

STATE OF MICHIGAN  
THE DEPARTMENT OF  
NATURAL RESOURCES



TWENTY-SIXTH BIENNIAL REPORT  
1971-1972



**LETTER OF TRANSMITTAL**

To the Governor and Members of the Seventy-Seventh Legislature:

Sir and Gentlemen:

In accordance with provisions of Section Four, Act No. 17, Public Acts of 1921, I am transmitting herewith the Twenty-Sixth Biennial Report, Department of Natural Resources, for the fiscal years, 1970-71 and 1971-72.

I am pleased to submit this summary of the activities and progress of this Department.

Respectfully,  
A. GENE GAZLAY, *Director*

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**GEOLOGICAL SURVEY DIVISION**

ARTHUR E. SLAUGHTER, *State Geologist*

With the counsel of the newly-appointed Mineral Wells Advisory Board, the Division formulated rules to be promulgated under Act 315 of the Public Acts of 1969. These were filed with the Secretary of State on June 28, 1972.

Dramatic successes by companies exploring for oil and gas opened a new chapter in Michigan petroleum exploration and production history. Most of the activity occurred along a belt roughly six to ten miles wide and 150 miles long extending from Manistee County northeastward through Presque Isle County. During the biennium approximately 150 wells were drilled from 5,000 to 7,000 feet in depth to Niagaran pinnacle reef targets. About half of the exploratory holes became producers, an unprecedented success ratio for the State. With similar success, several new wells were developed in Onondaga and Vevay townships of heretofore "dry" Ingham County. Recent sophistication of seismic geophysical exploration methods helped oil companies to locate and outline probable currents of relatively-small but highly-productive reefs prior to drilling. Individual well productive capabilities were generally much higher than rates of past Michigan well performances. Two-hundred-barrel-per-day wells became common with some having reported capabilities upwards of 1,000 barrels per day.

The new oil and gas developments were not without problems. The Division Chief, as Supervisor of Wells, found it necessary to issue an order curbing the flaring of gas, which constitutes a waste, and limited the production of some wells until pipelines can be constructed to carry the crude to refineries. Environmental concerns associated with the drilling, especially in the northern productive belt, had first order consideration. A new system of site evaluation prior to the permitting of a well was established and an environmental impact statement is now required with each permit application. The isolated, distinctive, and relatively-small size of most of the reef reservoirs necessitated a several-fold increase in the number of

public hearings by the Supervisor of Wells for establishment of well spacing and proration orders. Several rules promulgated under the Oil and Gas Act were amended, and changes in the basic act to modernize and strengthen it were proposed.

The Division acquired an additional important function with the passage of Act 92 of 1970. This Act calls for reclamation of lands associated with the mining of metallic minerals from open pits. At the close of the biennium the Act (Act 123 of 1972) was amended to include mining activities for coal, gypsum, and stone. The Division entered into contract with Michigan Technological University to study and determine the best and most effective method of vegetating and sloping of raw waste rock and disturbed lands.

Increased public awareness of environmental matters added to the work load of the Division. Statutory obligations for protection of both surface environments and subsurface resources are found in the 1929 Oil and Gas Act and in the new Mineral Well Act administered by the Division. Consultant services performed for the Bureau of Water Management and the Department of Public Health continue to be an increasing consequence in safeguarding the ground waters of the State.

## **OIL AND GAS CONSERVATION GROUP**

Development and production of oil and gas in Michigan is administered by the Supervisor of Wells who is also State Geologist and Chief of the Geological Survey Division. During the biennium, Survey units were restructured and re-titled. Units supervising and regulating oil and gas matters now come under Oil and Gas Conservation Group headed by an Assistant State Geologist in charge of these activities. The Group is made up of a Regulatory Control Section, a Petroleum Geology Section, and a Production and Proration Section whose staffs assist in all oil and gas matters. The over-all objective of the Group is the efficient recovery of all oil and gas resources of the State.

The head of the Group schedules and presides at public hearings before the Supervisor of Wells and the Oil and Gas Advisory Board. The Production and Proration Section supervisor serves as secretary to the Board. The number of causes considered in hearings nearly doubled during the biennium and are expected to continue to increase. Forty-one hearings covering 132 causes pertaining to oil and gas matters were heard and considered. Following these hearings, 123 orders and directives were issued by the Supervisor of Wells. Of these, 93 involved well spacing and proration, 22 were for applications to drill off-pattern wells, 2 for unitization of pools, and 6 for miscellaneous causes including compulsory pooling, show cause, surface waste, amended rules, no flaring of gas, and central tank-battery facilities.

Oil production, figured on a biennial basis, declined from 24,400,505 barrels to 24,013,278 barrels. However, figures for 1971 show an increase of nearly 200,000

barrels over the previous year, most of it from new reef fields in the northern and southern counties of the Lower Peninsula. Gas production, on a biennial basis, amounted to 58,170,336 Mcf of which 32,924,000 Mcf was oil well gas produced coincidental to oil production.

