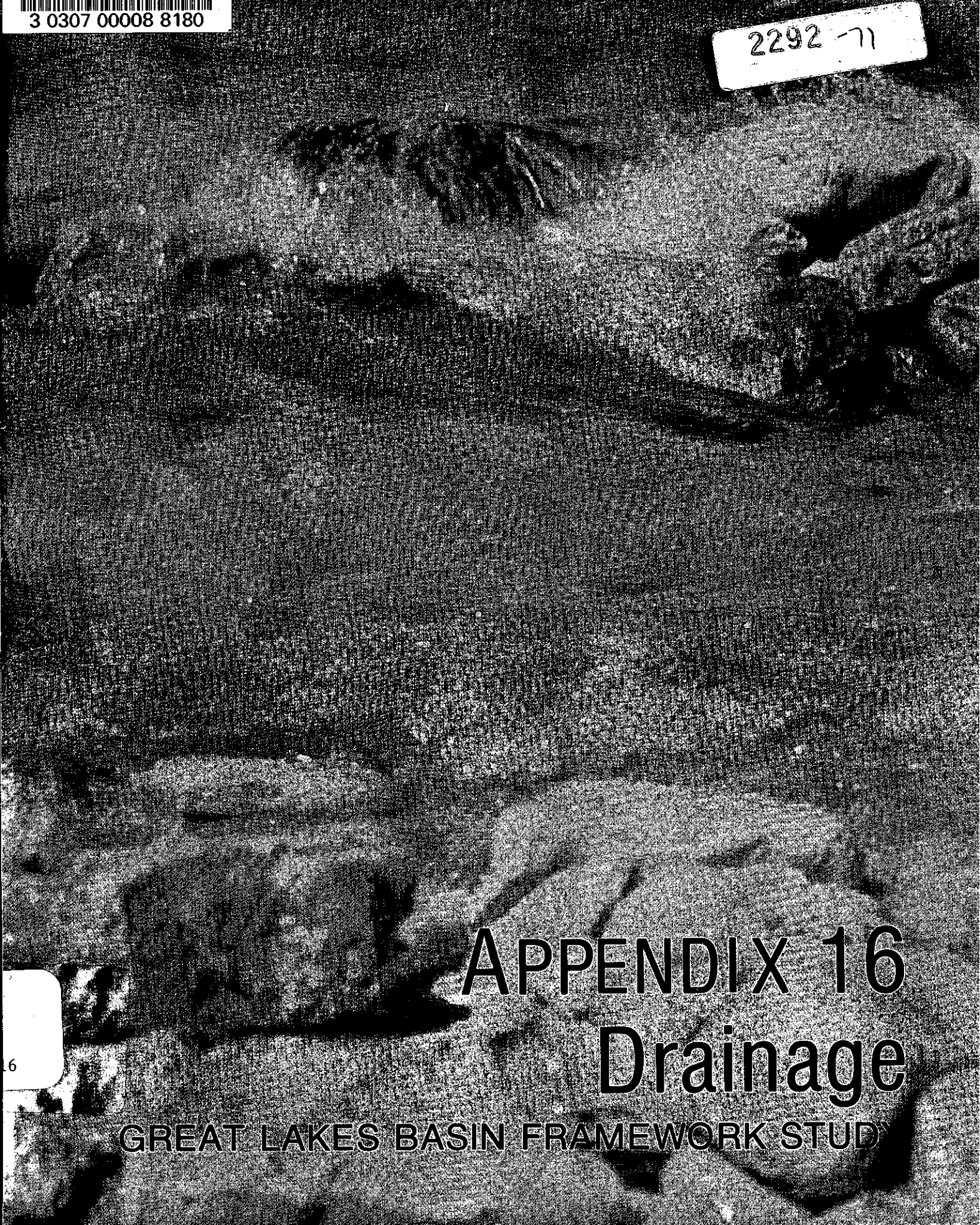

APPENDIX 16
Drainage

GREAT LAKES BASIN FRAMEWORK STUDY

Great Lakes Basin Framework Study

APPENDIX 16

DRAINAGE

GREAT LAKES BASIN COMMISSION

Prepared by Drainage Work Group

Sponsored by Soil Conservation Service

U.S. Department of Agriculture

Published by the Public Information Office, Great Lakes Basin Commission, 3475 Plymouth Road, P.O. Box 999, Ann Arbor, Michigan 48106. *Cover photo by Kristine Moore Meves.*

This appendix to the *Report* of the *Great Lakes Basin Framework Study* was prepared at field level under the auspices of the Great Lakes Basin Commission to provide data for use in the conduct of the Study and preparation of the *Report*. The conclusions and recommendations herein are those of the group preparing the appendix and not necessarily those of the Basin Commission. The recommendations of the Great Lakes Basin Commission are included in the *Report*.

OUTLINE

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SYNOPSIS

Drainage problems on agricultural and urban lands are assessed in this report. Drainage problems are caused by excess water in the soil profile that limits the use of the land. The economics of removing the excess are not included in the problem identification.

Most drainage problems of the Great Lakes occur in the Lake Erie region, where more than five million acres have drainage problems. In the whole Region, approximately 12 million acres need to be drained. An assessment of the severity of drainage problems indicates three million acres of cropland have severe problems and five million acres have lesser problems.

A review of problems and possible general solutions indicated the watershed areas that might be improved by group action. There are 217 watersheds that appear to be favorable with more than four million acres of cropland to be improved. Projections and recommendations for drainage include only a portion of these areas.

Urban growth will be limited by soil-water conditions. Naturally wet soils predominate in eight Basin cities. Demands for land, based upon projections of population, will require extensive development on less desirable wetland in five metropolitan areas.

Maps indicate the limitation for obtaining adequate soil drainage by planning subareas. They may be used to locate desirable use and growth patterns.

The regional economic development objective indicates need for a large amount of drainage installation on cropland. A large proportion of this more than 3.3 million acres is in Planning Subareas 2.3, 3.2, 4.1, and 4.2. Projections indicate that nearly 1.5 million acres will need project action to gain full benefit in 50 years. The national economic development objective projects drainage needs according to production of the Basin's share of the nation's food. Approximately one-third of this projected drainage, which is 1.5 million acres in 50 years, is in Planning Subarea 4.2. Project action is needed for some of these lands also, but for proportionately lower acreages.

General costs have been estimated for these projections. The regional program would cost nearly $150 million in the early time period and more than $500 million by 2020. The national economic development program cost is nearly $400 million for the 50 years with approximately $115 million in the early action period. Improved drainage will increase per-acre production and will lessen the amount of land needed to meet food demands.

FOREWORD

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INTRODUCTION

This appendix, a report of studies and data collected for the *Great Lakes Basin Framework Study*, includes a review of data sources, methodology used, and interpretation of results. Each section has a set of tables or maps or both, as appropriate to the data presented.

A drainage problem is defined as excess water on lands where a naturally high water table, normal precipitation, or seepage, limits agricultural production or urban use. Drainage measures will remove this excess water and provide for surface and/or subsurface drainage. Surface drainage measures remove water from the land before it damages the crop and diminishes production. Subsurface drainage methods, such as tile, remove excess ground water from the root zone portion of the soil profile. Agricultural drainage provides an environment suitable for maximum plant growth. Urban drainage removes excess soil moisture.

Description of the Basin

The Great Lakes Basin has large areas of relatively flat land with high water tables and fine-textured soils. The land areas of much of the Great Lakes Basin were formed as glaciers receded to the north. During this final northward recession of the ice sheet, there was ponding of melt waters between the ice and the exposed glacial deposits. These glacial lakes occurred at several different elevations. At each lake level sediments were deposited. Patterns and levels of those lakes were repeatedly changed as new lower outlets were uncovered. This left extensive, relatively flat areas with tight, fine-textured lake bed deposits. These deposits make up most of the drainage of Planning Subareas 2.2, 3.1, and 4.2. Large lake plains also occur in Planning Subareas 2.1, 2.3, 4.1, 4.3, 4.4, 5.1, and 5.2. Historically these areas have had poor drainage.

Lake plain soils are very fertile. When coupled with the favorable climatic conditions in the southern portions of the Great Lakes, drained lake plains become prime agricultural land.

Studies Included in the Report

Inventory data, presented and discussed in sections related to the source or type of base data used, were collected by county, or by watershed drainage area, from State soil association maps.

The county data base was obtained through the Conservation Needs Inventory (CNI) compiled by the U.S. Department of Agriculture (USDA) in 1967. Soil capability units and land use categories were obtained from this survey. This data base was supplemented and refined by the SCS district conservationist to give an inventory of soil drainage conditions and cropping patterns. Land drainage conditions on crop and pasture land are divided into categories of natural soil condition as well as present drainage condition. Natural soil conditions are listed as they occur in the nonurban land base of the Standard Metropolitan Statistical Areas (SMSA). The nonurban land base is the acreage in crop, pasture, forest, and other land categories that will be encountered as an urban area expands.

The watershed drainage area base was another phase of the CNI. Acres of inadequately drained agricultural land were inventoried by watersheds, and those requiring project or group action for solution were identified. Additional study was done to identify further the locations of and land uses in the problem areas. With this additional data an analysis of damage and general solutions, which identified the watersheds most favorable for project action, was possible. Drainage data are presented for the favorable watersheds, which are identified on maps.

The third set of data presents an interpretation of the soil association maps. The associations have been identified according to the degree of limitation to obtaining drainage. Three degrees of limitation have been established and are shown on a series of planning subarea maps.

Projections of drainage needs are presented for both regional development and national income objectives. Estimates of needed project-action are made as part of each objective.

Project action will be needed to realize the full benefit of local drainage measures. All of the acres included in the two projections need land treatment measures such as tile installation and field ditches. Project action measures would include channel improvement, pumps, dikes, or grade stabilization structures.

Relation to Other Programs

Drainage problems in urban or developing areas are difficult to assess with respect to magnitude and location. Some cities have assessments of their problems, but most metropolitan areas do not. Drainage is a potential need in most developing areas. A drainage system that handles potential storm runoff and drains the soil profile should be planned and installed before urban areas develop. Because no consistent data could be obtained for the entire Basin, little discussion of present urban drainage problems is included in the report. Only a brief review of soils data relating to urban expansion is included.

Studies reviewed in this report relate to lands used for agricultural purposes. Problems and possible benefits of drainage are defined for crop and pasture land. Some acreage not in active cultivation is included in the total cropland. This land, at the time of the survey, was classified either as conservation reserve, idle cropland, or cropland formerly cropped. Drainage problems were not inventoried for these lands. The watershed survey identifies some areas of woodland and other land with drainage problems, but no assessments of problems or possible drainage benefits are included.

Drainage of wetlands for agricultural use is a highly controversial subject. The Drainage Work Group supports the policy that wetland types III (seriously limited), IV (severly limited wetlands), and V (marshes and swamps) are not to be drained for agricultural use. Studies in this appendix are confined to active agricultural lands and the water problems present in them. There is no attempt to inventory, assess, or tabulate the various types of wetland areas or wildlife habitat. Drainage studies were restricted to active agricultural land to minimize conflict with wildlife and waterfowl studies.

In Appendix 14, *Flood Plains*, upstream flood problem programs and drainage programs are examined. Because flood plains are relatively flat, both flooding and drainage problems occur there. The watershed problem inventory lists the acreages with drainage problems. In Appendix 14, watersheds and flooded acres are listed according to planning subarea. The benefits listed in Table 16–19 refer only to drainage and do not include flood benefits, but the costs include total project costs for protection from both flood and drainage problems. This cost information is included in *Flood Plains*.

Section 1

AGRICULTURAL PROBLEM ANALYSES

1.1 Surveys Based on County Data

1.1.1 Data Collection

The Conservation Needs Inventory (CNI) was conducted in 1967 by the U.S. Department of Agriculture (USDA) in order to obtain data about acres in primary land uses, land capability units, and other information for each county. Primary land uses identified were: urban land, water, crop, pasture, non-Federal forest, and other land. All Federal land was inventoried separately. Cropland acreage data were obtained for corn, other row crops, close-grown field crops, hayland, conservation land, temporarily idle cropland, orchards, vineyards, and open land formerly cropped. The data for each county were reviewed, revised as necessary, and approved by a local conservation needs committee.

