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# USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

Annual Progress Report, June 1, 1978 - May 31, 1979

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Prepared for

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National Aeronautics and Space Administration  
Washington, D.C.

NASA Grant Number: NGL 23-004-083

Remote Sensing Project  
Michigan State University  
East Lansing, Michigan 48824

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February 1, 1980

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## S c o p e   o f   R e p o r t

The last Progress Report of activities and accomplishments of the Michigan State University Remote Sensing Project covered the period of December 1, 1977 through November 1978. We judged, subsequently, that reporting for a period which straddled halves of two separate grant years could cause possible confusion and ambiguity in the record. In an effort to minimize this possibility, this report, herewith, is for a full grant year period, namely June 1, 1978 to May 31, 1979.

We wish to call attention to the fact that this realignment of the reporting period requires inclusion of a six-month period (June 1, 1979 to November 31, 1979) which comprised the second half of the last report.

It is our intention hereafter to report progress for each subsequent full grant year, namely June 1 through May 31 of the following year.

## A C K N O W L E D G E M E N T S

The investigations described in this document under section "A" as "Research Applications" were supported predominantly by grant funds provided by the National Aeronautics and Space Administration through the Office of Space and Terrestrial Applications, Technology Transfer Division, University Applications Program, Joseph A. Vitale, Manager, under NASA Grant Number NGL 23-004-083. The remaining increments of support were in the form of continuing provision of university resources. . . space, facilities, equipment, furnishings, and faculty investigator cost-sharing, and some research staff personnel salaries.

Activities reported under section "B", "User Services and Project Institutionalization Progress", were supported from a number of funding sources, mostly from Michigan State University agencies, but including some time of principals supported by the NASA Grant funds.

While activities reported under section "C", "Contractual Services", were funded fully by separate agreements, with no direct dollar support from the NASA Grant, it is acknowledged that the critical mass of expertise and the widespread favorable reputation of the MSU Remote Sensing Project. . .those qualities which attracted requests for application and training services. . .have been originally initiated, developed, and progressively strengthened by the basic, continued provision of resources from the succession of NASA grants.

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## I N T R O D U C T I O N

The incidences of land-water-human interactions on terrain continue to increase, particularly those with negative consequences. Most of these result from a dynamic technology proliferating processes, substances, and artifacts that, when interacting with social dynamics, debilitate the quality and quantity of the supply of crucial elements of life-support systems. Fortunately, human ingenuity counters by inventing improved instruments and processes for detecting and measuring breakdowns in the stability of natural systems and resources.

Even though the many kinds and levels of monitoring and correcting agencies, public and private, take actions when adequately and competently informed, an unending flow of problems and issues of terrestrial-cultural interactions continue to surface. Monitoring and correcting dysfunctions of natural systems apparently must continue unabated.

The Michigan State University Remote Sensing Project continues to provide substantial contributions to public and private agencies in Michigan by helping them to bring into effect on-land and water related (i.e., terrestrial) actions of many different kinds by which preventative and corrective measures can be carried out to conserve and enhance remaining qualities of the natural and cultural environments. Much information essential for formulating effective measures continues to be derived from the many different categories of remote sensing imagery.

The activities and achievements within this June 1978 - May 1979 period demonstrate the versatility of the MSU Remote Sensing Project in addressing



a wide variety of problems and issues as well as persisting in broadening the community of utilizers of remote sensing-derived intelligence at all levels of government and business.

These efforts have been augmented by a variety of services, including some instruction and training. The synopses which follow describe the individual activities carried out during the reporting period. They are grouped under three headings, namely: A) research applications; B) user services and Project institutionalization progress; and C) contractual services.

Part (D), "Informational Summary" (pages 73-101), presents an update of quantitative data issued as a special report regarding selected categories of information originally requested by NASA and compiled by the Project principals during 1978, submitted September 22, 1978, and titled, "Project Information Report." This kind of a report was instituted as a regular element for inclusion with subsequent progress reports. The data reported in this report have been organized under the same seven "categories" as were those in the original one.

The "Appendix" consists of one additional schedule of updated abstracts of publications and presentations prepared and delivered by various members of the Remote Sensing faculty and staff.

While a predominant proportion of costs incurred by research applications were met by NASA Grant funds during this reporting period, agencies for whom investigations were being conducted were advised that continuations of studies would require sharing some, if not most, costs. The Project, in effect, has formulated cost-sharing as a policy. The progress report for the next grant period will describe instances of this participation.

## A. RESEARCH APPLICATIONS

The following five research application studies were conducted during this June 1978 - May 1979 Grant year:

1. Identification of Wood Energy Resources in Central Michigan
2. The Impact of Pipeline Construction on Stream and Wetland Environments
3. Identification of Hazardous Wastes Disposal Sites
4. Integrated Pest Management Systems
5. Analysis of Landsat Data in Updating Forest Inventories

Each of these five studies is summarized in the series of synopses which follow. Two of these were reported in the previous December 1977 - November 1978 Progress Report (dated March 9, 1979); but, as noted in the "Scope of Report" section, the second half of that previous report has been, in essence, included in this one in order to realign reporting to full grant year entities. These two "repeats" actually were continued into the second half of the June 1978 - May 1979 Grant year (wood energy resources and impact of pipeline construction).

Manifestly, the last three studies (hazardous wastes disposal sites, integrated pest management systems, and Landsat data re: forest inventories) were initiated in the second half of this reporting period.

The five studies represent a wide diversity of subject matter. All deal with issues of either human impact on natural resources (pipeline construction, hazardous wastes disposal) or finding ways to manage natural resources to serve human needs more effectively (wood resources for energy

generation, past management, Landsat data analysis for forest inventorying).

None of these studies was solicited by the MSU Remote Sensing Project (RSP); each was requested by particular private or public agencies which were in need of assistance for either solving problems or in meeting either a program commitment or a legislative mandate. In line with the criteria utilized by the RSP in responding to such requests for carrying out any study under NASA Grant support\*, these five studies were accepted by the RSP for operational investigation.

Subsequent to the ending of the reporting period, the separate sponsors of these five studies returned to the RSP to have them continued/extended in one or more respects, generally as follows:

- + The wood energy resources study has demonstrated such importance to the energy needs of Michigan that two separate research proposals have been submitted to continue work in this area.
- + The pipeline construction study for the Michigan Public Service Commission so impressed the principals of that agency of the utility of remote sensing processes that they have requested follow-up research for the development of analysis methods, using Landsat imagery, for determining rights-of-way for future pipeline construction.

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\* Criteria applied by the RSP to test eligibility for support under NASA Grant funds:

- a) study must require reliance on data and information derived from remotely-sensed imagery;
- b) resultant decisions and actions could be generated predominantly from this information;
- c) the research would require innovative, non-routine methods; and
- d) there is substantial promise that the findings will result in early actions.

- + The problems of hazardous wastes disposal in Michigan has exploded into a scandalous, an emergency, almost a disaster situation. The attack on this widespread problem has barely begun. The State of Michigan is seeking hundreds of millions of dollars for investigation and cleanup. One firm has already been fined 20 million dollars for its commissions. The MSU Remote Sensing Project will likely be involved in this activity for a long time.
- + The pest management studies have been augmented by additional tasks that were carried into the next reporting period.
- + The research on the utility of Landsat data for forest inventories proved sufficiently useful to have the State Forestry Management Division request additional elements and provide some dollar support.

We of the Remote Sensing Project faculty and research staff participants view these research applications as the central substance, the nucleus of intellectual energy, and the basic evidence of our competence in remote sensing technology. All the other missions we perform are spin-offs from the demonstrations of capabilities and expertise through years of research investigations via applications. We continue to grant first priority to the NASA supported research applications and we respectfully seek continuation of NASA confidence in our collective competencies.

Al. Identification of Wood Energy Resources in Central Michigan

Wolverine Electric Cooperative  
302 South Warren Street  
Big Rapids, Michigan 49037

Consumers Power Company  
212 West Michigan Avenue  
Jackson, Michigan 49201

Morbark Industries, Inc.  
Box 1000  
Winn, Michigan 48896

The task of meeting energy needs is particularly important in Michigan, considering its dependence on outside sources of energy (Michigan presently produces only about four percent of its energy requirements). Renewable resources, particularly wood biomass, are being viewed as a highly desirable alternative energy source. While fossil fuels are relatively scarce in Michigan, forests are widely distributed in the state (about half of Michigan's land area is forested). Developments in using wood as a "direct-burn" energy source have progressed to a stage where it is now viewed as technically feasible and cost-effective.

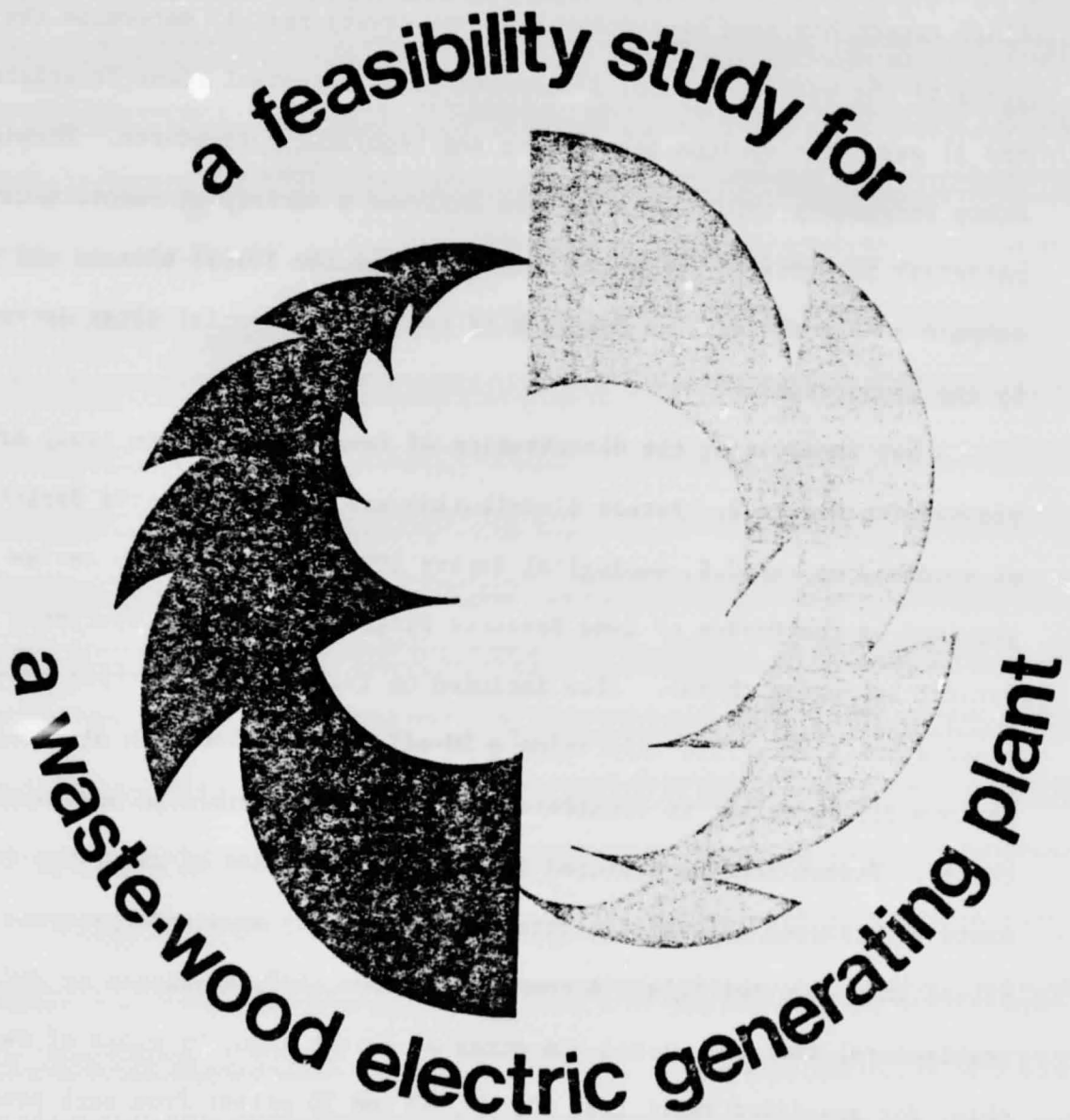
A cooperative venture by Wolverine Electric Cooperative (a publicly-owned electric generation and transmission cooperative), Morbark Industries, Inc. (a forest products firm which manufactures wood-harvesting equipment), and Consumers Power Company (a privately-owned electric and gas utility) are presently planning to build a demonstration wood-burning generating plant in the mid-Michigan area. There is a lack of information on the extent, availability, and location of non-commercial timber resources (standing tree residues, over-stocked stands, logging residues, sites in need of conversion, etc.) which will be needed for fuel in this power plant. Therefore, the enterprises requested assistance from the Remote Sensing Project

in acquiring information on available wood resources to be reduced to wood chips as an energy fuel.

The consortium of corporations (Wolverine Electric, Morbark Industries, and Consumers Power) contracted for a feasibility study (Fig. 1; copy of final report has been sent under separate cover) to: 1) determine the adequacy of the wood fuel base; 2) compare three potential plant locations; and 3) establish various engineering and regulatory procedures. Michigan State University (MSU) investigators analyzed a variety of remote sensing materials in order to determine the tonnage of the forest biomass and to compare supply estimations for each of the three potential sites determined by the consortium.

A map summarizing the distribution of forest land in the study area is provided in Figure 2. Forest distribution was derived from the depiction of woodland on the U.S. Geological Survey (USGS) 1:250,000 map series as provided by the Office of Land Resource Programs, Michigan Department of Natural Resources (MDNR). Also included on the map are the three proposed plant sites with a line indicating a 50-mile radius from each site (the maximum distance that is considered economically feasible to haul wood chips). Forest data as depicted on Figure 2 and class of ownership (federal, state or private) information shown on MDNR county maps were geocoded and placed on a computer file. A computer routine (RAP, developed by MSU investigators) then calculated the acres of forest land, by class of ownership, for specified radii (10, 20, 30, 40 and 50 miles) from each proposed plant site. The results are shown in Table 1. Based on this acreage information, plus environmental factors and the location of electrical

Figure 1. Feasibility study including MSU-RSP Landsat and aerial photography assessment of wood energy resources.



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Daverman Associates, Inc.  
Grand Rapids,  
Michigan

for: Consumers Power Company  
Morbark Industries Inc.  
Wolverine Electric Cooperative

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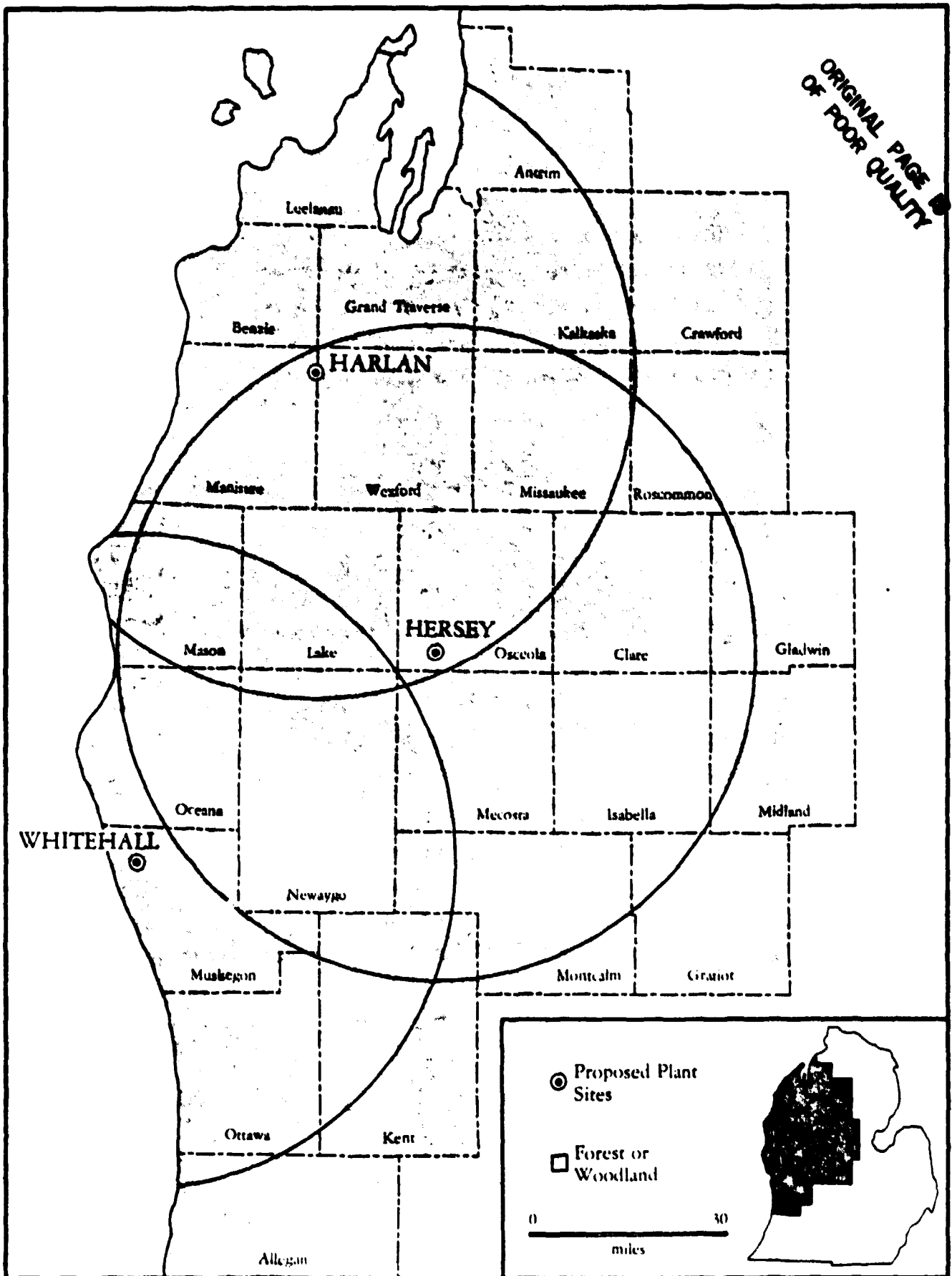


Figure 2.—Forest Distribution.



Table 1.--Acres of Forest Land by Site.

**HARLAN**

Radius (miles)	Acres of Forest Land			Total	% of Area Forested
	Federal	State	Private		
10	16640	33920	48640	99200	49.3
20	112000	85120	224640	421760	52.4
30	221440	182400	441600	845440	46.7
40	281600	284800	684160	1250560	38.9
50	355840	440320	973440	1769600	35.2

**HERSEY**

Radius (miles)	Acres of Forest Land			Total	% of Area Forested
	Federal	State	Private		
10	-0-	11520	20480	32000	15.9
20	33920	50560	227200	311680	38.7
30	224000	96000	524800	844800	46.7
40	364160	170880	879360	1414400	44.0
50	432000	370560	1266560	2069120	41.0

**WHITEHALL**

Radius (miles)	Acres of Forest Land			Total	% of Area Forested
	Federal	State	Private		
10	8960	1280	68480	78720	39.1
20	30080	8320	155520	193920	24.1
30	62080	10240	229760	302080	16.7
40	149120	12800	377600	539520	16.8
50	225920	30080	528640	784640	15.6

transmission routes and facilities, the consortium selected Hersey as the proposed site for a demonstration-experimental wood chip-fueled power plant of approximately 25 MW (Figs. 3 and 4).