Seventy-four new fields, field extensions and new pools were discovered. Of these, 45 were oil, 19 were gas-condensate, and 10 were dry-gas accumulations. The most significant of these were located in a belt extending from Manistee County to Presque Isle County in the north, and in the Ingham-Eaton-Calhoun county area to the south. As mentioned in the previous Biennial Report, these new discoveries produce from Niagaran pinnacle reef reservoirs of very limited areal extent and have been found by increasingly sophisticated seismographic surveying methods and interpretations. The geographic distribution of these pinnacle reefs along with those found in southeastern Michigan, suggest future development of new Niagaran pools around the entire periphery of the Michigan basin.

### *Regulatory Control*

This Section issues permits to drill, deepen, or rework oil and gas wells, brine disposal wells, liquid petroleum gas (LPG) storage wells, natural gas storage wells and other types of wells specified under the oil and gas statutes of the State. The Section controls the locating, spacing, drilling, reworking and plugging of oil and gas wells, casing and sealing programs; evaluates oil, gas, and other types of well location survey records, and evaluates environmental impact statements related to each well permit application.

Staffed largely with geologists who implement compliance with statutes and rules pertaining to oil and gas operations, the Section maintains field offices in Mt. Pleasant, Cadillac, Gaylord, Imlay City, Plainwell, and Lansing; the latter being operated from the Lansing headquarters. Each field office is assigned a geographic area throughout which attention is given to well site locations, preparation and approval, evaluation of environmental impact statements, surveillance of drilling, plugging, brine disposal operations, and lease conditions, and compliance with rules governing oil and gas operations.

Record files are maintained on all wells for which permits have been issued, on ownership, on well status, and on current well operations. Reports pertaining to phases of well operations are compiled and issued weekly, monthly, or on an annual basis.

During the biennium the Section issued 858 permits to drill oil, gas, gas storage, secondary recovery, or wells drilled in connection with LPG storage operations. In addition, 42 permits were issued to deepen wells and four to drill brine disposal wells. Permits were terminated for 51 issued permits after operators failed to begin drilling within six months of the date of issue. Applications were approved to rework 242 wells and permits were issued to plug and abandon 202 depleted

wells and 359 newly drilled wells which failed to produce oil or gas. In addition, the Section approved and processed 1,070 transfers of well ownership. Approximately 110 million barrels of oil well brine were disposed of under supervision of this Section.

### *Petroleum Geology*

Major work of this Section consists of collecting geological and engineering data on oil and gas wells drilled in Michigan; processing and distributing this information in the form of well logs, technical reports, and maps; and serving as geological consultant to the Supervisor of Wells and the other Sections of the Oil and Gas Conservation Group, various departmental and governmental agencies, universities, and the public. The Section also manages and maintains libraries of well sample sets, electric logs, and published drillers logs. Although many new sample sets were added to the library, selection was again curtailed for lack of space and funds. The electric log and drillers log libraries continued to expand as did oil and gas map coverage. These records continued to be used extensively by many oil and gas industry personnel, university students, the public, and the Division staff.

Information was given by phone, letter and office visits to approximately 2,500 persons, including industry personnel, researchers, landowners, geologists, students, and others interested in petroleum geology. Geological advice or information was provided to the Public Service Commission, Department of State Highways, Corporation and Securities Commission, United States Geological Survey, and many other agencies.

Members of the Section again kept comprehensive statistics on oil and gas field drilling and production activities. These and other types of data were incorporated into an annual oil and gas field summary widely used by the oil and gas industry and various governmental agencies. In addition, reports were prepared for the American Association of Petroleum Geologists, Interstate Oil Compact Commission, and several industry-related periodicals. Section personnel delivered geological lectures, provided assistance in field mapping and the study of outcrop geology, and served on several oil and gas industry committees.

A summary of logs and records received, processed, and distributed, and maps posted and constructed by the Section follows:

#### Oil and Gas Well Logs

New geological and driller's logs received .....	847	New logs sold by subscription (estimated) .....	27,994
Deepening and rework records received .....	274	Logs from file sold or distributed by special order to companies and public .....	30,314
New logs published and distributed .....	761	New logs distributed to each of the three principal universities .....	2,283

#### Electric Log Library

New electric log sets received ..... 628

#### Well Sample Library

New sample sets received ..... 118

Sample sets loaned or inspected:

Companies ..... 220

Consultants ..... 9

University students ..... 168

#### Maps

Oil and gas field maps are maintained and dispensed by Engineering Division personnel from data assembled by the petroleum geology unit. A summary of available maps follows:

New oil and gas maps constructed ....	12	Miscellaneous maps available for sale .....	56
Miscellaneous maps constructed .....	1		
Oil and gas maps available for sale....	270		

### *Production and Proration*

Primary functions of this Section are the acquisition and evaluation of engineering data on Michigan's petroleum reservoirs, and carrying out a surveillance and regulatory control program directed toward the maximum ultimate recovery of available hydrocarbon resources. This entails a continuous program of reservoir testing and evaluation for the purpose of maintaining efficient producing rates while at the same time conserving reservoir energy.