The information about land capability units was combined into soil resource groups (SRG), i.e., combinations of land capability units and soil types arranged according to similarities of texture and management problems. Problems considered included wetness, flood hazard, and droughtiness. The groups have similar cropping patterns, yield characteristics, responses to fertilizers, and require similar management and land treatment measures, e.g., strip cropping and terraces. The groupings were developed so that each was sufficiently homogeneous to permit projected yield comparisons between States as well as within States. Of the 23 SRGs that were developed, six were considered to have drainage problems under natural conditions.

CNI data was tabulated by using SRGs to indicate the acreages by county and by soil groups in four major land use categories. These categories were: cropland, pasture, non-Federal forest land, and other lands. The SMSA drainage study that appears in this appendix was based upon this compilation.

The Soil Conservation Service (SCS) district conservationist for all counties in the Basin further defined crops grown and land use problems. By using available data, estimates of the existing soil problem condition for each crop were made by SRG. Cropland had to be separated according to crops grown. SRGs with each crop were identified, and the soil condition of each was defined. Five soil condition categories were used:

(1) adequate drainage and flood protection (no flood or drainage problems)

(2) drainage problems with no drainage improvements in place (severe drainage problem)

(3) drainage problems with some drainage measures installed but not classified as adequately treated (some drainage problem)

(4) flood problems

(5) combined flood and drainage problems.

This breakdown by problem category was made only for the crop and pasture acreage. Three of the cropland categories, conservation use only, temporarily idle cropland, and open land formerly cropped, were not identified by problem class and are included in the data as "inactive cropland." The soil grouping and problem category information was used to determine the relative drainage problems in each county.

1.1.2 Development of Tables

The soils and crop information obtained through data collection was summarized by planning subareas, i.e., groupings of counties (Figure 16–1).

Agricultural land base is tabulated as a total figure and also as pasture and cropland figures. Based upon SRGs, cropland was divided into two classifications, generally dry soils and soils with wetness problems. Fifteen of the 23 soil groups do not normally have water problems and are classified as generally dry soils. The remaining eight SRGs are soils with potential wetness problems. Cropland soils with wetness problems were further identified as generally wet soil, muck soil, and alluvial soils. Alluvial and muck soils were listed separately because each has unique water problems. Data from other groups that

TABLE 16–1 Present Agricultural Problem Distribution,[1] Planning Subarea 1.1

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	530	344	37	39	2	2	107
Percent of Base	100	64.9	6.9	7.3	0.4	0.4	20.2
			1,000 Acres				
Pasture	100	70	20	8	1	1	---
Cropland	430	274	17	31	1	1	107
Generally Dry Soils	398	266	13	24	1	-	94
Soils with Wetness Problems	33	8	4	7	-	1	13
Generally Wet Soils	31	8	4	6	-	1	12
Muck Soils	2	---	--	1	-	-	1
Alluvial Soils	---	---	--	--	-	-	---
			Percent of Base				
Pasture	18.9	13.2	3.8	1.5	0.2	0.2	----
Cropland	81.1	51.7	3.2	5.8	0.2	0.2	20.2
Generally Dry Soils	75.1	50.2	2.4	4.5	0.2	---	17.7
Soils with Wetness Problems	6.2	1.5	0.8	1.3	---	0.2	2.5
Generally Wet Soils	5.8	1.5	0.8	1.1	---	0.2	2.3
Muck Soils	0.4	----	---	0.2	---	---	0.2
Alluvial Soils	----	----	---	---	---	---	----

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

normally have drainage problems were grouped together as generally wet soils. The acreage of each of these cropland categories was tabulated.

Each acreage tabulated in this breakdown of natural soil conditions was further divided to indicate present soil problem conditions. Five present soil problem categories (Section 1.1.1) were used. A sixth category, inactive cropland, was tabulated. This tabulation may be used to determine the acres of cropland that have severe drainage problems and to identify the degree of flood and/or drainage problems found in the agricultural land classifications.

Summations for each problem category give figures for the acreage with that problem. A percentage of the total land base is given for each problem category. Problem categories, their present uses, and natural soil conditions may then be compared. Tables 16–1 through 16–15 contain soil and crop information by planning subareas. These tables indicate the amount of land with water problems in each category and also those acres that have been or may need to be improved. The Basin total for each category from the tables is given in Table 16–16. Table 16–17 summarizes present agricultural problem distribution by planning subarea and gives the total land base and the total of each soil problem category within each planning subarea, Lake basin, and the whole Basin.

1.1.3 Interpretation of Tables

The tables present the natural soil condition of the total land base as well as the existing soil condition. The tabulation of natural soil condition may be used to determine acreage likely to have water problems. Soils classified as wet probably need further improvement before more intensive use. After soil problem categories were identified the amount of cropland that does not have a soil problem under present conditions was determined for each planning subarea. These tables also indicate the amount of naturally wet soil that has been drained or requires draining. These figures may be compared to the total agricultural base in order to identify the relative magnitude of water problems in each planning subarea.

The inactive cropland category is included as part of the total land base, but it is not divided according to soil problem category in the inventory. Thus land can be distributed

TABLE 16–2 Present Agricultural Problem Distribution,[1] Planning Subarea 1.2

Item	Total Land	No Flood or Drainage Problem	Problem Category				Inactive Cropland[2]
			Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	
Total Base (1,000 acres)	329	181	55	15	2	7	69
Percent of Base	100	55.0	16.7	4.6	0.6	2.1	21.0
	1,000 Acres						
Pasture	66	52	8	3	1	2	0
Cropland	263	129	47	12	1	5	69
Generally Dry Soils	158	109	7	6	-	2	37
Soils with Wetness Problems	105	21	40	6	1	3	32
Generally Wet Soils	96	19	40	6	-	1	31
Muck Soils	2	---	--	--	-	-	--
Alluvial Soils	7	2	--	--	1	2	1
	Percent of Base						
Pasture	20.1	15.8	2.4	0.9	10.3	0.6	0
Cropland	79.9	39.2	14.2	3.6	0.3	1.5	21.0
Generally Dry Soils	48.0	33.1	2.1	1.8	----	0.6	11.2
Soils with Wetness Problems	31.9	6.4	12.2	1.8	0.3	0.9	9.7
Generally Wet Soils	29.2	5.8	12.2	1.8	----	0.3	9.4
Muck Soils	0.6	----	----	---	----	---	----
Alluvial Soils	2.1	0.6	----	---	0.3	0.6	0.3

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

into soil problem categories in two ways. It may be assumed that the land is distributed among the soil problem categories in the same percentages as the other reported acres. This presumes that the acreage identified by the soil problem category is typical of other land. Distribution of this land into soil problem categories may also be made by assuming that inactive cropland is in its natural condition, i.e., acreage in a generally dry soil category would have no flood or drainage problems under normal conditions, and acreage in the generally wet soil category would have a major drainage problem. Muck soil would have a severe drainage problem.

The summary table indicates that of the 32 million acres in agricultural cropland and pastureland, 18 million acres have no present drainage problem. Figure 16–2 is a graphic analysis of the flood and drainage problems on agricultural land in the Basin. More than three million acres have severe drainage problems, and nearly 5.5 million acres have some drainage problem. Of the 5.5 million acres, or 17 percent, of agricultural land base in the inactive cropland cateogry, some acres may have imperfect drainage. Approximately 27 percent of the total agricultural land has a drainage problem.

Agricultural drainage problems occur primarily within the Lakes Erie and Michigan drainage basins. Forty-seven percent of the land with problems is in the Lake Erie basin with 30 percent of this in Planning Subarea 4.2. Lake Michigan drainage basin has 28 percent of the drainage problems of the Great Lakes Basin. Lake Ontario and Lake Huron drainage basins each contain approximately a million acres of agricultural land with water problems, or slightly more than 10 percent of the total problem acres in each lake basin. Lake Superior drainage basin has a small drainage problem because it has a relatively small amount of agriculture. Distribution of the problems of each Lake basin is given in Figure 16–3. The sum of the drainage problem acreages of Planning Subareas 3.2, 4.1, and 4.2 is 4.75 million acres, which is more than 50 percent of the total Basin problem acres. These three planning subareas form a band that includes southern Lake Huron and western Lake Erie.

The percent of total agricultural land that needs drainage improvement indicates the intensity of drainage problems. Forty percent of Lake Erie basin has inadequate drainage. Lake Huron and Lake Ontario basins each have about 25 percent with a drainage

TABLE 16–3 Present Agricultural Problem Distribution,[1] Planning Subarea 2.1

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	3,680	2,430	276	460	22	113	379
Percent of Base	100	66.0	7.5	12.5	0.6	3.1	10.3
	1,000 Acres						
Pasture	356	212	64	36	9	34	---
Cropland	3,324	2,218	212	424	13	79	379
Generally Dry Soils	2,575	2,042	76	149	7	28	273
Soils with Wetness Problems	750	176	136	275	6	51	105
Generally Wet Soils	709	170	134	254	6	50	94
Muck Soils	40	6	2	21	--	1	11
Alluvial Soils	1	-----	---	---	--	--	---
	Percent of Base						
Pasture	9.7	5.8	1.7	1.0	0.2	0.9	----
Cropland	90.3	60.3	5.8	11.5	0.4	2.2	10.3
Generally Dry Soils	70.0	55.5	2.1	4.0	0.2	0.8	7.4
Soils with Wetness Problems	20.4	4.8	3.7	7.5	0.2	1.4	2.9
Generally Wet Soils	19.3	4.6	3.6	6.9	0.2	1.4	2.6
Muck Soils	1.1	0.2	0.1	0.6	0	---	0.3
Alluvial Soils	---	---	---	---	---	---	---

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–4 Present Agricultural Problem Distribution,[1] Planning Subarea 2.2

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	3,077	2,133	161	331	13	86	352
Percent of Base	100	69.3	5.2	10.8	0.4	2.8	11.5
	1,000 Acres						
Pasture	237	181	23	23	3	7	---
Cropland	2,840	1,952	138	308	10	79	352
Generally Dry Soils	1,592	1,384	2	20	--	2	184
Soils with Wetness Problems	1,248	568	136	288	10	78	168
Generally Wet Soils	1,053	501	118	247	4	57	125
Muck Soils	117	40	13	35	6	13	11
Alluvial Soils	78	27	5	6	--	8	32
	Percent of Base						
Pasture	7.7	5.9	0.7	0.7	0.1	0.2	----
Cropland	92.3	63.4	4.5	10.0	0.3	2.6	11.4
Generally Dry Soils	51.7	45.0	0.1	0.6	---	0.1	6.0
Soils with Wetness Problems	40.6	18.5	4.4	9.4	0.3	2.5	5.5
Generally Wet Soils	34.2	16.3	3.8	8.0	0.1	1.9	4.1
Muck Soils	3.8	1.3	0.4	1.1	0.2	0.4	0.4
Alluvial Soils	2.5	0.9	0.2	0.2	---	0.3	1.0

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–5 Present Agricultural Problem Distribution,[1] Planning Subarea 2.3

Item	Total Land	No Flood or Drainage Problem	Problem Category				Inactive Cropland[2]
			Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	
Total Base (1,000 acres)	5,822	3,588	314	586	30	51	1,252
Percent of Base	100	61.6	5.4	10.1	0.5	0.9	21.5
	1,000 Acres						
Pasture	465	323	62	66	6	8	-----
Cropland	5,357	3,265	252	520	24	43	1,252
Generally Dry Soils	3,579	2,650	13	75	2	1	836
Soils with Wetness Problems	1,778	614	239	445	21	42	416
Generally Wet Soils	1,537	541	224	411	14	32	314
Muck Soils	200	63	10	32	1	9	85
Alluvial Soils	41	10	5	2	6	1	17
	Percent of Base						
Pasture	8.0	5.5	1.1	1.1	0.1	0.1	----
Cropland	92.0	56.1	4.3	8.9	0.4	0.7	21.5
Generally Dry Soils	61.5	45.5	0.2	1.3	---	---	14.4
Soils with Wetness Problems	30.5	10.6	4.1	7.6	0.4	0.7	7.1
Generally Wet Soils	26.4	9.3	3.8	7.1	0.2	0.5	5.4
Muck Soils	3.4	1.1	0.2	0.5	---	0.2	1.5
Alluvial Soils	0.7	0.2	0.1	---	0.1	---	0.3

