

Jean C. Prior  
Iowa Geological Survey

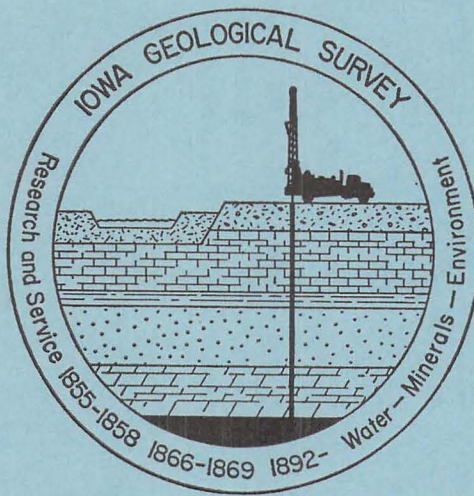
# ANNUAL REPORT

*of the*

STATE GEOLOGIST

*to the*

GEOLOGICAL BOARD



Volume 47

30 June 1976

GEOLOGICAL BOARD

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STATE OF IOWA  
**IOWA GEOLOGICAL SURVEY**

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**Iowa**  
a place to grow

Stanley C. Grant  
Director and State Geologist

Orville J. Van Eck  
Associate State Geologist

Donald L. Koch  
Assistant State Geologist

September 10, 1976

TO: Governor Robert D. Ray, Chairman,  
and Members of the Geological Board

Gentlemen,


Herewith is the Annual Report of the State Geologist made in accordance with the requirements of the Code of Iowa, Section 305.7 and Section 17.4. It describes the activities and accomplishments of the Iowa Geological Survey for the period of 1 July 1975 to 30 June 1976.

This has been an historical year for the Iowa Geological Survey. We have benefitted from our new facilities and found new staff to be particularly helpful in carrying out the assignments of the Geological Board and the Legislature. Significant publications were produced during this year including Land-Use in Iowa 1976 and the first edition of the Newsletter which we hope to produce twice each year in the future.

Significant progress has been made on projects and publications. Several new projects, including the western Iowa water availability study have begun.

The legal responsibilities of the Iowa Geological Survey are set forth in the Iowa Code, Chapters 305 and 84. Additional appointive responsibilities require that the State Geologist or a Survey staff member serve as a technical or scientific advisor to several State government agencies, boards, and commissions.

Respectfully submitted,



Stanley C. Grant  
Director and State Geologist

SCG:rs

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Iowa Geological Survey

ANNUAL REPORT

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1 July 1976

Figure 1 shows the table of organization for the Geological Survey for this date.

Figure 2 shows the functional relationships of the Survey. During the past year the Survey has accomplished the following major tasks:

I. GEOLOGICAL SURVEY PUBLICATIONS

1. Anderson, R.A., McAdams, M.P., and Hoyer, B.E., 1976, Land-use in Iowa 1976: Misc. Map Series 5.
2. Huelsbeck, C.J. et. al., 1976, Iowa Geological Survey Newsletter: Vol. 1, No. 1, 40 p.
3. Hallberg, G.R., Anderson, R.A., 1975, Relief Map of Iowa: black line and white line series, scale 1:500,000 and 1:1,000,000.
4. Garvin, P.L., and Van Eck, O.J, 1976, Strippable coal reserve study in seven Iowa counties--Appanoose, Davis, Jasper, Jefferson, Polk, Van Buren and Warren Counties: open file report.

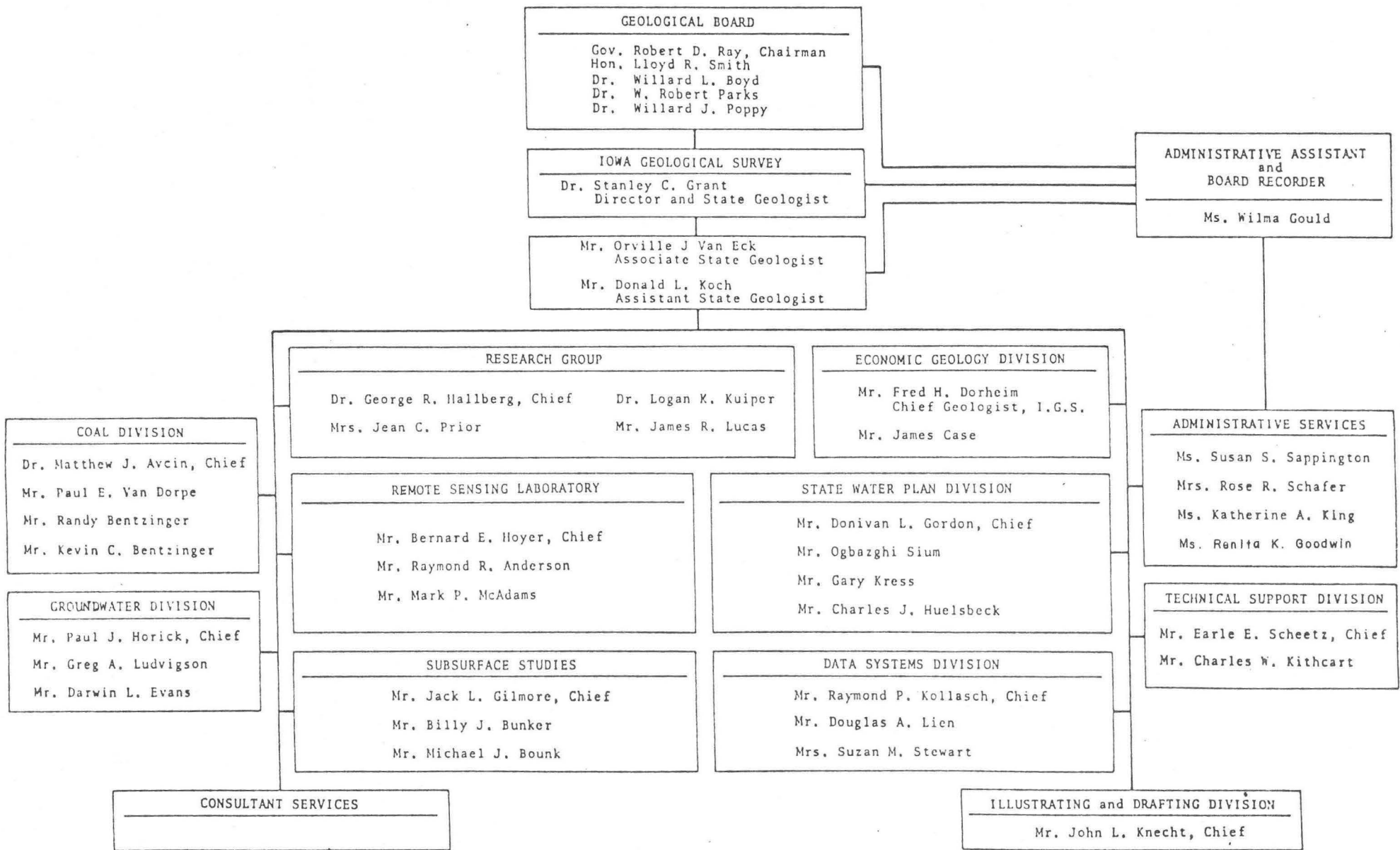


Figure 1. Staff Organization and Responsibility Assignment.