During the biennium the number of prorated reservoirs increased to 22 (820 wells) as compared with 10 (674 wells) at the end of the last period. The combined production from these 22 reservoirs amounts to about 56 percent of the 33,000 barrels of oil produced daily in the State. In regulating the 22 prorated reservoirs, and the significant new reservoirs which were discovered at the rate of about three per month during the past year, the Section maintained a continuous program of utilizing, evaluating, and compiling engineering and production data, as well as a perpetual record of production from about 4,000 wells not subject to proration.

The Section participated in 16 Public Hearings covering 97 causes heard before the Supervisor of Wells and the Oil Advisory Board. Quarterly performance and progress reports relating to prorated reservoirs and miscellaneous developments were submitted to the Supervisor and the Board.

Observations were maintained and data compiled and published annually on 17 oil reservoirs under State-approved secondary recovery projects. Continuous monthly records of Michigan's seven operating refineries show that about 30,000 to 33,000 barrels of imported domestic and Canadian crude was processed and refined daily by Michigan refineries. Reserve studies, made cooperatively within the industry, indicated that Michigan's petroleum reserves increased from 51.5 million barrels as of December 31, 1969 to 58.8 million

barrels as of December 31, 1970. The latter reserves figure includes about 28 million barrels of oil which will be recovered by Michigan's 3,350 stripper wells through primary and secondary recovery operations.

## **ECONOMIC AND ENVIRONMENTAL GEOLOGY GROUP**

The Economic and Environmental Geology Group was structured out of the General Geology Section; the retitled Mineral & Mining Economics Section and Water & Environmental Geology Section; and the newly constituted Mineral Well Section. This expansion and reorganization reflects the growing awareness and vastly increased work load in these areas of resource development and environmental protection. The head of the group served as secretary to the Mineral Well Advisory Board during much of the biennium and assisted in the final drafting of the rules for administration of the Mineral Wells Act (Act 315 of Public Acts of 1969).

Legislation enacted early in the biennium (Act No. 92 of the Public Acts of 1970) provides for the reclamation of land subjected to the open pit mining of metallic minerals. The Act also provides that a study be made in the public interest to determine the extent and type of regulation made necessary by these activities. Field investigations and conferences with mining company representatives led to the preliminary drafting of rules to this end. However, before these were finalized and adopted the Act was amended to include stone quarries of all types (Act 123 of Public Acts of 1972). After further field investigations of the problems relating to the reclamation of stone quarries the proposed rules will be revised to include these additional mineral operations.

### **Mining and Economic Geology**

#### *Mines Appraisal and Precambrian Geology*

Approximately 55 iron ore and copper mines, and other mineral properties, were appraised for general property tax purposes during each year of the biennium. This required the review and study of drill hole records and mine maps to determine ore reserves. Also involved were examinations of surface facilities and underground workings of the mines. These data, along with consideration of the economics of the individual properties and the metal market, are used in determining valuations. Total values of the properties reported to the State Tax Commission were:

Type of Property	1971	1972
Iron ore	\$ 6,172,000	\$ 3,093,000
Copper	42,157,000	35,850,000
Total	\$48,329,000	\$38,943,000

Decreased valuation of iron ore properties reflects continued decline in the use of underground direct-shipment iron ores. The Tracy Mine was closed in January, 1972 and a number of other idle reserve properties were removed as not having sufficient

economic potential for modern day mining. Liquidation of the native copper mining properties began in 1971 after prolonged strikes closed the mining and smelting operations begun in August, 1968.

Production of iron ore pellets from low-grade surface iron formation and underground ore continues to replace production from closed underground mines. A new mine, the Tilden, began construction in 1972 and will have an initial capacity of 4 million tons and an ultimate production of 12 million tons of pelletized ore. The Empire Mine began expansion from 3.6 to 5.2 million tons of pellets per year. The Humboldt Mine was exhausted in December, 1971 and its pelletizing facilities will replace the Eagle Mills pelletizing plant in agglomerating a portion of the concentrate from the Republic Mine. Beneficiation and agglomeration operations are subject to a specific tax in lieu of general property taxes. The annual determination of these taxes, and especially their allocation to the assessing districts involved, is an increasingly important activity of this Section. Total specific taxes determined by the appraisers were:

Type of Property	1971	1972
Low-grade ore	\$1,476,536.87	\$1,416,847.96
Underground (agglomerated)	462,993.73	451,401.34
Total	\$1,939,530.60	\$1,868,249.30

Geologic mapping of the Precambrian rocks of the western Upper Peninsula continued at a modest pace. The geology of the Florence East and Florence West quadrangles were published. Preliminary geologic maps of the Greenland, Rockland, North Ironwood, Little Girls Point, Ishpeming, Greenwood and Republic quadrangles were made available in open-file. In addition, the geology of the Porcupine Mountain area and Isle Royale was completed. Five new aeromagnetic maps were also published as part of this program.