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–6 Present Agricultural Problem Distribution,[1] Planning Subarea 2.4

Item	Total Land	No Flood or Drainage Problem	Problem Category				Inactive Cropland[2]
			Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	
Total Base (1,000 acres)	1,834	993	121	58	10	10	642
Percent of Base	100	54.1	6.6	3.2	0.5	0.5	35.0
	1,000 Acres						
Pasture	352	274	52	17	5	5	---
Cropland	1,482	719	69	41	5	5	642
Generally Dry Soils	1,262	682	30	15	2	2	532
Soils with Wetness Problems	219	38	39	26	3	3	110
Generally Wet Soils	198	34	38	22	2	2	100
Muck Soils	16	2	1	4	-	-	8
Alluvial Soils	5	2	--	--	1	1	2
	Percent of Base						
Pasture	19.2	14.9	2.8	0.9	0.3	0.3	----
Cropland	80.8	39.2	3.7	2.2	0.3	0.3	35.0
Generally Dry Soils	68.8	37.2	1.6	0.8	0.1	0.1	29.0
Soils with Wetness Problems	11.9	2.1	2.1	1.4	0.1	0.2	6.0
Generally Wet Soils	10.8	1.9	2.1	1.2	0.1	0.1	5.5
Muck Soils	0.9	0.1	---	0.2	---	---	0.4
Alluvial Soils	0.3	0.1	---	---	---	---	0.1

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–7 Present Agricultural Problem Distribution,[1] Planning Subarea 3.1

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	696	390	85	59	3	6	153
Percent of Base	100	56.0	12.2	8.5	0.4	0.9	22.0
	1,000 Acres						
Pasture	164	109	39	15	-	2	---
Cropland	532	281	46	44	3	4	153
Generally Dry Soils	364	238	4	19	-	-	103
Soils with Wetness Problems	167	43	42	25	3	4	50
Generally Wet Soils	162	42	42	24	3	3	47
Muck Soils	3	1	--	1	-	-	2
Alluvial Soils	2	---	--	--	-	1	1
	Percent of Base						
Pasture	23.6	15.7	5.6	2.2	---	0.3	----
Cropland	76.4	40.4	6.6	6.3	0.4	0.6	22.0
Generally Dry Soils	52.3	34.2	0.6	2.7	---	---	14.8
Soils with Wetness Problems	24.0	6.2	6.0	3.6	0.4	0.6	7.2
Generally Wet Soils	23.3	6.0	6.0	3.4	0.4	0.4	6.8
Muck Soils	0.4	0.1	---	0.1	---	---	0.3
Alluvial Soils	0.3	----	---	---	---	0.1	0.1

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–8 Present Agricultural Problem Distribution,[1] Planning Subarea 3.2

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	2,555	1,273	385	339	42	93	424
Percent of Base	100	49.8	15.1	13.3	1.6	3.6	16.6
	1,000 Acres						
Pasture	185	102	64	17	2	2	---
Cropland	2,370	1,171	321	322	40	91	424
Generally Dry Soils	604	394	7	18	--	1	184
Soils with Wetness Problems	1,766	776	314	304	40	90	240
Generally Wet Soils	1,730	762	311	300	39	89	228
Muck Soils	28	13	2	4	--	--	10
Alluvial Soils	8	1	1	---	1	1	2
	Percent of Base						
Pasture	7.2	4.0	2.5	0.7	0.1	0.1	----
Cropland	92.8	45.8	12.6	12.6	1.6	3.6	16.6
Generally Dry Soils	23.6	15.4	0.3	0.7	---	---	7.2
Soils with Wetness Problems	69.1	30.4	12.3	11.9	1.6	3.5	9.4
Generally Wet Soils	67.7	29.8	12.2	11.7	1.5	3.5	8.9
Muck Soils	1.1	0.5	0.1	0.2	---	---	0.4
Alluvial Soils	0.3	----	----	----	---	---	0.1

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–9 Present Agricultural Problem Distribution,[1] Planning Subarea 4.1

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	2,328	957	316	428	18	105	505
Percent of Base	100	41.1	13.6	18.4	0.8	4.5	21.7
	1,000 Acres						
Pasture	112	60	29	12	3	9	---
Cropland	2,216	897	287	416	15	96	505
Generally Dry Soils	787	551	1	5	--	--	229
Soils with Wetness Problems	1,429	346	287	410	15	96	275
Generally Wet Soils	1,339	324	278	401	13	83	240
Muck Soils	59	15	6	5	--	6	27
Alluvial Soils	31	7	3	4	2	7	8
	Percent of Base						
Pasture	4.8	2.6	1.2	0.5	0.1	0.4	----
Cropland	95.2	38.5	12.3	17.9	0.6	4.1	21.7
Generally Dry Soils	33.8	23.7	----	0.2	---	---	9.8
Soils with Wetness Problems	61.4	14.9	12.3	17.6	0.6	4.1	11.8
Generally Wet Soils	57.5	13.9	11.9	17.2	0.6	3.6	10.3
Muck Soils	2.5	0.6	0.3	0.2	---	0.3	1.2
Alluvial Soils	1.3	0.3	0.1	0.2	0.1	0.3	0.3

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–10 Present Agricultural Problem Distribution,[1] Planning Subarea 4.2

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	4,949	1,966	756	1,665	50	71	441
Percent of Base	100	39.7	15.3	33.6	1.0	1.4	8.9
	1,000 Acres						
Pasture	214	93	62	44	4	11	---
Cropland	4,735	1,873	694	1,621	46	60	441
Generally Dry Soils	746	584	21	53	--	--	87
Soils with Wetness Problems	3,989	1,289	673	1,568	46	59	354
Generally Wet Soils	3,851	1,240	661	1,548	24	40	337
Muck Soils	27	11	2	5	1	4	4
Alluvial Soils	111	38	10	15	21	15	13
	Percent of Base						
Pasture	4.3	1.9	1.3	0.9	0.1	0.2	---
Cropland	95.7	37.8	14.0	32.8	.9	1.2	8.9
Generally Dry Soils	15.1	11.8	0.4	1.1	---	---	1.8
Soils with Wetness Problems	80.6	26.0	13.6	31.7	0.9	1.2	7.2
Generally Wet Soils	77.8	25.1	13.4	31.3	0.5	0.8	6.8
Muck Soils	0.5	0.2	----	0.1	---	0.1	0.1
Alluvial Soils	2.2	0.8	0.2	0.3	0.4	0.3	0.3

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–11 Present Agricultural Problem Distribution,[1] Planning Subarea 4.3

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	873	297	113	205	7	11	241
Percent of Base	100	34.0	12.9	23.5	0.8	1.3	27.6
	1,000 Acres						
Pasture	131	56	39	31	1	5	---
Cropland	742	241	74	174	6	6	241
Generally Dry Soils	259	160	3	11	-	-	85
Soils with Wetness Problems	483	81	71	163	6	6	156
Generally Wet Soils	430	73	69	151	-	2	134
Muck Soils	7	3	--	1	3	-	1
Alluvial Soils	46	5	2	11	3	4	21
	Percent of Base						
Pasture	15.0	6.4	4.5	3.6	0.1	0.6	----
Cropland	84.9	27.6	8.4	19.9	0.7	0.7	27.6
Generally Dry Soils	29.7	18.3	0.3	1.3	---	---	9.7
Soils with Wetness Problems	55.3	9.3	8.1	18.7	0.7	0.7	17.9
Generally Wet Soils	49.3	8.4	7.9	17.3	---	0.2	15.3
Muck Soils	0.8	0.3	---	0.1	0.3	---	0.1
Alluvial Soils	5.3	0.6	0.2	1.3	0.3	0.5	2.4

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–12 Present Agricultural Problem Distribution,[1] Planning Subarea 4.4

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	1,111	553	137	204	11	13	194
Percent of Base	100	49.8	12.3	18.4	1.0	1.2	17.5
	1,000 Acres						
Pasture	253	150	37	51	5	10	---
Cropland	858	403	100	153	6	3	194
Generally Dry Soils	464	310	25	55	-	1	72
Soils with Wetness Problems	394	92	75	98	6	2	122
Generally Wet Soils	361	80	72	94	2	1	114
Muck Soils	1	---	---	---	-	--	1
Alluvial Soils	32	12	3	4	4	1	7
	Percent of Base						
Pasture	22.8	13.5	3.3	4.6	0.5	0.9	----
Cropland	77.2	36.3	9.0	13.8	0.5	0.3	17.5
Generally Dry Soils	41.8	27.9	2.3	5.0	---	0.1	6.5
Soils with Wetness Problems	35.5	8.3	6.8	8.8	0.5	0.2	11.0
Generally Wet Soils	32.5	7.2	6.5	8.5	0.2	0.1	10.3
Muck Soils	0.1	----	---	----	---	---	0.1
Alluvial Soils	2.9	1.1	0.3	0.4	0.4	0.1	0.6

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–13 Present Agricultural Problem Distribution,[1] Planning Subarea 5.1

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	1,218	668	145	87	9	8	300
Percent of Base	100	54.8	11.9	7.1	0.7	0.7	24.6
	1,000 Acres						
Pasture	163	115	33	9	2	4	---
Cropland	1,055	553	112	78	7	4	300
Generally Dry Soils	674	430	54	29	-	-	162
Soils with Wetness Problems	381	122	58	49	7	4	138
Generally Wet Soils	306	94	55	43	-	-	114
Muck Soils	9	6	---	2	-	-	---
Alluvial Soils	66	22	3	4	7	4	24
	Percent of Base						
Pasture	13.4	9.4	2.7	0.7	0.2	0.3	----
Cropland	86.6	45.4	9.1	6.4	0.6	0.3	24.6
Generally Dry Soils	55.3	35.3	4.4	2.4	---	---	13.3
Soils with Wetness Problems	31.3	10.0	4.8	4.0	0.6	0.3	11.3
Generally Wet Soils	25.1	7.7	4.5	3.5	---	---	9.4
Muck Soils	0.7	0.5	---	0.2	---	---	----
Alluvial Soils	5.4	1.8	0.2	0.3	0.6	0.3	2.0

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–14 Present Agricultural Problem Distribution,[1] Planning Subarea 5.2

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	2,202	1,349	164	234	25	24	405
Percent of Base	100	61.3	7.4	10.6	1.1	1.1	18.4
	1,000 Acres						
Pasture	444	326	43	55	6	14	---
Cropland	1,758	1,023	121	179	19	10	405
Generally Dry Soils	1,374	932	58	95	--	--	290
Soils with Wetness Problems	384	91	63	83	19	10	115
Generally Wet Soils	298	57	62	77	--	--	101
Muck Soils	19	10	-	4	--	4	1
Alluvial Soils	67	24	1	2	19	6	13
	Percent of Base						
Pasture	20.2	14.8	2.0	2.5	0.3	0.6	----
Cropland	79.8	46.5	5.5	8.1	0.9	0.5	18.4
Generally Dry Soils	62.4	42.3	2.6	4.3	---	---	13.2
Soils with Wetness Problems	17.4	4.1	2.9	3.8	0.9	0.5	5.2
Generally Wet Soils	13.5	2.6	2.8	3.5	---	---	4.6
Muck Soils	0.9	0.5	---	0.2	---	0.2	----
Alluvial Soils	3.0	1.1	---	0.1	0.9	0.3	0.6

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–15 Present Agricultural Problem Distribution,[1] Planning Subarea 5.3

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	888	376	258	117	3	8	127
Percent of Base	100	42.3	29.1	13.2	0.3	0.9	14.3
	1,000 Acres						
Pasture	254	153	80	18	1	3	---
Cropland	634	223	178	99	2	5	127
Generally Dry Soils	353	222	---	55	-	-	76
Soils with Wetness Problems	281	2	178	44	2	5	51
Generally Wet Soils	260	1	170	43	-	-	46
Muck Soils	11	---	6	1	-	-	4
Alluvial Soils	10	1	2	--	2	5	1
	Percent of Base						
Pasture	28.6	17.2	9.0	2.0	0.1	0.3	----
Cropland	71.4	25.1	20.0	11.1	0.2	0.6	14.3
Generally Dry Soils	39.8	25.0	----	6.2	---	---	8.6
Soils with Wetness Problems	31.6	0.2	20.0	5.0	0.2	0.6	5.7
Generally Wet Soils	29.3	0.1	19.1	4.8	---	---	5.2
Muck Soils	1.2	----	0.7	0.1	---	---	0.5
Alluvial Soils	1.1	0.1	0.2	---	0.2	0.6	0.1