## IOWA GEOLOGICAL SURVEY

### Research Cooperative Programs

U.S. Geological Survey  
Groundwater (50/50)  
Surface Water (50/50)  
National Aeronautics and  
Space Administration  
U.S. Bureau of Mines  
U.S. Geological Survey  
Geologic Division  
U.S. Department of Agriculture

### Consultation, Advisory, and Data-Source Services

Iowa Department of Revenue  
Iowa Water Well Drillers  
Local and Regional Planning Commissions  
Iowa Counties and Municipalities  
Iowa Commerce Commission  
Iowa Development Commission  
Office for Planning and Programming  
Iowa State Department of Health  
Dept. of Environmental Quality  
Air Quality Commission  
Solid Waste Management Division  
Water Quality Commission  
Chemical Technology Commission  
Iowa State Hygienic Laboratory  
Iowa Department of Justice  
Iowa Natural Resources Council  
Iowa Department of Soil Conservation  
Iowa Agricultural Experiment Station  
State Archaeologist  
Iowa Department of Agriculture  
Iowa Department of Transportation  
Iowa Preserves Board  
Iowa Conservation Commission  
The University of Iowa  
Iowa State University  
University of Northern Iowa  
Iowa Department of Public Instruction  
U.S. Department of Agriculture SCS  
Iowa Citizens  
Private Industry  
Engineering Consultants

### Participation in Other Agencies

Iowa State Map Advisory Council  
Iowa Conservation Education Council  
Iowa City Chamber of Commerce  
Environmental Concerns Committee  
Dept. of Environmental Quality  
Inter-Agency Resources Council  
Dept. of Soil Conservation  
Land Rehabilitation Advisory Board  
Watershed Advisory Board  
Conservancy District Task Force  
U.S. Department of Agriculture  
Iowa-Cedar Rivers Basin  
Coordinating Committee  
Energy Policy Council

Fig. 2 Functional Relationships of the Iowa Geological Survey

## II. GEOLOGICAL SURVEY PUBLICATIONS IN FINAL PREPARATION

1. List and index of publications of the Iowa Geological Survey.  
This list will be printed in a loose-leaf format that includes a subject and author index. This format will permit easy revision and updating and will facilitate identification of publications of interest to the user.
2. Drake, L.D., Prior, J.C., Environmental geology atlas of Linn County: Misc. Map Series.
3. Prior, J.C., 1976, A regional guide to Iowa landforms: Ed. Series No. 3, 71 p.
4. Gilmore, J.L., 1976, Gravity survey of the Randalia magnetic anomaly, Fayette County, Iowa: Rept. of Invest. 11.
5. Kuiper, L.K., 1976, A thermal model for the surface temperature of materials on the earth's surface: Tech. Inf. Series No. 1.
6. Gockel, D.J., 1976, Summary of ADP drill hole information: Part I, northeast Iowa: Tech. Inf. Series No. 2.
7. Hallberg, G.R., and Van Zant, K.L., 1976, A late-glacial pollen sequence from northeast Iowa - Sumner bog revisited: Tech. Inf. Series No. 3.
8. Anderson, R.R., 1976, Land-use in Iowa 1976 - an explanation of the map: Tech. Inf. Series No. 4.
9. Hoyer, B.E., 1976, Development and testing of operational flood mapping techniques: Pub. Inf. Circ. No. 6.



10. Horick, Paul J., 1976, Jordan aquifer of Iowa: Misc. Map Series 6.
11. Cagle, J.W., and Heinitz, A.J., Water resources of south-central Iowa: Water Atlas No. 5.
12. Ludvigson, G.A. et. al., Water resources of east-central Iowa: Water Atlas No. 6
13. Steinhilber, W.L., and Hansen, R.H., 1976, Geohydrology of Muscatine Island, Muscatine County, Iowa: Water Supply Bull. No. 11.
14. Garvin, P.L., Van Eck, O.J, 1976, Strippable coal reserve study in Lucas, Mahaska, Marion, Monroe, and Wapello Counties, Iowa: Misc. Map Series 7.

### III. EXTRINSIC PUBLICATIONS

1. Kuiper, L.K., 1975, A state-wide hydrologic model: EOS Trans. Am. Geophys. Union, v. 56, No. 56, p. 982 (abstract).
2. Prior, J.C. (editor), 1975, Karst topography along the Silurian Escarpment in southern Clayton County, Iowa: Geol. Soc. Ia. Field Trip, 13 p.
3. Hallberg, G.R., 1976, The use of COLE values for soil engineering evaluation: Soil Sci. Soc. Am. Jour., in preparation.
4. Hoyer, B.E., and Hallberg, G.R., (contributing authors), 1975, Water Resources Assessment, in American Society of Photogrammetry, Manual of remote sensing, Falls Church, Va., p. 1479-1552.
5. Harmon, R.S., Schwarcz, H.P., Ford, D.C., and Koch, D.L., 1976, The Wisconsinan glaciation in the terrestrial record - a comparison of the glacial stratigraphic and speleothem oxygen isotopic records: in preparation.

Publications sales increased over the past ten years from about \$2,000 for fiscal 1967 to nearly \$9,000 for fiscal 1976 (fig. 3). Several factors account for this increased demand for geologic and hydrologic information:

1. Availability of the popular 7-1/2 minute topographic map quadrangle has increased from about 25% coverage of the State in 1967 to nearly 60% in 1975. These maps are utilized by engineers in planning pipeline routes for hydrocarbon products, distribution lines for rural water systems, and for location of electrical power lines and transpor-

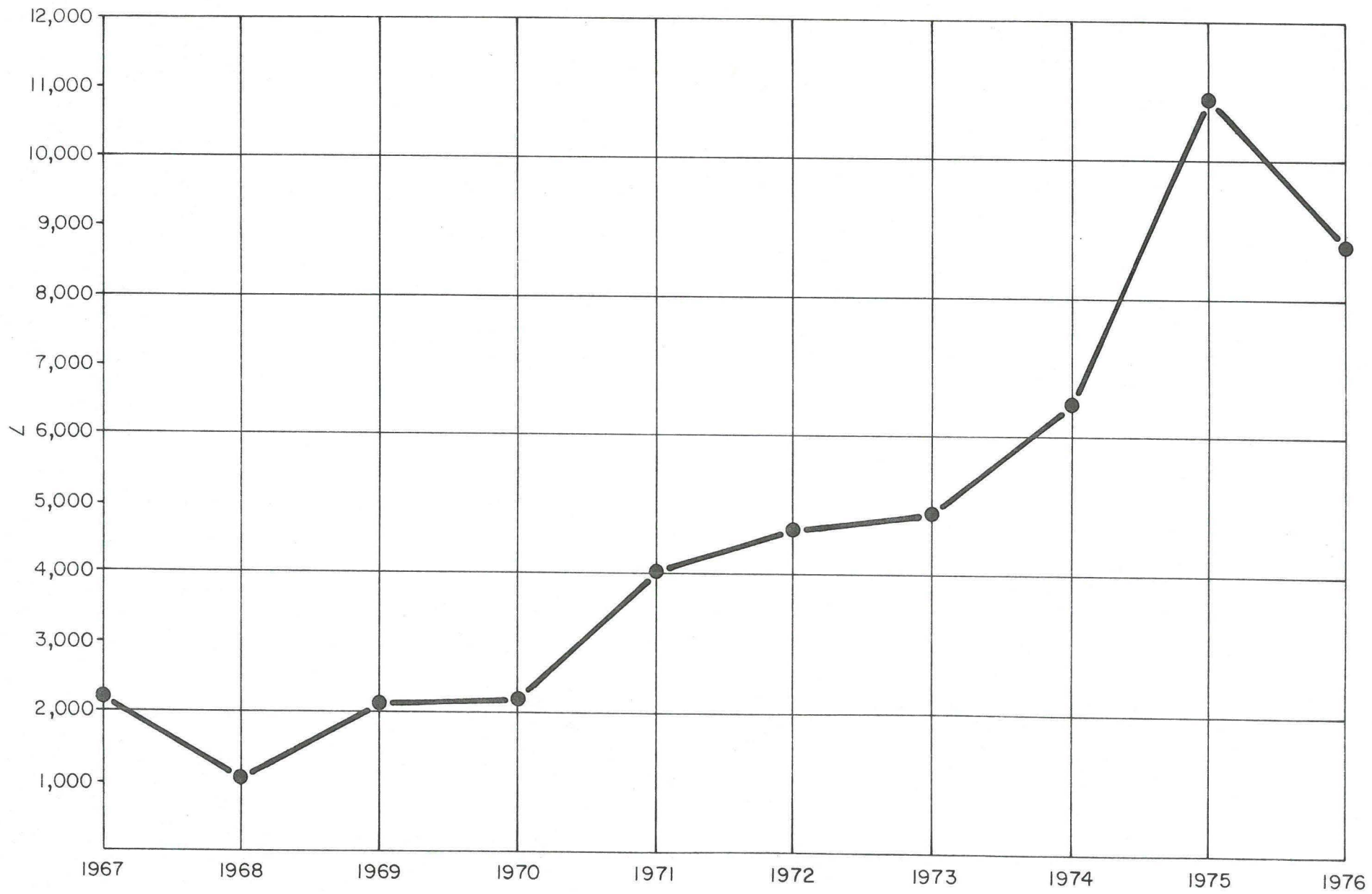


Figure 3. Publications Sales by Fiscal Year.

tation routes. The maps are relied upon for many other construction projects where information is needed for vertical control and slope analysis, or where information is required for drainage basin studies and zoning of flood plains.