#### *Mineral Statistics and Nonmetallic Minerals*

Collection and publication of mineral statistics, along with the gathering and provision of information on the nonmetallic mineral resources of the State, are the prime responsibility of this unit. Two separate canvasses of the State's mineral producers were made with the cooperation of the U. S. Bureau of Mines in order to compile the annual mineral statistics required by Michigan Statute (CL 48 S 319.202). Replies from 456 mineral producers on production and value of some 895 individual pits, mines, quarries and manufacturing plants were received. The production and value of three metallic minerals (iron ore, copper and silver) and twelve nonmetallic building and industrial minerals (cement, lime, gypsum, stone, salt, sulfur, natural salines, peat, marl, clay, shale, and sand and gravel) were reported. Data on use, location, and labor and business trends was also provided by the canvass.

Two Annual Statistical Summaries (13 and 15) and two Annual Directories (4 and 5) of Michigan mineral producers were published from the data obtained.

These mineral reports show that the value of the State's mineral production increased significantly during the biennium. Valuation was up \$24.7 million in 1970 over the previous year, and increased a moderate \$2.2 million in 1971. The leveling-off in value of mineral production in 1971 was attributed to the general economic decline during this period and especially due to slack in demand for materials by the building industry. Iron ore continued to be first in value of minerals produced, followed by cement, natural salines, copper, petroleum, sand and gravel, and salt. The total value of nonmetallic minerals, however, continued to exceed the combined value of both metallic minerals and petroleum by better than 55 percent.

In addition to the collection and publication of mineral statistics, the unit was involved in a number of projects investigating high-grade dolomite deposits in the Upper Peninsula, limestone and low-grade dolomite deposits in the Lower Peninsula, and a study of brine resources of the State. A paper concerning brines and their chemical constituents from the Devonian Detroit River Formation was prepared and given at the 1972 annual meeting of the Michigan Academy of Science, Arts and Letters. Brines from the Detroit River Formation are produced by chemical companies at Ludington, Manistee, Mayville and Midland. Calcium-magnesium chloride, magnesium compounds, bromine, iodine and potash were extracted from these natural brines.

Late in the biennium the Legislature amended (Act 123, PA 1972) the Reclamation Act (Act 92, PA 1970) to "provide for reclamation of lands subjected to the mining of (all) minerals; to control possible adverse environmental effects of mining; to preserve the natural resources; to encourage the planning of future land use; and to promote the orderly development of mining, the encouragement of good mining practices, and the recognition and identification of beneficial aspects of mining." The act, in effect, now covers all quarrying operations in the State except sand and gravel. This includes all areas affected by strip mining of coal, quarrying of gypsum, lime, stone and other similar rock materials, or substances excavated from natural deposits on or near the surface of the earth for commercial, industrial, or construction uses. In anticipation of the implementation of this law, and additional pending legislation to include sand and gravel quarrying operations, this unit made contact with a number of the state's mineral producers and visited their quarries and plants to discuss the requirements of these operations pursuant to the drafting of rules for administration of the Reclamation Act.

Appraisal of nonmetallic mineral values on plotted lots, isolated parcels, and properties of sizeable acreage offered in exchange for state lands, or requests for reuniting of severed mineral rights, continue as a regular obligation of this unit. In many cases evaluations were made from knowledge of the general geology of the areas supplemented by office data. However, when the presence of commercially valuable minerals was

suspected or in evidence, field inspections were made. Occasionally, test pits were called for at the expense of the applicant in order to properly evaluate the prospect.

The unit acted as a consultant to the Department of State Highways in a program to locate and test silica rich limestone deposits suitable for use in concrete aggregate for medium traffic throughways. Detailed stratigraphy for many active quarrying operations in the State was furnished the Testing and Research Division, supplemented with field assistance in collecting representative samples of selected beds for testing and analysis.

Under a 1971 revision of the "Disposal of Minerals" policy by the Forestry Division, all permits for gravel pit operations in excess of 10,000 cubic yards on state forest lands are referred to this unit for evaluation plus advice on their operation and eventual reclamation. Ten requests were processed in the last month of the biennium after the new policy went into effect, with geological assistance of the Lands Division. Areal extent of sand and gravel reserves determined by field inspections aided in providing the Area Forester with operational instructions including plant location, working area, stockpile placement, and disposal sites for overburden and waste.

Supplies of 24 rocks and minerals to provide over 4,000 mineral kits to meet the growing demand for educational material for the earth and environmental sciences were collected by the unit. These kits are assembled in a cooperative project by prison inmates at Camp Pontiac. The kits are sold to students, teachers, rockhounds and other interested parties.