After selection of the Hersey site, the consortium requested the MSU Remote Sensing Project to provide them with more detailed biomass and non-commercial timber figures for a six-county area surrounding the site. Acreage data for four of the counties (Lake, Newaygo, Osceola and Mecosta) were compiled from the forest land management and inventory data service maintained by the West Michigan Regional Planning Commission (WMRPC). Forest cover-type information for the four counties was originally interpreted from medium-scale (1:33,000) color-infrared aerial photography. Forest lands were categorized into nine cover types, four size classes and four stocking levels. This effort was a continuation of the Mason County Forest Inventory compiled previously by the Remote Sensing Project.

Forest cover information for the two other counties, Clare and Isabella, was derived from analysis of Landsat satellite data. A density analysis, using a Spatial Data Datacolor Image Enhancement system, was performed on separate Landsat bands. Band 6 was analyzed to determine the presence (acreage) of water on a county basis and was subtracted from the acreage estimate of forest land and water derived from band 5. Preliminary comparisons with NASA high-altitude RB-57 photographs (1975) indicate the forest acreage estimates to be better than 90 percent accurate.

In order to determine what the tonnage of the standing non-commercial timber and the potential surplus annual volume growth might be, it was necessary to estimate the total biomass of the forest land. This was

# EXHIBIT 2.02-1 SITE SELECTION AREAS AND LOCATIONS

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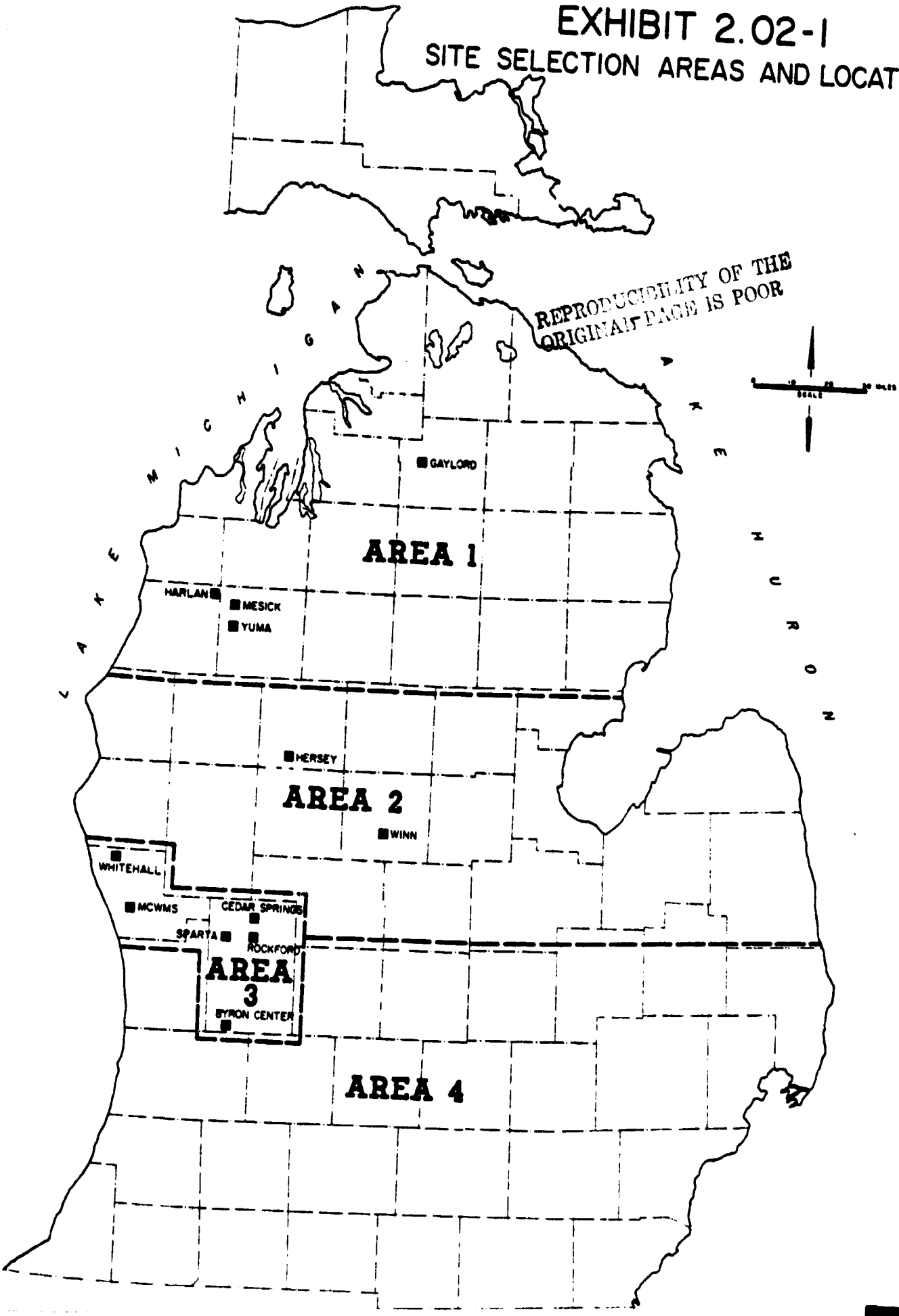
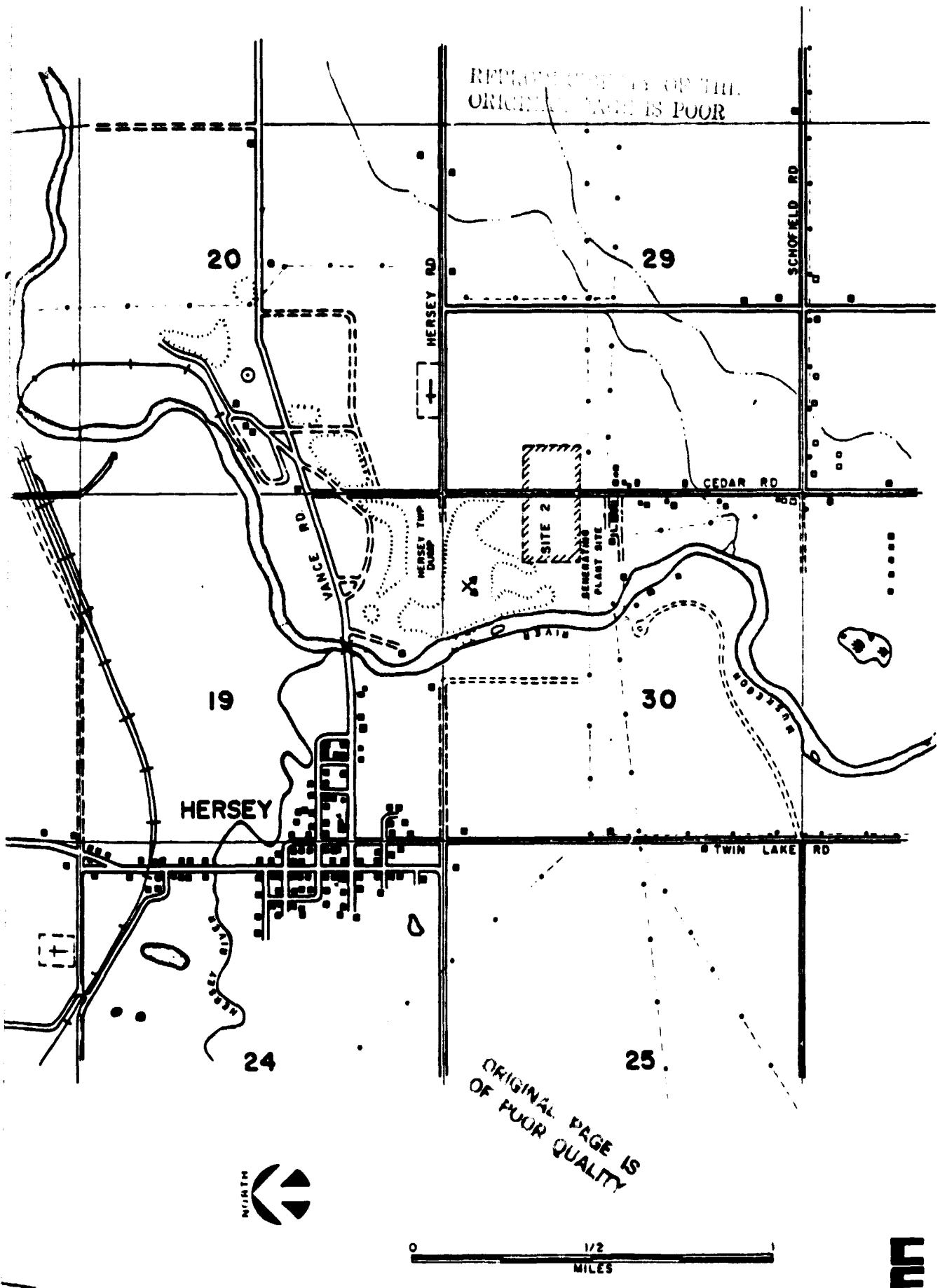


Figure 4.

# EXHIBIT A-2 HERSEY SITE LOCATION



accomplished by sampling biomass plots on representative forest cover types. Sample plots were set up by a Consumers Power Company forestry team, and the entire plot was harvested and weighed by a Morbark Whole-Tree Harvesting system (Fig. 5). The per-acre tonnage of biomass, as derived from these sample plots, was then applied to a net acreage of forest land which had been derived from remote sensing analysis. Table 2 compares the tonnages as derived from the ground cruise and weight tables with actual harvested tonnages.

Table 2.--Summary of Predicted vs Actual Tonnages Per Acre for Selected Ground Plots.

Plot No./Sample Forest Type	Predicted T/A	Harvested T/A	% Error (of prediction)
1/06	90.2	92.1	-2
3Pr6	128.9	133.5	-3
4/05	93.7	97.8	-4
6+7/04	50.1	49.6	+1
9/Pr6	125.3	126.4	+1
10/Ps3	14.0	26.6	-47
11/Pj6	164.8	132.7	+24

Applying the tonnages from Table 2, total biomass for sample forest plots, for the six-county study area, are presented in Table 3.

This project constitutes the first all-inclusive treatment of the wood-energy concept from the gathering of waste wood, with its particular environmental and socioeconomic considerations, through a detailed preliminary design of wood-handling equipment and a medium-sized (25 MW) power plant. This perception of the project makes it all the more innovative considering the state-of-the-art technologies available and further

Table 3.--Biomass of Sample Forest Types.

Forest Type	B I O M A S S ( T o n s )				Total
	Lake	Newaygo	Osceola	Macosta	
04	621,591	710,318	29,008	35,922	1,396,839
05	3,812,840	3,566,784	127,807	260,673	7,768,104
06	4,313,184	3,481,900	231,543	859,425	8,886,052
Pr6	622,329	303,817	418,023	304,204	1,648,373
Pj6	1,939,202	495,389	5,109	20,765	2,460,465
Ps3	--	--	7,294	--	7,294
Total	11,309,146	8,558,208	818,784	1,480,989	22,167,127

consideration of other technologies which may become available in the future. Based upon the findings of the overall feasibility study, including the MSU Remote Sensing Project analysis, the consortium determined that a waste wood-fired plant with a gross output of 25 MW is both technically and economically feasible, subject to regulatory approvals and financing arrangements. The consortium has decided to build the experimental plant which could be in commercial operation in 1983 (Fig. 6).

It is the stated intention of the consortium that "the plant will be used to gather operating experience, to evaluate equipment, to demonstrate environmental compatibility, to develop appropriate forest management practices, and to foster overall public acceptance of a technology that could lead to the serial production of similar units throughout the forest lands of Michigan. Because of the unique developmental aspects of this project, the MSU Remote Sensing Project is continuing to work with the consortium on developing remote sensing techniques that can serve as methods for calculating the biomass supply and harvesting program for the experimental/demonstration wood chip-fired electrical power generating plant.

Figure 5.  
EXHIBIT 3.02.3-1  
MOBILE CHIPPER

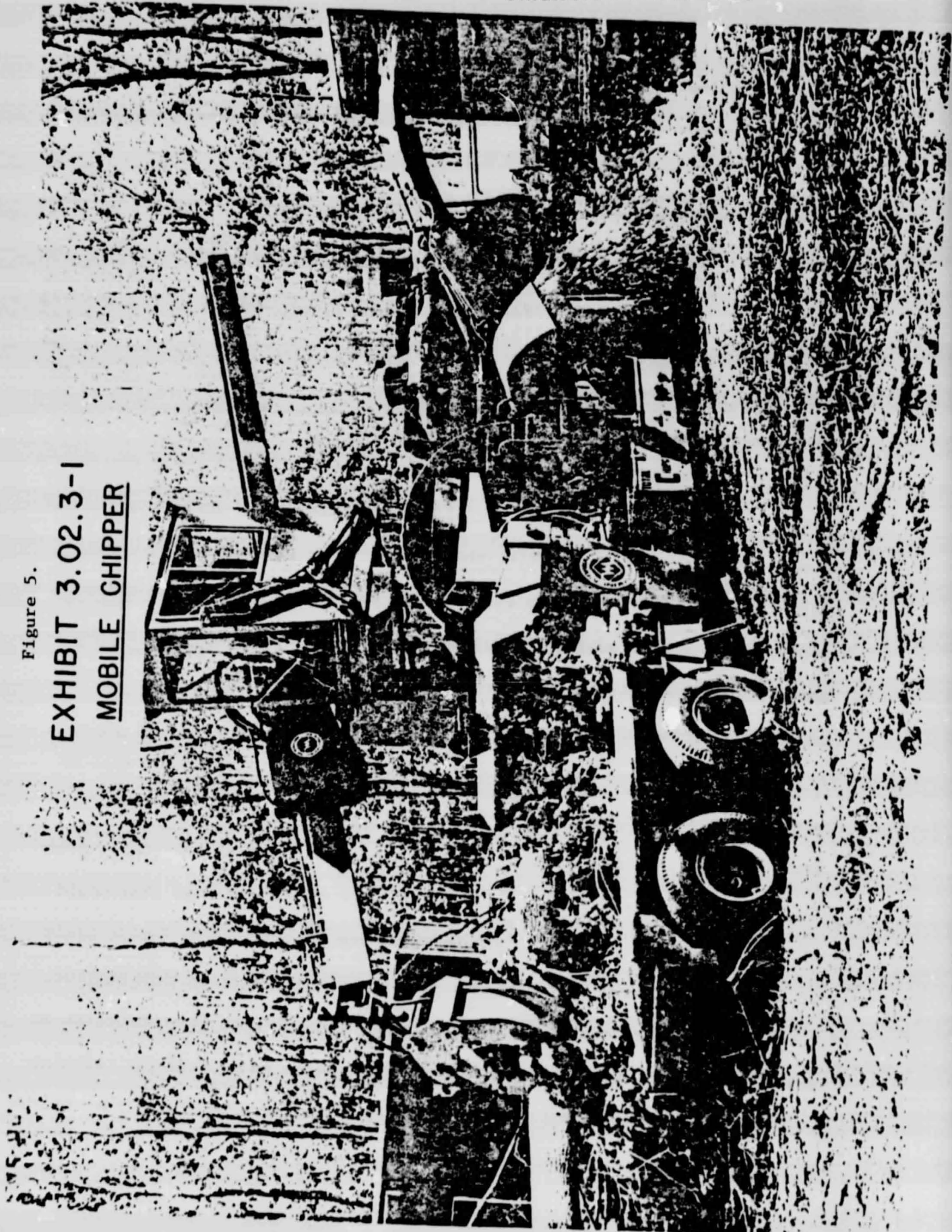


Figure 6. PERSPECTIVE VIEW OF A 25-MW PLANT AT HERSEY



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A2. The Impact of Pipeline Construction on Stream and Wetland Environments

State of Michigan Public Service Commission  
6545 Mercantile Way  
Lansing, Michigan 48910

In connection with its jurisdiction over pipelines, the Michigan Public Service Commission (MPSC) is charged with assessing the environmental impact of gas and oil pipeline construction on wetlands and stream crossings in northern Michigan. The Remote Sensing Project conducted a demonstration project to show that drainage alteration and vegetation damage associated with pipeline construction could be monitored with temporal aerial photography.

In 1977, field investigators, using ground sampling techniques, recorded present conditions at wetland and stream rights-of-way (ROWs) noting vegetation damage, invasion of new species and drainage conditions, particularly standing water within 50 feet of the ROW. Since the sites were not evaluated on the ground prior to construction, the cause of any damage observed could not be pinpointed, and value recommendations to improve future routing and construction methods could not be made.

Since repetitive aerial photography may allow both pre- and post-construction vegetation and drainage conditions to be mapped, the MPSC approached the MSU Remote Sensing Project for assistance. Photo interpretation is also likely to be less expensive than field investigation and such conditions as ponding of water upstream or in the ROW, vegetation change, windthrow and dieback should be detectable on medium-scale photography.

Within the study area (Fig. 7), available black-and-white panchromatic photographs at scales of 1:20,000 and 1:15,840 with coverage dating back to 1938 were utilized. In addition, 1973 and 1977-78 color-infrared photographs provided recent records of the pipeline sites. These sources combined to give adequate pre- and post-pipeline photo coverage for each site.

In the first phase of the project, a site in northwest Wexford County (Fig. 8) was studied. The vegetation cover map prepared from a 1973 photograph shows pre-pipeline conditions, with healthy vegetation and no apparent standing water (Fig. 9); but Figure 10 is the same site in 1977 with ponding upstream from the ROW and accompanying vegetation damage following construction. The company responsible for the pipeline fired the construction contractor and has subsequently taken the following corrective actions.

A construction crew was brought in to ditch across the pipeline causeway to reinstate the surface flow across the swamp and lower the impounded area. At the same time, the crew cut the stems of trees which had wind-thrown so that the stumps would fall back in place. The pipeline company, and personnel from the MPSC, will check the wetland crossing in the early summer of 1980 to see how effective these efforts have been.

Project personnel are currently involved with additional site interpretation and documentation of ROWs to fully evaluate the potential for remote sensing detection of vegetation damage and change and drainage alteration. The study is being conducted on a random sample of sites identified by the MPSC. MPSC studies of these and other sites, using terrestrial surveys, concluded that damage to wetlands was widespread and serious. To date, photographic analysis of both pre- and post-pipeline

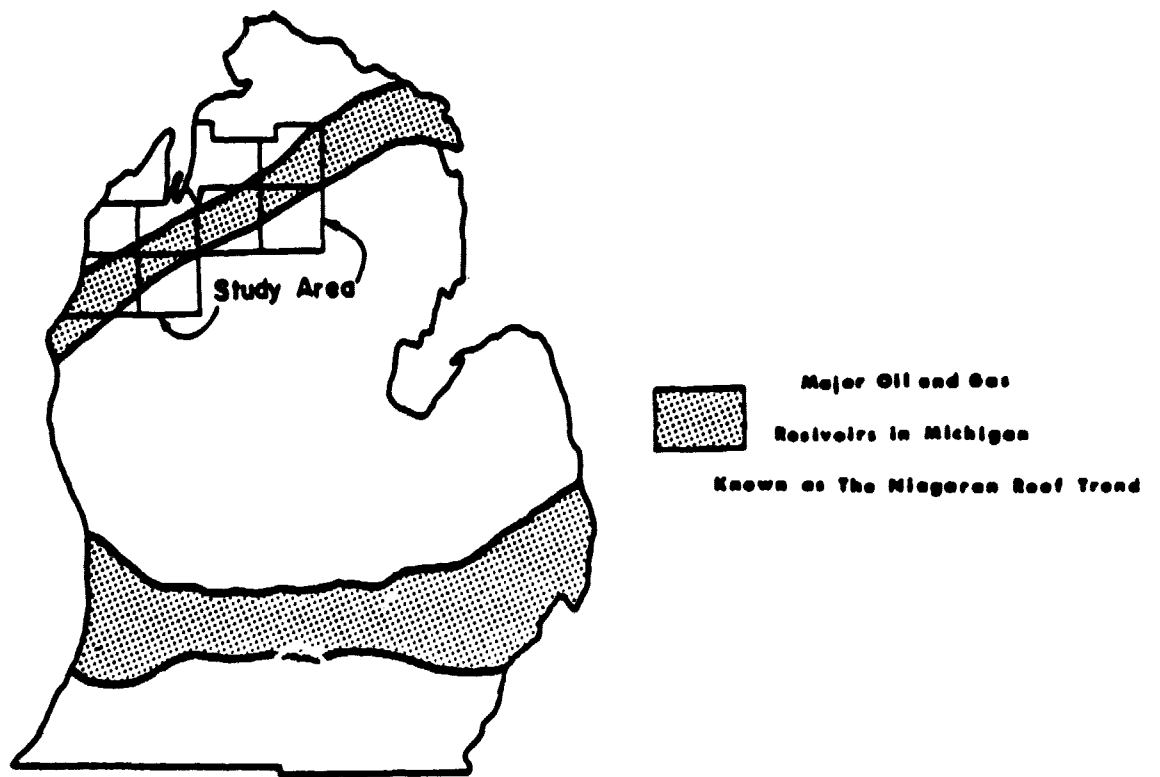


Figure 7.--Pipeline Construction Study Area.