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–16 Present Agricultural Problem Distribution,[1] Basin Totals

Item	Total Land	No Flood or Drainage Problem	Problem Category: Severe Drainage	Some Drainage	Flooding	Flooding & Drainage	Inactive Cropland[2]
Total Base (1,000 acres)	32,092	17,498	3,323	4,828	247	610	5,591
Percent of Base	100	54.5	10.4	15.0	0.8	1.9	17.4
	1,000 Acres						
Pasture	3,502	2,276	655	405	50	117	-----
Cropland	28,595	15,222	2,669	4,422	197	493	5,589
Generally Dry Soils	15,191	10,958	314	629	12	38	3,246
Soils with Wetness Problems	13,399	4,267	2,355	3,792	185	455	2,345
Generally Wet Soils	12,357	3,946	2,278	3,628	107	361	2,037
Muck Soils	542	170	42	116	11	37	166
Alluvial Soils	500	151	35	48	67	57	142
	Percent of Base						
Pasture	10.9	7.1	2.0	1.3	0.2	0.4	----
Cropland	89.1	47.4	8.3	13.8	0.6	1.5	17.4
Generally Dry Soils	47.3	34.1	1.0	2.0	---	0.1	10.1
Soils with Wetness Problems	41.8	13.3	7.3	11.8	0.6	1.4	7.3
Generally Wet Soils	38.5	12.3	7.1	11.3	0.3	1.1	6.3
Muck Soils	1.7	0.5	0.1	0.4	---	0.1	0.5
Alluvial Soils	1.6	0.5	0.1	0.1	0.2	0.2	0.4

[1] Includes crop and pasture land, values may not add due to rounding.
[2] Inactive cropland includes conservation reserve, idle cropland, and open land formerly cropped. These acres are not available by problem categories.

TABLE 16–17 Summary—Present Agricultural Problem Distribution[1] (1,000 Acres)

Planning Subarea	Total Land Area	Total Agricultural Land[2]	No Flood or Drainage Problem	Soil Problem Category				Inactive Cropland[3]
				Severe Drainage	Some Drainage	Flooding	Flood and Drainage	
1.1	9,473.5	530	344	37	39	2	2	107
1.2	6,441.8	329	181	55	15	2	7	69
Superior[4]	15,915.3	859	525	92	54	4	9	176
2.1	10,010.7	3,680	2,430	276	461	22	113	379
2.2	5,212.1	3,077	2,133	161	331	13	86	352
2.3	8,955.4	5,822	3,588	314	586	30	51	1,252
2.4	8,094.2	1,834	993	121	58	10	10	642
Michigan[4]	32,272.4	14,413	9,144	872	1,436	75	260	2,625
3.1	4,017.8	696	390	85	59	3	6	153
3.2	4,424.1	2,555	1,273	385	339	42	93	424
Huron[4]	8,441.9	3,251	1,663	470	398	45	99	577
4.1	3,980.4	2,328	957	316	428	18	105	505
4.2	6,319.5	4,949	1,966	756	1,665	50	71	441
4.3	2,308.6	873	297	113	205	7	11	241
4.4	3,069.9	1,111	553	137	204	11	12	194
Erie[4]	15,678.4	9,261	3,773	1,322	2,502	86	199	1,381
5.1	2,458.7	1,218	668	145	87	9	8	300
5.2	5,427.4	2,202	1,349	164	234	25	24	405
5.3	3,385.6	888	376	258	117	3	8	127
Ontario[4]	11,271.7	4,308	2,393	567	438	37	40	832
TOTAL	83,579.7	32,092	17,498	3,323	4,828	247	610	5,591

[1] Based upon 1967 CNI, values may not add due to rounding.
[2] Agricultural land includes cropland and pasture.
[3] Inactive cropland is that land inventoried as conservation reserve, temporarily idle cropland, and open land formerly cropped.
[4] Subtotal.

problem. The Lake Michigan basin has the least agricultural land with drainage problems, 16 percent. Nearly 50 percent of agricultural land in Planning Subarea 4.2 has a drainage problem. Each of the Lake Erie basin planning subareas has more than 30 percent of its agricultural base with drainage problems. Should existing drainage improvements malfunction or deteriorate due to lack of maintenance, drainage problems would return and gradually increase.

1.2 Studies Based on Watershed Data

1.2.1 Analysis of CNI

An inventory of problems in small watersheds made in 1967 by the USDA covered the entire Great Lakes Basin. The drainage area of the Basin was divided into watersheds of no more than 250,000 acres. The total number of acres with problems such as agricultural flooding, urban flooding, erosion, drainage, and irrigation was reported for each watershed.

This inventory showed that 12 million acres, or nearly 16 percent, of the Great Lakes Basin have agricultural drainage problems. Differences between the figures given here and those reported in previous sections are due primarily to differences in area between county lines and hydrologic area, and the inclusion of forest and miscellaneous land uses in hydrologic analysis. Sixty percent or 7.3 million acres are cropland, nearly two million acres are pastureland, and the remainder has miscellaneous uses. Nearly half (5.5 million acres) of the problem acres are in the Lake Erie drainage basin. The Lake Michigan area reported 2.4 million acres with problems, and Lakes Huron and Ontario each have nearly 1.7 million problem acres. Forty percent of the land draining into Lake Erie has agricultural drainage problems. Lakes Huron and Ontario each have problems in approximately 15 percent of their drainage areas. Lake Michigan has problems in only eight percent of its acres, although it is second only to Lake Erie in total problem acres. Table 16–18 summarizes the watershed problem inventory. The total drainage area and problem acres figures are shown for each river basin group.

TABLE 16–18 Agricultural Drainage Problems by Watershed Survey (1,000 Acres)

River Basin	Total Drainage Area	With Problems	Need Project Action
River Basin Group 1.1			
Superior Slope	1,470	114	2
St. Louis River	2,334	477	89
Apostle Island	1,269	126	12
Bad River	637	11	--
Montreal River	197	2	1
Total	5,907	730	104
River Basin Group 1.2			
Porcupine Mts.	672	5	4
Ontonagon River	872	9	8
Keewenaw Peninsula	865	2	1
Sturgeon River	452	6	5
Huron Mt.	623	--	--
Grand Marais	768	2	--
Tahquamenon River	540	--	--
Sault	173	--	--
Total	4,964	23	17
Lake Superior	10,871	753	122
River Basin Group 2.1			
Menominee	674	39	10
Menominee River	2,621	51	10
Peshtigo River	737	31	2
Oconto R. & Pennsaukee	680	14	9
Saumico	310	60	33
Fox River	4,225	344	226
Green Bay	1,544	88	34
Total	10,791	626	323
River Basin Group 2.2			
Chicago-Milwaukee	1,392	127	94
Total	1,392	127	94

TABLE 16-18(continued) Agricultural Drainage Problems by Watershed Survey (1,000 Acres)

River Basin	Total Drainage Area	With Problems	Need Project Action
River Basin Group 2.3			
St. Joseph River	2,992	203	108
Black River	229	70	37
Kalamazoo River	1,285	148	56
Ottawa River	163	50	19
Grand River	3,567	864	448
Grand-Muskegon Complex	57	5	3
Total	8,292	1,341	671
River Basin Group 2.4			
Muskegon River	1,692	141	28
Sable	1,242	116	21
Manistee River	1,284	42	26
Traverse	1,690	18	4
Seul Choix Groscap	353	4	1
Manistique River	926	---	---
Bay De Noc	765	10	1
Escanaba River	586	2	---
Total	8,536	333	81
Lake Michigan	29,011	2,427	1,169
River Basin Group 3.1			
Les Cheneaux	315	12	1
Cheboygan	1,010	25	11
Presque Isle	357	16	2
Au Sable	1,299	8	4
Thunder Bay	808	78	8
Alcona	123	5	---
Rifle-Au Gres	709	175	65
St. Marys River	585	44	2
Total	5,208	362	93
River Basin Group 3.2			
Kawkawlin	248	135	51
Saginaw	3,996	989	525
Thumb	907	234	91
Total	5,150	1,359	667
Lake Huron	10,358	1,721	758

TABLE 16–18(continued) Agricultural Drainage Problems by Watershed Survey (1,000 Acres)

River Basin	Total Drainage Area	With Problems	Need Project Action
River Basin Group 4.1			
St. Clair	383	172	86
Clinton River	501	66	39
Rouge River	468	43	15
Huron River	543	188	112
Swan Creek	182	122	98
Raisin River	805	461	58
Black River	446	113	36
Total	3,328	1,165	444
River Basin Group 4.2			
Maumee River	4,338	2,088	687
Toussaint-Portage	656	356	91
Sandusky	980	471	114
Huron-Vermilion	661	413	24
Total	6,635	3,327	916
River Basin Group 4.3			
Black-Rocky	568	156	38
Cuyahoga	578	38	15
Chagrin	189	28	19
Grand River	525	245	52
Ashtabula-Conneaut	222	43	14
Total	2,082	509	139
River Basin Group 4.4			
Erie-Chautauqua	418	34	5
Cattaraugus	355	25	9
Tonawanda	917	386	123
Total	1,690	445	137
Lake Erie	13,735	5,446	1,636
River Basin Group 5.1			
Niagara-Orleans	664	358	267
Genesee	1,588	240	62
Total	2,252	597	329

TABLE 16–18(continued) Agricultural Drainage Problems by Watershed Survey (1,000 Acres)

River Basin		Total Drainage Area	With Problems	Need Project Action
River Basin Group 5.2				
Wayne-Cayuga		437	74	6
Oswego		3,252	515	70
Salmon-Perch		674	114	---
Total		4,363	703	77
River Basin Group 5.3				
Black River		1,289	22	5
St. Lawrence		311	57	---
Oswegatchie		1,066	62	---
Grass-Raquette-St. Regis		2,033	215	161
Total		4,696	356	166
Lake Ontario		11,309	1,656	572
Illinois	RBG 2.2	39	5	---
Indiana	RBG 2.2	426	12	11
	RBG 2.3	1,085	51	45
	RBG 4.2	821	77	20
	Total	2,332	141	76
Michigan	RBG 1.2	4,989	24	18
	RBG 2.1	2,301	80	20
	RBG 2.2	142	31	21
	RBG 2.3	7,207	1,290	626
	RBG 2.4	8,536	333	81
	RBG 3.1	5,208	362	93
	RBG 3.2	5,150	1,359	667
	RBG 4.1	3,313	1,165	444
	RBG 4.2	328	93	3
	Total	37,174	4,737	1,973
Minnesota	RBG 1.1	3,931	632	101
New York	RBG 4.4	1,467	435	135
	RBG 5.1	2,189	597	329
	RBG 5.2	4,363	703	77
	RBG 5.3	4,696	356	166
	Total	12,715	2,091	707

TABLE 16–18(continued) Agricultural Drainage Problems by Watershed Survey (1,000 Acres)

River Basin		Total Drainage Area	With Problems	Need Project Action
Ohio	RBG 4.2	5,501	3,158	893
	RBG 4.3	1,979	509	139
	Total	7,480	3,667	1,032
Pennsylvania	RBG 4.3	103	-----	-----
	RBG 4.4	223	10	3
	RBG 5.1	61	-----	-----
	Total	387	10	3
Wisconsin	RBG 1.1	1,892	97	3
	RBG 1.2	59	-----	-----
	RBG 2.1	8,490	545	303
	RBG 2.2	821	80	62
	Total	11,262	722	368
Basin		75,284	12,005	4,260

Areas in the Basin that need project action to solve drainage problems total 4.3 million acres, most of which is cropland. Two-thirds of this amount (2.8 million acres) is in the Lake Erie and Lake Michigan basins. Table 16–18 also shows the amount of river basin acres, nearly half of which is in Lake Michigan drainage, that needs project action. Thirty percent of the Lake Erie problem acres require action. Figure 16–4 shows for each Lake basin the relationship between problem acres and those needing project action.

