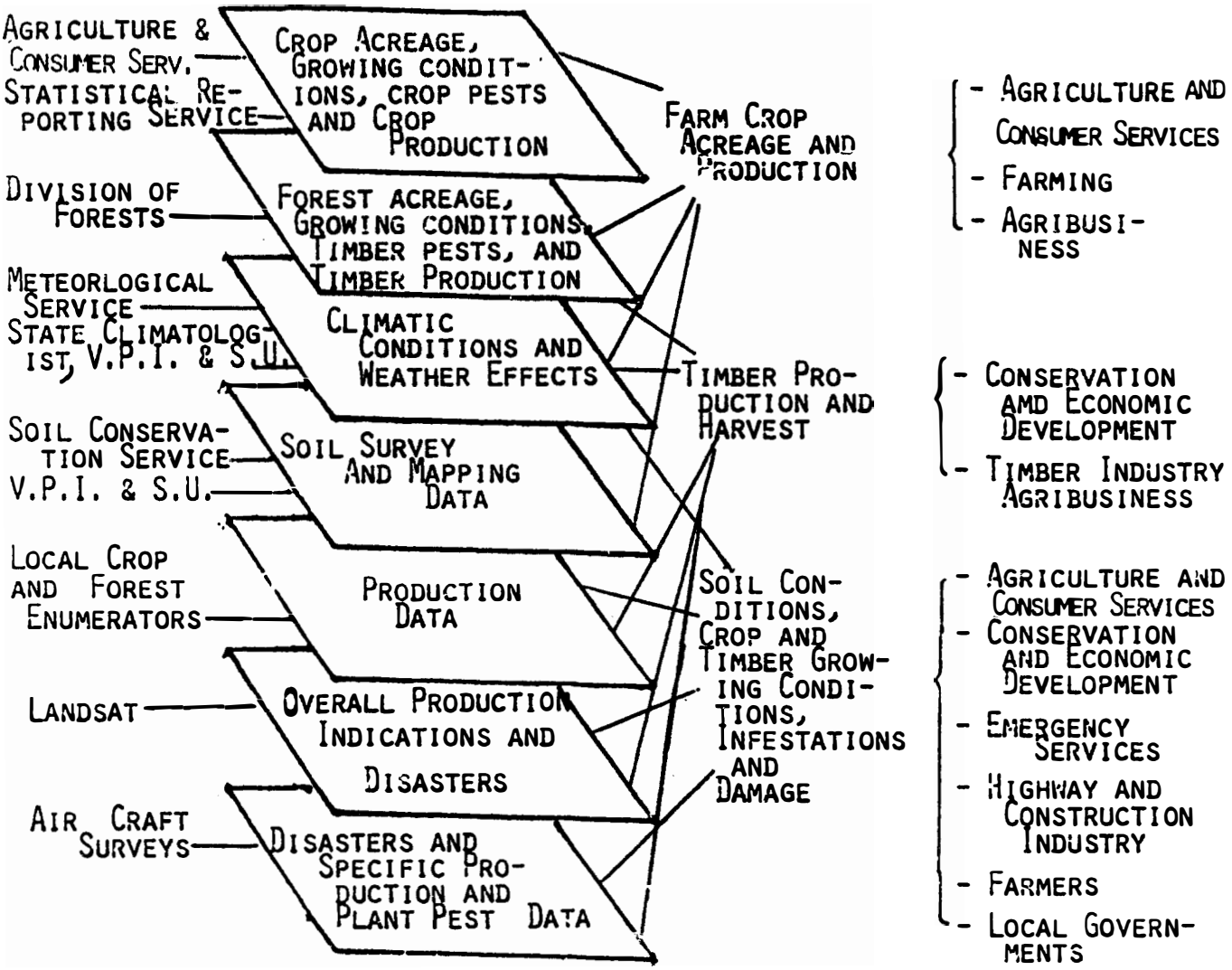


CHART # 10

MONITORING - FORESTS, TIMBER PRODUCTION AND REFORESTATION
(CONCEPT)