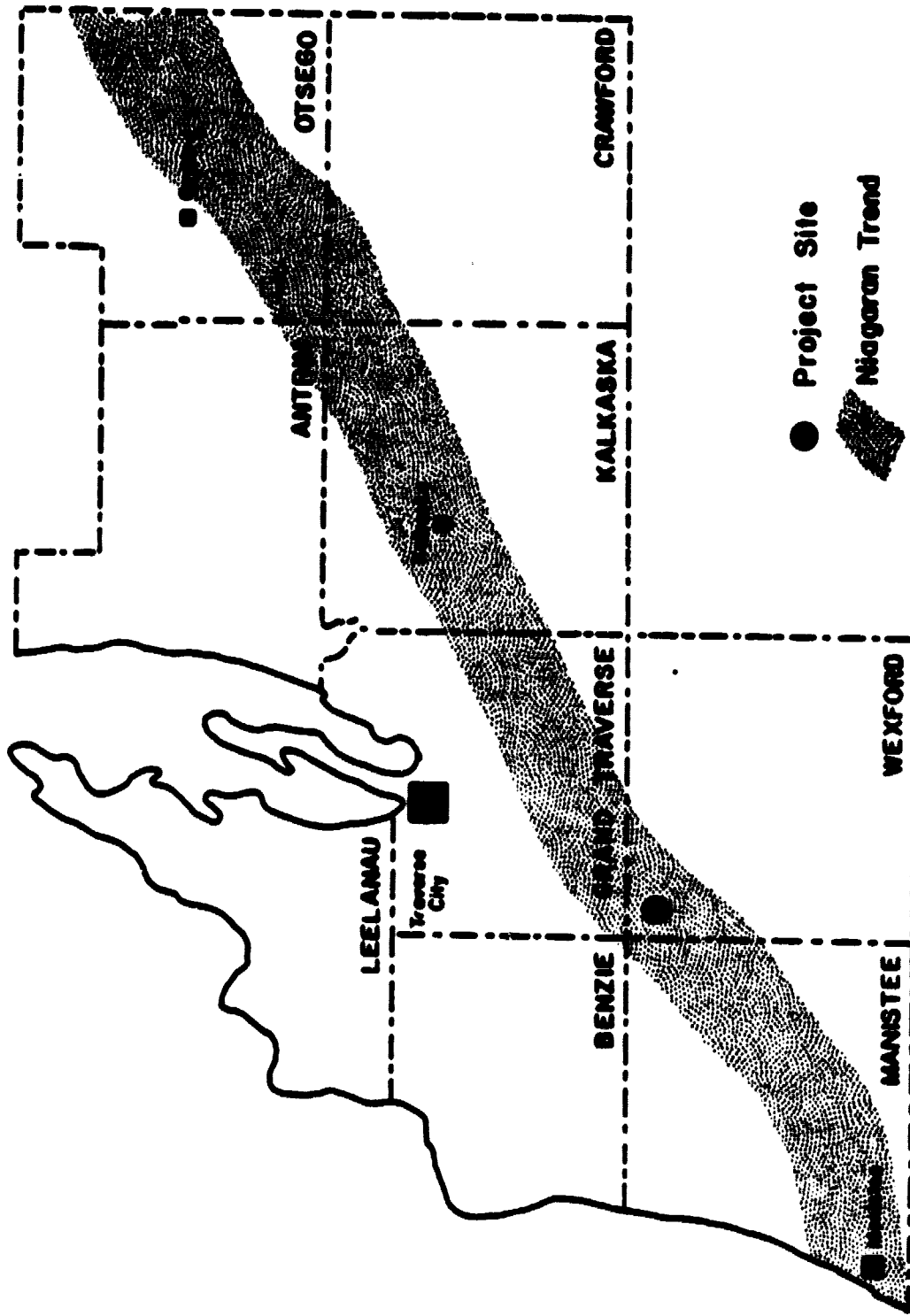
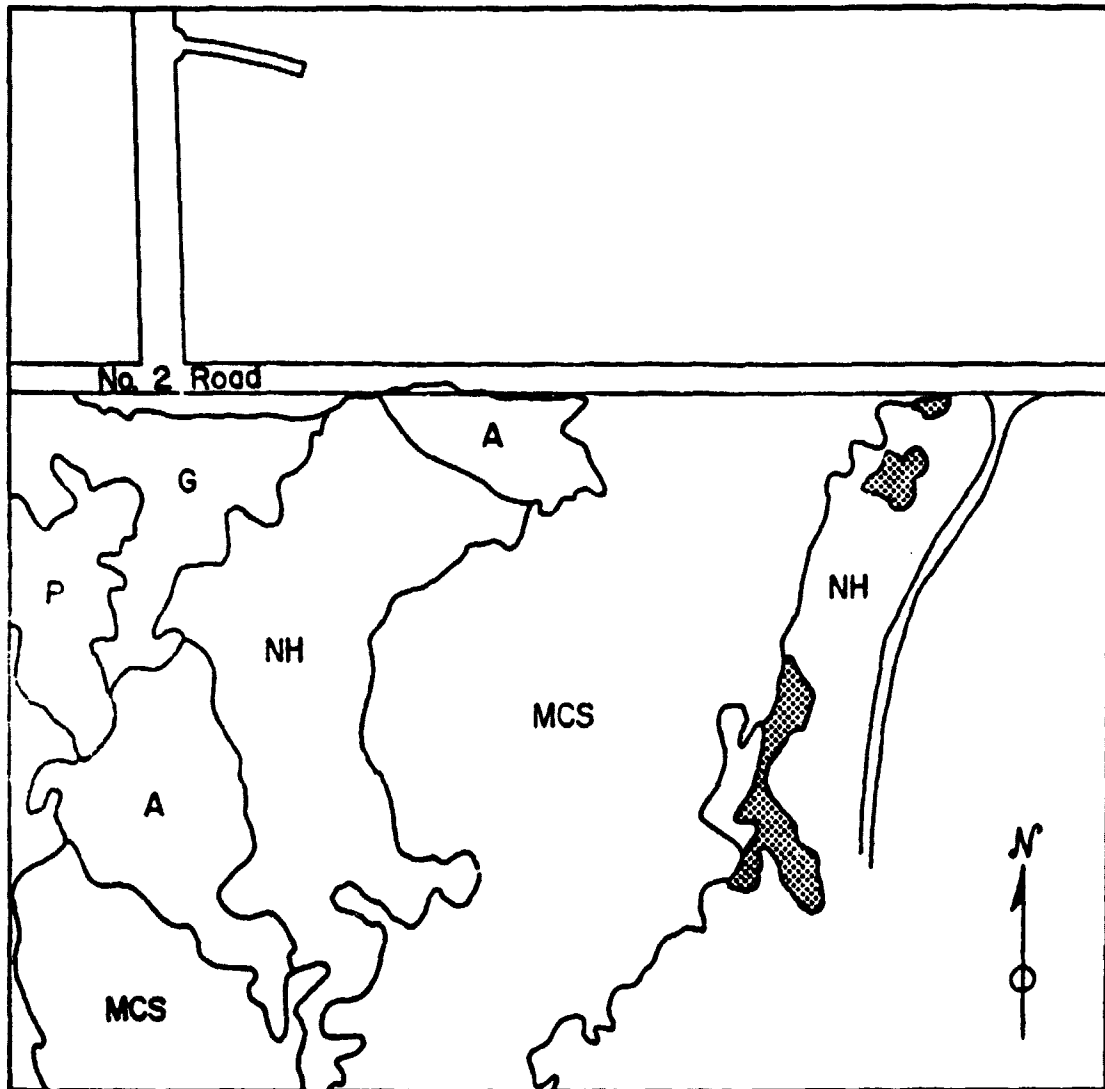


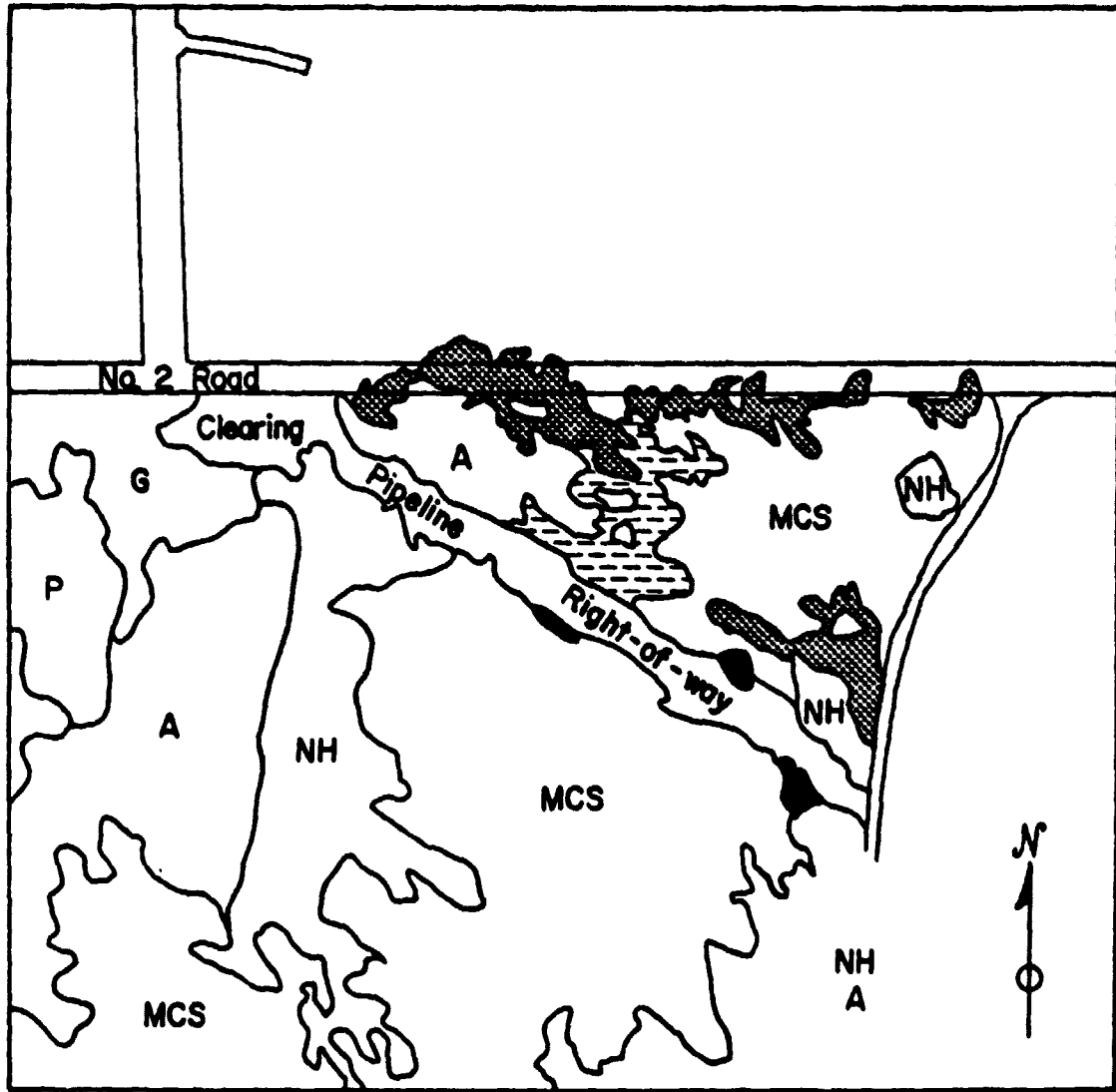
Figure 8.—Location of Project Site in Northwest Wexford County, Michigan.



1:2000  
Scale

A	Aspen		
G	Grass		
MCS	Mixed Conifer Swamp		Shadows (details uninterpretable)
NH	Northern Hardwoods		
P	Pine		

Figure 9.--Pre-Pipeline Vegetation Cover-Type Map.



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Scale




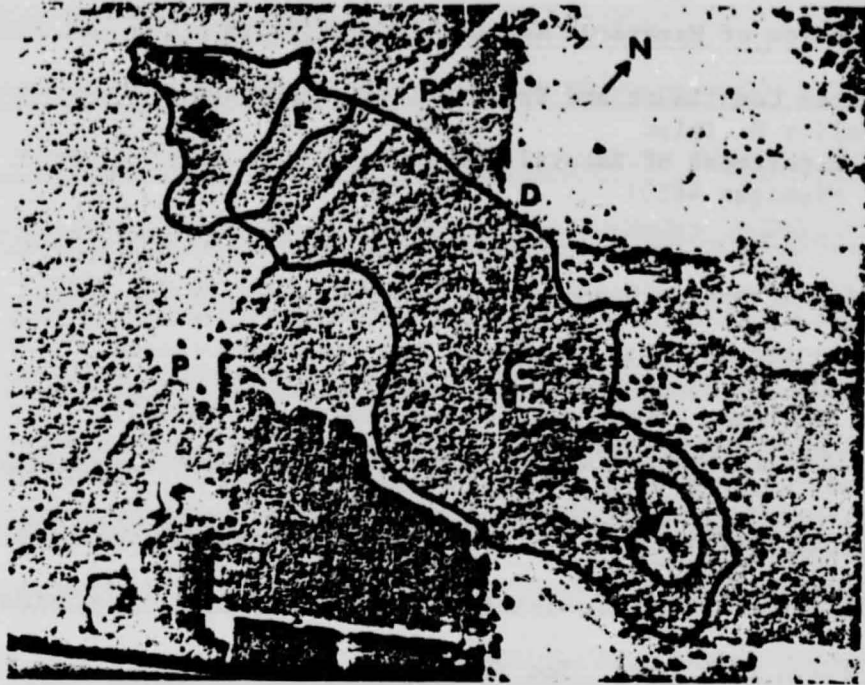
- |     |                     |  |                                   |
|-----|---------------------|--|-----------------------------------|
| A   | Aspen               |  | Windthrow                         |
| G   | Grass               |  | Dieback and Ponding               |
| MCS | Mixed Conifer Swamp |  | Shadows (details uninterpretable) |
| NH  | Northern Hardwoods  |  |                                   |
| P   | Pine                |  |                                   |

Figure 10.--Post-Pipeline Vegetation Cover-Type Map.

conditions has correctly identified several non-pipeline causes of damage. For example, in western Kalkaska County, desiccation associated with a pipeline crossing near the lower end of a seepage wetland appeared to be the cause of death in a nearly 40-acre stand of eastern larch (Larix laricina) and white cedar (Thuja occidentalis) (Fig. 11). The damaged area was immediately downflow from the pipeline, and apparently the desiccation was due to impoundment of wetland seepage by the pipeline. However, the pipeline was installed in 1962, and on 1973 CIR (1:36,000) photographs, the trees appeared quite healthy. Inspection of 1978 CIR (1:24,000) photographs under medium-power magnification revealed that three-quarters of a mile upflow from the pipeline a colony of beaver had constructed a large dam and lodge. This dam captured the flow of a previously undetected artesian well near the head of the wetland, creating a 4-acre pond. In so doing, the beaver severely reduced the water available for seepage flow through the wetland, resulting in desiccation. The time of construction of the beaver dam corresponds closely with the appearance of the stressed and dying trees downflow from the pipeline. Therefore, it appears that the beaver are responsible for the swamp damage (if damage remains the proper term).

Efforts are continuing to complete an evaluation of the impact of natural gas pipeline construction through streams and wetlands in Michigan's northern Lower Peninsula. Study conclusions will be compared with the traditional (terrestrial) survey methods currently used by the MPSC.



- A. Dead trees in impoundment above beaver dam
- B. Beaver dam site
- C. Taylor Creek
- D. Edge of wetland
- E. Dead trees below pipeline ROW
- P-P Pipeline ROW

Figure 11.--Taylor Creek Swamp.

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### A3. Identification of Hazardous Wastes Disposal Sites

Ground Water Compliance and Special Studies Section  
Water Quality Division  
Michigan Department of Natural Resources  
Lansing, Michigan 48909

Serious toxic waste contamination problems, such as the highly publicized Love Canal situation in New York, have recently created concerns over the potential for human exposure to these hazardous chemicals. In response to similar concerns in Michigan, Governor William Milliken has requested the Michigan Department of Natural Resources (MDNR) to analyze potential hazardous chemical disposal sites and initiate a plan of action to eliminate any hazards associated with them. The MDNR is currently making a concerted effort to identify disposal sites which need prompt abatement action. Approximately 20 such critical problem situations are in various stages of abatement at this time, with several cases already in litigation. Copies of several related news stories together with a copy of a letter from Howard Tanner, Director of MDNR to Governor Milliken (attached) provide a sampling of documentation of this dangerous situation.

Despite the concerted efforts of the MDNR to identify these critical sites, many potentially hazardous sites go undetected. The assistance of the MSU Remote Sensing Project was requested in applying remote sensing technology in locating these toxic wastes disposal sites. Project investigators developed two techniques which show promise in providing the necessary information.

Using both historical and current aerial photography (1938-1979), investigators compiled time-sequential maps of areas surrounding selected

chemical plants (selected by the MDNR). These maps portray the sequence of events (e.g. road building, pit filling, bulk dumping, site growth, etc.) which have taken place around these plants. Preliminary evaluation by MDNR staff indicated that these maps will allow them to "reconstruct" the process and placement of hazardous wastes much more reliably than by the present method of studying existing conditions and interviewing plant management.

Additionally, Project personnel are obtaining large-scale, color aerial photographs over areas of "suspected" dumpings. These photos will be analyzed and compared with current ground survey techniques to determine their utility and cost effectiveness. Several MDNR offices (Water Quality, Ground Water Compliance, and Air Quality) have expressed substantial interest in this project with the anticipation of adding a new tool to their investigative procedures.

Subsequent progress reports and grant refunding requests will provide continuing descriptions of this extremely hazardous situation and how the MSU Remote Sensing Project is contributing to the actions for correction.



Governor Milliken

-2-

October 4, 1973

3. A cooperative effort under development for some time between EPA, the State Health Department and the Department of Natural Resources will begin in October to locate all pits, ponds and lagoons where former waste disposal activities have occurred in the state. Following completion of this inventory in May, 1979, an analysis will be made of their groundwater pollution potential. The end product, due in January 1980, will be an overview of the state's groundwater contamination problems resulting from improper disposal of hazardous liquids and a plan of action to solve them.

4. The Resource Recovery Division will be conducting an inventory and evaluating all of the solid waste disposal facilities on record in the next two years. The inventory is being conducted as part of the State's participation in the Resource Conservation and Recovery Act (RCRA) P.L. 94-580. The Division will be evaluating all solid waste disposal facilities to determine if they meet criteria established by the EPA and our present standards relative to the potential of the sites posing a reasonable probability of adverse effects on health or the environment.