Planning Subarea 4.2 has the most acreage and the most drainage problems. Fifty percent of this planning subarea, or 3.3 million acres, has problems. The neighboring planning subarea, 4.1, has 35 percent with drainage problems. The six planning subareas from the Saginaw River, Michigan, around Lake Erie and through the Genesee River, New York, contain nearly two-thirds of the problem acres. The percentage of each planning subarea with a drainage problem and the percentage that needs project action are given in Figure 16–5 for these six areas. Fourteen percent of each of the Planning Subareas 3.2, 4.1, 4.2, and 5.1 needs project action for drainage problems. The largest acreage in need of project action is the 915,000 acres in Planning Subarea 4.2. Planning Subareas 2.3 and 3.2 also have large acreages needing project action.

1.2.2 Watershed Project Analysis

A further analysis was made for each Great Lakes basin watershed that reported a significant flood or drainage problem. Additional information was obtained from the district conservationists of the SCS in the counties in each of these watersheds. Problem area acres in field crops, specialty crops, pasture, woodland, and other uses were tabulated and generally located on maps. The amount of average annual benefits lost through impaired drainage was determined by using the problem acres in cropland data and a composite acre value. A map study was made to determine probable needed channel improvement in order to alleviate cropland drainage problems. An estimated cost based upon similar construction projects in the area was applied to this channel length.

Potential drainage benefits and estimated improvement costs were combined with damage and development costs for flooding problems by the Flood Plains Work Group to obtain total damages and cost. The damage and cost information was tabulated in a damage-cost

TABLE 16–19 Drainage Problem Watershed Inventory—Watersheds Most Favorable for Project Action—1970

Planning Subarea	Number of Watersheds	Drainage Area[1]	Agricultural Drainage Problems						Total Average Annual Net Drainage Benefits[2]	Project Installation Cost[2]
			Total[1]	Field Crop[1]	Specialty Crop[1]	Pasture[1]	Woodland[1]	Other[1]		
1.1	3	229.2	91.6	2.3	-----	27.0	51.7	10.6	79.2	693.0
1.2	2	219.7	6.0	.8	-----	2.0	2.4	.8	11.4	945.0
2.1	25	2,275.4	358.0	98.0	17.3	53.4	100.6	88.7	1,326.9	7,352.0
2.2	7	574.3	57.8	16.8	7.6	9.2	8.8	15.4	317.0	2,060.0
2.3	26	1,431.4	258.9	147.4	29.8	33.9	20.9	26.9	1,922.8	29,008.3
2.4	7	269.0	49.1	5.7	1.8	3.8	22.7	15.1	102.4	1,826.0
3.1	3	298.1	114.8	37.8	2.4	25.1	46.7	2.8	315.5	4,249.0
3.2	28	2,385.8	946.8	583.8	12.0	90.5	161.2	99.3	8,936.0	56,482.0
4.1	31	2,157.0	926.3	563.3	60.3	70.8	127.5	104.4	7,748.0	104,869.0
4.2	54	2,711.1	2,988.9	2,511.8	112.7	234.6	96.3	33.5	10,734.0	91,817.0
4.3	15	971.2	412.6	218.0	21.0	147.9	17.2	8.5	1,263.2	9,617.0
4.4	8	783.9	91.1	35.3	7.6	19.3	6.1	22.8	667.1	3,400.8
5.1	2	195.8	52.7	33.1	11.3	5.4	.9	2.0	336.7	4,877.9
5.2	3	72.7	10.7	6.6	2.4	.9	.7	.1	96.3	2,812.9
5.3	3	266.6	67.5	30.7	-----	21.3	4.0	10.4	364.6	2,600.0
Total	217	14,841.2	6,432.8	4,291.4	286.2	745.1	667.7	441.3	34,221.1	322,609.9

[1] 1000 acres
[2] $1000.00

relationship for each watershed. Analysis of the damage versus cost data indicated a relative potential for project action. Pertinent data about the watersheds most favorable for project action were tabulated by planning subarea (Table 16–19). If benefits are to be derived from these programs, designs should include sediment control and a continuing maintenance program.

This watershed analysis was repeated to determine which areas would become favorable for drainage in future years due to increased yields, anticipated changes in cropping patterns, and increased crop values. A damage-per-acre value was calculated for 1980, 2000, and 2020 by using projected yields and cropping data from the economic base study that appears in Appendix 19. This damage value and present problem acres were used to get a total damage figure for the future. Watersheds that are favorable for project action and those that may become favorable within the projected span are shown by planning subarea in Figures 16–6 through 16–20. Table 16–20 lists the number of watersheds with potential for project action and the year evaluated as favorable for each. The total number of watersheds in the planning subarea is given for comparison.

TABLE 16–20 Number of Watersheds With Potential for Project Action

Planning Subarea	Number of Watersheds in PSA	Number of Watersheds with Potential for Project Action				
		1970	Added by 1980	Added by 2000	Added by 2020	Total by 2020
1.1	73	3	3	2	1	9
1.2	51	2	–	–	–	2
2.1	122	25	2	–	1	28
2.2	29	7	–	–	–	7
2.3	163	26	3	4	–	33
2.4	102	7	2	4	–	13
3.1	61	3	–	1	–	4
3.2	77	28	3	2	4	37
4.1	49	31	2	–	–	33
4.2	60	54	3	–	1	58
4.3	22	15	2	1	–	18
4.4	28	8	–	–	–	8
5.1	35	2	1	–	–	3
5.2	76	3	–	–	–	3
5.3	81	3	–	–	–	3
Total	1029	217	21	14	7	259

1.2.3 Interpretations

Tables 16–19 and 16–20 give pertinent data for watersheds most favorable for project ac-

tion in each river basin group. Acreage with drainage problems is indicated for each land use by 1000–acre units. There are 4.3 million acres of field crops and 286,000 acres of specialty crops that are in potential project action watersheds. Nearly 60 percent of the field crop areas are in Planning Subarea 4.2, northwest Ohio. An additional 27 percent is in Planning Subareas 3.2 and 4.1. The specialty crop acreage is spread over a large area. Forty percent of this acreage is in Planning Subarea 4.2. An additional 40 percent is in Planning Subareas 2.3, 4.1, and 4.3, which include southern Michigan and all of Ohio drainage. Potential net average annual benefits are shown based upon drainage improvement of the field crop, specialty crop, and pasture acreages. No improvement was considered for forests or other land. An estimated total installation cost for channels needed to provide drainage is given.

This information describes what could be done under project action. The potential for development is shown here, but not recommended programs. As the need for productive land develops, some of these watersheds would be activated. Additional cropland acreage has drainage problems that could be solved without project action. These are areas that need only on-farm measures or group cooperative action in order to provide improved drainage.

Section 2

POTENTIAL URBAN PROBLEMS

Future urban developments built on soils with wetness problems could intensify present problems and create new ones. Development could alter or cut off natural surface or subsurface drainage patterns. Water problems are observable in many urban areas, especially near interstate highways. Natural conditions, such as high water table or temporary ponding of surface waters, which may not be a problem for low-intensity uses of the land, are critical to urban uses. Proper drainage stabilizes building foundations and prevents basement wetness.

Developments intensify existing drainage problems while creating new problems. Drainage systems that are adequate for agricultural lands may not be adequate for urban land. In urban developments a drainage system has to handle a great deal of water quickly. Runoff water is a great drainage problem in urban areas because of the high percentage of impervious surface. Urban developments will not normally tolerate ponded water. Capital investment in urban drainage improvements within the Great Lakes is approximately $175 per person.

The following studies indicate the drainage problems that could occur when metropolitan areas expand. Urban drainage could become a major water resource problem in the Great Lakes Basin both in terms of dollars expended for prevention or correction and in dollar benefits derived.

2.1 Soils of Nonurban Land Base in SMSAs

2.1.1 Development of Table

Soil condition information for nonurban lands from the CNI was grouped into four soil categories for each SMSA. The nonurban areas included in this analysis are cropland, pasture, forest, and other land. Other land includes farmsteads, areas immediately around farms, rural non-farm residences, and investment tracts. This tabulation does not include urban or water areas (pond and/or stream), nor the Federal land in each county. The tabulation of data is in the same soil resource groupings that were developed for the Agricultural Problem Distribution (Tables 16–1 through 16–15). These groupings are generally dry soils, generally wet soils, muck soils, and alluvial soils. Information about soil resource groups for the counties in each SMSA of the Great Lakes was tabulated in the soil problem categories. The sum of the three wet soil categories indicates the total of soils with wetness problems. The sum of the generally dry soils and the soils with wetness problems gives the total nonurban base within the metropolitan areas. This figure gives an indication of the natural soil condition in portions of the SMSAs available for development. A percentage of the total nonurban base is given for each of the soil condition categories. Table 16–21 gives the acreage and percentage breakdown for soil conditions in each SMSA in the Great Lakes Basin. Table 16–22 lists the counties that are included in each SMSA.

2.1.2 Interpretation of Table

Table 16–21 indicates the natural soil condition of the nonurban land base. The land base is the land that is available for future urban development. It indicates the relative degree of drainage problems that would be encountered as metropolitan areas expand. The soils classified as generally dry will have few water problems if involved in urban expansion. The soils with wetness problems will need additional drainage before they can be properly used for urban development. Some of the land in this category will have been previously improved for agriculture use, but will probably need additional drainage to be used for urban development. The amount of wet soil that has previously been improved is not indicated in these tables. Generally wet soils are fine-textured and high water table soils. The alluvial soils category indicates land that may be subject to flooding.

TABLE 16–21 Soil Conditions of Nonurban Land Base,[1] Standard Metropolitan Statistical Areas (SMSA)

Natural Soil Condition	Standard Metropolitan Statistical Area[2]					
	Duluth, Minnesota	Green Bay, Wisconsin	Milwaukee, Wisconsin	Kenosha-Racine, Wisconsin	Chicago, Illinois	Gary-Hammond, Indiana
	1,000 acres					
Total Nonurban Base	1,312.0	282.9	623.7	316.4	1,644.3	526.4
Generally Dry Soils	846.4	196.5	417.8	164.0	962.8	203.6
Soils with Wetness Problems	465.6	86.4	206.0	152.5	681.6	322.7
Generally Wet Soils	247.3	74.2	143.2	132.7	404.0	289.2
Muck Soils	201.7	4.8	56.1	16.8	-----	11.7
Alluvial Soils	16.6	7.4	6.7	3.0	277.6	21.8
	Percent of Total					
Generally Dry Soils	64.5	69.5	67.0	51.8	58.5	38.7
Soils with Wetness Problems	35.5	30.5	33.0	48.2	41.5	61.3
Generally Wet Soils	18.8	26.2	23.0	41.9	24.6	54.9
Muck Soils	15.4	1.7	9.0	5.3	----	2.2
Alluvial Soils	1.3	2.6	1.0	1.0	16.9	4.2

Natural Soil Condition	Standard Metropolitan Statistical Area[2]					
	South Bend, Indiana	Muskegon-Grand Rapids, Michigan	Lansing-Jackson, Michigan	Kalamazoo-Battle Creek, Michigan	Saginaw-Bay City, Michigan	Flint, Michigan
	1,000 acres					
Total Nonurban Base	520.4	981.1	1,396.8	699.0	711.8	678.2
Generally Dry Soils	269.2	582.6	745.3	496.0	40.1	315.4
Soils with Wetness Problems	251.1	398.5	651.4	203.0	671.6	362.8
Generally Wet Soils	219.6	297.6	467.7	122.5	652.2	309.4
Muck Soils	27.0	54.3	162.4	68.8	3.1	42.5
Alluvial Soils	4.5	46.6	21.3	11.7	16.3	10.9
	Percent of Total					
Generally Dry Soils	51.8	59.4	53.4	71.0	5.6	46.5
Soils with Wetness Problems	48.2	40.6	46.6	29.0	94.4	53.5
Generally Wet Soils	42.2	30.3	33.5	17.5	91.6	45.6
Muck Soils	5.2	5.6	11.6	9.8	0.5	6.3
Alluvial Soils	0.8	4.7	1.5	1.7	2.3	1.6

[1] Land base includes crop, pasture, forest, and other land. Values may not add due to rounding.
[2] List of counties in each SMSA is found in Table 16-23.