Gathering information for the preparation of maps and mineral commodity reports; identifying rocks, minerals, and fossil specimens sent or brought in by individuals; directing industrialists to supplies of clay, gravel, stone, and other mineral resources; and answering inquiries on all phases of geology continued as routine work of this unit.

### **Mineral Wells**

The mineral well program includes the regulation of brine, disposal, storage, and test wells under Act 315 of the Public Acts of 1969. It has not been fully implemented due to budget problems, but some progress was made in the following areas:

**Rules:** After several revisions, public hearings, and meetings the rules for implementing the act were finalized, approved and adopted.

**Solution mining:** The occurrences of a serious case of subsidence from these operations in the Detroit River led to adoption of guidelines designed to help prevent this type of occurrence in the future.

**Foundation borings:** Guidelines for abandoning shallow borings were formalized and adopted.

**Interim procedures:** Approvals for 443 mineral wells were given under interim procedures. The approvals

covered programs such as drilling, testing, operating, reworking, converting and abandoning different types of mineral wells. The procedures were initiated to provide some controls until the rules could be adopted and fully implemented. The partial compliance under these procedures excluded permitting and bonding requirements called for under the act.

Until proper implementation of the law is accomplished, attempts will continue to carry out the intent of the Mineral Well Act in order to protect public interests and the environment.

### **Water and Environmental Geology**

The Water Section and the Glacial & Environmental Geology Section were consolidated due to the similar nature of their duties. Also, the Special Studies Unit of the Bureau of Water Management joined the Section.

The Section served as geologic consultant to the Bureau of Water Management, the Department of Public Health, and to other Department Divisions in matters relating to waste disposal, ground water supplies, area hydrologic investigations, and other water and environmental problems. About 80 percent of the Section's time was spent with liquid and solid waste concerns and the remainder in services to the public, industry, and agencies. More than 3,000 man hours were spent in the field. An additional 1,000 hours were required for conferences on waste disposal and various Departmental, professional, and organizational meetings. The Section presented some 30 talks to organizations. Expert testimony was given in six hearings and court trials.

#### *Water Resources Unit*

The Unit acts as a consultant to State agencies, other DNR divisions, municipalities, industries, and individuals in matters relating to the occurrence, availability, quantity, and quality of ground water supplies. To assist in performing this duty the Unit maintains a file of over 100,000 well records, a large portion of which have been submitted during the past seven years by Michigan well drillers as required by law (Act 245, P.A. 1965). During the biennium, 33,994 water well records were received, processed, and filed for ready reference. Copies of 12,498 water well records were sold to various parties seeking hydrologic information.

As part of its normal service responsibilities in matters relating to water resources, the unit replied to 306 information requests from the public, 237 requests from industry, consultants, and well drillers, and 100 requests from federal, state, and local agencies. These requests were received by letter, phone, or personal visit. In the Upper Peninsula, information was supplied or investigations were made in response to 60 requests for assistance in ground-water problems. Visits were made to assist with well problems in 17 cases regarding municipal or school wells.

**Ground Water.** The unit assisted the Bureau of Water Management in the investigation and evaluation of 187

sites proposed for disposal of liquid wastes to the ground waters for possible pollution and hazards to health. Assistance on an additional 20 sites involving various ground and surface-water problems were investigated. At the end of the biennium a backlog of 20 liquid waste disposal site evaluations remained to be completed.

Expert testimony was given in a legal suit involving the Department's removal of a dam on the Muskegon River at Newaygo.

The unit provided field supervision for the Engineering Division for 17 wells drilled at state parks, fish hatcheries and other installations. Reports of the drilling, completion, and well capacities were submitted as well as recommendations on bid items for contracts on an additional eleven proposed new wells.

A geologic and hydrologic evaluation of the Department's proposed impoundment in the Island Lake Area was completed to assist the Research and Development Division in preparing an environmental impact statement for this project. Additionally, geologic and hydrologic interpretations of Au Sable watershed features were prepared as a part of the Department's contribution to a study of this area by the Northeast Regional Planning Commission.

The unit investigated and prepared reports on 25 water supply and sewage disposal projects for the Department of Public Health. Six of these were investigations of sewage irrigation or land spreading of sewage wastes, eight were municipal aquifer evaluations, and the remaining eleven were evaluations of on-site water supply and sewage disposal proposals for new subdivisions.

Advice and information on the water well records and geohydrology of 80 miscellaneous well problems were provided the DPH-Ground Water Quality Control Unit. In the Upper Peninsula evaluations of the possible effects of waste effluents on ground-water supplies were made for 30 sewage lagoon sites, 16 trailer park sites, and 30 new subdivisions.

**Surface Water.** The unit provided information and geologic advice to the Bureau of Water Management and the public for 67 surface-water problems, including dredging in or near inland lakes, proposed impoundments of surface water, and problems related to lake levels. An additional 15 requests were investigated by the Upper Peninsula office.