2. The format for presentation of water resources information was changed so that the information can be readily understood and used by those with no background in geology or geohydrology. Publication of The Water Story in Central Iowa in 1965, and Mississippian Aquifer of Iowa in 1973 confirmed the need for less esoteric reports, with supporting illustrations, that can be utilized by engineers, well contractors and private citizens in planning and developing water supplies.
3. An awareness by society in the past decade of the necessity to live in a rational state of balance with nature has resulted in a greater appreciation of our natural surroundings. Fossils and Rocks of Eastern Iowa (1967) and The Minerals of Iowa (1974) were extremely well received by the public. A Regional Guide to Iowa Landforms, the latest publication in our Educational Series, doubtless will receive widespread appreciation.

#### IV. CONSULTATIVE, ADVISORY, AND DATA-SOURCE SERVICES

##### Well Predictions

Requests for information on ground-water resources for private,

municipal, industrial and other uses constitute a continuously increasing portion of work assigned to staff of both the Ground Water Division and the Subsurface Division. Information is provided on water availability and water quality for each potential aquifer source at the respective development site. Extant data is summarized in the form of letter reports, or, when information is needed immediately, as telephoned reports. The requests derive from a wide range of users as follows:

<u>Category</u>	<u>No.</u>
Municipal	52
Industrial	16
Domestic	75
Feedlots	16
Irrigation	32
Recreational	10
Rural Water Districts	3
Other	55
Total	<u>259</u>

#### Well Logging

Drill cuttings from approximately 50 wells were logged for a total footage of about 11,000 feet. Because in most well drilling procedures a sample is collected for each 5-feet of drill penetration, the detailed logging (descriptive and colored graphics) of 11,000 feet of drill samples means a microscopic study of about 2,200 individual samples.

With the increased load of service work, the number of sample sets and total footage logged has decreased markedly over the last six years. Currently, samples from about 6,000 different wells remain to be studied. Emphasis is being placed on the logging of deep municipal and industrial wells, and those wells located within special project areas, such as the coal exploration program.

#### Casing Points

Drill cuttings from five municipal wells were examined during the drilling of the wells to define optimum casing points for various well contractors and engineers. The average depth of these wells is 1,600 feet. Verification of formation tops by the Geological Survey is relied upon to insure that drilling has reached proper depth for placement of casing in wells.

#### Oil and Gas Administrator

The State Geologist is designated Administrator of Oil and Gas under Chapter 84, Code of Iowa. In this capacity the Geological Survey reviewed and processed 15 applications for drilling permits during the period of 1 July 1975 to 1 July 1976. All of these were issued to Natural Gas Pipeline Company of America for injection/withdrawal wells at their underground storage facilities at Cairo and Columbus City, Louisa County.

Drilling statistics accumulated in the administration of Chapter 84 were reported quarterly to the Iowa Natural Resources Council and monthly to the American Petroleum Institute.

The Geological Survey continues to serve as consultant to the Iowa Commerce Commission in the review of procedures being followed by Northern Natural Gas Company in the abandonment of the Vincent gas-storage facility. The original acreage under lease for this facility when abandonment began in 1971 was 12,373 acres. Gas Storage Agreements on approximately 10,133 acres on the outer periphery of the field have been dropped through December, 1975. This leaves 2,240 acres remaining under lease. The total gas-in-place as of May 26, 1976 was 2,688,831 Mcf (thousand cubic feet), a reduction of 176,503 Mcf from the same date one year ago.

#### Requests for Information

The Survey regularly responds to a large number of requests for geologic and hydrologic information. With the onset of public concern over environmental and energy problems, the number of requests has increased substantially. The manner in which the requests are answered is largely predicated by the nature and scope of the request.

For those requests that are general in nature, one of the publications of the Survey often will fulfill the needs. For those of a more specific or localized nature a special letter report is prepared. These reports are generally interpretive.

In contrast to the requests for interpretive reports, we also are called upon to supply much data. Recognizing this need some time ago,

we have worked to develop an automated geologic and hydrologic data bank. These efforts have progressed to the point where we now can provide such data to well drillers, planning agencies, engineers and so forth, rapidly with comparatively little demand on staff time and at a nominal cost to the user.

Coincident with the public concern about energy and environmental problems has come a greater demand for public addresses by staff members. These have ranged from short presentations to various service groups to seminars devoted to specific subjects. The results have been gratifying in that there seems to have developed among the general public an entirely new appreciation of our earth resources.

#### Consultative Contacts

The Survey is often called upon to provide consultative services to various state agencies, industries, and individuals. These services frequently require interpretation of data and quite often on-site investigations in various parts of the state. The following tabulation indicates the approximate number of contacts that fall within this category:

<u>Agency or Group</u>	<u>No. of Contacts</u>
Iowa Natural Resources Council	25
Iowa Commerce Commission	12
Department of Environmental Quality	82
Iowa Conservation Commission	25
Iowa Department of Transportation	10



<u>Agency or Group</u>	<u>No. of Contacts</u>
Office for Planning and Programming	6
Energy Policy Council	5
Iowa Department of Public Instruction	5
Iowa Health Department	5
Iowa Development Commission	6
Iowa Department of Justice	9
State Hygienic Laboratory	9
State Archaeologist	16
Iowa Department of Soil Conservation	14
State Universities and Public Schools	55
Counties and Cities	69
Federal Agencies (U.S.D.A., F.H.A., etc.)	72
Engineering Consultants	98
Water Well Drillers	85
Industry	58
Individual Citizens	<u>143</u>
Total	804