TABLE 16-21(continued) Soil Conditions of Nonurban Land Base,[1] Standard Metropolitan Statistical Areas (SMSA)

Natural Soil Condition	Standard Metropolitan Statistical Area[2]: Detroit-Ann Arbor, Michigan	Toledo, Ohio	Fort Wayne, Indiana	Lima, Ohio	Cleveland-Lorain-Elyria, Ohio	Akron, Ohio
	1,000 acres					
Total Nonurban Base	1,090.7	811.0	362.8	763.9	890.8	397.8
Generally Dry Soils	646.4	90.7	66.5	53.6	304.3	235.9
Soils with Wetness Problems	444.4	720.2	296.2	710.3	586.5	161.9
Generally Wet Soils	341.6	701.7	278.7	674.7	481.0	114.1
Muck Soils	89.9	-----	-----	-----	-----	2.7
Alluvial Soils	12.9	18.5	17.5	35.6	105.5	45.1
	Percent of Total					
Generally Dry Soils	59.3	11.2	18.3	7.1	34.2	59.3
Soils with Wetness Problems	40.7	88.8	81.7	92.9	65.8	40.7
Generally Wet Soils	31.3	86.5	76.9	88.3	54.0	28.6
Muck Soils	8.2	----	----	----	----	0.8
Alluvial Soils	1.2	2.3	4.8	4.6	11.8	11.3

Natural Soil Condition	Standard Metropolitan Statistical Area[2]: Erie, Pa.	Buffalo, New York	Rochester, New York	Syracuse, New York	Utica-Rome, New York
	1,000 acres				
Total Nonurban Base	469.1	627.8	1,253.4	1,424.3	1,638.8
Generally Dry Soils	186.7	278.0	846.2	1,089.8	1,341.9
Soils with Wetness Problems	282.4	349.7	407.2	334.4	296.8
Generally Wet Soils	249.0	333.2	317.8	261.7	197.1
Muck Soils	19.8	.1	4.7	1.6	-------
Alluvial Soils	13.6	16.4	84.7	71.1	99.7
	Percent of Total				
Generally Dry Soils	39.8	44.3	67.5	76.5	81.9
Soils with Wetness Problems	60.2	55.7	32.5	23.5	18.1
Generally Wet Soils	53.1	53.1	25.4	18.4	12.0
Muck Soils	4.2	----	0.4	0.1	----
Alluvial Soils	2.9	2.6	6.7	5.0	6.1

[1] Land base includes crop, pasture, forest, and other land. Values may not add due to rounding.
[2] List of counties in each SMSA is found in Table 16-23.

TABLE 16–22 Counties in Standard Metropolitan Statistical Areas

SMSA	Counties in SMSA
Duluth, Minnesota	Carlton, Minn.; Douglas, Wisc.
Green Bay, Wisconsin	Brown, Wisc.
Milwaukee, Wisconsin	Milwaukee, Ozaukee, Washington, Waukesha, Wisconsin
Kenosha-Racine, Wisconsin	Kenosha, Racine, Wisconsin
Chicago, Illinois	Cook, DuPage, Kane, Lake, McHenry, Will, Illinois
Gary-Hammond, Indiana	Lake, Porter, Indiana
South Bend, Indiana	St. Joseph, Marshall, Indiana
Muskegon-Grand Rapids, Mich.	Kent, Muskegon, Ottawa, Michigan
Lansing-Jackson, Michigan	Clinton, Eaton, Ingham, Jackson, Mich.
Kalamazoo-Battle Creek, Mich.	Calhoun, Kalamazoo, Michigan
Saginaw-Bay City, Michigan	Bay, Saginaw, Michigan
Flint, Michigan	Genesee, Lapeer, Michigan
Detroit-Ann Arbor, Michigan	Macomb, Oakland, Washtenaw, Wayne, Michigan
Toledo, Ohio	Lucas, Wood, Ohio; Monroe, Michigan
Fort Wayne, Indiana	Allen, Indiana
Lima, Ohio	Allen, Putnam, Van Wert, Ohio
Cleveland-Lorain-Elyria, Ohio	Geauga, Cuyahoga, Lake, Lorain, Medina, Ohio
Akron, Ohio	Portage, Summit, Ohio
Erie, Pennsylvania	Erie, Pennsylvania
Buffalo, New York	Erie, Niagara, New York
Rochester, New York	Livingston, Monroe, Orleans, Wayne, New York
Syracuse, New York	Onondaga, Oswego, Madison, New York
Utica-Rome, New York	Herkimer, Oneida, New York

The shortage of dry soil conditions is acute in Saginaw-Bay City, Michigan; Toledo, Ohio; Fort Wayne, Indiana; and Lima, Ohio. Less than 20 percent of the undeveloped land in each area has dry soil conditions. Metropolitan areas with less than 50 percent dry soils are: Gary-Hammond, Indiana; Flint, Michigan; Cleveland-Lorain-Elyria, Ohio; Erie, Pennsylvania; and Buffalo, New York. In most other cities, 25 to 50 percent of the available land is classified as wet soil. These wet soils would be logical places to locate lower-intensity land uses such as parks and playgrounds. Among soils with wetness problems, muck soil is significant in Duluth, Minnesota; Milwaukee, Wisconsin; Lansing-Jackson, Michigan; and Kalamazoo-Battle Creek, Michigan. In many cases, metropolitan areas are expanding into counties not now included in the SMSAs or into particular portions of counties that may either increase or decrease potential soil wetness problems.

The SMSA tables, which were developed from generalized county data, give the relative magnitude of soil problems. The acreage in each of the soil categories has not been located in the field or on any map. If more precise information is desired, a detailed soil survey with soil interpretations would be necessary.

2.2 Comparison of Soils with Projected Demand for Urban Land

Projected demands for land for urban uses within SMSAs were developed by the Land Use and Management Work Group. These projected areas were based primarily upon population and are not related to land available nor to soil conditions.

Soil conditions given in Table 16–21 for each planning subarea were compared to the projected demand for urban land in each metropolitan area. Both the total available nonurban land base and the land base without water problems were reviewed. The total land base indicates the pressure within the SMSA for urban land. The amount of dry land conditions shows the relative problems of development in the areas.

The Chicago and Detroit-Ann Arbor metropolitan areas have large percentages of generally dry soils needed for development by 2020. The six-county Chicago metropolitan area will require more than 70 percent of the land remaining undeveloped for urban development. The Detroit-Ann Arbor area will need more than 80 percent of the open land for development in its four-county area. Need for open space and greenbelts will increase if this growth takes place. The Milwaukee, Cleveland-Lorain-Elyria, and Akron metropolitan areas will require 45, 51, and 35 percent of their remaining open land for urban development. Wet areas may be critical for development. Other metropolitan areas show a lesser degree of pressure for urban development.

A review of the amount of the Basin soils without water problems and the projected urban land use demands indicates some severe drainage problems in development. Water problems will be severe in five metropolitan areas by 2020. These areas do not have enough land with dry soil conditions to meet projected demands. Three of the areas, Saginaw-Bay City, Detroit-Ann Arbor, and Cleveland-Lorain-Elyria, must obtain more than 30 percent of the development area from wet soil types. Chicago and Toledo will also have to develop on less desirable wet soils. If all projected development were to occur on dry soils, Milwaukee, Gary-Hammond, Fort Wayne, Akron, and Buffalo would use more than 50 percent of the available land. Kenosha-Racine and Lima also have shortages of dry soils, but they are not as severe as those experienced by the other ten cities. Due to demands for land and the soil conditions, extensive drainage will be required in each of these 12 metropolitan areas. These factors also give support to the need for enlightened land use planning, particularly in these areas.

Section 3

SOIL INTERPRETATION FOR DRAINAGE

Each State bordering the Great Lakes Basin has developed and published a soil association map. Soil associations are groupings of two or more similar or dissimilar soil series and land units that occur together in the landscape in a characteristic pattern. They are named for the soils series, such as "Miami, Conover." The dominant soil series is listed first and the others follow in descending order. Within the soil association small units of unlisted soil series may occur.

The information from these maps was transferred to the planning subarea maps used in this study. This was a direct transfer of the data in most cases, although adjustments were necessary occasionally due to scale limitations. The association delineations are included as background on Figures 16–21 through 16–35.

Degree of limitation for drainage has been determined for each soil association. Limitation refers to difficulty in providing adequate drainage within each of the soil series. Many of the soil series do not need drainage. The associations that have 20 percent or less of soil series needing drainage were tabulated as not needing drainage. Limitations were defined based upon three rating factors: texture of topsoil, subsoil, and substrata, permeability of the most restrictive layer, and natural fertility based on texture. Each soil series was rated for each of these factors. In addition to drainage not needed, three other degrees of limitations were defined: slight, moderate, and severe. Table 16–23 shows the criteria used to determine the rating of each of the factors.

Soil series with slight limitations are medium to moderately fine-textured. Very fine sand and stratified silt and silty clay loam are exceptions. The permeability of the most restricting layer is rapid to very rapid and the natural fertility is high.

Severe limitations are involved in soil series that are either coarse- or fine-textured. Medium-textured silt and very fine stratified sandy loam are also included in this group. The coarse-textured soils and very fine sandy loam and silt require special blending to prevent tile plugging. Ditch banks are subject to sloughing. Low natural fertility and low available water capacity of coarse-textured soil negate the advantages that might be gained through drainage.

Soil series with moderate limitations are those with moderately coarse texture, moderate permeability, and medium fertility.

The analysis and rating of the soil series were made from the National Cooperative Soil Survey's soil series descriptions. Ratings reflect the condition of undrained soil and do not recognize the effect of existing drainage improvement. Availability of drain outlets is not considered in the analysis becuase this requires on-site investigation. The unusual factors in the soil profile that were considered are layers of fine sand and silt, fragipan, shallow depth to bedrock, coarse substratum, fine substratum, and any other factors influencing water movement through the soil.

A rating for each soil series was made, and a rating was determined for the entire association. The relative weights of the various factors used in determining the rating of the soil series and the relative abundance of the soil series within the association were considered in determining the rating for the association.

A series of maps (Figures 16–21 through 16–35) and tables (Tables 16–24 through 16–38) presents the results of this rating for each planning subarea. The maps show drainage limitations. The tables list the soil associations with each identified soil series and assigned ratings.

The information on these maps and tables generally reviews the soil conditions in each planning subarea. The maps do not give the soil conditions of specific locations within the area. According to the established criteria a slight limitation indicates that there are some wetness problems inherent in the soil, but that they are minor or relatively easy to overcome. Severe limitations indicate considerable problems in developing drainage, but do not necessarily mean that these soils cannot be used for cropland.