#### **U.S. Geological Survey Cooperative Program.**

Several cooperative programs with the Water Resources Division of the U.S. Geological Survey were continued. The work involves gaging streams, monitoring groundwater levels and quality, and detailed investigations of local and regional water quality. Most of these studies are published as Water Investigations Series reports when completed. Additional material is available as open file reports. The Unit participated in an evaluation study of federal actions and contributed

many suggestions for improvement of services and assistance by federal agencies.

**Geographic Names.** The Unit served as a clearinghouse for information and procedures on selecting and revising geographic names. New and proposed geographic names were reviewed and processed through the U.S. Board of Geographic Names. Over 50 requests were handled by the Unit in 15 formal namechanges or clarifications. At the end of the biennium a backlog of 15 requests remained to be handled.

#### *Glacial and Environmental Geology Unit*

This Unit was created in July, 1968 to handle increased requests for detailed surface geology maps and for geological assistance in solving environmental problems. During the biennium the Unit became a part of the Water and Environment Section.

**Environmental Geology.** Activities have been almost entirely devoted to the geologic evaluation of solid-waste disposal sites for ground-water and surface-water pollution possibilities for the Department of Public Health. In contrast to 33 solid-waste disposal site evaluations by the Unit during the 1969-70 biennium, 148 sites, including eight in the Upper Peninsula, necessitating 170 preliminary and final geologic reports, were evaluated during this biennium. At the end of the period a backlog of 47 sites remained to be evaluated. About one-third of the Unit's time (1,110 man hours) was spent in the field performing site reconnaissance and conferring with landfill-site applicants. In addition, five lectures were presented to organizations on geologic considerations for solid-waste disposal. Expert testimony was given at one court trial and two preliminary hearings involving solid-waste disposal sites.

Preparation of criteria and guidelines for solid-waste disposal in Michigan continued. Maps showing acceptability of areas for solid-waste disposal in southeastern Isabella County and northwestern Ingham County were completed. Geologic response to numerous inquiries relating to waste disposal, environmental geology, and glacial geology continued as a function of the Unit.

**Glacial Geology.** Surface and bedrock geologic maps with narratives were completed early in the biennium on the geology and ground-water in Baraga County as part of a cooperative report with the U.S. Geological Survey. Preparations for field-reconnaissance mapping for a similar report on Marquette County are under way.

#### *Special Studies Unit*

This Unit performs field studies, frequently in areas where ground-water pollution exists, to aid the Bureau of Water Management in making decisions on ground-water pollution control. Since joining the section in March, 1971 the unit has devoted full time to field studies and report preparation, independent of the normal service functions of the Section.

During the first half of the biennium a two-year study was completed documenting the effects of waste effluents from salt, paper, and brine industries on ground-water quality in the Manistee area. This report was of material assistance to the Bureau of Water Management in obtaining major improvements to industrial disposal systems in the Manistee area.

The second half of the biennium was spent in planning and gathering basic geologic and a ground-water quality data for a study presently being conducted in the Houghton Lake area by the Bureau of Water Management under sponsorship of the Upper Great Lakes Commission. The primary goal of the geological portion of this two-year study is to establish the relationship between domestic septic tank waste effluents and local ground-water quality, with emphasis on the quality of ground water which migrates into Houghton Lake.

About twenty lectures were presented to school and environmental groups, including the American Water Works Association.

#### **General Geology**

Principal activities of this Section were: acquisition of general geologic and geographic information, responding to inquiries relating to the geology, geography and mineralogy of the State, providing consultant services to other state agencies, editing and distributing Division publications, coordinating mapping programs, giving occasional talks, maintaining a reference library, assisting in occasional field investigations, providing counsel on state boundary problems, and coordinating the Division training program. The most typical recipients of these services were teachers, students, planners, developers, state employees, legislators, vacationers, hobbyists, librarians, and professional geologists, geographers, mineralogists, and ecologists. Significant additional activities were: coordinating recruitment and appraisal of technical and clerical personnel, production of a divisional procedures manual, participating in various departmental committee activities, including shorelands management, word processing, GLBC-Aesthetic and Cultural Work Group No. 22, and an increasing load of administrative reports and correspondence. Early in the biennium the sale at public auction of Douglass Houghton's grave at Elmwood Cemetery (Detroit) was prevented by the influence of this Section. Houghton, Michigan's first State Geologist, 1837-1845, contributed importantly to the State's early pre-eminence and development.

#### *Geoscience Information*

Service in this area continued to comprise a substantial part of the Section's activities reflecting the increased interest of students, teachers, and the public in the environment and natural resources of the State. During the biennium, 1,700 letters were written, 1,500 publication requests were filled, and over 1,600 people visited the office for aid and assistance. Conversely,

increased emphasis on teaching geology and earth science in schools and colleges has tended to decrease requests for general talks and lectures on these subjects.

Approximately 50 students participated in field trips led by Section personnel.