## Sanitary Landfills

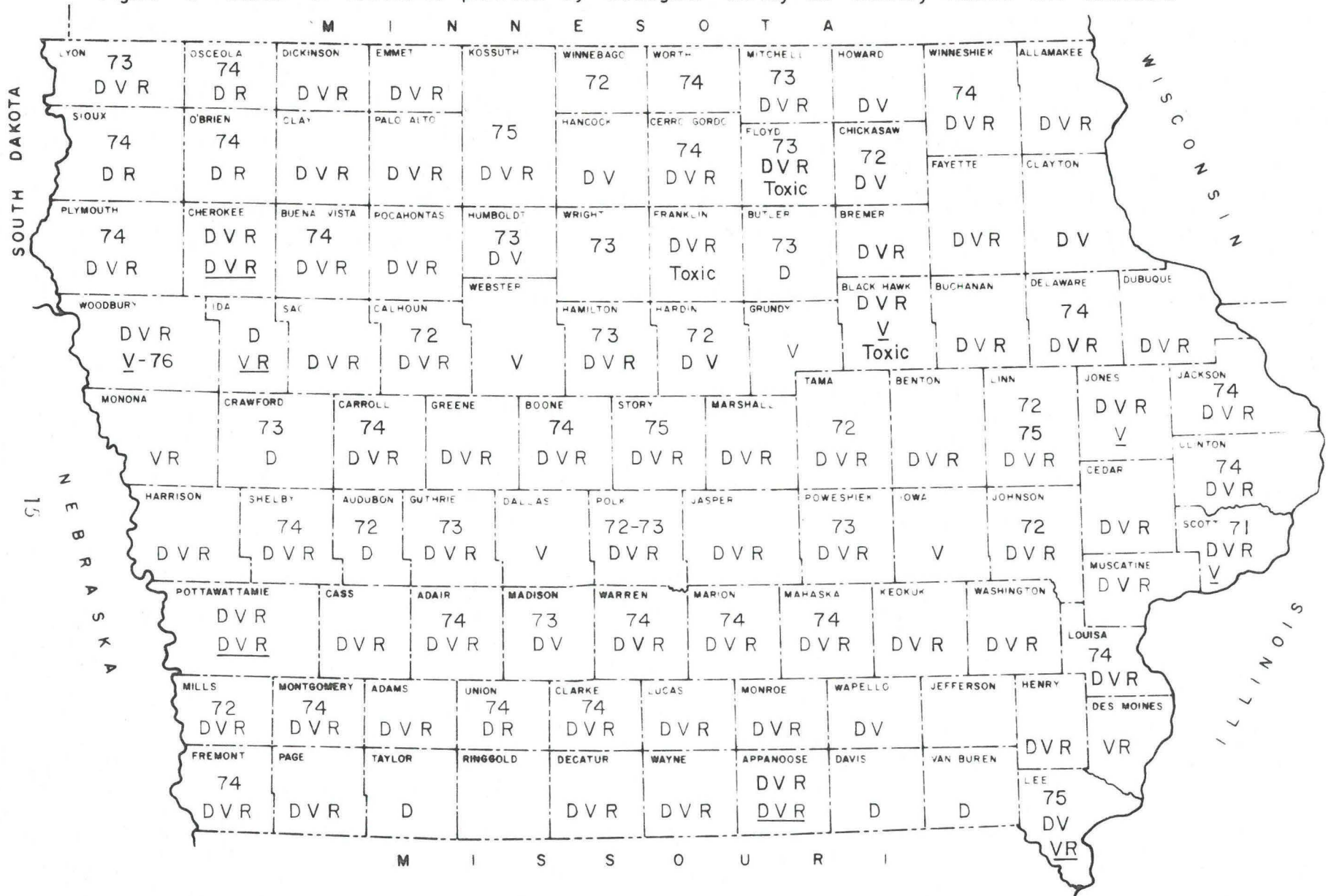
The Geological Survey established geologic and hydrologic criteria to be included in the rules that govern sanitary landfill siting, under the jurisdiction of the Solid Waste Management Division, Department of Environmental Quality. These criteria are designed to protect the water resources of the state. To assist municipal and county governmental agencies in the selection of sites that will best meet the geologic and hydrologic criteria, the Geological Survey has upon request either furnished extant data, made on-site inspections, or conducted earth-resistivity surveys on potential landfill sites for those county or local governmental agencies that had no operating permit from the Department of Environmental Quality as of 1 July 1975 (fig. 4). In addition to site investigations for toxic waste disposal in Black Hawk, Floyd and Franklin Counties, I.G.S. has provided data and has made site inspections and/or earth resistivity surveys for counties that already are seeking new landfill sites. The Keokuk County landfill facility is approaching capacity earlier than was anticipated, and the Woodbury County facility is seeking a second facility to accomodate solid wastes that are objected to at the present site.

## V. RESEARCH

### 1. Strippable Coal Reserves

In December, 1975 the Geological Survey received a grant of \$15,854 from the U.S. Bureau of Mines for support of a project entitled Strippable Coal Reserve Study in Seven Iowa Counties (fig. 5). The counties

Figure 4. Status of assistance provided by Geological Survey for sanitary landfill site selection.



71 - Date permit issued by DEQ  
 D - IGS data requested and provided  
 V - IGS site inspection  
 R - IGS Earth Restivity Survey

Toxic - Visit and public hearing  
DVR - 1976 Work Activities

1 JULY 1976

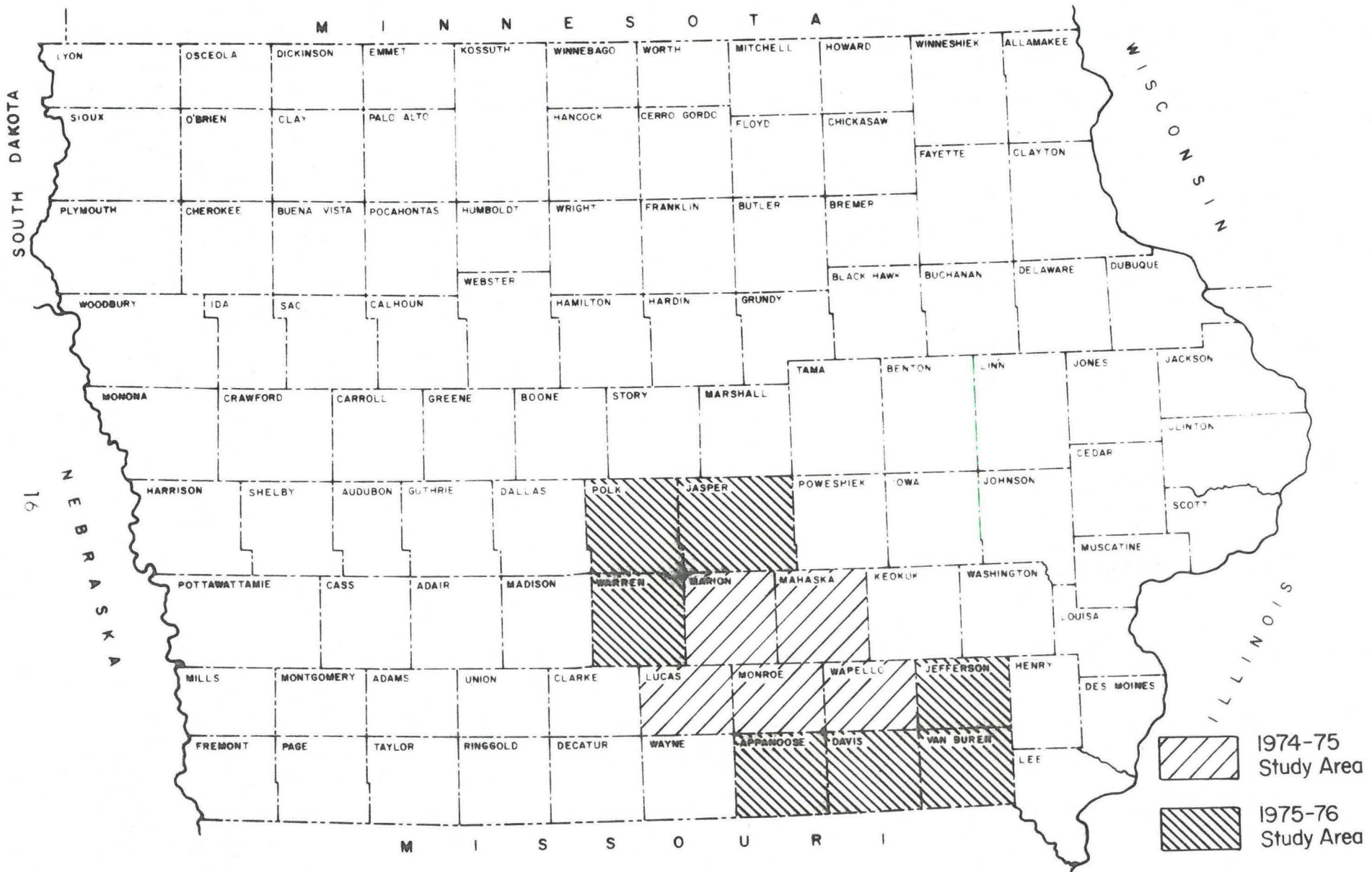


Figure 5. Strippable Coal-Reserves Study Areas

included in the study are Appanoose, Davis, Jasper, Jefferson, Polk, Van Buren and Warren. Those counties were selected for study because it was estimated that sufficient stratigraphic control exists to permit valid evaluations for the U.S. Bureau of Mines needs.