TABLE 16–23 Drainage Limitation Criteria

	Slight	Moderate	Severe
Texture of Topsoil, Subsoil, Substrate	Moderately Fine and Medium except very fine sandy loam, silt and silty clay loam when stratified	Moderately Coarse	Fine and Coarse and very fine sand and silt when stratified
Permeability of most restricted layer, inches/hour	Rapid to very rapid 6.30 to over 20.00	Mod. slow to mod. rapid 0.20 to 6.30	Slow to very slow Less than 0.20
Natural Fertility	High	Medium	Low

TABLE 16–24 Drainage Limitations—Great Lakes Basin, Planning Subarea 1.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	TEXTURE: SUB-STRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
MINNESOTA									
29	MILACA			DRAINAGE NOT NEEDED				30	Moderate
	MORA			DRAINAGE NOT NEEDED					
	RONNEBY	Slight	Slight	Moderate	Moderate	Slight	Moderate		
31	HIBBING			DRAINAGE NOT NEEDED				35	Severe
	ZIM	Slight	Moderate	Severe	Moderate	Slight	Severe		
32	ONTONAGON			DRAINAGE NOT NEEDED				30	Severe
	BERGLAND	Moderate	Severe	Severe	Severe	Slight	Severe		
40	HIWOOD			DRAINAGE NOT NEEDED				30	Moderate
	PEAT						Moderate[1]		
41	INDUS	Moderate	Moderate	Moderate	Severe	Slight	Severe	70	Severe
	TAYLOR			DRAINAGE NOT NEEDED					
	PEAT						Moderate[1]		
43	SPOONER	Slight	Slight	Slight	Moderate	Slight	Slight	70	Moderate
	PEAT						Moderate[1]		
	SWATARA			DRAINAGE NOT NEEDED					
45	PEAT						Moderate[1]	100	Moderate
	SPOONER	Slight	Slight	Slight	Moderate	Slight	Slight		
	SOIL ASSOCIATIONS 24, 28, 40, 46, 47, 48, 49, 52, 55, and 56 DO NOT NEED DRAINAGE.								
WISCONSIN									
53	SANTIAGO			DRAINAGE NOT NEEDED				30	Slight
	FREEON			DRAINAGE NOT NEEDED					
	FREER	Slight	Slight	Slight	Moderate	Moderate	Slight		
122	ONTONAGON			DRAINAGE NOT NEEDED				70	Severe
	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe		
	BERGLAND	Moderate	Severe	Severe	Severe	Slight	Severe		
	PEAT						Moderate[1]		
125	PEAT & MUCK (deep over clay)						Moderate[1]		Moderate
	SOIL ASSOCIATIONS 56, 69, 70, 71, 77, 106, and 123 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–25 Drainage Limitations—Great Lakes Basin, Planning Subarea 1.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
MICHIGAN									
1	MUNISING			DRAINAGE NOT NEEDED				20	Moderate
	KEWEENAW			DRAINAGE NOT NEEDED					
	SKANEE	Moderate	Moderate	Moderate	Slight	Moderate	Moderate		
16	ONTONAGON			DRAINAGE NOT NEEDED				40	Severe
	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe		
17	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe	90	Severe
	BERGLAND	Moderate	Severe	Severe	Severe	Slight	Severe		
	PEATS						Moderate[1]		
23	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	RICHTER	Moderate	Severe	Severe	Slight	Moderate	Severe		
	PEATS						Moderate[1]		
24	BRUCE	Slight	Slight	Severe	Slight	Slight	Severe	90	Severe
	BRIMLEY	Slight	Slight	Severe	Slight	Slight	Severe		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
43	ORGANIC SOILS						Moderate[1]		
	SOIL ASSOCIATIONS 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 22, 26, 27, 28, and 30 DO NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. The restrictions are not inherent within the soil as permeability is rapid in the organic material. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Drainage outlets are usually lacking and frost is often a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–26 Drainage Limitations—Great Lakes Basin, Planning Subarea 2.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
WISCONSIN									
21	DODGE			DRAINAGE NOT NEEDED				40	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
	KENDELL	Slight	Slight	Moderate	Moderate	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		
22	McHENRY			DRAINAGE NOT NEEDED				40	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	MUCK						Moderate[1]		
24	RIPON			DRAINAGE NOT NEEDED				30	Moderate
	CORWIN			DRAINAGE NOT NEEDED					
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		
31	ELLIOT	Slight	Moderate	Slight	Moderate	Slight	Moderate	75	Moderate
	MORLEY			DRAINAGE NOT NEEDED					
	BLOUNT	Slight	Moderate	Slight	Moderate	Slight	Moderate		
	ASKUM	Slight	Moderate	Slight	Moderate	Slight	Moderate		
37	ONAWAY			DRAINAGE NOT NEEDED				30	Slight
	EMMET			DRAINAGE NOT NEEDED					
	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight		
	PEAT						Moderate[1]		
38	ONAWAY			DRAINAGE NOT NEEDED				60	Slight
	SOLONA	Slight	Slight	Slight	Slight	Slight	Slight		
	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight		
39	ONAWAY			DRAINAGE NOT NEEDED				40	Slight
	KEWAUNEE			DRAINAGE NOT NEEDED					
	SOLONA	Slight	Slight	Slight	Slight	Slight	Slight		
	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight		
40	SOLONA	Slight	Slight	Slight	Slight	Slight	Slight	50	Slight
	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight		
	OSHKOSH			DRAINAGE NOT NEEDED					
	ONAWAY			DRAINAGE NOT NEEDED					
41	LONGRIE			DRAINAGE NOT NEEDED				40	Slight
	ONAWAY			DRAINAGE NOT NEEDED					
	DETOUR	Slight	Slight	Slight	Slight	Slight	Slight		
	RUSE	Slight	Slight	Moderate	Moderate	Slight	Moderate		
42	TRENARY			DRAINAGE NOT NEEDED				30	Slight
	EMMET			DRAINAGE NOT NEEDED					
	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight		
44	KEWAUNEE			DRAINAGE NOT NEEDED				40	Severe
	OSHKOSH			DRAINAGE NOT NEEDED					
	MANAWA	Slight	Severe	Severe	Moderate	Slight	Severe		
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		
45	OTTAWA			DRAINAGE NOT NEEDED				40	Severe
	OSHKOSH			DRAINAGE NOT NEEDED					
	WAUSEON	Slight	Severe	Moderate	Moderate	Moderate	Severe		
	POYGAN	Slight	Moderate	Severe	Moderate	Slight	Moderate		
47	OTTAWA			DRAINAGE NOT NEEDED				20	Moderate
	OSHKOSH			DRAINAGE NOT NEEDED					
	KEWAUNEE			DRAINAGE NOT NEEDED					
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–26(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 2.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
WISCONSIN									
64	AUBURNDALE	Slight	Slight	Moderate	Moderate	Slight	Moderate	100	Moderate
	WITHEE	Slight	Slight	Slight	Moderate	Slight	Moderate		
	DOLPH	Slight	Slight	Moderate	Moderate	Slight	Moderate		
	ADOLPH	Slight	Slight	Moderate	Slight	Slight	Moderate		
74	MEDIUM TEXTURE POORLY DRAINED							100	Severe
100	ANTIGO			DRAINAGE NOT NEEDED				30	Moderate
	BRILL			DRAINAGE NOT NEEDED					
	POSKIN	Slight	Slight	Severe	Slight	Slight	Moderate		
101	POSKIN	Slight	Slight	Severe	Slight	Slight	Moderate	40	Moderate
	BRILL			DRAINAGE NOT NEEDED					
	ANTIGO			DRAINAGE NOT NEEDED					
107	NEKOOSA			DRAINAGE NOT NEEDED				50	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
	MOROCCO	Severe	Severe	Severe	Slight	Severe	Severe		
	PLAINFIELD			DRAINAGE NOT NEEDED					
	PEAT & MUCK						Moderate[1]		
120	OSHKOSH			DRAINAGE NOT NEEDED				70	Severe
	POYGAN	Slight	Severe	Severe	Severe	Slight	Severe		
	WAUSEON	Slight	Severe	Moderate	Severe	Moderate	Severe		
	MUCK						Moderate[1]		
126	GRANBY	Severe	Severe	Severe	Slight	Severe	Severe	60	Severe
	BERRIEN			DRAINAGE NOT NEEDED					
	OTTAWA			DRAINAGE NOT NEEDED					
	SHIOCTON	Slight	Moderate	Moderate	Slight	Moderate	Moderate		
	AU GRES	Severe	Severe	Severe	Slight	Severe	Severe		
	SHAWANO			DRAINAGE NOT NEEDED					
127	SHAWANO			DRAINAGE NOT NEEDED				40	Severe
	OCONOTO			DRAINAGE NOT NEEDED					
	AU GRES	Severe	Severe	Severe	Slight	Severe	Severe		
	GRANBY	Severe	Severe	Severe	Slight	Severe	Severe		
128	SHAWANO			DRAINAGE NOT NEEDED				50	Severe
	LEEMAN			DRAINAGE NOT NEEDED					
	AU GRES	Severe	Severe	Severe	Slight	Severe	Severe		
	GRANBY	Severe	Severe	Severe	Slight	Severe	Severe		
	PEAT						Moderate[1]		
129	MUCK						Moderate[1]	80	Moderate
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		
	KEOWNS	Slight	Moderate	Moderate	Slight	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Slight	Slight	Slight		
130	TUSCOLA			DRAINAGE NOT NEEDED				40	Moderate
	SHIOCTON	Slight	Moderate	Moderate	Slight	Slight	Moderate		
	KEOWNS	Slight	Moderate	Moderate	Slight	Slight	Moderate		
	PEAT						Moderate[1]		
	SOIL ASSOCIATIONS 23, 25, 26, 54, 75, 77, 78, 80, 84, 102, 105, 106, 109, and 131 DO NOT NEED DRAINAGE.								
MICHIGAN									
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Slight	Moderate	Severe	Severe		
	PEATS	Slight	Slight	Slight	Slight	Severe	Severe		
	SOIL ASSOCIATIONS 2, 3, 5, 7, 9, 11, 13, 22, and 26 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–27 Drainage Limitations—Great Lakes Basin, Planning Subarea 2.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	TEXTURE: SUB-STRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCIATION
MICHIGAN									
31	ST. CLAIR			DRAINAGE NOT NEEDED				40	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
	MORLEY			DRAINAGE NOT NEEDED					
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
41	PLAINFIELD			DRAINAGE NOT NEEDED				30	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
	OTTAWA			DRAINAGE NOT NEEDED					
	SOIL ASSOCIATIONS 37 and 39 DO NOT NEED DRAINAGE.								
INDIANA									
7	ALIDA	Slight	Slight	Slight	Moderate	Slight	Moderate	70	Moderate
	DEL REY	Slight	Slight	Slight	Severe	Slight	Severe		
	WHITAKER	Slight	Slight	Moderate	Moderate	Slight	Moderate		
9	PLAINFIELD			DRAINAGE NOT NEEDED				40	Severe
	WATSEKA	Severe	Severe	Severe	Slight	Severe	Severe		
9A	OAKVILLE			DRAINAGE NOT NEEDED				40	Severe
	TAWAS	Slight	Slight	Severe	Slight	Moderate	Severe		
10	GILFORD	Moderate	Moderate	Severe	Moderate	Moderate	Severe	80	Severe
	RENSSELAER	Slight	Slight	Severe	Severe	Slight	Severe		
10A	BONO	Slight	Severe	Severe	Severe	Slight	Severe	90	Severe
	WARNERS	Slight	Slight	Severe	Severe	Moderate	Severe		
	MAUMEE	Severe	Severe	Severe	Slight	Moderate	Severe		
10B	MAUMEE	Severe	Severe	Severe	Slight	Moderate	Severe	80	Severe
	TRACY			DRAINAGE NOT NEEDED					
	HOUGHTON						Moderate[1]		
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
10C	MAUMEE	Severe	Severe	Severe	Slight	Moderate	Severe	90	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
	GILFORD	Moderate	Moderate	Severe	Moderate	Moderate	Severe		
	RENSSELAER	Slight	Slight	Severe	Severe	Slight	Severe		
12	BLOUNT	Slight	Severe	Slight	Severe	Slight	Moderate	90	Moderate
	MORLEY			DRAINAGE NOT NEEDED					
	PEWAMO	Slight	Severe	Moderate	Moderate	Slight	Moderate		
16	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	60	Moderate
	GALENA			DRAINAGE NOT NEEDED					
	OTIS	Slight	Slight	Slight	Moderate	Slight	Moderate		
	HILLSDALE			DRAINAGE NOT NEEDED					
19	ELLIOT	Slight	Severe	Slight	Moderate	Slight	Moderate	60	Moderate
	MARKHAM			DRAINAGE NOT NEEDED					
	PEWAMO	Slight	Severe	Moderate	Moderate	Slight	Moderate		
	SOIL ASSOCIATIONS 1, 5C, 8, 9B, 9C, 12A, DO NOT NEED DRAINAGE								
ILLINOIS									
B	SIDELL			DRAINAGE NOT NEEDED				40	Moderate
	CATLIN			DRAINAGE NOT NEEDED					
	FLANAGAN	Slight	Moderate	Slight	Moderate	Slight	Moderate		
	DRUMMER	Moderate	Moderate	Slight	Moderate	Slight	Moderate		