5. More currently we are making a concerted effort to identify disposal sites which need prompt abatement action. Local governmental agencies (county health officials and regional planning agencies) have been asked along with the general public, as mentioned in paragraph 1, to advise us of potentially hazardous sites. Evaluations will be made of all such sites, and those that cannot be upgraded will be closed in an environmentally sound manner to protect the health and safety of area residents. Approximately 20 such critical problems are in various stages of abatement at this time as identified in my July 26, 1978, report to you. If, in the case of abandoned or closed facilities, corrective actions by facility owners or operators cannot be brought about, it will be necessary that we discuss a reliable procedure with legal counsel to assure initiation of any necessary measures to protect the public health and safety. *(September 29, 1978 updated report attached)*

6. The goal of the Department is to develop a program to insure the adequacy of all hazardous waste disposal facilities. We believe we can accomplish that goal through a combination of existing authority under Act 87, P.A. of 1965, through proposed legislation (House Bill 4804) and by obtaining authorization to implement a state program under the Hazardous Waste Management Section, Subtitle C, of the Resource Conservation and Recovery Act which is in progress.

7. To help prevent unauthorized dumping of hazardous wastes in the future, Michigan plans to soon implement a voluntary hazardous waste manifest system which will track each load of waste from the waste generator to its final disposal at an approved site. The system has been developed with the cooperation of the Liquid Industrial Control Association and

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October 4, 1978

will be computerized so that follow-up actions can be quickly initiated on shipments of wastes failing to reach their intended destination. Such a manifest system is required for all states under the RCRA Hazardous Waste Management Section. As you pointed out, H.B. 4804, when passed, will give Michigan the statutory authority for implementing the system with respect to both solid and liquid wastes.

8. The Resource Recovery Commission with technical guidance from the Resource Recovery Division has contracted with the firm of Hennington, Durkin and Richardson to develop a Solid Waste Management Plan for the State of Michigan. The plan consists of 13 individual task reports. A preliminary draft of the 13th report dealing specifically with Hazardous Waste Management was received in August and is currently undergoing staff review. The plan covers all aspects of hazardous waste control and appears to provide valuable guidance to our Department. This report will undergo the critical review and input from a Public Response Panel established in 1977 to oversee the project. This plan when finalized will be incorporated as appropriate into an overall DME strategy on Toxic Materials Control currently being developed by the Environmental Protection Bureau.

9. The Department is currently evaluating all known potentially hazardous disposal practices. Many are in the process of active litigation (as noted in my report under Item 5) and others are in the fact finding stage under review by a special Problem Evaluation Committee established in the Department the first of this year. This is an on-going review process so that new problems will be continually prioritized and acted on in a manner appropriate to the severity of the situation.

10. The Department's Environmental Enforcement Division is actively reviewing legally actionable toxic materials problems. Environmental strategies are being developed which include potential fact finding costs and clean-up costs. Our position, however, is that any costs required for the clean-up of toxics and pollutants will have to be borne by those responsible, and not the taxpayers of Michigan.

While there are serious toxic waste contamination problems such as Hooker Chemical, Lakeview Chemical and the Gratiot County Landfill, none can be compared to the New York, Love Canal situation. Except for those cases already in litigation, we expect voluntary clean-up to be accomplished and those pursued through court action we expect court ordered clean-up at the discharger's expense. However, we will take whatever actions are necessary to safeguard the public health if a critical need is identified in the future. This may require the initial expenditure of public funds to assure speedy protection of public safety.

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Governor Milliken

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October 4, 1978

I will keep you informed as we progress in these activities.

Sincerely,

Howard A. Tanner  
Director

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JRobinson:sk

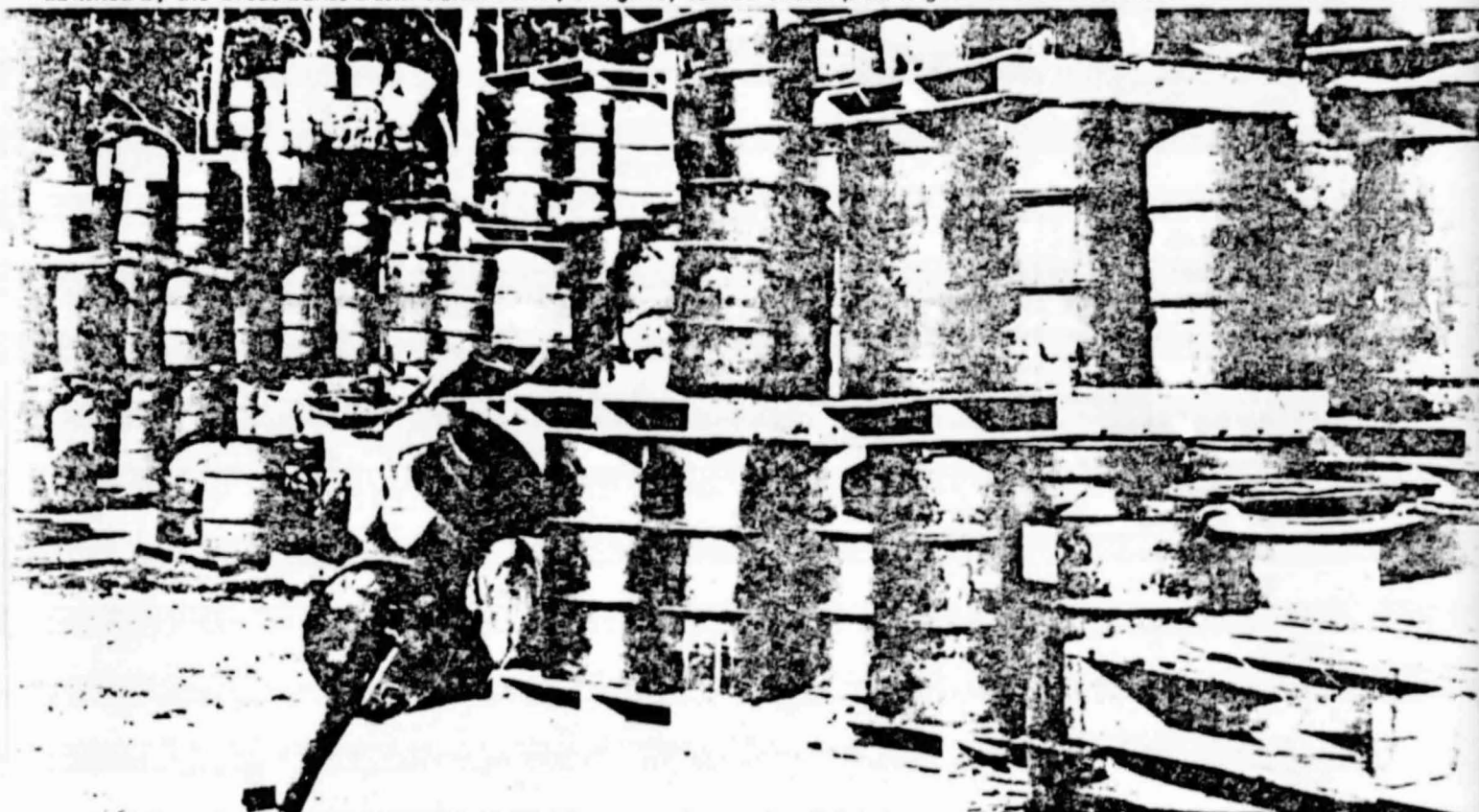
- Attachments: news release
- status report
- letter to local health agencies
- letter to EPA
- letter to 208 agencies

- bcc: C. Guenther
- R. Courchain
- G. Guenther
- F. Kellow
- J. Bails
- S. Freeman



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Corroding barrels of wastes at Story Chemical Corp. in Muskegon, Mich., in late 1977. A cleanup is in progress.

Michigan Department of Natural Resources

## To Dwarf A Sleeping Giant

### Great Lakes Region Takes On Hazardous Wastes

Last year, officials declared an emergency after increased birth defects, miscarriages, and other health problems focused national attention on the former Niagara County, N.Y. chemical disposal site called Love Canal.

Every year, spills and leaks involving unwanted industrial by-products occur throughout the Great Lakes Basin.

Seventeen percent of the nation's hazardous waste producers are located in the industrialized Great Lakes states. One-fourth of the hazardous materials are produced here. The lakes themselves have accumulated hazardous wastes for decades, with those not flushed out settling to the lake and harbor bottoms. The

Great Lakes Basin Commission has drafted a strategy to cope with the wastes (see *From the Chairman*, p.7).

Hazardous wastes are in every community. Some corrode storage containers and can damage human tissue. Others may explode or otherwise react if exposed to heat, shock, air, or water. Still others may explode spontaneously, catch on fire, or emit toxic gases or fumes. But the most worrisome wastes are toxic. They threaten human health, can cause cancer and birth defects, can harm or kill fish and wildlife, and can result in serious economic losses.

The U.S. Environmental Protection Agency (EPA) estimates that only 10

percent of the nation's hazardous wastes removed from plant sites are disposed of adequately. The rest could contaminate groundwater through leaching or runoff, pollute the air through inadequate incineration, burn or explode, poison people through direct contact, or — most importantly, in the Great Lakes — poison us through the food chain.

Despite the urgent need for safe disposal of hazardous wastes, public consciousness of the problem's extent and possible solutions remains low. One U.S. Senator called the disposal problem "the environmental sleeping giant of the decade." Now, government is beginning to respond.

# THE ISSUE: Toxic Substances



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Published by the Great Lakes Basin Commission, an agency to coordinate planning for Great Lakes water and land resources.



Photos: B.H. Mills, MI DNR

## Basin Plan Aims at Toxic Problems

By John Hall, Water Resources Planner  
Great Lakes Basin Commission staff

Last month New York Health officials warned pregnant women and children under two to evacuate the Love Canal area of Niagara Falls. Their homes were being polluted by toxic chemicals seeping from the ground. More than 80 chemicals, some of them suspected of causing cancer, were buried in a landfill there 26 years ago.

This was only the latest incident in the much larger set of problems posed by toxic substances contamination in the Great Lakes basin.

This edition of the *Communicator* presents some of the many issues we face in solving these very complex problems. Many programs to manage toxic substances are now being carried out. This fall, the Great Lakes states and the federal government will be setting a regional strategy for toxic control as part of the Great Lakes Basin Plan.

### Toxic Control—How?

There are two basic problems in controlling toxic substances: managing those already in the environment and preventing future contamination. Where

toxics are already present, we can either physically remove them or protect public health by limiting people's exposure to contaminated food, water, or other materials.

An International Joint Commission study on pollution (PLUARG) concluded that effective, large-scale removal of in-place toxics is not feasible because of limited technology and prohibitive costs. Typical removal methods are dredging and confined disposal, purging of contaminated groundwater, and excavation and incineration or storage of contaminated soils.

Such measures are only a reaction to a more fundamental problem. The most effective way to avoid toxic substance contamination is to prohibit manufacture and use of a harmful substance altogether. Levels of DDT, for example, have been declining in the Great Lakes since it was banned in 1971 by the US Environmental Protection Agency. Outright bans on a chemical, however, are not always desirable. Economic, political, and social factors must be considered along with public health and environmental effects.

Control of toxics at the source of their

discharge into the environment is effective in some cases and difficult in others (especially diffuse or nonpoint sources). Source control is costly, but the price must be paid when the benefits of producing and using a chemical are thought to outweigh these costs.

Which of these measures are most appropriate as part of a future control strategy in the Great Lakes basin? The answer depends on at least four critical issues: money, risks, disposal sites, and public attitudes.

### Money

The key obstacle in controlling toxic substances may be money. If fully implemented, federal and state laws now on the books are probably adequate to protect the Lakes and the basin's residents. The problem is that lack of adequate funding and manpower could make implementation of these laws slow and ineffective.

Many of today's taxpayers feel their burden is becoming unbearable. California's tax limitation (Proposition 13) has triggered interest in Michigan and other states. At the same time, inflation pinches both taxpayers and government. Possible future curtailments of state and local





Published by the Great Lakes Basin Commission, an agency to coordinate planning for Great Lakes water and land resources.

## States Discuss Toxic Problems and Solutions

By John Hall  
Regional Planner/Policy Analyst  
Great Lakes Basin Commission

"No issue is more important or more urgent today than the management of hazardous materials. The states collectively must put in place the steps necessary to achieve agreed upon measures to assure protection of human health and the environment."

These were the words of Michigan's Governor William G. Milliken in his opening address to the first International Conference on Hazardous Materials Management, held at Detroit's Renaissance Center on December 4-5.

Addressing the conference as the keynote speaker, Governor Milliken said he was "...increasingly concerned with what amounts to a non-system in the United States which copes with hazardous materials." He called for substantial action within one year. His remarks set the tone for the two-day conference.

The State of Michigan and the National Governors Association sponsored the event to sharpen understanding of the problems and the need for early state action. The Great Lakes Basin Commission developed several graphic displays for the conference and an information packet that was distributed to all participants.

Participants of the conference included representatives from 29 states, four Canadian provinces, the U.S. EPA and Department of Transportation, the Great Lakes Basin Commission, the International Joint Commission, and several other agencies. Private industry was also represented.

Billed as an international event, the conference was aimed in part at recognizing the substantial movement of both hazardous wastes and dangerous products across the U.S./Canadian border. To this end, Governor Milliken called for the establishment of an international forum for effectively sharing information on hazardous materials.



Photo by John Hall, GLBC

Discussing the disposal of hazardous waste disposal during a break in the conference are (left to right) Gary Guenther and William Marks from the Michigan Department of Natural Resources and Lee Botts, Chairman of the Great Lakes Basin Commission.

Through a series of major presentations, panel discussions, and informal interaction, participants were able to discuss the problems in great depth. After all the concerns and frustrations were aired, recommendations were formulated on how to effectively handle the situation.

General agreement and consensus was reached by the conferees on the following points:

- Toxic and hazardous materials prob-

lems are too serious to wait for the slow and often tedious process of the development of adequate federal regulations.

- States must take the initiative and act together within one year to solve the nation's serious hazardous materials problems.

- Liability for hazardous waste disposal incidents such as Love Canal in Buffalo, New York must be resolved by Congress as soon as possible.

(Continued on page 7)

The GLBC prepared a 17 page information packet for the International Conference on Hazardous Materials Management, held in Detroit on December 4-5, 1978. Included in the packet is a profile of all state toxic and hazardous substance programs, a chart detailing the responsibilities for federal agencies under existing federal hazardous and toxic materials laws, existing federal regulations for interstate commerce shipment of hazardous materials, and examples of some emergencies involving hazardous materials.

For your free copy of the packet, request it from: Great Lakes Basin Commission, Public Information Office, P.O. Box 999, Ann Arbor, MI 48106.

## Hooker, state pact reached

By The Associated Press

Hooker Chemical and Plastics Corp. officials in Montague have agreed to abide by a preliminary court injunction and intercept contaminated groundwater around the plant before it reaches a nearby lake.

Ingham County Circuit Judge Michael Harrison granted the injunction Wednesday to Attorney General Frank Kelley, who called for installation and operation of a "purge well" system to intercept the company's contaminated water before it flows into White Lake.

**KELLEY SAID** Hooker officials have agreed to install the purge wells. "We still have a long way to go be-

fore we solve the problem, but this is a beginning," Kelley said.

He termed the company's attitude cooperative.

Kelley filed suit against the company Feb. 25, after the Department of Natural Resources showed toxic wastes, including C-56, had been dumped on the firm's 880-acre site since the early 1950s.

The wells will prevent further contamination of White Lake while the state lawsuit pursues a full cleanup of the Hooker facilities, according to Kelley's office.

**THE WELLS** must be sunk within 60 days, according to the court order.

## Poison-dumping firm agrees to clean mess

By The Associated Press

A Grand Rapids waste hauler has agreed to pay cleanup costs for illegally burying 7,500 gallons of the toxic chemical C-56 in a Montcalm County landfill, Attorney General Frank Kelley announced Monday.

Approved Industrial Remover Inc. must also pay the state \$18,000 in fines and reimbursement for expenses in removing the toxic waste and contaminated soil from the Central Sanitary Landfill.

**C-56 IS** the major component of the

pesticides Kepone and Mirex. The dumping of C-56 into the sewer system of Louisville, Ky., in 1976 resulted in the temporary closing of the sewer system, expenditure of millions of dollars and the forced dumping of raw sewage into the Ohio River.

Burial of C-56 in the Montcalm County landfill was discovered in 1977, before any of the chemical had spilled into the surrounding areas.

Under the agreement with the state, Approved Industrial Removal must place \$15,000 in escrow until March 1978 in the event money is needed for cleaning nearby water wells.

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# State launches study of toxic waste disposal

By JERRY MOSKAL  
Capitol Bureau

Toxic industrial wastes are piling up at the rate of 10 million gallons a year in Michigan as temporary storage facilities become scarcer.

Because of the problem, the state is stepping up efforts to get into the waste disposal business itself or to encourage private enterprise to undertake the task.

"THERE'S NO place in Michigan to dispose of toxic hazardous material," said William Marks, assistant deputy director of the Department of Natural Resources. "The normal industrial waste is being handled.

"But things like PCBs are in temporary storage. Sooner or later the containers are going to start to deteriorate."

State officials said that 100 million gallons of industrial waste are produced each year in Michigan, 10 per cent of them toxic.

CONCERN OVER the problem prompted the Legislature's Capital Outlay Committee to put up \$50,000 to start a DNR study that will

take four or five months to complete.

"We're working on site criteria," said Marks, DNR's environmental protection chief. "I doubt if we'll be selecting a site. But we need this information if the state goes ahead or not."

He said the heavily industrialized southern part of the Lower Peninsula is the most likely spot for the \$50 million facility. The site will have an incinerator as well as burial grounds.

ONCE THE study is completed, DNR will submit its recommendations to the Public Health Committee. DNR officials lean to a state-operated facility while some legislators favor a privately-operated disposal under state supervision. Several bills have been introduced.

Besides PCBs, the state also faces the mind-boggling problem of what to do with PBBs, hexachlorobenzene, cyanides, phenyls and a host of other dangerous wastes.

Marks estimates that tens of thousands of pounds of PCBs are stockpiled in industrial areas of the state, much of it in warehouses and other temporary facilities in the South-

east Michigan area near Detroit.

PCBS, A HEAT absorber, contaminated Great Lakes fish to the point where the U.S. Food and Drug Administration issued a health warning. Since state and federal laws banning the use of PCBs were adopted several years ago, PCB levels in fish have dropped.

The chemical came into use in the late 1930s and early 1940s as a heat absorber in electrical transformers, auto brake fluids, television capacitors, light ballasts and in industrial processes.

The material worked its way into the lakes as PCBs were dumped into sewage systems, from spills in rivers and streams that flow into the lakes, and industrial smokestack discharges.

ONLY INCINERATION, Marks said, can destroy PCBs. They have to be burned at temperatures of more than 2,500 degrees for long periods of time. Only a handful of such incinerators exist in the country, including Alabama, Arkansas and Oregon.

After the study is complete, he added, it

would take two years before a site is designated plus an additional two years to build it.

"The longer this goes into the future the more it will cost, the way things are going," he warns.

SUCH A LONG list of toxic compounds are in use that state officials aren't exactly sure where everything is or the exact extent of the problem.

The situation is similar throughout the eight-state Great Lakes Basin. The International Joint (U.S.-Canada) Commission's annual report called for both countries to inventory more than 2,800 toxic compounds known to be in use in the basin.

Rep. Thomas C. Mathieu, D-Grand Rapids, who heads a special committee studying the toxic waste problem, said stiff opposition can be expected whatever location is picked for the toxic waste disposal site.