The study will provide an estimation of the amount of coal reserves recoverable by surface mining techniques. Reserves will be calculated in the categories of measured-indicated (most accurate) and inferred (less accurate) for coals 28-42 inches thick and greater than 42 inches thick under overburden thicknesses of 0-50, 50-100 and 100-150 feet.

Completion date for the study is scheduled for August, 1976, at which time a report will be filed with the U.S. Bureau of Mines and released to the public. This is a companion study to a similar study completed in May 1975 that estimated strippable coal reserves for Lucas, Mahaska, Marion, Monroe and Wapello Counties.

## 2. Coal Research Project

The research goals of this project were presented in the 30 June 1974 Annual Report.

The drilling phase of the project continued at a satisfactory rate, despite changes in personnel on the drilling crew. Drill sites were located on approximately six-mile centers, with a few intermediate sites selected where additional stratigraphic control was necessary.

Twenty-one holes were drilled with a cumulative drilling footage of 6,272 feet, of which 3,869 feet were in the coal-bearing rocks of the

Pennsylvanian System and were core sampled. The remainder of the drilled footage was in the unconsolidated materials overlying the rocks of the Pennsylvanian System.

The cumulative footage represents an increase of 7.3% over that of the preceding year. In the 21 cores, a total of 84 coals were encountered, of which 38 were 14 inches or greater in thickness. Coals less than 14 inches thick are not considered in coal reserve estimates in conformity with standard procedures followed by the U.S. Bureau of Mines. The 38 coals 14 inches or greater have a cumulative thickness of 79.68 feet, or an average thickness of approximately 2.09 feet. A further breakdown shows the following distribution:

<u>Thickness category</u>	<u>No. of coals</u>	<u>Total thickness</u>	<u>Average thickness</u>
14 to 28 inches	25	37.21 feet	1.49 feet
28 to 42 inches	9	24.05 feet	2.67 feet
over 42 inches	4	18.42 feet	4.60 feet

These data can be translated into reserve estimates by using standard procedures. Coal weight is considered to be 1,800 tons per acre foot, measured reserves are considered within a one-quarter mile radius of the data point, and inferred reserves are considered outside a one-quarter mile radius but within a one-mile radius of the data point. With these constraints, the drilling accomplished this year shows the following reserves:

<u>Thickness category (inches)</u>	<u>Measured (tons)</u>	<u>Inferred (tons)</u>	<u>Total (tons)</u>
14-28	8,418,589	126,278,825	134,697,414
28-42	5,431,933	81,479,006	86,910,939
42-	<u>4,166,864</u>	<u>62,502,956</u>	<u>66,669,820</u>
Total	18,017,386	270,260,787	288,278,173
Total (fiscal '75, '76)	37,269,402	559,191,027	596,460,429

An additional 104,796,170 tons of coal in beds less than 14 inches thick have been identified, compared with 65,111,040 tons for fiscal 1975. Although coals that thin probably never will be mined, they do constitute a potential resource if in situ gasification is developed as a viable technology.

Although the cores drilled to date have provided data that permit preliminary interpretation of depositional environments, they reveal a complexity of geologic events. Several analytical studies have been initiated that will provide additional information on coal and the containing rocks:

1. Analysis of coal quality.
2. Trace metal analysis .
3. Spore and pollen composition of the coals.
4. Botanical composition of the coals.
5. Fossil content of rocks above and below the coals.
6. Ceramic properties of clay minerals above and below the coals.

Data on quality and trace element analysis of Iowa coal is being generated through cooperative programs with the U.S. Geological Survey and the U.S. Bureau of Mines. Studies of fossil flora and fauna of Iowa coals and the containing rocks, conducted in cooperation with various university researchers, are designed to develop a better understanding of coal occurrence, to develop a tool for identification of a particular coal, and to determine which trace elements are concentrated by the plants that make up the coal.

Personnel of the Coal Research Project have assisted the Soil Conservation Service in the development of an adequate strip mine code for Iowa. In addition, I.G.S. has developed communications with Iowa coal producers and out-of-state mining companies with interest in Iowa coal.

### 3. Pleistocene Stratigraphy, Southwestern Iowa

The Geological Survey is participating in a joint project with the Nebraska Conservation and Survey Division to evaluate the Pleistocene stratigraphy of southwestern Iowa in relation to volcanic ash beds which may be radiometrically dated. This will provide a framework for an absolute chronology of these deposits, and is a significant aspect of safety analyses for proposed nuclear power-plant sites in Iowa and adjacent states.

The Nebraska Conservation and Survey Division (N.C.S.D.) is doing the test drilling and N.C.S.D. and I.G.S. are jointly evaluating



the stratigraphy and conducting laboratory analyses of the materials. Data on engineering and hydrologic properties are also being collected. To date, eight sites have been test drilled and cored with a total footage of approximately 1,660 feet.

#### 4. Electrical Resistivity of Earth Materials

The increased use of electrical resistivity data to interpret the sequence of unconsolidated materials overlying bedrock has led to extensive testing of computer programs for data reduction and analysis of sounding curves. A computer program has been refined that will indicate the most reliable stratigraphic breaks for traverses that are designed for penetration depths of about 100 feet. This geophysical method provides a relatively inexpensive reconnaissance tool for investigating unconsolidated earth materials, especially sand and gravel deposits, in valleys of the state's interior streams.

#### 5. Randalia Gravity Anomaly, Fayette County

The analysis and interpretation of supplementary gravity data on an anomaly delineated from an aeromagnetic survey of northeastern Iowa has been completed. The gravity survey included 240 observation stations located at section corners from central to Western Fayette County. Analysis of the simple Bouguer map, residual gravity maps, and gravity profiles suggests that the observed gravity anomalies probably derive primarily from large fault blocks within the Precambrian crystalline complex

and related variations in the thickness of superjacent clastic deposits. Two areas that exhibit high gravity and magnetic values may warrant exploration for potential mineralization.

6. Cherokee Sewer Site

The National Science Foundation awarded the Geological Survey \$5,842 as a subcontract to the University of Iowa to participate in the construction of an environmental model for the last 10,000 years in Iowa. The Cherokee Sewer Site contains a series of at least three horizons of soil development with associated human artifacts and events. These horizons were buried by earth materials that were washed into the Little Sioux Valley from the uplands. Data obtained on buried soils, artifacts, animal bones, burned seeds and wood, and snail shells will provide a unique opportunity to reconstruct the changing climate and environment of the region over approximately the last 10,000 years.

VI. COOPERATIVE RESEARCH

To implement geologic and hydrologic research in Iowa, the Geological Survey uses the authority granted in Section 305.8, Code of Iowa, to cooperate with federal agencies in cost-sharing programs.

During the current reporting period, the survey continued a 50/50 cost-sharing cooperative program with the Water Resources Division of the U.S. Geological Survey. The objectives of the program are threefold: (1) to inventory the groundwater resource, which involves

an overall appraisal of groundwater occurrence and quality in an aquifer- or basin-wide organization of information; (2) to maintain surveillance of the groundwater resources which involves maintaining a network of observation wells to determine water-level and chemical quality changes; and (3) to maintain a system for collection and compilation of basic records of daily stage and flow rate of streams, and the concentration and total load of sediments carried by streams. The data gathered in these programs form the foundation for good water-management policies and comprehensive planning.

In addition to the broad program objectives, the Iowa Geological Survey is actively cooperating in the following research projects:

1. Hydrology of Carbonate Aquifers of the Eastern Iowa Groundwater District.

The research objectives for this project were outlined in the 30 June 1973 Annual Report.