#### *Library*

During the first half of the biennium the library was reorganized to allot more room to the geology of Michigan and geologic topics of current interest, such as environmental geology, waste disposal, and land use. More than 50 boxes of out-of-state, U. S. Geological Survey, and U. S. Bureau of Mines material were sent to the State Library to be catalogued and incorporated into its collection of public documents.

#### *Mapping*

The Section continued to monitor the state cooperative topographic mapping program. Topographic map allotments received from the U. S. Geological Survey are distributed by this Section. During the biennium 111 newly published quadrangles (totalling 22,200 sheets), 54 advance prints of new quadrangles in progress (totalling 270 sheets) and 66 new advance proofs (totalling 330 sheets) were distributed. This comprised 5,676 acres of new territory mapped and published, and 5,479 acres of the State that are in the process of being mapped and will be published shortly. These enhanced figures reflect the final results of the increased state participation in the cooperative topographic mapping program begun in 1966. The advanced \$150,000 appropriations begun in that year were abruptly discontinued after 1969 because of the general national economic downturn and resulting state financial crisis. The program continued on a \$50,000 contribution from the Highway Trunkline Fund during the biennium.

#### *Training*

After a lapse of several years, inservice training was reinstated in the last half of the biennium. A successful joint training session was held with Lands Division at Higgins Lake with the theme "A Time of Change." A two-day program and field trip exploring the changing picture of resource management in the State was well received. Section geologists represented the Division in departmental training discussions and also attended geological conferences and field trips.

#### *Personnel*

Coordination of recruitment and appraisal of new divisional technical and clerical employees was assigned to the Section. The flood of unsolicited applications by letter, phone, and personal visit, resulting from the national economic downturn and dearth of hiring by all segments of the economy these past two years, has greatly added to the workload of the Section. Nearly 150 applications in all categories were received, processed, and answered. Over 50 applicants were interviewed.

#### *Publications*

The automated publications mailing system was put into effect soon after the onset of the biennium and is very effective in speeding up this operation. The work load in handling over 929 names on the mailing list has been greatly reduced.

Increased demands for geological and natural resource publications by the many new geology and earth science departments at schools and colleges throughout the State and country have strained the capacity to turn out and distribute this material. Pressures to inflate our gift and exchange list, particularly by new out-of-state institutions, has been and will continue to be resisted. Over 52,000 copies of Geological Survey publications were sold, exchanged, or used in answering inquiries by the Tourism Division's Publication Room, or by this Section. An additional 3,000 pieces of material were reproduced from Section files to provide answers to resource related inquiries.

Publications released during the biennium are listed below.

#### *GEOLOGICAL SURVEY PUBLICATIONS*

- \*Report of Investigation 4*—Geology and magnetic data for Northern Iron River area (U. S. Geological Survey cooperative).
- Report of Investigation 8*—Geology and magnetic data for the Northern Crystal Falls area, Michigan (U. S. Geological Survey cooperative).
- \*Report of Investigation 10*—Geology and magnetic data for Alpha-Brule River and Panola Plains area (U. S. Geological Survey cooperative).
- Report of Investigation 11*—Geology and magnetic data for Northeastern Crystal Falls area, Michigan (U.S. Geological Survey cooperative).
- Report of Investigation 12*—Geologic interpretation of aeromagnetic data in Western Upper Peninsula of Michigan (Mich. State Univ. cooperative).
- Report of Investigation 13*—Geology for environmental planning in Monroe County, Michigan.
- Water Investigation 10*—Ground water and geology of Keweenaw Peninsula, Michigan (U.S. Geological Survey cooperative).
- Annual Statistical Summary 12*—Michigan's oil and gas fields, 1969.
- Annual Statistical Summary 13*—Mineral industry of Michigan, 1969 (U.S. Bureau of Mines cooperative).
- Annual Statistical Summary 14*—Michigan's oil and gas fields, 1970.
- Annual Directory 4*—Michigan mineral producers, 1969.
- Annual Directory 5*—Michigan mineral producers, 1971.
- \*Circular 8*—Geologic map index of Michigan 1843-1962.
- Circular 9*—General rules governing oil and gas operations.
- Miscellany 1*—Sixth Forum on geology of industrial minerals.
- Water Information Series Report 1*—Upper Rifle River basin, northeastern lower Michigan (U.S. Geological Survey cooperative).
- List 11*—Available maps of the Geological Survey.
- List 12*—Available publications of the Geological Survey.
- List 13*—Available publications of the Geological Survey.
- Twenty-fifth Biennial Report, 1970-1972.
- \*Small Scale Map 1*—Morainic systems of Michigan.

\**Pamphlet 1*—Douglass Houghton, Michigan's First State Geologist 1837-1845, revised (Information and Education Division cooperative).

\**Pamphlet 3*—Guide to Michigan fossils.

\**Pamphlet 4*—Collecting minerals in Michigan.