"NO ONE IS going to hold up their hand to volunteer to be the location for a hazardous materials waste site," he said. "That's not going to happen."

#### A4. Integrated Pest Management Systems

Departments of Botany & Plant Pathology and Entomology  
Michigan State University  
East Lansing, Michigan 48824

Remote Sensing Project investigators, in collaboration with faculty of the MSU Departments of Botany & Plant Pathology and Entomology, conducted several small pilot studies aimed at incorporating information from remote sensing data into on-line integrated pest management programs. Two major studies were carried on during the grant year period.\* The first study investigated damage distribution assessment and biomass loss to small grains caused by the cereal leaf beetle. The objectives of this investigation are:

1. To estimate within-field damage and biomass loss caused by the cereal leaf beetle using infrared aerial photography of individual oat and wheat fields in Kalamazoo County, Michigan;
2. To identify small grain fields (oats and winter wheat) using infrared aerial photography by photographing a transect across Kalamazoo County; and
3. If objective 2 is possible, then to identify, using techniques developed in objective 1, different levels of damage and biomass loss caused by the cereal leaf beetle from county transect photographs.

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\* It should be realized that seasonal constraints limited the period of time for carrying out active field research.

Faculty investigators, through ground surveys, have identified sample fields for objective 1 and conducted a survey to identify a flight transect for objective 2. Aerial photographic data will be collected on a periodic basis with actual timing of the flights to be determined from ground conditions as measured by the faculty investigators.

The second study was conducted to determine the utility of aerial IR photography to detect X-disease (a fruit tree disease transmitted by several species of leaf hoppers) infected trees in individual cherry and peach orchards located in southwest Michigan. Procedures similar to those outlined for the cereal leaf beetle project are being employed. Faculty investigators have already identified sample orchards which: 1) contain X-disease infected trees; 2) have ground collected data over several years; and 3) are owned by individuals willing to cooperate with the researchers. Actual flights were scheduled for mid-summer (1979) when the disease symptomology would first begin to appear. Additional flight lines were scheduled over areas, determined by ground observations, to determine the ability to detect host chokecherry bushes. Because chokecherry is the main source of X-disease propagation, a major control technique is the identification and eradication of all chokecherry plants near stone fruit orchards.

These dual studies were not completed during the grant progress report year; they were continued into the summer of the next (1979-80) research year; so, more findings and actions will be described in the next reporting.

A5. Analysis of Landsat Data in Updating Forest Inventories

County Director  
Cooperative Extension Service  
Courthouse  
Reed City, Michigan 49677

Packaging Corporation of America  
Woodlands Department  
Filer City, Michigan 49634

Remote sensing, in the form of small-scale color-infrared photography, has been successfully applied to forest cover type mapping and inventory in Michigan. Five counties have completed inventories with several more in various stages of production. Each of these inventories involves a substantial expenditure of time and money. Although the forests may remain ecologically stable over a short time if left alone, man's impact is often sudden and dramatic. Clearing of forests for highway rights-of-way, second home developments, and similar intensive uses and the harvesting and silvicultural treatments (e.g. thinnings and plantings) applied to the growing of trees for fiber can produce a profound impact on the forest resources of an area.

Project investigators designed updating methods and sequential procedures using Landsat data (CCT's, black-and-white imagery, and diazo composites) to detect and identify changes in the forest since the original inventory. This pilot demonstration was conducted in Osceola County, Michigan, in connection with a forest management portfolio being developed through a grant from the MSU Agricultural Experiment Station. The procedures developed during this study will be applied to a test site during the upcoming grant year.

B. USER SERVICES and INSTITUTIONALIZATION of the REMOTE SENSING PROJECT

Through the full extent of the reporting year, the Project personnel continued to respond to a myriad of requests from individuals and organizations for information and assistance. In an overall fashion, the RSP serves as a "reference service" for an increasing number of public and private organizations. Requests range from how to gain access to NASA photography and Landsat frames; to providing some training in image interpretation and use of various kinds of equipment; to giving presentations at on-campus and off-campus classes, workshops, and conferences; to providing more sets of aerial obliques of the Detroit River land edges and of other terrain situations; to directing inquirers to productive sources of further materials and information sources; to helping users analyze problem situations and how to set about probing for solutions; to deriving data classifications and related procedures; to correlating remotely-sensed data with other natural and cultural resource information. These many kinds of inquiries are responded to as well as time, space, and facilities can accommodate. Such services are unsolicited, ad hoc, and are fit in among the on-going units of research applications.

As requests for special services are generated by the reputation of the RSP, so too do the performing of services sometimes lead to developing contractual arrangements for research endeavors, for a variety of information collecting, tabulating and analyzing, and for training. In all these experiences, awareness of the capabilities and versatility of remote sensing

imagery for both short- and long-term usage increases. . .an ever-expanding "community of users" is sustained.

These cannot be reported simply in categorical and specific terms; but, surely, these smaller scale activities continue to press our staff and facilities. One major kind of special service, that of training of staff professionals of State departments, continued to be an ever-present market. The Project logistics are severely limited in terms of "up-front" development funds, manpower, equipment, space, etc. to do more than respond, ad hoc, to requests for training. To perform effectively in a training medium, enabling support is needed. With a modest sum of support funds, the MSU Remote Sensing Project could develop materials for units of training (or call such, "technology transfer"), train in-house instructors, tool up with training equipment and related software and undertake an aggressive, on-going center for training all kinds of clientele in remote sensing methods and related analytical processes. We view this kind of mission as a most important one whereby the productivity of NASA investments can be maximized in terms of benefiting people and resources. . .at least, the people and environment in Michigan.

As reported in the last Progress Report, the initiation of workshops for Cooperative Extension Service personnel (with a large portion of costs covered by the CES) continued through the reporting period. And, during the latter half of this period the possibilities of having the MSU Project organize a continuing schedule of training workshops for staff of several State agencies began to be discussed. (Note: In January 1980, these agencies have initiated actual negotiations for training services.)



The second activity to be reported on under this section relates to the processes of achieving official recognition of the Project as a "Center" within the University structure.

What we have come to call "institutionalization" of the RSP advanced to the stage where, after many conferences (as previously reported) with higher administrative officials, a formal petition was submitted in May 1979 to the Deans of the four Colleges with which we have been working and to the Associate Provost who agreed to serve as the coordinator of this endeavor.

During June 1979, a series of conferences with the Deans and Provost developed into basic acceptance of the proposal, leaving joint negotiations between these principals for deciding on essential support features to be followed by signing of a joint declaration. Because some of these principals had to be absent during the summer months, it devolved that final action had to be delayed until early fall.

In the following text, part B-2 (page 51) consists of a synopsis of the institutionalization petition text which summarizes the plan the faculty and staff of the RSP judged most reasonable and workable, together with the rationale justifying the requested enactment.

### Bl. Cooperative Extension Service Workshops

As reported in the last Progress Report, arrangements were initiated on a cost-sharing basis with the Michigan Cooperative Extension Service (CES) to introduce remote sensing technology and applications to the staff of county-level agencies in Michigan.

A series of seven one-day remote sensing workshops were conducted for 278 participants from 38 counties in Michigan. The workshops were set up by the District Extension Leaders in cooperation with the County Extension Directors who invited appropriate persons or representatives from organizations and agencies in their counties. Most of the participants were local governmental officers, county planners or CES personnel (Table 4).

Table 4.--Agency Affiliation of Workshop Participants.

Agency	No.	Agency	No.
County Government	34	Road/Drain Commissions	16
Cooperative Extension Service	43	Tax Equalization Depts.	23
Health Departments	9	Township Government	19
Planning Offices	49	U.S.D.A. (ASCS/SCS)	21
Private Firms	9	Unspecified/Other	55

The major objective of each workshop was to improve participants' awareness and understanding of remote sensing technology and applications. A typical agenda for a workshop is given in Table 5. The program started with an overview of aerial imagery that included a slide presentation on the spectral, radiometric, spatial and temporal advantages of remote sensing for earth

Table 5.--Remote Sensing Workshop Agenda.

- 
- A. Introduction to Remote Sensing and Resource Inventory Techniques
1. An Overview of Aerial Imagery: Types and Characteristics
  2. Sources of Aerial Imagery
  3. Inventory Procedures
- B. Applications of Remotely-Sensed Data in Michigan
1. Organizations Conducting Applications
  2. Land Cover/Use Inventories
  3. Improving Local On-Land Action Programs
  4. Implementing Environmental Legislation
  5. Agricultural Assessment
  6. Computer-Based Mapping Systems
- 

resource studies and a series of examples of its utility. Participants were shown a variety of aerial image types with emphasis on color-infrared (CIR) photography and Landsat data. Examples of aerial imagery along with hand magnifiers and stereoscopes were available for inspection between sessions. These examples included demonstration boards and selected prints and transparencies of the local area. For many participants it was the first time that they had seen Landsat imagery and CIR photography of their area, and stereoscopic viewing of the CIR transparencies was an important and graphic aid to realizing the potential of remote sensing technology.

The availability and major sources of aerial imagery were presented through a review of a packet of handout materials given to each participant. A slide presentation was made on land classification systems, photographic interpretation, equipment, and mapping techniques.

The second half of the workshop dealt with applications of remotely-sensed data in Michigan. The organizations conducting remote sensing

applications in the state were identified and listed and a description of their activities was provided either in handout materials or in demonstration materials on display tables. The presentation focused on the activities of the Remote Sensing Project and highlighted selected applications. These exemplified the nature, scope and "real world" benefits of remote sensing. During the past eight years, over 40 applications have been undertaken by the Remote Sensing Project which have been grouped under four major categories: land cover/use inventories, on-land action programs, environmental legislation, and agricultural assessment. Several applications within each group were discussed in detail. These were selected based on issues important in the specific geographic area of the participants (Table 6).

Table 6.--Selected Remote Sensing Project Applications.

---

LAND COVER/USE INVENTORY

- + Land Use Planning
- + Detroit Riverfront Analysis
- + Forest Management and Timber Acquisition
- + Recreation Potential of Wild Areas
- + Wetlands Analysis

IMPROVING LOCAL ON-LAND ACTIONS PROGRAMS

- + Abandoned Vehicle Clean-Up
- + Control of Mosquito Breeding Sites
- + Surface Water for Recharging Fire Trucks
- + Impact of Off-Road Vehicles on Sand Dunes
- + Impact of Pipelines on Wetlands

IMPLEMENTING ENVIRONMENTAL LEGISLATION

- + Soil Erosion and Sedimentation Control Act
- + Farmland and Open Space Preservation Act
- + Wilderness and Natural Areas Act
- + Sand Dune Protection and Management Act
- + Federal Resource Conservation and Recovery Act

Table 6.--(cont'd.).

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**AGRICULTURAL ASSESSMENT**

- + Identification of "Important Farmlands"
  - + Facility Location Studies
  - + Plant Biomass
  - + Crop Damage
  - + Pest Management
- 

The applications were presented through slides and a summary narrative. Other examples of remote sensing applications were illustrated through demonstration boards, display literature or handout materials.

The last topic addressed was geographic information systems. Specific attention was paid to grid-based computer mapping systems and in particular the Resource Analysis Program (RAP) developed at the Remote Sensing Project. The advantages of spatially referencing and analyzing other resource information (e.g. soils, topographic and geologic) with that obtained from remotely-sensed data were emphasized. Examples of computer-generated interpretive maps, derived through several overlay and site index scaling routines, illustrated the versatility of integrating and displaying resource information using a geographic information system. Application topics covered included general land use planning, limitations and suitabilities of the resource base for selected on-land developments (e.g. solid waste disposal sites), farmland appraisal and forest resource inventory and management.

A discussion period followed each session and in most of the workshops there was active participation by the attendees. They were mainly interested in: 1) more detailed information on the applications that were presented; 2) the costs of conducting such applications; 3) what types of products and

services are available from remote sensing groups; and 4) whether remote sensing could provide information relevant to a local problem.

The workshops were well attended because of the enthusiasm of the Cooperative Extension personnel, the effectiveness of their network in alerting people to new developments in the natural resource field, and the high level of participant interest and curiosity about remote sensing. The participants were generally surprised that remote sensing has practical utility and is cost-effective in so many resource problem areas. Overall, the series of workshops were highly successful and participant feedback has been very favorable. A substantial number of decision makers in Michigan are now aware of a new tool to call upon in their response to local land use problems.

B2. Synopsis--A Petition for Establishment of a Center Function: Michigan State University's Role in Remote Sensing Research and Service

Michigan State University was among the first universities to experiment with the use of remote sensing imagery for dealing with issues of man's use of land and its many related resources. From such tentative beginnings in the mid-1960's came a major grant from the National Aeronautics and Space Administration (NASA) in late 1971 for exploration in uses of remote sensing for land use policy formulation and programs of implementing actions. Over this brief span of 15 years, MSU has developed a substantial competence in scientific personnel, facilities, and equipment. This growth has been incremental, based on ad hoc endeavors with specific allocations of financial support from grants and contracts. . .all from sources outside the University.

These increments of growth have been drawn together since 1971 in an unofficial collaborative organization, self-titled as the "Remote Sensing Project" (RSP), made up of faculty scientists and staff from a diversity of disciplines from nine departments/schools distributed among four colleges. The nature of the Project's mission was determined by the commitment of the original proposal and grant from NASA, namely to provide public and private agencies in Michigan essential information derived from sensor imagery which can assist them in resolving issues and needs, and interpreting and analyzing such information so that more effective management of economic and environmental resources may be achieved.

At this stage, in early 1979, the variety and magnitude of engagements and the scale of financial support are such that this harvest of continuing commitments and achievements needs to be drawn together into a recognized institutionalized structure.

Accordingly, the faculty investigators and research staff of the MSU Remote Sensing Project respectfully petition the deans of the four colleges participating in the activities of the Project to join in appropriate consortium to recognize the Remote Sensing Project as a worthy research and service entity of the University by establishing it as a continuing, official "Center for Remote Sensing."

#### Objectives

What is being requested, basically, is to receive appropriate recognition and confirmation of the remote sensing enterprises as an official entity under the support and direction of four colleges whereby a continuing operation may be assured. We are essentially asking to be enabled to continue, with consistency and dependability, those kinds of engagements that have been done over the eight-year lifetime of the current Project; but to do such more effectively regardless of fluctuations in funding support and to strengthen certain capabilities not yet adequately achievable.

More specifically, the objectives of a Center are to advance the application of remote sensing through varieties of information formats and systems related to terrestrial resources by means of research, extension services, technology transfer, training and instruction services, and experimentation with methods for information derivation, storage, and analysis, etc. The Project has been engaged with varying emphases and concentrations in all of these aspects; no new emphases are being proposed as additions. What is sought is that all of the component areas of research, service, and training be strengthened and built up under appropriate sponsorships.



### Organizational Structure and Administrative Placement

The organizational structure within the proposed Center would be essentially the same as within the current Project. The principal features of the existing management format of a four-member Executive Committee, the Faculty Investigators Group, the Director and an Associate and an Assistant Director, Managers, and a potpourri of functions performed by other functionaries, such as the Principal Investigator of the NASA Grant.

However, it is proposed that all functional requirements, duties, responsibilities, and authority be re-adjusted and redistributed in more systematic, vertical line-of-authority configuration. The essential features of a new Center call for reshaping the internal structure with the Director acting as the chief executive performing full leadership and principal executive roles reinforced by Associate and Assistant Directors. The "Executive Committee" will be lowered in profile and blended into the "Center Executive."

A high-level Consultive, Advisory Group consisting of deans and/or their representatives will act as the administration's guiding force. An Administrative Assistant will be a new role whereby the Director will be relieved of the routine features of management. . . budget monitoring, personnel processing, reports, office supervision, etc.

Contacts and interactions with department chairmen, deans, and other higher administrative officers within the University, with NASA officers, and with federal, state, and regional agencies, plus private firms would be clearly regularized in a conventional vertical flow. The juxtaposition of the Center with higher administrative levels is proposed to consist of

placement under a consortium of the Colleges of Agriculture and Natural Resources, Social Science, Natural Science, and Engineering. . .plus other functional entities judged by the deans as needed and appropriate (e.g. Office of Research Development, Agricultural Experiment Station, and Co-operative Extension Service).

The manifest need for one college to serve as the "lead" unit for direct administrative supervision and actions is viewed by the Faculty Investigators and Research Staff Principals as logically being the College of Agriculture and Natural Resources with the appointment of a particular officer as the interfacing, liaison administrator for direct policy, program and management needs. The RSP Principals suggest this College for a number of reasons, such as past and current administrative relationships with Agriculture and Natural Resources, recent budget contributions (over the past year), plus favorable signs as to continued and expanded support by the AES and CES; the subject matter issues involved in Project applications over the years have been predominantly in natural resource related issues. The recent entry (1977) of the international agricultural concerns of land cover and land categories, productivity, crop stress, and information systems in developing countries (CRIES\* project) indicate potential continuity and growth in these kinds of involvements.

In light of such considerations, the Faculty Investigators and Research Staff judge the placement of the Center under the administrative lead of the College of Agriculture and Natural Resources to be the means for providing optimal administrative effectiveness for a productive and highly functional

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\* CRIES: "Comprehensive Resource Information and Evaluation System"

research-service-training entity. However, we wish to underscore the crucial, indispensable importance of all four colleges and nine departments participating fully in the substantive activities of the Center, whereby Faculty Investigators are judged to be the initiators, the leaders, the catalysts. . .and the crucial interface with departmental faculty and students. There would be considerable potential for direct participation and cooperative ventures by additional disciplines and research units.

The success of the Center, as proposed, will depend on the realization of three key administrative features:

1. The forming of a WORKING CONSORTIUM OF COLLEGES related to the fundamental need for sustaining the integrity of the multidisciplinary nature of the Center and providing open entree for all interested scholars from the host of disciplines represented by the Colleges.
2. ADMINISTRATIVE AUTONOMY--The Center should function administratively in ways and procedures similar to those of instructional departments and schools. There should be no department intervening between the Center and the "lead college."
3. Institution of a CONTINUING BASE OF FINANCIAL SUPPORT to insure maintenance of a core staff, providing basic operational security, and imparting flexibility and versatility of performance.

#### Status of Remote Sensing at MSU

Remote sensing technology is increasingly expanding in scope and capability. New opportunities for viewing the natural and man-made environment

are repeatedly opening up in magnitude and contexts never before adequate or possible. Increasing numbers of individuals and agencies are becoming familiar with remote sensing as a valuable means for deepening and extending environmental understanding; remote sensing is being "discovered" by officials and technicians as a means for gaining essential information for resolving old issues and problems. Furthermore, as such understanding and utilization grows and as new generations of sensors are launched into space (e.g. Landsat), more elaborate and sophisticated hardware and software systems are steadily proliferating.

The tempo of remote sensing activities is increasing and so is the atmosphere of competition. MSU must escalate its range of competencies to advance its productivity for the benefit of ecological and societal conditions in Michigan and to maintain its national and international prominence as a center of remote sensing experience.

The conversion of the functional elements of the RSP into an institutionalized Center can be justified on many reasons of strength and vulnerability. The RSP is an existing, dynamic, successful venture; it is not a theoretical, promising concept. . .it is a reality! It is fully reflective of the land-grant principle; it has become the center of interest and productivity for remote sensing activities within MSU (other than instruction). It can serve this purpose more fully as a central resource for support of faculty and students, for special kinds of technical information, for research management, for technical back-up of expertise and equipment for both routine and complex research enterprises.

The nine Faculty Investigators and 22 Technical Staff Members (four full-time research specialists and 18 part-time research assistants) are currently carrying on over \$500,000 worth of grant and contract research. Over the past eight years, a total of \$1,591,522 has been paid into MSU by remote sensing engagements, and of this, \$313,380 in University overhead costs have been collected. By the end of 1978, a total of 33 research studies had been completed under NASA grant sponsorship, and an additional 11 were carried out under contracted efforts.