The principal work activity for the reporting period involved cleaning and/or reaming of previously drilled holes in order to obtain a suite of down-hole geophysical logs and to obtain quantitative water production data. Seven additional deep wells were drilled at locations where additional stratigraphic and hydrologic data were needed. Automatic recorders have been placed on five wells to monitor fluctuations of water levels in the various aquifers penetrated. A tabulation of drill samples recovered for specific purposes follows:

<u>Type of Sample</u>	<u>Sample Use</u>	<u>Footage Drilled</u>
1. Cuttings from unconsolidated sediments (Pleistocene deposits).	Lithologies and stratigraphic control.	663
2. Rock cuttings.	Stratigraphic control, structural mapping.	2,203
3. 2-1/8" dia. rock core.	Porosity and permeability tests, quantitative chemistry; Petrology & diagenesis.	<u>906</u>
	Total	3,772

The integration of surface and subsurface geologic and hydrologic data that includes analyses of core samples, down-hole geophysical logs, and information from pumping tests, permit delineation of the major water bearing zones of the region. Previously, little was known concerning the relationships of these zones to the regional structure and stratigraphy. The Silurian age rock units, although generally considered to constitute a good aquifer, historically have been undifferentiated in subsurface work. Core drilling alone has not solved this problem, but combined with borehole geophysics, recognizable horizons have been observed within the system. One of these zones outcrops as the main cavern zone of the Maquoketa Cave System in Jackson county.

The investigation has also revealed that the structure of the area is not as simple as previously conceived. A study by the Illinois

Geological Survey has defined a fault zone that extends from western Illinois into east-central Iowa. This zone, formerly termed the "Savanna-Sabula Anticline" has now been renamed the Plum River Fault Zone. Analysis of structural data obtained from the carbonate hydrology project suggests that this fault zone continues westward into Linn County, Iowa. Vertical displacement near the fault may have played an important role in the deposition and deformation of the Devonian Wapsipinicon formation, and may control differences in the quantity of water available from wells on either side of the fault trace.

## 2. Jordan Aquifer Research

The Jordan aquifer constitutes the most widespread source of relatively large yields of good to moderate quality groundwater in Iowa. It is the source of supply for many municipalities and industries in the state. As a result, the capabilities of the aquifer to meet the withdrawal demands are being severely taxed in some areas. This is evidenced by significant losses in pressure head at a number of points in the state. For example, at Ottumwa the pressure head has decreased 100 feet in 70 years, at Grinnell 100 feet in 80 years, and at Mason City 140-200 feet in 57 years. In an artesian aquifer such as the Jordan, these affects have to be widespread.

To determine just how widespread and significant the head loss is, we have conducted inventories on all wells in the state that produce

water from the Jordan aquifer. The inventory includes measurement of the depth to the non-pumping water level to determine what head loss has occurred. We are also gathering well production records to determine how much water has been pumped from the aquifer at that point. From these data we will be able to not only define the historic loss of pressure head in the aquifer but also to predict future loss.

The information is to be presented in a Water Atlas. Also to be included are maps depicting variations in water quality in the aquifer.

### 3. Irrigation in Iowa

The number of applications for irrigation permits received by the Iowa Natural Resources Council has increased markedly during the past two years. In response to the growing interest in irrigation in Iowa, and at the request of the Governor, the Geological Survey began a review of the status of irrigation, including an analysis of the several uses of water for irrigation, the permitted rates and volumes of water withdrawal, the availability of water for irrigation, the climatic conditions (historical and present) that have resulted in the current trend of increased use of water for irrigation, the economics of irrigation, and the potential problems that follow as a consequence of irrigation, such as aquifer depletion, soil erosion and increased energy consumption. A status report on irrigation in Iowa will be submitted to the Geological Board upon completion of this review.

Because of the likelihood of drought conditions in parts of Iowa during 1976, especially in northern and western Iowa, the Iowa and U.S. Geological Surveys developed preliminary plans to investigate the availability of water from the alluvial aquifers of interior streams in these regions. The study will include an inventory of present water withdrawals for municipal, irrigation, and domestic use, geophysical exploration for thick alluvial sand and gravel deposits, and drilling and aquifer testing. The first study area is along the Floyd River north of Sioux City.

Notwithstanding the impact of irrigation on available water resources, some areas have been burdened with water supply and/or quality problems for many years. Future investigations should include studies of alluvial aquifers of other river basins and the Dakota Sandstone Formation, the principal bedrock aquifer of northwest Iowa.

4. Water Atlases for South-central and East-central Iowa

Data collection and interpretive analysis of geologic and hydrologic information has been completed for these regions. The published atlases will include water resource information on all of the aquifers within the two regions.

5. Cooperative Applied Soils Research

During the past several years representatives of the Iowa Soil Survey Program from the U.S. Soil Conservation Service, the State

Soil Survey staff of Iowa State University Experiment Station, the Iowa and U.S. Geological Surveys, and members of the Soils Engineering Group at Iowa State University have discussed and initiated a cooperative integrated program of research and information exchange. These efforts have grown into an active and mutually beneficial program.

The purpose of the program is to form an integrated research team applying the different kinds of available expertise to the mutual problems of the represented groups. Each of the represented disciplines utilize many of the same techniques in the analysis of materials to solve their individual problems. These data can and should be jointly collected and used.

Each of the groups involved have various resources and facilities to contribute. For maximum effectiveness, there must be a core of people involved from each of the disciplines for two reasons: (1) To translate the results and utility of the combined data to specialists in their field; and (2) To make the overall program and its resultant data credible to specialists and others outside the cooperative group who will be the critical users.

Hopefully, the end product of these efforts is information on the physical limitations of the land and water resources of the state which has not been available before. It is expected that this information will aid in the wise and judicious use of Iowa's resources, which are a part of the charge of all of the participating groups.



As part of this effort the Iowa Geological Survey is providing basic geologic data to aid in the initial stages of the County Soil Survey, such as:

1. The thickness of unconsolidated material and the topography of the bedrock;
2. The distribution and lithology of rock outcrops;
3. Flood hazard maps;
4. The general nature and distribution of geologic materials, which may include providing computer printouts of well logs, or typical well logs for different areas of the county;
5. The participation of Geological Survey staff in soil survey field reviews, which is educational for all involved.

In addition, the Geological Survey is carrying on the following specific studies as part of this cooperative research effort:

1. Comparison and correlation of particular soil series with large magnitude floods. This analysis has been very successful to date. It appears that soil series can be quantified adequately to allow the extrapolation of flood hazard areas with soil survey information. This potentially presents a very useful planning tool. During this past year work was initiated with the Johnson County Zoning Board to assist in the development of their floodplain zoning ordinance using this information. Similar assistance was provided to

several communities and counties relative to flood insurance and flood damage assessment problems.

2. The stratigraphic, mineralogic, and hydrologic analysis of unconsolidated materials in eastern Iowa. The Iowa-U.S. Geological Survey Carbonate Aquifer Program involves detailed test drilling to analyze the nature of the unconsolidated materials. Part of this study will include the relationship of soils and parent materials, and their relationship to groundwater recharge and availability in eastern Iowa.
3. Quantification of soils engineering information. The number of requests received for soils engineering information is increasing. For this reason the Iowa Cooperative Soil Survey Program is attempting to quantify engineering ratings to enhance the use, understanding, and confidence in utilizing this information for such things as preliminary site evaluation. An active program to quantify cohesion, angle of internal friction, bearing capacity, optimum moisture and density, Atterberg limits, shrinkage properties, etc., is underway for soil profiles and their geologically correlative parent materials. This program will provide data useful for foundation engineering planning in particular.

About 30 sites have been investigated to date, and data has been obtained on approximately 90 soil series. It has been suggested that the Geological Survey and the Iowa Cooperative Soil Survey sponsor a short course for engineers and consultants to discuss how to best utilize this information.

4. Cooperative evaluation of the use of remote sensing in soil surveys.
5. Continuing evaluation of the stratigraphy, mineralogy, hydrology, and geochronology of the unconsolidated materials of the state, including detailed soil-geomorphic studies to model soil-landscape relationships. This year joint detailed studies were conducted in Butler, Calhoun, Carroll, Des Moines, Marshall, and Webster Counties. Another detailed cooperative investigation was initiated in Johnson County which involves the National Soil Survey Laboratory staff, Lincoln, Nebraska.
6. Sand and gravel resources. Soil survey information provides a data base for the location of potential sand and gravel resources.