\**Pamphlet 5*—Geologic Sketch of Michigan sand dunes (revised).

\**Bulletin 4*—The glacial lakes around Michigan.

#### *Publications in Press*

*Annual Statistical Summary 15*—Mineral industry of Michigan 1970 (U.S. Bureau of Mines cooperative).

*Annual Statistical Summary 16*—Michigan's oil and gas fields, 1971.

*Report of Investigation 9*—Geology and magnetic data for Southern Crystal Falls area, Michigan (U.S. Geological Survey cooperative).

\**Water Investigation 3*—Water Resources of Van Buren County, Michigan (U.S. Geological Survey cooperative).

*Water Investigation 11*—Ground water and geology of Baraga County, Michigan (U.S. Geological Survey cooperative).

\**Water Information Series Report 1*—Upper Rifle River basin, northeastern lower Michigan (U.S. Geological Survey cooperative).

*Water Information Series Report 2*—Flowing wells of Michigan (U.S. Geological Survey cooperative).

\**Michigan Conservation reprint*—Michigan's colorful minerals.

\**Michigan Conservation reprint*—Michigan beach stones.

\**Chart 1*—Stratigraphic succession in Michigan.

\*Re-issue

## U. S. GEOLOGICAL SURVEY PUBLICATIONS

*Prepared in cooperation with Geological Survey Division  
Published Reports and Maps*

*Professional Paper 633*—Geology of the Florence area, Wisconsin and Michigan.

*Circular 634*—Chemical quality of Michigan streams (Cooperative with Water Resources Commission).

*Geophysical Investigations Map GP-711*—Aeromagnetic map of the Menominee-Northland area, Dickinson, Marquette, and Menominee Counties, Michigan, and Marinette County, Wisconsin.

*Geophysical Investigations Map GP-750*—Aeromagnetic map of the Western part of the Northern Peninsula, Michigan and part of Northern Wisconsin.

*Geophysical Investigations Map GP-828*—Aeromagnetic map of central Gogebic County, Michigan, and Northern Vilas County, Wisconsin.

*Geophysical Investigations Map GP-829*—Aeromagnetic map of the Bergland Quadrangle and part of the White Pine Quadrangle, Ontonagon and Gogebic Counties, Michigan.

*Geophysical Investigations Map GP-831*—Aeromagnetic map of the Watersmeet region, Ontonagon and Gogebic Counties, Michigan, and Vilas County, Wisconsin.

*Geophysical Investigations Map GP-833*—Aeromagnetic map of Gladstone and vicinity, Delta, Alger, Menominee and Marquette Counties, Michigan.

*Geophysical Investigations Map GP-834*—Aeromagnetic map of northwestern Ontonagon County, Michigan.

*Hydrologic Investigations Atlas HA-338*—Water Resources of the Black River Basin, southeastern Michigan.

*Hydrologic Investigations Atlas HA-353*—Reconnaissance of the Sturgeon River, a cold-water river in the northcentral part of Michigan's Southern Peninsula.

*Hydrologic Investigations Atlas HA-354*—Reconnaissance of the Black River, a cold-water river in the northcentral part of Michigan's Southern Peninsula.

*Hydrologic Investigations Atlas HA-356*—Water Resources of the River Rouge Basin, southeastern Michigan (cooperative with U.S. Army Corps of Engineers).

*Hydrologic Investigations Atlas HA-384*—Reconnaissance of the Pere Marquette River, a cold-water river in the central part of Michigan's Southern Peninsula.

*Hydrologic Investigations Atlas HA-426*—Reconnaissance of the Rifle River, a cold-water river in the northeastern part of Michigan's Southern Peninsula.

*Water Supply Paper 1973*—Availability of water in Kalamazoo County, southwestern Michigan.

*Water Resources Data for Michigan 1969*—Part 1, Surface water records.

*Water Resources Data for Michigan 1969*—Part 2, Water quality records.

*Water Resources Data for Michigan 1970*—Part 1, Surface water records.

*Water Resources Data for Michigan 1970*—Part 2, Water quality records.

#### *Open-File Reports and Maps*

*Summary of ground-water hydrological data in Michigan, 1969.*

*Summary of ground-water hydrological data in Michigan in 1970.*

*Compilation of data for Michigan lakes.*

*A proposed stream flow data program for Michigan.*

*Geologic map of the Greenwood Quadrangle, Marquette County, Michigan.*

*Geologic map of the Ishpeming Quadrangle, Marquette County, Michigan.*

*Geologic map of the Republic Quadrangle, Marquette County, Michigan.*

*Preliminary geologic map of the Negaunee SW Quadrangle, Michigan.*

*Geologic map and section of Little Girl Point, North Ironwood, and the northern part of Ironwood Quadrangles.*

*Map showing approximate top of Jacobsville sandstone, an erosion surface, in parts of Rockland and Greenland Quadrangles, Ontonagon County.*