In contrast to such positive factors, there are many of a limiting or constraining nature. The Project operates with no official standing; it is a series of ad hoc, day-to-day cooperative efforts supported by soft money. It cannot legitimately represent itself or the University in any situation, and thereby, does not have official back-up, rendering it highly vulnerable to a host of possible negative forces and events. It has no base of continuing support and must work strictly within the limits of ad hoc grant and contract commitments. It has no clear-cut, coherent administrative roles and executive structure, with indistinct chain-of-command linkages and flows to and from upper levels of administration.

Administrative authority is ambiguous and dispersed and administrative leadership is piecemeal, lacks focus, authority, strength, and consistency. The full sweep of administration from broad-scale policies and actions to the minutiae of daily tasks is handled by reaction rather than systematic rational management. Budget management is conducted by a departmental process that understandably has to consider the departmental missions, needs and issues in higher priority.

Management of personnel is dispersed among several functionaries, the responsibility of no one executive authority. Again, such are handled by reaction rather than coherent, efficient administrative processes. With the limiting scopes of grants and contracts, potential promising opportunities for additional funding are regularly lost for want of budget latitude and flexibility whereby personnel can legitimately pursue them.

Admittedly, converting the current Project into an official Center will not automatically erase constraints and reinforce strengths. With the establishment of the administrative structure and placement among the four Colleges, it will be possible to utilize executive competencies from within the Center and from administrative resources of the Colleges and their agencies to reorganize management elements into an effective operating system.

With the establishment of a Center and the realization of the three key features of: 1) the consortium of Colleges; 2) a degree of Center autonomy; and 3) a continuing base budget, it would be possible to address these issues of leadership and management forcefully, and to moderate, even eliminate, most limitations--if not all. Furthermore, with the organizational structure and administrative linkages being proposed, it will be possible to strive aggressively and steadily toward achieving stated objectives.

Supported by the provision of an adequate base budget, the Center principals will be enabled to pursue and develop other sources of support for the different phases of the Center's operations from a host of potential sponsors for research, training, and service programs. The Center

could make known its competencies through the University for assisting scholars appropriately in their research endeavors.

### Conclusion

The momentum of the MSU Remote Sensing Project is in full motion. We are compelled to admit our enthusiasm and the sensing of excitement of new enriching dimensions to be gained. We lay claim to being agents for bringing enhancement to MSU's reputation--in this case as a recognized center for remote sensing research applications and information services. We seek to capture and systematize this critical mass into a stable instrument to enable the University to serve still better the people of Michigan.

Whatever the resolution of this petition for institutionalization may be, it is highly important that MSU maintain its leadership in such a rapidly developing technology. Whatever the organizational format, adequate laboratory space and facilities, up-to-date equipment and software must be in adequate supply, and key personnel must be retained if our continuing endeavors in remote sensing are to nurture the expansion of knowledge and the continuing education and training of new generations of scientists and technicians.

### C. CONTRACTUAL SERVICES

When inquiries for services for research and/or surveys do not meet Project criteria for execution under NASA funding support\*, and when such fall reasonably within the competencies of the Project and offer promise of advancing competencies and reputation as new and significant experiences, they can be accepted as undertakings with the user paying for all costs incurred. When mutually agreeable, such enterprises are arranged for under either contractual or cooperative agreements.

The MSU Remote Sensing Project has been serving, now, for several years as a laboratory for public and private agencies which do not need remote sensing sources of information frequently enough to set up their own technical staffs with all the essential related equipment, imagery sources, and other logistical means. Even if agencies wanted to and could afford to install their own units of remote sensing, they would experience great difficulty in finding qualified personnel which are not in ready supply. The MSU Project fills this need most adequately by responding, when appropriate, to requests for assistance for remote sensing applications services.

Four kinds of contractual engagements are reported in the units which follow. One kind was international in locale, which provided services in three developing countries consisting of land cover/use inventories and some basic quantitative analysis. One of these produced a need for parallel studies in crop stress (e.g. cane rust diseases). Services of these kinds

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\* See footnote under section "A", introduction to "Research Applications".



have been initiated and accomplished through cooperative agreements with the U.S. Department of Agriculture for the Agency for International Development. Similar field research services have been under consideration for extension to other third world countries.

Two other studies relating to monitoring sand mining operations and sand dune mapping are continuing undertakings for the Michigan Department of Natural Resources (MDNR). Additional contractual agreements for other issues were subsequently set up with the MDNR.

The mapping of important farmlands by blocks of counties is an extension of similar studies for blocks previously completed under agreements with the USDA Soil Conservation Service.

As this recitation can suggest, these four projects represent an interesting variety of studies. All of these have deepened and broadened the capabilities and lustre of the MSU Project. We feel gratified to have been able to assist such entities with these important information logistics.

Cl. Comprehensive Resource Inventory and Evaluation System (CRIES)

U.S. Department of Agriculture  
Economics, Statistics, and Cooperatives Service  
Room 305, Manly Miles Building  
1405 South Harrison Road  
East Lansing, Michigan 48823

Cooperative Agreement:  
Oct 1976 - Sep 1980  
\$620,470

The CRIES project continued through this reporting period. CRIES is a cooperative program between Michigan State University and the Economic Research Service of the U.S. Department of Agriculture and is funded by the Agency for International Development. The objective of the project is to create the technical skills and institutional capabilities of developing countries to conduct agricultural planning and other resource management studies. The project is a multi-agency and multi-disciplinary effort. The Remote Sensing Project at MSU is contributing technical skills and services in two major project areas: remote sensing and geographic information system development.

This report summarizes field and laboratory research activities performed for three Third World countries, namely, the Dominican Republic, Costa Rica, and Syria. During the reporting year, several reports were issued. Two of the reports explain the CRIES geographic mapping system and were used in a workshop on the mechanics of geocoding that was held in the Dominican Republic. The workshop was part of a program that included the installation of the Resource Analysis Program (RAP) onto an IBM 370/115 computer, and a training seminar on how to use RAP. A week-long training session was also held in East Lansing for the Dominican counterparts (to the CRIES staff). This was an on-site workshop on the remote sensing activities and the mapping system in the Dominican Republic.

In January of 1978, the Agency for International Development (AID) and the U.S. Department of Agriculture held an 18-month review of the CRIES project. The outcome of the session was very favorable. While at the meeting, the CRIES staff became acquainted with Dr. Ernest Hardy's (a member of the evaluation team) computerized diazo process to enhance LANDSAT scenes, and this process will be incorporated into future LANDSAT interpretation procedures.

Part of the CRIES effort is to test and evaluate different techniques which could be used for collecting land use data. One such test was a comparison of LANDSAT data that had been interpreted both visually and digitally for a province in the Dominican Republic. The purpose of the test was to evaluate the compatibility of the data obtained from each of the methods. Results show that, overall, only 65 percent of the information was classified similarly. However, when comparing just the agricultural land use categories, there was only a 10 percent discrepancy.

CRIES has also been involved in a study which compared the costs of manual and digital processing of geographic information. Personnel at the Remote Sensing Project did the manual geocoding while Bendix Aerospace Systems Division (Ann Arbor, Michigan) did the digital processing. Initial results indicate similar costs, but the level of technology involved with manual geocoding is more easily transferred to developing countries.

Another geocoding activity that took place during the period was encoding the Cantone map for Costa Rica into the geographic information system. The land area totals were in close agreement with published national

totals; a discrepancy of only 40 km<sup>2</sup> was found out of a total area of 51,100 km<sup>2</sup>.

During the summer, a sugar cane rust infection occurred in a majority of the sugar cane fields of the Dominican Republic. The rust primarily affected cane variety B-4362 which accounts for nearly two-thirds of the total planted cane acreage of the State Sugar Council (CEA). The Dominican government requested that the Remote Sensing Project, through the CRIES Project, undertake a survey using light-plane aerial photography in order to help evaluate the severity of the problem. A photographic team was dispatched to the country and a research program initiated. A team of Dominican specialists visited East Lansing to assist in the photographic evaluation. The preliminary results indicated cane stress is readily detectable on large-scale color-infrared film. The study continued to the end of the reporting period.

In conjunction with a contract extension from AID Washington, a complete land cover/use map of the Dominican Republic was begun. The map was developed by visual interpretation of Landsat imagery.

Contract work was begun in Syria under the CRIES project. The Remote Sensing Project was responsible for developing a land cover/use map from visual interpretation of Landsat and to develop the geographic information base.

C2. Inventory of Sand Mining Sites in Michigan's High-Priority Sand Dune Areas

Geology Division  
Michigan Department of Natural Resources  
Stevens T. Mason Building  
Lansing, Michigan 48909

Contract: Nov 1977 - Sep 1980  
\$41,000

The Sand Dune Protection and Management Act (PA 222, 1976) requires the development of sand mining monitoring procedures to be used by the enforcing agency. The Geology Division of the DNR has contracted with the Remote Sensing Project to assist them in the development and implementation of these procedures. The initial work was broken down into the following four objectives: 1) determination of the optimal remote sensing techniques and information system structure to periodically monitor sand mining activities; 2) acquisition of aerial photography for sand mining operations in the high-priority sand dune areas of Michigan; 3) preparation of an inventory of sand mining activities in the high-priority sand dune areas of Michigan utilizing the information generated in objective 1; and 4) development of a sand mining surveillance procedure manual.

The first task, concerning the evaluation of remote sensing techniques for monitoring of sand mining activities, has been completed. Medium- and high-altitude photography is currently considered the best source for the provision of general land cover/use information required to evaluate environmental impacts on a bi-annual basis. Low-altitude photography of scales ranging from 1:15,000 to 1:30,000 is currently being used for acquisition of information regarding the status of sand mining sites on a semi-annual basis. Low-level systems with flexible operational characteristics (stand-by

basis, local applications) currently provide the best guarantee for sufficient and qualitatively acceptable information collection at a low cost, and provide a sound basis for the legal enforcement of the Act.

In response to the second objective, the acquisition of aerial photography, color, near-vertical 70mm photography of scales ranging from 1:15,000 to 1:25,000 was acquired for all mining sites identified on existing photography and during an in-flight survey. Land cover/use information of the shoreland zone is being mapped using 1:24,000 CIR photography recently acquired by the DNR on a statewide basis. The land cover/use categories (see Table 7) are being mapped on clear acetate overlays which can be positioned on mylar base maps of topographic sheets by means of registration pins. The sand mining sites are coded to facilitate cross-referencing with a compiled photobase consisting of 70mm color transparencies. The mining site coding scheme consists of a unique indicator for the designated area, a sequence number for unique flight planning purposes, and UTM coordinates to the nearest 100 meters, indicating the approximate location of the center of the mining site (e.g. A1-7-753/628). An acetate overlay with a 100 x 100 meter grid based on UTM coordinates (1:24,000) will be provided to aid in future referencing.

A procedure for sand mining surveillance was established (Fig. 12) and a report has been prepared which outlines the monitoring and inventory procedures for sand mining operations in Michigan (see reference 78). The procedures recommended were accepted by the DNR which contracted for an additional inventory of a shoreline zone of approximately 100 miles and a bi-annual monitoring of on-going mining activities during the 1978-79 period and identified by the lake shore zone inventory of the previous year.

TABLE 7.--Land Cover/Use Categories Used for the Sand Dune/Mining Inventory (modified after Michigan Land Cover/Use Classification System, 1975; Division of Land Resource Programs, Michigan Department of Natural Resources).

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LAND COVER/USE CLASSIFICATION SYSTEM FOR THE MICHIGAN  
SAND DUNE/MINING INVENTORY PROJECT

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Interpretation based on predominant Land Cover/Use type of  
1 ha (100 x 100 m) (approx. 2.5 acres)

- 11 Residential
  - 111 Medium and High Density
  - 112 Low Density (less than 1 D.U./acre)
- 12 Commercial, Services and Institutional
- 13 Industrial
- 14 Transportation, Communication and Utilities
- 17 Extractive, Surface Mining
  - 171 Active Status, Spring 1978
  - 172 Inactive Status, Spring 1978
  - 173 Sand Storage
- 18 Cemetery
- 19 Recreational
  - 191 Public
  - 192 Private
- 21 Cultivated Cropland and Improved Pasture
- 22 Specialty Crops (orchards, bushfruits, vineyards, ornamental horticulture, Christmass tree farms, and other specialty crops)
- 31 Herbaceous Ground Cover
- 32 Shrub Ground Cover
- 41 Deciduous Forest
- 42 Coniferous Forest
- 43 Mixed Forest
- 44 Dune Grasses
- 5 Water
- 61 Forested Wetlands
- 62 Non-Forested Wetlands (brush swamp)
- 63 Vegetated Open Water
- 7 Barren
  - 72 Beaches
  - 73 Sand Other Than Beaches
  - 74 Transitional Areas

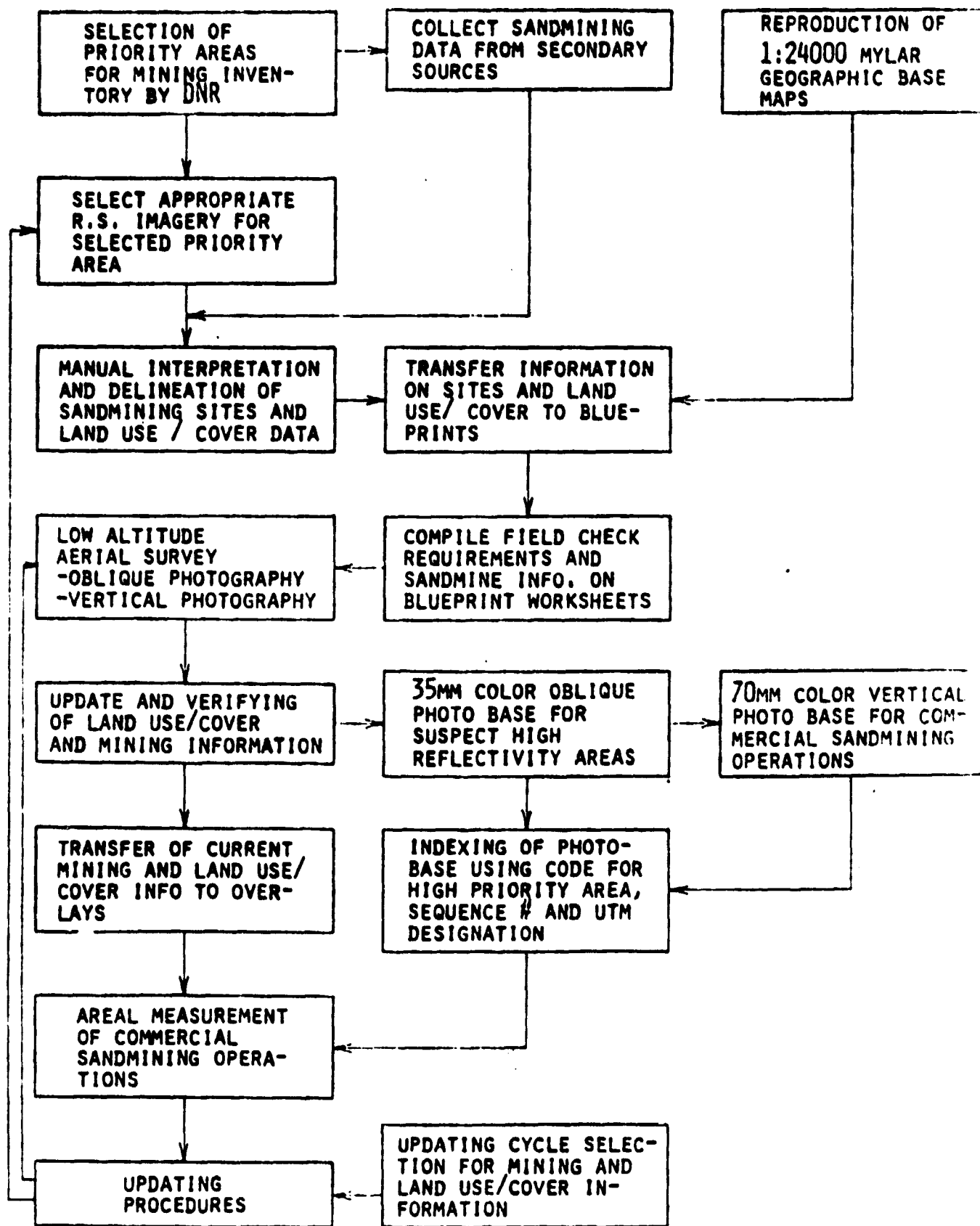


Figure 12.--Flowchart Outlining the Procedures for the Michigan Sand Dune Mining Inventory.



C3. Sand Dune Classification and Inventory of Michigan's High-Priority Sand Dune Areas

Geology Division  
Michigan Department of Natural Resources  
Stevens T. Mason Building  
Lansing, Michigan 48909

Contract: Nov 1977 - Sep 1980  
\$33,040

The Sand Dune Protection and Management Act (PA 222, 1976) requires the development of a dune classification system for Michigan and an associated inventory of dune types, specifically the delineation of barrier dune complexes along the Great Lakes shoreline in the state. The Michigan Department of Natural Resources is the agency designated to implement this legislation, and has contracted with the Remote Sensing Project to complete a series of work elements to assist them in this process.

A dune classification has been developed (see Fig. 13) based on dune form, orientation, relative relief, arrangement and the relationship of the dune to the underlying formation. The scheme is objective in that it relies on morphologic and geometric patterns which can be interpreted from large-scale aerial imagery. No attempt is made to incorporate genetic aspects into the classification.

A two-mile strip along 90 miles of Lake Michigan shoreline was classified according to the classification scheme in the 1977-78 period. Currently a similar inventory is being carried out for a coastal strip of approximately 100 miles located in the northwestern portion of the state. The major information source consists of 1:20,000 panchromatic ASCS photography supplemented with secondary data like soils information.