## VII. COMPREHENSIVE STATE WATER PLAN

The Geological Survey staff assigned to the Water Plan Division have concentrated their efforts on the task of developing three comprehensive

reports for the Iowa Water Resources Framework Study. These reports were the assigned responsibility of three water plan study task forces chaired by the Geological Survey, namely: Data Base and Needs, Water Availability, and Fuel and Energy. The task force reports for the latter two categories have been forwarded to the technical coordinating committee for review. The report of the task force on Data Base and Needs will be completed in July, 1976.

As an adjunct of the Iowa Water Resources Data System (IWARDS), another Geological Survey function in support of state water planning, the Water Plan Division has been working cooperatively with the Survey's Data System Division in the development of an IWARDS catalog. Three sections of this catalog are nearly completed; an index of state and federal agencies, and state institutions involved in water resources management and/or data collection which will define their responsibilities, data collection programs, and current activities; a cross-referenced subject index of the Iowa Legal Code and the Iowa Administrative Code regulations pertinent to water resources; and finally, a subject-indexed bibliography of Iowa water resources publications. The bibliographic material, in time, will include all water-related publications. However, the initial section which is now being developed includes primarily measurement information and data references. It presently consists of over 600 references.

Apart from in-house functions in support of the water plan effort,

staff of the Geological Survey have participated further as:

member-	Technical Coordinating Committee - State Water Plan
chairman-	Task Force on Data Base and Needs
chairman-	Task Force on Water Resources Availability
chairman-	Task Force on Fuel and Energy
member-	Advisory Committee to IWARDS
member-	Water Resources Framework Study Committee

#### VIII. MIDWESTERN GOVERNORS' CONFERENCE TASK FORCE ON MIDWEST ENERGY REQUIREMENTS AND ENVIRONMENTAL PROTECTION

In August, 1972, the Midwestern Governors' Conference under the Chairmanship of Governor Robert D. Ray established the Task Force on Energy Requirements and Environmental Protection. The task force serves as advisory body and as a forum for information exchange in the fields of natural resources, energy and environmental protection to the Governors of the 15 included states. The Iowa task force delegation is composed of the State Geologist, the Director of the Energy Policy Council and the Chairman of the Iowa Commerce Commission.

The Geological Survey has supported the task force by providing information on coal and water resources for electrical power generating plants, and by participation in discussions that resulted in the proposed policy statements for consideration at the Midwest Governors Conference.

During the 7-8 April 1976 meeting of the Midwest Governors' Conference Task Force on Energy, a three-man subcommittee that included Dr. Stanley C. Grant was appointed to investigate uranium supplies available to fuel the proposed expansion of nuclear power plants

in the United States. The results of this investigation were reported at the 16 June 1976 Energy Task Force Meeting. Inadequacies of federal studies in defining uranium resources and uranium reserves were pointed out in the report, and the principal conclusion was that the availability of supplies of uranium to fuel 300 present generation nuclear plants of the 1,000 megawatt class for their anticipated 30-year life span is questionable.

#### IX. REMOTE SENSING LABORATORY

During the last fiscal year several of the Remote Sensing Laboratory's (RSL) cooperative research and technical assistance programs with other agencies have become operational. The Iowa Conservation Commission is continuing to assess forest diseases and is beginning to obtain imagery of other forested areas. In addition, the Commission is obtaining imagery of much of the recreational land under its management. The U.S. Soil Conservation Service is utilizing color-infrared photography for soil mapping in problem areas, such as the Mississippi River bottomlands. The Rock Island District of the U.S. Army Corps of Engineers plans to continue monitoring major rivers for permit violations and assessment of inundations that result from major floods. Adoption of this flood mapping technique is especially gratifying as it has been a major effort of RSL since 1972.

A significant achievement was the completion and publication of the map, Land-Use in Iowa 1976. This was a major effort in staff time

which involved development of special interpretation skills and the resolution of graphic arts problems. Discussion and review by state agencies and regional planning groups resulted in a product with the highest potential utility.

Less imagery was acquired by RSL as compared with the last fiscal year. In part, this reflects a growing awareness by other agencies of the many potential uses of imagery, to the extent that they are beginning to acquire their own imagery for direct application. For the first time, imagery was acquired at the request of the Attorney General's Office. The RSL continues to catalogue information on extant photography over the state. New imagery acquired by RSL is shown in figure 6.

Two new contracts were entered into during the past year. The Iowa Office for Programming and Planning awarded a contract for \$8,325 to prepare a series of maps on land and water resources. This project will be completed by 31 July 1976.

Work has been completed on a \$2,000 contract written by the U.S. Army Corps of Engineers for flood inundation mapping technique development and evaluation. An oral presentation of the results has been presented to the Corps, and a formal report is being drafted for publication.

Work is nearly completed on the NASA, Goddard, \$28,000 contract for producing enhanced satellite images of the Iowa landscape in cooperation with the Jet Propulsion Laboratory, California Institute of Technology, and the Eros Data Center, Sioux Falls.