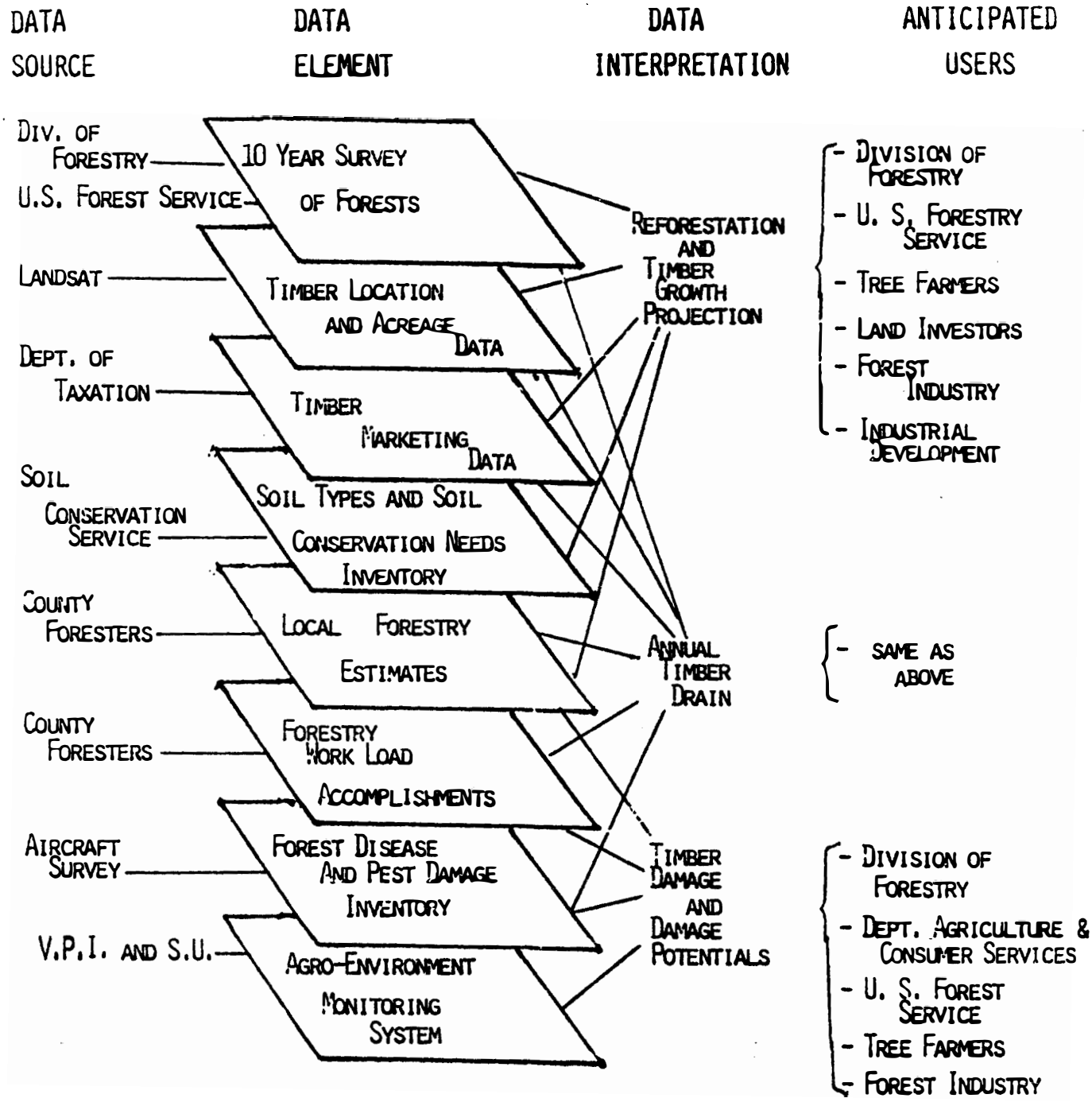
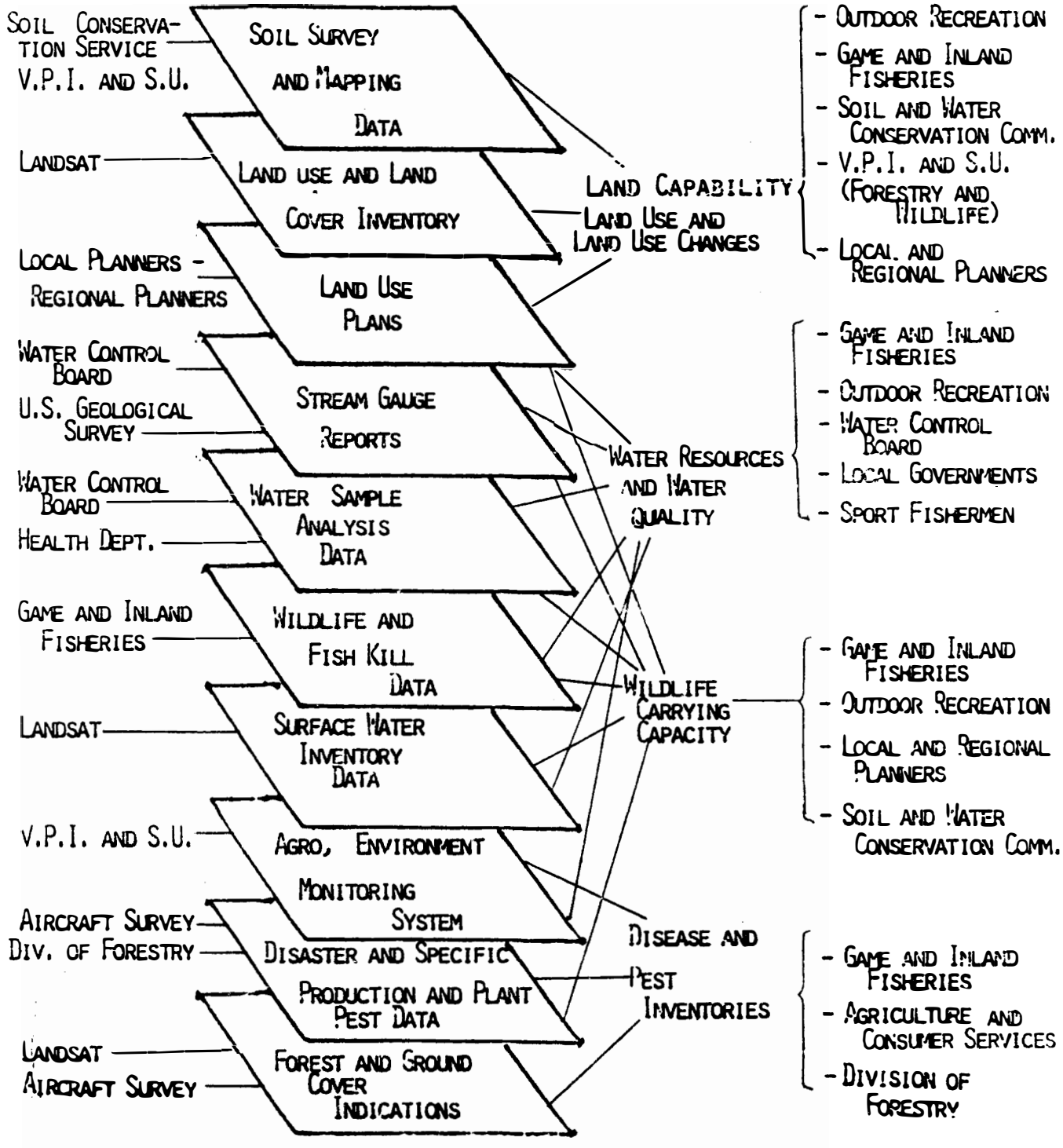


CHART # 11

MONITORING - WILDLIFE, WILDLIFE COVER, FISHERY AND MARINE RESOURCES (CONCEPT)



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