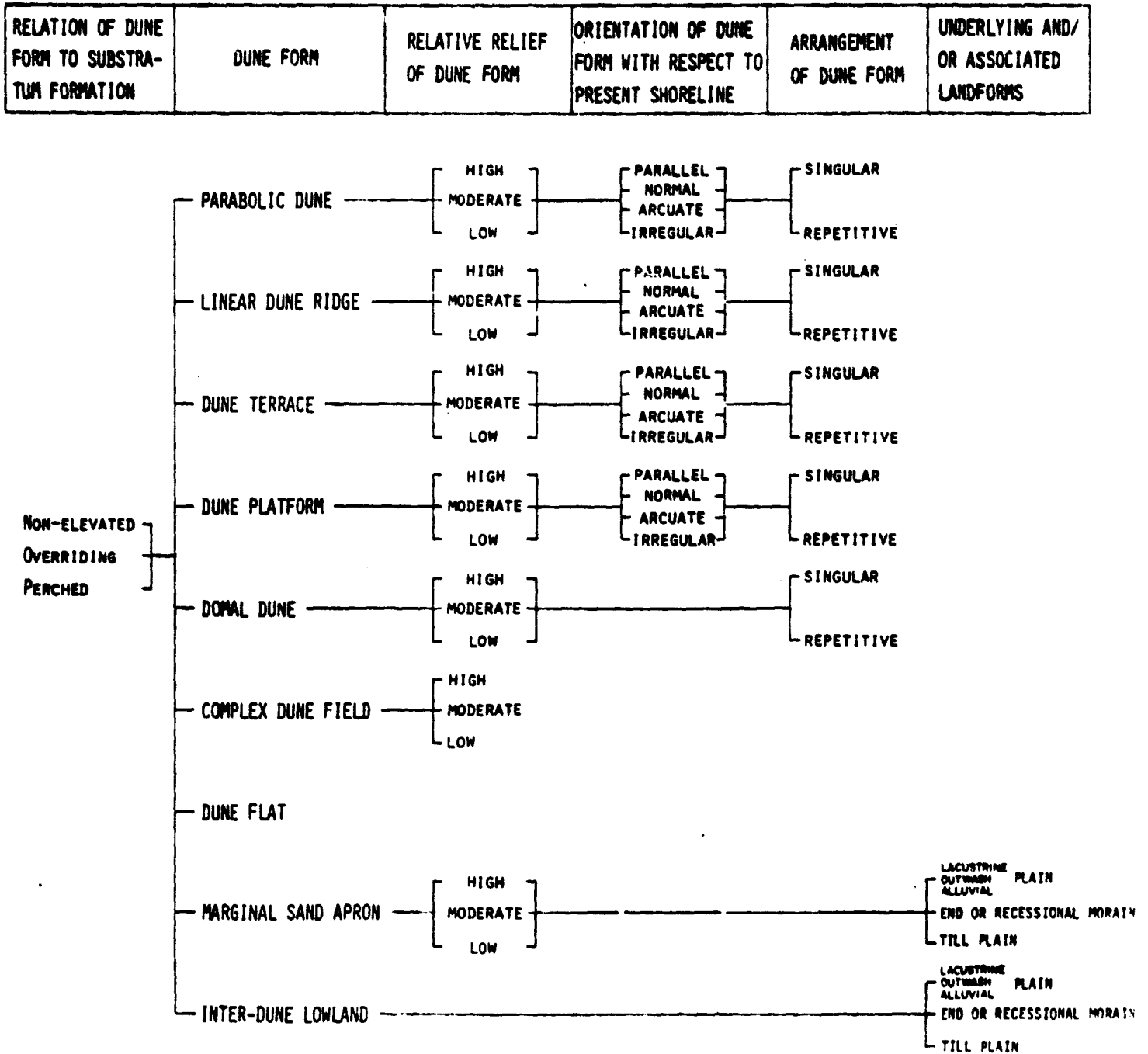


Figure 13.--DUNE MORPHOLOGY CLASSIFICATION OF THE LAKE MICHIGAN SHORE

WILLIAM R. BUCKLER  
with the assistance of  
DIETER H. BRUNNSCHWEILER  
REMOTE SENSING PROJECT  
MICHIGAN STATE UNIVERSITY

The following features are delineated on the photobase:

1. Boundaries of the individual dune complex, with appropriate identifying codes (a fractional code indicator developed from the classification scheme)
2. Barrier dune boundary
3. Discernible dune crest lines
4. Notable bluff crests and shorelines of older, higher, glacial lakes
5. Present land/water boundaries
6. Beach zone
7. Selected spot elevations
8. Location indicators

The preliminary working definition of a barrier dune boundary is: "that landward boundary line of the dune complex which displays the greatest relative relief within the two-mile-wide Lake Michigan shore zone."

The delineated dune inventory information is being transferred to 1:24,000-scale acetate overlays compatible with the land cover/use and surface mining information that is being compiled under a separate contractual arrangement with the Geology Division of the DNR (see Section ). Together these sources will facilitate the review of future sand mining permit applications as required by law. A continuation of this inventory work is anticipated for the period 1979-80 covering additional dune areas along Michigan's shoreline.

C4. Important Farmlands Inventory

Soil Conservation Service  
U.S. Department of Agriculture  
1405 South Harrison Road  
East Lansing, Michigan 48823

Contract: Apr 1979 - Sep 1980  
\$41,500

The Remote Sensing Project, under contract with the Soil Conservation Service, is preparing Important Farmlands maps for 14 counties in Michigan. This is a continuation of work already accomplished in five counties. The mapping involves the delineation of prime soil (U.S. Department of Agriculture, Secretary's memorandum no. 1827, revised, October 30, 1978) areas from soil survey information, and the identification of unique farmland, water and urban built-up areas from aerial photography. Unique farmlands are lands other than those designated prime that are used for the production of specific high-value food and fiber crops (e.g. tree and bush fruits, vineyards and vegetables).

The information is compiled onto a 1:50,000 base map of each county and area statistics per category are determined. The Important Farmland maps are being produced under the Land Inventory and Monitoring (LIM) program of the U.S. Department of Agriculture.

INFORMATIONAL SUMMARY

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## D. INFORMATIONAL SUMMARY

Category One: PROJECTS CONDUCTED WITH NASA GRANT FUNDS

1. M-14 Highway Environmental Impact Assessment (Michigan Department of State Highways and Transportation; 1972): Remote sensing data from high and medium altitude photography provided information on land use, vegetation, soils, and hydrologic characteristics of a proposed highway corridor in Washtenaw County which provided the bases for assessing the potential environmental impact of this highway construction. The MDSHT subsequently adopted procedures for route location determinations based on remote sensing techniques and the findings of the M-14 research.
2. Pte. Mouillee Waterfowl Habitat Assessment (Michigan Department of Natural Resources; 1972-73): Wetland vegetative communities and shoreline erosion in a marsh area on Lake Erie were mapped using remote sensing data from high, medium, and low altitude photography. Recommendations were made, in collaboration with the DNR, for improving marsh management, alleviating erosion, and reclaiming land lost through erosion. Many of these measures were progressively implemented, such as purchase of adjoining land for expanded habitat.
3. Upper Kalamazoo River Basin Inventory (Soil Conservation Service; 1973): The first extensive Michigan land cover/use inventory from NASA high altitude CIR photography was prepared for a 2,590 sq. km. (1,000 sq. mi.) area of the river basin. SCS used the information in analyzing wildlife habitats and wetlands from which specific management priorities and county recommendations were identified.
4. Michigan Department of State Highways and Transportation Environmental Inventory (MDSHT; 1973): NASA RB-57 imagery and technical assistance in photo interpretation were provided to MDSHT as the Department implemented remote sensing procedures (developed under the M-14 highway project) for assessing the environmental impact of four proposed highway corridors. MDSHT now operationally uses remote sensing procedures and has contracted aerial survey firms to acquire new imagery.
5. Tri-County Regional Planning Commission Land Use Update (TCRPC; 1973): NASA RB-57 imagery and technical assistance in photo interpretation were provided to Commission personnel for updating a 1965 land use inventory. A spin-off occurred in 1976 when the MSU Project prepared a land use inventory for the three-county area under a contract from TCRPC.

6. Michigan Land Cover/Use Classification System (Michigan Department of Natural Resources; 1974): RSP personnel helped develop a four-level statewide land cover/use classification system based on remote sensing as the primary data source. The system was operationally tested by the RSP using a variety of remote sensing data which resulted in several categorical changes. The classification system has been in use by the DNR and other agencies as a standard operational routine ever since.
7. Kent County Land Resource Information System (West Michigan Regional Planning Commission; 1974): Land use data was derived from aerial photos and encoded for use in a computer information system being developed by the WMRPC. The system has been expanded to cover the entire nine-county region and the WMRPC contracted private firms to provide aerial photo coverage and land use data for its region.
8. Mason County Forest Inventory (West Michigan Regional Planning Commission, Mason County Soil Conservation District, and Packaging Corporation of America; 1974): Forests were classified into species groups, stocking levels and maturity classes from high-altitude CIR imagery. The forest information is being used by wood procurement firms to locate marketable timber and by SCS in establishing forest management cooperatives. The study helped the Michigan DNR secure funding support from 21 private forest industries for statewide CIR photo coverage.
9. Retention of Agricultural Land in Wayne County (Wayne County Planning Commission and Cooperative Extension Service; 1974): NASA RB-57 imagery and photo interpretation training were provided to WCPC staff who then prepared agricultural and open land use maps. The maps were used to identify lands which were zoned for retention in agricultural or open space use in five townships that fringe the Detroit Metropolitan area. Three townships amended master development plans to implement these decisions. Litigations have delayed amending zoning ordinances to conform to plans.
10. Grand Traverse County Special Environments Inventory (Michigan Department of State Highways and Transportation and Traverse Bay Regional Planning Commission; 1974): Personnel of the RSP and the MDSHT jointly developed a 24-category land use and 34-category special environments inventory from CIR imagery and a computer information system for the County. The system was used in selecting a site for an industrial park and in locating optimal low environmental impact highway corridors.
11. Implementation of Michigan Soil Erosion and Sedimentation Control Act (Antrim County Planning Department; 1974): CIR imagery provided an expeditious, legally acceptable means for evaluating the site construction plans required in earth-change operations and for detecting potential violations of the Act.

12. Charlevoix County Land Value Appraisal (Charlevoix County Equalization Department; 1975): NASA RB-57 imagery and photo interpretation training were provided to Department personnel. Land cover maps of the major islands in the county located in Lake Michigan were prepared and used in reassessing all property valuations by the Department.
13. Antrim County Abandoned Vehicle Inventory (Antrim County Planning Department; 1975): Abandoned vehicles in the County were identified from CIR imagery and the inventory results were used by the Department to direct junk vehicle removal activities.
14. Optimizing Agri-Business Processing Plant Location (Wickes Agriculture; 1975): All tillable land within Gratiot County was identified from NASA RB-57 and Skylab imagery. Using this information and soils data, a computer routine generated potential crop productivity estimates for alternative crop processing plant sites and service areas and confirmed a location for a new plant.
15. Assessment of Recreation Potential for Backcountry Rivers (U.S. Forest Service and MSU Department of Geography; 1975): Interpretation of aerial photography provided a range of information necessary for an assessment of the recreational potential of the Pine River in the Manistee National Forest. Photo-derived data for 38 variables were integrated with float survey data and weighted in relation to 16 potential recreational uses by a computer routine.
16. Aerial Detection of Stressed City Trees (City of Lansing Parks & Recreation Department; 1975): The interpretation of large-scale 35 mm CIR transparencies provided a 35 percent increase in the detection of total number of stressed trees as compared to the number detected by conventional eye-level surveys. Photo interpretation, in turn, missed detecting some stress observed on the ground, indicating that remote sensing can supplement but not replace conventional techniques.
17. Crop Damage Assessment (MSU Department of Crop and Soil Sciences; 1975): Three levels of damage to a navy bean field due to excessive rainfall were identified and quantified from large-scale 35 mm photos. Photo-based yield estimates were compared with estimates made by a crop insurance representative and were found to be an accurate method for determining an equitable settlement.
18. Survey and Analysis of the Detroit Riverfront (Wayne County Planning Commission, State of Michigan Department of Commerce, and Department of Natural Resources; 1975-76): As a component of a multi-agency task force study, the MSU/RSP completed inventories of marinas, nature and extent of industrial uses of river-abutting land including material stockpiles, plus all other land and water uses. Data gained from NASA RB-57 imagery and RSP-acquired low-altitude 35 mm color photos demonstrated current conditions and provided useful information for



determining the development potential of 37 miles of riverfront. Specific recommendations were made by the task force. Fifteen sets (20-40 slides) of the 35 mm photos have been purchased by public and private agencies.

19. Energy Park Site Selection (Consumers Power, Detroit Edison, ERIM and MSU Department of Agricultural Engineering; 1975): The physical characteristics of seven potential energy park sites were derived from NASA RB-57 imagery supplemented by 35 mm oblique photos. The information was evaluated to determine which site was best suited for agricultural and aquacultural applications of waste heat.
20. Inventory of Potential Mosquito Breeding Sites for Vector Control (City of Lansing Vector Control Section; 1975-76): All standing water and wetlands in the Lansing area were mapped from 70 mm aerial photos acquired by the RSP. The maps indicate 33 percent more potential mosquito breeding sites than previously known and are operationally used as the primary reference document by field treatment teams.
21. Inventory of Surface Water Accessible to Fire Trucks (Antrim County Planning and Fire Departments; 1975-77): Surface water locations, potential access sites for recharging fire truck water supplies, and physical limitations to recharging were identified from 1:36,000 CIR photos. Township maps and computer listings of the information are used by firemen to locate the closest suitable water source and access point from the site of a fire.
22. Agricultural-Use Valuation (Eaton County Equalization Department, West Michigan Regional Planning Commission and Kent County Equalization Department; 1975-76): A computer-assisted farmland appraisal system which utilizes remotely sensed land use data was developed for two townships. The RSP has subsequently prepared farmland appraisal computer maps for all of Eaton County on a cost-reimbursable basis.
23. Search for Buried Murder Victims in Berrien County (Office of the Prosecuting Attorney, County of Berrien; 1976): A variety of aerial imagery and real-time thermal data were used to identify possible murder victim burial sites on a suspect farm. The information provided documentation for securing a search warrant and facilitated a systematic and efficient search of the property by State Police teams; however, no bodies were recovered.
24. Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources (Bendix Aerospace Systems Division; 1976): The RSP and Bendix jointly developed a procedure to merge photo-derived land use data with computer-categorized Landsat data in order to maximize effective use of both data sources in the provision of an integrated information system for regional analysis. The procedure was subsequently used in a three-county land use inventory performed under contractual funds.

25. Resource Analysis Program--RAP (Tri-County Regional Planning Commission; 1976-77): RAP, a grid-based computer mapping system, was developed for integration, comparative analysis, and display of remotely sensed data and other natural resource information. The RAP system has been used in several townships, four counties, and one foreign country for mapping projects conducted with contractual funds.
26. Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling (MSU Institute of Water Research; 1976): Large-scale 35 mm CIR photos were used to estimate plant biomass of experimental plots in an old-field ecosystem that was being treated with different levels of sewage treatment waste-water. The method accurately estimated plant biomass as early as one month before harvest, is more accurate and cost-efficient, and demonstrates a real potential in the improvement of management of waste-water irrigation projects.
27. Preservation of the Grand Mere Dune Environment (Grand Mere Association; 1976-77): The loss of dune vegetative cover between 1970 and 1976 due to Off-Road-Vehicle (ORV) activities was determined by a temporal analysis of aerial photography. This study led to an ORV enforcement program, initiated under a special appropriation of funds for the township police department, which has subsequently reversed vegetative recession.
28. Muskegon Sand Mining Inventory (Michigan Department of Natural Resources; 1977): A procedure to inventory and monitor sand mining operations using existing aerial imagery and specifically acquired 70 mm photos was developed. The procedure is being used in implementing the Michigan Sand Dune Protection and Management Act (1976) under contractual arrangements between the DNR and the RSP.
29. Re-Evaluation of the I-69 Highway Corridor (Citizens Concerned About I-69; 1978): The selection of a corridor for the extension of Interstate Highway 69 in central Michigan has been challenged by the Citizen's group. Two major issues are involved in the discussion of alternative corridors: the loss of prime farmlands and the effect on wetlands. A land cover map of the area in question from NASA high-altitude CIR imagery, was provided to the Citizen's group to assist them in formulating their arguments. The issue is currently being decided in the courts.
30. Mosquito Control in Saginaw and Bay Counties (Saginaw-Bay Mosquito Control Commission; 1978): Information on potential mosquito habitats and residential areas derived from aerial photography has been used by the SBMCC to prioritize treatment areas and formulate operational strategies for the control of early season Aedes mosquitoes.
31. Identification of Wild Areas in Southern Lower Michigan (Michigan Department of Natural Resources; 1978): The RSP has developed a procedure to identify "wild areas" using Landsat and aerial imagery in a multi-stage process. Environmental characteristics of candidate sites were

interpreted from photos and used in a grading system to determine a final point value for each area. The Michigan DNR is using this information to identify sites which they will recommend for dedication as natural preserves.

32. Identification of Wood Energy Resources in Central Michigan (Morbark Industries, Inc., Dow-Corning Corp., Consumers Power, and Wolverine Electric Corp.; On-going): Landsat imagery, supplemented by NASA RB-57 and other aerial photography, was used to determine the location, extent and biomass of non-commercial timber resources in a candidate multi-county supply area. The information was used in determining that a wood-chip burning electric power generating plant is feasible.
33. The Impacts of Pipeline Construction on Stream and Wetland Environments (Michigan Public Service Commission; On-going): The RSP is interpreting temporal aerial photos to assess environmental (particularly drainage alteration) impacts of existing gas and oil pipeline crossings of streams and wetlands. The study is aimed at identifying better pipeline construction methods which prevent or mitigate impacts on sensitive environments.
34. Identification of Hazardous Waste Disposal Sites (Michigan Department of Natural Resources; On-going): Time-sequential maps of areas around specified chemical plants are being compiled from historical and current aerial photography (1938-1979). These maps, along with new large-scale color, aerial photography, will be tested to determine their effectiveness at locating critical disposal sites.
35. Integrated Pest Management Systems (Departments of Botany & Plant Pathology and Entomology, Michigan State University; On-going): RSP investigators, in collaboration with MSU faculty, are investigating damage distribution assessment and biomass loss to small grains caused by the cereal leaf beetle. If detection and analysis appear successful, a county transect inventory will be attempted. These results should provide immediate input to the state's on-going disease control program. A similar study is being conducted over orchards which are suffering from X-disease.
36. Analysis of Landsat Data in Updating Forest Inventories (Cooperative Extension Service and Packaging Corporation of America; On-going): Project investigators have designed and are currently testing an updating procedure using Landsat data (CCT's, black-and-white imagery, and diazo composites) to detect and identify changes in the forest since the original inventory. If successful, this procedure may provide the only cost-effective method available to update existing forest mapping inventories.

M S U / R S P

Category Two-(a): NASA FUNDED PROJECTS BY COOPERATING AGENCY

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Federal	Soil Conservation Service	Upper Kalamazoo River Basin Inventory	3
		Mason County Forest Inventory	8*
	U.S. Forest Service	Assessment of Recreational Potential for Backcountry Rivers	15
State	Michigan Department of State Highways and Transportation	M-14 Highway Environmental Impact Assessment	1
		MDSHT Environmental Inventory	4
		Grand Traverse County Special Environments Inventory	10*
		Pte. Mouillee Waterfowl Habitat Assessment	2
	Michigan Department of Natural Resources	Michigan Land Cover/Use Classification System	6
		Muskegon Sand Mining Inventory	28
		Identification of Wild Areas in Southern Lower Michigan	31
		Identification of Hazardous Waste Disposal Sites	34
Michigan Public Services Commission	The Impacts of Pipeline Construction on Stream and Wetland Environments	33	

\* Project listed under more than one agency

Category Two-(a) (cont'd.)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Regional	Tri-County Regional Planning Commission	TCRPC Land Use Update	5
		Resource Analysis Program	25
	West Michigan Regional Planning Commission	Kent County Land Resource Information System	7
		Mason County Forest Inventory	8*
	Agricultural-Use Valuation	22*	
Traverse Bay Regional Planning Commission	Grand Traverse County Special Environments Inventory	10*	
County	Wayne County Planning Commission	Retention of Agricultural Land in Wayne County	9
		Survey and Analysis of the Detroit Riverfront	18
	Antrim County Planning Department	Implementation of Michigan Soil Erosion and Sedimental Control Act	11
		Antrim County Abandoned Vehicle Inventory	13
	Charlevoix County Equalization Department	Charlevoix County Land Value Appraisal	12
	Eaton and Kent County Equalization Departments	Agricultural Use Valuation	22*
	Office of the Prosecuting Attorney, County of Berrien	Search for Buried Murder Victims in Berrien County	23
Saginaw-Bay Mosquito Control Commission	Mosquito Control of Saginaw and Bay Counties	30	

\* Project listed under more than one agency

Category Two-(a) (cont'd.)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Town-Local	City of Lansing	Aerial Detection of Stressed Trees	16
		Inventory of Potential Mosquito Breeding Sites for Vector Control	20
	Departments of Michigan State University	Crop Damage Assessment	17
		Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling	26
		Integrated Pest Management System Analysis of LANDSAT Data in Up-Dating Forest Inventories	35 36*
		Grand Mere Association	Preservation of the Grand Mere Dune Environment
	Citizens Concerned About I-69	Re-evaluation of the I-69 Highway Corridor	29
	Private	Packaging Corporation of America	Mason County Forest Inventory
Analysis of LANDSAT Data in Up-dating Forest Inventories			36*
Wickes Agriculture		Optimizing Agri-Business Processing Plant Location	14
Consumers Power & Detroit Edison		Energy Park Site Selection	19
Bendix Aerospace Systems Division		Merging Land Cover/Use from LANDSAT, Aerial Photography and Map Sources	24
Morbark Industries, Inc., Dow-Corning Corp., Consumers Power and Wolverine Electric Co-Op.		Identification of Wood Energy Resources in Central Michigan	32

\* Project listed under more than one agency

## Category Two-(a) (cont'd.)

AGENCY	NUMBER OF PROJECTS	PERCENT
Federal	3	7.3
State	9	22.0
Regional	6	14.6
County	9	22.0
Town-Local	8	19.5
Private	<u>6</u>	<u>14.6</u>
TOTAL	41	100.0

M S U / R S P

Category Two-(b): NASA FUNDED PROJECTS BY DATA SOURCE

SOURCE	PROJECT	PROJECT NUMBER
Landsat	Michigan Land Cover/Use Classification System	6*
	Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources	24*
	Identification of Wild Areas in Southern Lower Michigan	31*
	Identification of Wood Energy Resources in Central Michigan	32*
	Analysis of Landsat Data in Updating Forest Inventories	36
Skylab	Michigan Land Cover/Use Classification System	6*
	Optimizing Agri-Business Processing Plant Locations	14*
High Altitude Aircraft	M-14 Highway Environmental Impact Assessment	1*
	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Upper Kalamazoo River Basin Inventory	3
	MDSHT Environmental Inventory	4
	Tri-County Regional Planning Commission Land Use Update	5
	Michigan Land Cover/Use Classification System	6*
	Retention of Agricultural Land in Wayne County	9

\* Project utilized more than one source



Category Two-(b) (cont'd.)