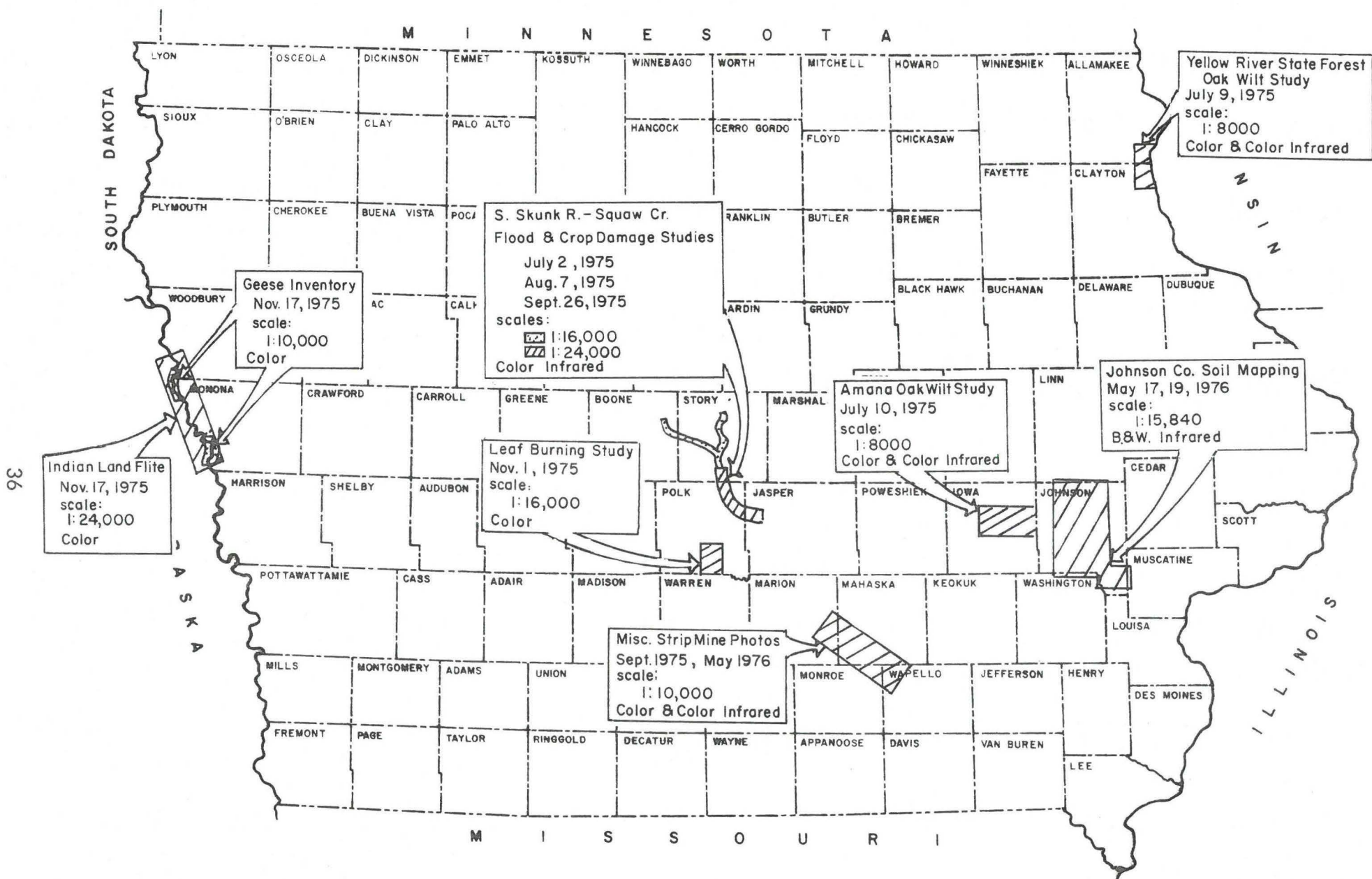


Figure 6. Aerial photography acquired through the *Remote Sensing Lab*, July 1975 - June 1976.



In addition, a service contract was awarded by the Department of General Services to Precision Photographic Laboratories for film processing. A service contract entered into last year was renewed with Tri-State Aero Engineering Company for flying aerial photography and buying film. These service contracts greatly facilitate the work of RSL.

1. Projects of the Remote Sensing Laboratory

A. Land-Use Map. A general landuse map of Iowa was completed and published in color at a scale of 1:500,000.

Land-Use in Iowa 1976, Misc. Map Series 5, was constructed by interpretation of satellite imagery and comparison with other data. Fourteen regional planning areas helped to correct the map prior to final publication. A report documenting the procedure used in producing the map is in preparation.

B. Land Classification of South-central Iowa from Computer Enhanced Images. The Jet Propulsion Laboratory, Eros Data Center, and Area XV Regional Planning Commission have continued cooperating with RSL on developing computer enhanced images that are useful for obtaining land use information from LANDSAT data. This research was sponsored by NASA under contract NAS5-20832. Results indicate that computer enhancement may be best accomplished using a linear contrast stretch, and that the photographic processing of color negatives derived from computer processing may be a limiting factor to the

enhancement process. The development of inexpensive color processing of the enhanced images at the Geological Survey was a significant achievement because it provided timely, quality imagery of the specific areas being analyzed by the Regional Planning Commission. Seasonality is important in extracting land use data, with spring being best for interpreting physiographic and agricultural land use, and late summer-fall being most useful for interpreting cultural features, water, forestland, and crops. Final report preparation is in progress and will be completed early in fiscal 1976.

C. Flood Inundation Mapping. RSL continued cooperative study of aerial methods of mapping flood boundaries with the U.S. Geological Survey, Water Resources Division, and the U.S. Army Corps of Engineers, Rock Island District. Research over the past year was directed at evaluating the accuracy of the techniques previously developed. Ground data, aerial photography, engineering control, and photogrammetric contour mapping were utilized to evaluate the interpretation of flood inundation mapped from color infrared imagery of the 27 June 1975 flood near Ames. The results indicated that the mean position of the interpreted flood boundary was within one foot of the predicted position and that 80% of all points are within 20 feet of the predicted flood boundary. Results will be presented

at a future national meeting and a publication is in preliminary draft form. The Corps plans to utilize this technique in the Rock Island District. Cooperation from the EROS Data Center, Applications Assistance Branch, permitted comparison of mapping results that can be obtained by satellite systems with those constructed from aerial imagery. The satellite system is as accurate as the resolution allows.

D. Migratory Geese Inventory. Additional color imagery was obtained over geese along the Missouri River flyway in the fall of 1975. Automatic techniques designed to obtain a census of geese have been unsuccessful. Presently, conventional human interpretation is the best method for an inventory from color imagery.

E. Oak Wilt Studies. The successful identification of oak wilt from imagery of the Amana Society forestlands in 1974 and 1975 has led to an expansion of this program. RSL is cooperating with the Amana Society, Iowa Commerce Commission, and U.S. Forest Service to continue observations on the spread of the disease in forestland of the Amana Society, and to use imagery for identification of diseased trees in the Yellow River State Forest. Color and color-infrared imagery at a scale of 1:10,000 was obtained for both areas using Conservation Commission aircraft. Color film was determined to be the most suitable film. Infestation of oak wilt was determined to be 0.3% and 0.8% of the oak trees

in the Amana and Yellow River Forests, respectively. The Conservation Commission plans to use this aerial technique to monitor other state forests. RSL will continue to provide technical support for interpretation.

F. Archaeology. Indian mounds had been carefully mapped on the ground over about 13 square miles in Hardin County near Steamboat Rock. No positive identification of mounds could be made from either color infrared or black-and-white photography.

G. Evaluation of Several Film Types for Soil Mapping. Since 1974 the RSL has cooperated with the U.S. Soil Conservation Service and the ISU Agricultural Extension Service in evaluating the relative merits of color, color-infrared, and black-and-white photography for soil mapping. Superior soil moisture detecting capabilities of color-infrared film have been demonstrated in both Johnson and Des Moines Counties. Evaluation of the imagery will continue with more emphasis on the applications that are most appropriate.

H. Environmental Studies. The U.S. Environmental Protection Agency, Environmental Photographic Interpretation Center has completed an environmental inventory of feedlots, junkyards, and waste treatment facilities in 12 northwest Iowa counties. This project was requested by the Iowa Department of

Environmental Quality and Region VII of the Environmental Protection Agency. RSL has helped coordinate the work.

I. Monitoring Leaf Burning. RSL assisted the Iowa Department of Environmental Quality, Air Quality Division, in monitoring leaf burning in Des Moines. On 1 November 1975, Department of Environmental Quality obtained ground measures of air quality using both stationary and mobile sampling stations. Color aerial photography, obtained concurrently, was used to provide a means for determining the distribution of air quality degradation sources. Manual interpretation of the imagery revealed 230 sources in Des Moines and adjacent westside cities. Significant deterioration of image quality corresponded to concentrations of leaf fires. The air quality data, in conjunction with the images, were presented to many city councils in large communities that still allow burning. This was done in an effort to emphasize the potential short term dangers inherent in permitting open burning.

J. Strip Mine Reclamation. Fourteen strip mines near Oskaloosa were imaged in September, 1975, and May, 1976 at a scale of 1:10,000 to evaluate what aerial imagery might be most suitable to monitor reclamation activities. Sites were selected to monitor the rate of natural revegetation as well as the progress of plant growth at planned reclamation sites. Color-

infrared film was found to be suitable for evaluating vegetative cover. Ground information was obtained under the excellent support of Dr. Paul Christianson, Cornell College, Mt. Vernon, Iowa. Additional imagery will be obtained over these areas in the future to continue this study.

K. Evaluation of Crop Damages from Floods. In cooperation with the U.S. Army Corps of Engineers, Rock Island District, the laboratory is examining the potential for evaluating crop damages that result from floods. Color infrared imagery was obtained in August and September, 1975, over the same portion of the Skunk River that flooded in late June. Evaluation of the sequential photography indicates that flooded areas can be delineated, the flooded crop identified, post-flood management practices determined, and replanted areas recognized. Evaluation of the imagery produced a total damage figure which closely agreed with ground data obtained by the Corps, but field-by-field correlations did not agree. Many factors suggest problems with the ground data which was obtained by field interviews alone. Results of this study are encouraging and the study will continue.

L. Temporal Vegetation Study. In an effort to provide better information on the response of color-infrared film to various vegetative cover materials, 35 mm photography is being obtained

repetitively over selected areas in Johnson County. The response of the film to row crops, hay crops, forested areas and grass is being monitored throughout the entire growing season.