SOURCE	PROJECT	PROJECT NUMBER
High Altitude Aircraft	Charlevoix County Land Value Appraisal	12*
	Optimizing Agri-Business Processing Plant Location	14*
	Survey and Analysis of the Detroit Riverfront	18*
	Energy Park Site Selection	19*
	Agricultural-Use Valuation	22
	Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources	24*
	Resource Analysis Program	25
	Muskegon Sand Mining Inventory	28*
	Re-Evaluation of I-69 Highway Corridor	29
	Mosquito Control in Saginaw and Bay Counties	30
	Identification of Wild Areas in Southern Lower Michigan	31*
	Identification of Wood Energy Resources in Central Michigan	32*
	The Impacts of Pipeline Construction on Stream and Wetland Environments	33*
Identification of Hazardous Waste Disposal Sites	34*	
Medium Altitude Aircraft	M-14 Highway Environmental Impact Assessment	1*
	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Michigan Land Cover/Use Classification System	6*
	Mason County Forest Inventory	8

\* Project utilized more than one source

Category Two-(b) (cont'd.)

SOURCE	PROJECT	PROJECT NUMBER
Medium Altitude Aircraft	Grand Traverse County Special Environments Inventory	10
	Implementation of Michigan Soil Erosion and Sedimentation Control Act	11
	Antrim County Abandoned Vehicle Inventory	13
	Assessment of Recreational Potential for Backcountry Rivers	15
	Survey and Analysis of the Detroit Riverfront	18
	Inventory of Surface Water Accessible to Fire Trucks	21
	Search for Buried Murder Victims in Berrien County	23*
	Preservation of the Grand Mere Dune Environments	27*
	The Impacts of Pipeline Construction on Stream and Wetland Environments	33*
	Identification of Hazardous Waste Disposal Sites	34*
Low Altitude Aircraft	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Kent County Land Resource Information System	7
	Aerial Detection of Stressed City Trees	16
	Crop Damage Assessment	17
	Survey and Analysis of the Detroit Riverfront	18*
	Energy Park Site Selection	19*
	Inventory of Potential Mosquito Breeding Sites for Vector Control	20

\* Project utilized more than one source

Category Two-(b) (cont'd.)

SOURCE	PROJECT	PROJECT NUMBER
Low Altitude Aircraft	Search for Buried Murder Victims in Berrien County	23*
	Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling	26
	Preservation of the Grand Mere Dune Environment	27*
	Muskegon Sand Mining Inventory	28*
	Identification of Hazardous Waste Disposal Sites	34*
	Integrated Pest Management Systems	35

\* Project utilized more than one source

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SUMMARY BY DATA SOURCE

SOURCE	NUMBER OF PROJECTS	PERCENT
LANDSAT	5	9.3
Skylab	2	3.7
High Altitude Aircraft	21	38.9
Medium Altitude Aircraft	14	25.9
Low Altitude Aircraft	<u>12</u>	<u>22.2</u>
TOTAL	54	100.0

M S U / R S P

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**Category Three: ALL OTHER FUNDING RECEIVED**


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**A. Non-NASA Funding by Year**

YEAR	AMOUNT
1973	\$ 4,295
1974	25,000
1975	10,000
1976	18,221
1977	86,011
1978	191,513
1979	336,626
1980 (to date)	<u>278,261</u>
TOTAL	\$ 949,927

**B. Non-NASA Funding by Agency**

SOURCE	NUMBER OF CONTRACTS	AMOUNT
Federal Agencies	7	\$ 698,832
State Agencies	9	128,920
Regional Agencies	4	18,949
County Agencies	4	9,026
Town-Local	3	584
Private	7	24,562
University		75,083
TOTAL	34	\$ 995,956

## Category Four: COMMERCIAL SPIN-OFFS FROM NASA FUNDED PROJECTS

SPIN-OFF	AGENCY	CONTRACTOR(S)	YEAR	NASA/MSU PROJECT NUMBER	COST
1. Lower Kalamazoo River Basin Land Cover/Use Inventory	Soil Conservation Service	MSU/RSP	1974	3	\$27,000
2. Acquisition of 1:36,000 CIR Photos (30,000 sq. km. area)	Michigan Department of State Highways and Transportation	Mark Hurd Aerial	1973	1,4	\$27,000
3. Acquisition of 1:31,680 CIR Photos (7,500 sq. km. area)	South Central Michigan Planning and Development Council of Region 3	Abrams Aerial Survey	1974	3	\$12,500
4. Forest Type Mapping of Four Counties	West Michigan Regional Planning Commission and Packaging Corp. of America	Environmental Surveys, Inc.	1975-77	8	\$35,000
5. Reproduction of Aerial Photos of Detroit Riverfront	15 Agencies	MSU/RSP	1975-76	18	\$ 300
6. Windsor Township Natural Resources Information System	Clinton-Eaton-Ingham Tri-County Regional Planning Commission	MSU/RSP	1976	25	\$ 980
7. Region V Land Cover/Use Inventory	Region V Planning and Development Commission	MSU/RSP, Bendix Aerospace Division	1977	24	\$21,000
8. Tri-County Natural Resource Information Files	Clinton-Eaton-Ingham Tri-County Regional Planning Commission	MSU/RSP	1978	25	\$ 2,000

Category Four (cont'd.)

SPIN-OFF	AGENCY	CONTRACTOR(S)	YEAR	NASA/MSU PROJECT NUMBER	COST
9. Inventory of Sand Mining Activities	Michigan Department of Natural Resources	MSU/RSP	1978-79	27	\$41,000
10. Inventory of Sand Dune Types	Michigan Department of Natural Resources	MSU/RSP	1978-79	27, 28	\$33,040
11. Farmland Appraisal Maps	Eaton County Equalization Department	MSU/RSP	1978	22	\$ 3,580
12. Statewide Aerial Photography	Michigan Department of Natural Resources	Kucera and Associates	1977-78	8	\$309,000
				<b>TOTAL</b>	<b>\$512,400</b>

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**Category Five-(a): EDUCATIONAL ACTIVITIES**

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**A. Conferences and Workshops****1. Conference on the Practical Applications of Remote Sensing in Michigan (1973)**

This two-day conference brought together 85 representatives of Michigan agencies for a series of presentations and workshops on remote sensing.

**2. Northwest Michigan Region Training Session (1974)**

A two-day training session on color infrared photography and photointerpretation was given to 25 public officials from 8 counties in Michigan.

**3. Michigan Land Cover/Use Classification System Workshop (1976)**

A one-day workshop was held to familiarize personnel from 8 regional planning agencies with the Michigan Classification System and the various remote sensing inventory options available for preparing land cover/use maps.

**4. Association of American Geographers' Special Session: Applied Remote Sensing (1977)**

A session was organized for the 73rd AAG Meetings in Salt Lake City by Michigan State, which brought together speakers from three other Office of University Affairs Remote Sensing Projects to explain the thrust of activities in their particular states: Dr. Stan Morain of TAC, New Mexico was the discussant.

**5. Cooperative Extension Service Workshops (1978)**

Two one-day workshops on the sources, techniques and applications of remote sensing were given to 64 individuals from various agencies of 8 counties.

**6. Conference on Applications of Cartography and Remote Sensing (1978)**

A one-day conference was held to provide information on recent developments in both fields to 87 paid attendees from public agencies and private firms in Michigan.

\*7. Cooperative Extension Service Workshops (1979)

Four one-day workshops on the sources, techniques and applications of remote sensing were given to 156 individuals from various agencies of 30 counties.

\*8. Michigan Landscape Architecture Days Workshop (1979)

A one-day workshop on the sources, techniques and applications of remote sensing was given to 26 landscape architects.

\* Conducted during current reporting period.



**B. Major Technical Assistance and Briefing Activities**

1. Red Cedar River Basin Watershed Plan Development (Soil Conservation Service and Michigan Department of Agriculture, 1973)
2. Northwest Michigan Resource Conservation and Development Project Land Resources Inventory Mapping Program (Soil Conservation Service, 1973)
3. Forest Plantation Classification and Inventory Program (Forest Service, 1973)
4. Huron Pines Resource Conservation and Development Project (Soil Conservation Service, 1973)
5. Northwest Michigan Economic Development District and Regional Planning Commission (Northwest Michigan Planning Commission, 1973)
6. Arcadia Power Plant Construction (Northwest Michigan Planning Commission, 1973)
7. Traverse Bay Residential Development Survey (Northwest Michigan Planning Commission, 1973)
8. High School Vocational Education Program Development (MSU Agriculture and Natural Resources Education Institute, 1973)
9. Land Planning Data Bank (West Michigan Regional Planning Commission, 1973-75)
10. Photographic Acquisition Assistance and Interpretive Training (Michigan Department of State Highways and Transportation, 1973-75)
11. Photographic Acquisition Assistance (South Central Michigan Planning and Development Council of Region 3, 1974)
12. Augusta Creek Drainage Analysis (Kellogg Biological Station, Michigan State University, 1974-75)
13. Evaluation of Proposed Utility Corridors (Michigan Public Service Commission, 1974)
14. Effects of Accelerated Erosion Control Measures (Michigan Department of Agriculture, 1974)
15. Antrim County Land Use Inventory (Antrim County Planning Department, 1974)

16. Evaluation of the Area Surrounding Houses for Sale (Roger Pavilik Realty, 1974)
17. Power Transmission Corridor Planning (Consumers Power Corporation, 1974)
18. Oil Exploration (Cities Service Oil Company, 1974-75)
19. Use of Remote Sensing for Soil Mapping (Soil Conservation Service, 1974)
20. Determination of House Counts in Antrim County (John R. Snell Engineers, Inc., 1975)
21. Lake Erie Coastal Wetlands Assessment (Bureau of Sport Fisheries & Wildlife, 1976)
22. Development of Benjamin Davies Park (City of Lansing Parks & Recreation Department, 1976)
23. Development of the Red Cedar Bike Path (City of Lansing Parks & Recreation Department, 1976)
24. Shoreline Recession Rate Determination and Wetlands Interpretation (Michigan Department of Natural Resources, 1977-78)
25. Frost Impact on Grape Vineyards in Berrien County (National Grape Cooperative Association, Inc. and MSU Departments of Agricultural Engineering and Horticulture, 1977-78)
26. Statewide Aerial Photography Project (Michigan Department of Natural Resources, 1977-78)
27. Forest Type Mapping of Barry County (Soil Conservation Service, 1978)
28. Michigan Land Cover/Use Classification System Slide/Tape Program (Michigan Department of Natural Resources, 1978)
- \*29. Forest Type Mapping of Montmorency County (Soil Conservation District and Michigan Department of Natural Resources, 1979)
- \*30. Forest Type Mapping of Otsego County (Soil Conservation District and Michigan Department of Natural Resources, 1979)
- \*31. Wetlands Protection Legislation (The State Senate and the Michigan Department of Agriculture, 1979)
- \*32. Acquisition of Small Format Aerial Photos of Research Plots (MSU Department of Entomology, Botany & Plant Pathology, and Crop and Soil Sciences, 1978-79)

- \*33. Woodcock Habitat Mapping (MSU Department of Fisheries & Wildlife, 1979)
- \*34. Identification of Pits, Ponds and Lagoons (Michigan Department of Public Health, 1979)
- \*35. Community Development and City Planning (Design Michigan, 1979)
- \*36. Aerial Photos in Support of Legal Cases (Law, Weathers, Richardson and Dutcher, 1979)
- \*37. Michigan Resource Inventory Legislation (Michigan Department of Natural Resources, 1979)
- \*38. Identification of Forage Crops and Other Lands Related to Apiary (Beehives) Locations (Michigan Bee Keepers Association and MSU Department of Entomology, 1979)
- \*39. Forest Resource Inventory and Computer Mapping (Forest Management Division, Michigan Department of Natural Resources, 1979)
- \*40. Topographic Sampling Procedures for Archeological Investigations of Extinct 19th Century Town Sites in Mississippi (MSU Museum and Department of Anthropology, 1979)

\*Conducted during current reporting period.

**C. Major Educational Presentations and Materials**

1. Users Guide to High Altitude Imagery of Michigan, published by the Remote Sensing Project, 1973.
2. Educational Self-Training Slide Modules, 1974-75:
  - a. "Basic Photo Interpretation"
  - b. "Basic Photo Measurements and Stereoscopic Viewing"
  - c. "Photo Interpretation in Forestry"
3. Guide to Aerial Imagery of Michigan, published by the MSU Agricultural Experiment Station, 1977.
4. "Window to the World" exhibit at Impression 5 Museum, 1978.
- \*5. "Applications of Remote Sensing and Computer Information Systems to County-Level Programs," County Commissioners Day, MSU, 1979.
- \*6. "Making Land Use Decisions and Tax Assessments via Remote Sensing," Michigan Northern Counties Association, 1979.
- \*7. "Computer-Assisted Farmland Appraisal," Northern Michigan Equalization Directors Association, 1979.

\*Conducted during current reporting period.

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Category Five-(b): NUMBER OF "REMOTE SENSING" COURSES OFFERED ON CAMPUS  
AND ENROLLMENTS

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1. Geography 224: Remote Sensing--Airphoto Interpretation

Use of aerial photographs in the identification and interpretation of physical and cultural features of the terrestrial environment. Includes principles of photogrammetry, and stresses application and practice.

Offered two terms per year/6 sections

Annual enrollment 1977-78: 166 students

2. Geography 424: Advanced Remote Sensing Techniques

Extraction, analysis, and interpretation of information obtained from remote sensors including conventional, infrared and radar imagery. Introduction to stereo-plotting devices, stressing theories of remote sensing and applications.

Offered one term per year

Annual enrollment 1978: 27 students

Category Five-(c): NUMBER OF FACULTY AND RESEARCH ASSISTANTS INVOLVED IN  
THE PROGRAM

1. 13 faculty-rank persons from 9 departments
2. 5 full-time research "specialists" (MSU classification for most technical/professional personnel not holding faculty rank)
3. 19 student research assistants (mostly half- to three-quarter-time)

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**Category Six: AGENCY CONTACTS**

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**Federal Agencies**

- + U.S. Army Corps of Engineers
- + U.S. Department of Agriculture
  - Economics, Statistic, & Cooperative Services (formerly Economic Research Service)
  - Forest Service
  - Office of International Development
  - Science & Education Administration
  - \*Soil Conservation Service
- + U.S. Department of Interior
  - Bureau of Sports Fisheries & Wildlife
- + U.S. Department of State
  - Agency for International Development

**State of Michigan Agencies**

- + Department of Agriculture
- + Department of Natural Resources
  - \*Forest Management Division
  - Geological Survey Division
  - Inland Lakes Division
  - Land Resource Programs Division
  - \*Environmental Services Division
  - \*Resource Recovery Division
  - \*Water Quality Division
- + Department of State Highways and Transportation
  - Environmental Liaison Section
  - Photogrammetry Section

- + \*Public Service Commission
- + \*Department of Management & Budget
- + \*The Michigan Senate
- + \*Department of Public Health

#### Regional Planning and Administrative Agencies

- + East Central Michigan Planning and Development Council
- +\*Northeast Michigan Council of Governments
- +\*Northwest Michigan Regional Planning Commission
- + Region 2 Planning Commission
- + Region V Planning and Development Council
- + South Central Michigan Planning and Development Council of Region 3
- + Southeast Michigan Council of Governments
- + Southwest Michigan Regional Planning Commission
- + Traverse Bay Regional Planning Commission
- + Tri-County Regional Planning Commission
- +\*West Michigan Regional Planning Commission
- + West Michigan Shoreline Regional Planning Commission

#### County Agencies

- +\*Alpena County Equalization Department
- + Antrim County Planning Department
- + Berrien County Office of Prosecuting Attorney
- + Charlevoix County Equalization Department
- + Eaton County Equalization Department
- + Genesee County Planning Commission

- + Grand Traverse County Planning Commission
- + Ingham County Drain Commission
- + Kent County Equalization Department
- + Mason County Soil Conservation District
- + Monroe County Planning Commission
- +\*Montmorency County Soil Conservation District
- +\*Otsego County Soil Conservation District
- +\*Osceola County Cooperative Extension Service
- + Saginaw-Bay Mosquito Control Commission
- + Wayne County Planning Commission

#### Town-Local Agencies

- + Citizens Concerned About I-69
- + City of Lansing Parks and Recreation Department
- + City of Lansing Vector Control Section
- +\*Design Michigan
- + Grand Mere Association
- + Lakefield Township, Saginaw County
- + Saginaw-Chippewa Indian Tribe
- +\*Sault Ste. Marie Tribe of Chippewa Indians
- + City of Mason: City Administrator and Planning Commission

#### Private Agencies

- + Abrams Aerial Survey, Inc.
- + Bendix Aerospace Systems Division
- + Cities Service Oil Company



- +\*Columbia Gas System Service Corporation
- + Consumers Power Company
- +\*CRW Associates
- + Dow-Corning Corporation
- +\*Durkee Lake Club
- + Environmental Research Institute of Michigan
- + John R. Snell Engineers, Inc.
- + Johnson, Johnson & Roy, Inc.
- +\*Law, Weathers, Richardson & Dutcher
- +\*Menasha Corporation
- + Morbark Industries, Inc.
- + National Grape Cooperative Association, Inc.
- +\*Packaging Corporation of America
- +\*Richard Morris, Attorney-at-Law
- + Roger Pavilik Realty
- + S.D. Warren Co.
- + Wakely-Kushner Associates
- + Wickes Agriculture
- + William Brehm
- +\*Wolverine Electric Cooperation

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\* Contacts during current reporting period.

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**Category Seven: TRAFFIC TO THE RSP LABORATORY--An Approximation**

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"Traffic" is interpreted to mean any of the many possible inquiries for information, guidance, or simply interest. . .contacts either by telephone or visiting in person.

- A. Telephone Inquiries: Average--two per day/500 per year
- B. Personal Drop-Ins: Average--one per day/250 per year

## A p p e n d i x

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