[1]Organic soils are rated as having moderate restrictions for drainage. The restrictions are not inherent within the soil, as permeability is rapid in the organic material. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–27(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 2.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	TEXTURE: SUB-STRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCIATION
ILLINOIS									
I	LA ROSE			DRAINAGE NOT NEEDED				30	Slight
	SAYBROOK			DRAINAGE NOT NEEDED					
	LISBON	Slight	Slight	Slight	Moderate	Slight	Moderate		
J	ELLIOT	Slight	Moderate	Slight	Moderate	Slight	Moderate	90	Moderate
	ASKUM	Slight	Moderate	Slight	Moderate	Slight	Moderate		
	ANDRES	Slight	Slight	Slight	Moderate	Slight	Slight		
K	SWYGERT	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	BRYCE	Severe	Severe	Severe	Severe	Slight	Severe		
	CLARENCE	Moderate	Severe	Severe	Severe	Moderate	Severe		
	ROWE	Severe	Severe	Severe	Severe	Moderate	Severe		
M	BIRKBECK			DRAINAGE NOT NEEDED				30	Moderate
	WARD	Slight	Moderate	Slight	Severe	Slight	Severe		
	RUSSELL			DRAINAGE NOT NEEDED					
S	FOX			DRAINAGE NOT NEEDED				40	Moderate
	HOMER	Slight	Slight	Moderate	Moderate	Slight	Moderate		
	CASCO			DRAINAGE NOT NEEDED					
V	MORLEY			DRAINAGE NOT NEEDED				70	Severe
	BLOUNT	Slight	Severe	Slight	Severe	Moderate	Severe		
	BEECHER	Slight	Severe	Slight	Severe	Slight	Severe		
	NAPPANEE	Slight	Severe	Severe	Severe	Severe	Severe		
W	LITTLETON	Slight	Slight	Slight	Moderate	Slight	Slight	40	Moderate
	PROCTOR			DRAINAGE NOT NEEDED					
	PLANO			DRAINAGE NOT NEEDED					
	CAMDEN			DRAINAGE NOT NEEDED					
	HURST	Slight	Severe	Severe	Severe	Moderate	Severe		
	GINAT	Slight	Moderate	Moderate	Moderate	Moderate	Moderate		
X	SPARTA			DRAINAGE NOT NEEDED				30	Moderate
	RIDGEVILLE	Moderate	Slight	Severe	Slight	Moderate	Moderate		
	BLOOMFIELD			DRAINAGE NOT NEEDED					
	ALVIN			DRAINAGE NOT NEEDED					
	SOIL ASSOCIATIONS G, H, T, U, Y, DO NOT NEED DRAINAGE.								
WISCONSIN									
21	DODGE			DRAINAGE NOT NEEDED				30	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
	KENDELL	Slight	Slight	Moderate	Moderate	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		
22	McHENRY			DRAINAGE NOT NEEDED				40	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	MUCK						Moderate[1]		
24	RIPON			DRAINAGE NOT NEEDED				30	Moderate
	CORWIN			DRAINAGE NOT NEEDED					
	PELLA	Slight	Slight	Slight	Moderate	Slight	Moderate		
	KOKOMO	Slight	Slight	Slight	Moderate	Slight	Moderate		

[1] Organic soils are rated as having moderate restrictions for drainage. The restrictions are not inherent within the soil, as permeability is rapid in the organic material. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–27(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 2.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
WISCONSIN									
32	MORLEY			DRAINAGE NOT NEEDED				65	Moderate
	BLOUNT	Slight	Moderate	Slight	Moderate	Slight	Moderate		
	ELLIOT	Slight	Moderate	Slight	Moderate	Slight	Moderate		
	ASKUM	Slight	Moderate	Slight	Moderate	Slight	Moderate		
44	KEWAUNEE			DRAINAGE NOT NEEDED				40	Severe
	OSHKOSH			DRAINAGE NOT NEEDED					
	MANAWA	Slight	Severe	Severe	Moderate	Slight	Severe		
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		
91	WEA			DRAINAGE NOT NEEDED				30	Moderate
	WARSAW			DRAINAGE NOT NEEDED					
	FOX			DRAINAGE NOT NEEDED					
	MATHERTON	Slight	Slight	Severe	Slight	Slight	Moderate		
	SEBEWA	Slight	Slight	Severe	Slight	Slight	Moderate		
120	OSHKOSH			DRAINAGE NOT NEEDED				70	Severe
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		
	WAUSEON	Slight	Moderate	Moderate	Moderate	Moderate	Moderate		
	MUCK						Moderate[1]		
128	SHAWANO			DRAINAGE NOT NEEDED				50	Severe
	LEEMAN			DRAINAGE NOT NEEDED					
	AU GRES	Severe	Severe	Severe	Slight	Severe	Severe		
	GRANBY	Severe	Severe	Severe	Slight	Severe	Severe		
	PEAT						Moderate[1]		
129	MUCK						Moderate	80	Moderate
	POYGAN	Slight	Severe	Severe	Moderate	Slight	Severe		
	KEOWNS	Slight	Moderate	Moderate	Slight	Slight	Moderate		
	PELLA	Slight	Slight	Slight	Slight	Slight	Slight		
	SOIL ASSOCIATIONS 26, 28, 43, 93, 94, and 95 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. The restrictions are not inherent within the soil, as permeability is rapid in the organic material. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered nonagricultural land.

TABLE 16–28 Drainage Limitations—Great Lakes Basin, Planning Subarea 2.3

SOIL ASSOCIATIONS	SOIL SERIES	TEXTURE: TOPSOIL	TEXTURE: SUBSOIL	TEXTURE: SUBSTRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCIATION
MICHIGAN									
19	NESTER			DRAINAGE NOT NEEDED				60	Severe
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	SELKIRK	Slight	Severe	Severe	Severe	Slight	Severe		
20	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CAPAC	Slight	Slight	Slight	Slight	Slight	Slight		
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
25	BREVORT	Severe	Severe	Slight	Slight	Severe	Severe	80	Moderate
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
31	ST. CLAIR			DRAINAGE NOT NEEDED				40	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
	MORLEY			DRAINAGE NOT NEEDED					
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
32	BROOKSTON	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	HOYTVILLE	Moderate	Severe	Severe	Severe	Slight	Severe		
34	MIAMI			DRAINAGE NOT NEEDED				30	Slight
	CONOVER	Slight	Slight	Slight	Slight	Slight	Slight		
35	COLDWATER	Slight	Moderate	Severe	Severe	Moderate	Severe	30	Severe
	HILLSDALE			DRAINAGE NOT NEEDED					
	ELMDALE	Slight	Moderate	Slight	Moderate	Moderate	Moderate		
41	PLAINFIELD			DRAINAGE NOT NEEDED				30	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
43	ORGANIC SOILS						Moderate[1]		Moderate
	SOIL ASSOCIATIONS 22, 26, 27, 28, 36, 37, 38, 39, and 42 DO NOT NEED DRAINAGE.								
INDIANA									
3	CARLISLE						Moderate[1]		Moderate
	HOUGHTON						Moderate[1]		
	EDWARDS						Moderate[1]		
3A	CARLISLE						Moderate[1]		Moderate
	HOUGHTON						Moderate[1]		
9D	PLAINFIELD			DRAINAGE NOT NEEDED				60	Severe
	GILFORD	Severe	Moderate	Severe	Moderate	Moderate	Severe		
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
10C	MAUMEE	Severe	Severe	Severe	Slight	Moderate	Severe	90	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
	GILFORD	Severe	Moderate	Severe	Moderate	Moderate	Severe		
	RENSSELAER	Slight	Moderate	Severe	Severe	Slight	Severe		
11	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe	90	Severe
	PEWAMO	Slight	Moderate	Moderate	Moderate	Slight	Moderate		

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–28(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 2.3

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	TEXTURE: SUB-STRATA	PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
INDIANA									
12B	MORLEY			DRAINAGE NOT NEEDED				30	Severe
	BLOUNT	Slight	Moderate	Slight	Severe	Slight	Severe		
	ST. CLAIR			DRAINAGE NOT NEEDED					
13	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	70	Moderate
	CROSBY	Slight	Slight	Slight	Moderate	Slight	Moderate		
	GALENA			DRAINAGE NOT NEEDED					
13A	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	90	Moderate
	CROSBY	Slight	Slight	Slight	Moderate	Slight	Moderate		
13B	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	60	Moderate
	ST. CLAIR			DRAINAGE NOT NEEDED					
13C	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	60	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
	CROSBY	Slight	Slight	Slight	Moderate	Slight	Moderate		
15B	CROSBY	Slight	Slight	Slight	Moderate	Slight	Moderate	60	Moderate
	MIAMI			DRAINAGE NOT NEEDED					
15C	MIAMI			DRAINAGE NOT NEEDED				40	Moderate
	CROSBY	Slight	Slight	Slight	Moderate	Slight	Moderate		
	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate		
16	BROOKSTON	Slight	Slight	Slight	Moderate	Slight	Moderate	60	Moderate
	GALENA			DRAINAGE NOT NEEDED					
	OTIS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	HILLSDALE			DRAINAGE NOT NEEDED					
42	HOMER	Slight	Slight	Severe	Moderate	Moderate	Severe	80	Severe
	GILFORD	Severe	Moderate	Severe	Moderate	Moderate	Severe		
	WESTLAND	Slight	Slight	Severe	Severe	Moderate	Severe		
	SEBEWA	Slight	Slight	Severe	Moderate	Moderate	Severe		

SOIL ASSOCIATIONS 4, 4A, 5, 5A, 5C, 8A, 9E, 9F, 15A, 15D, 16A, 16B, 40, 41, and 43 DO NOT NEED DRAINAGE.

TABLE 16–29 Drainage Limitations—Great Lakes Basin, Planning Subarea 2.4

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
MICHIGAN									
16	ONTONAGON			DRAINAGE NOT NEEDED				40	Severe
	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe		
17	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe	90	Severe
	BERGLAND	Moderate	Severe	Severe	Severe	Slight	Severe		
	PEATS						Moderate[1]		
19	NESTER			DRAINAGE NOT NEEDED				30	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	SELKIRK			DRAINAGE NOT NEEDED					
20	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CAPAC	Slight	Slight	Slight	Slight	Slight	Slight		
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
23	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	RICHTER	Moderate	Severe	Severe	Slight	Moderate	Severe		
	PEATS						Moderate[1]		
25	BREVORT	Severe	Severe	Slight	Slight	Severe	Severe	80	Moderate
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
43	ORGANIC SOILS						Moderate[1]	100	Moderate
	SOIL ASSOCIATIONS 1, 5, 7, 8, 9, 10, 12, 13, 18, 22, 26, 27, 28 and 30 DO NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–30 Drainage Limitations—Great Lakes Basin, Planning Subarea 3.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	TEXTURE: SUB-STRATA	PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
MICHIGAN									
16	ONTONAGON			DRAINAGE NOT NEEDED				40	Severe
	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe		
17	PICKFORD	Severe	Severe	Severe	Severe	Slight	Severe	90	Severe
	BERGLAND	Moderate	Severe	Severe	Severe	Slight	Severe		
	PEATS						Moderate[1]		
19	NESTER			DRAINAGE NOT NEEDED				60	Severe
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	SELKIRK	Slight	Severe	Severe	Severe	Slight	Severe		
20	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CAPAC	Slight	Slight	Slight	Slight	Slight	Slight		
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
21	WISNER	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	ESSEXVILLE	Severe	Severe	Slight	Slight	Severe	Severe		
	MARSH			NON-AGRICULTURAL					
23	ANGELICA	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	RICHTER	Moderate	Severe	Severe	Slight	Moderate	Severe		
	PEATS						Moderate[1]		
24	BRUCE	Slight	Slight	Severe	Slight	Slight	Severe	90	Severe
	BRIMLEY	Slight	Slight	Severe	Slight	Slight	Severe		
	PEATS						Moderate[1]		
25	BREVORT	Severe	Severe	Slight	Slight	Severe	Severe	80	Moderate
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
43	ORGANIC SOILS						Moderate[1]	100	Moderate
	SOIL ASSOCIATIONS 22, 26, 27, 28 and 30 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–31 Drainage Limitations—Great Lakes Basin, Planning Subarea 3.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE: TOP-SOIL	TEXTURE: SUB-SOIL	SUB-STRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCIATION
MICHIGAN									
19	NESTER			DRAINAGE NOT NEEDED				60	Severe
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	SELKIRK	Slight	Severe	Severe	Severe	Slight	Severe		
20	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CAPAC	Slight	Slight	Slight	Slight	Slight	Slight		
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
21	WISNER	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	ESSEXVILLE	Severe	Severe	Slight	Slight	Severe	Severe		
	MARSH			NON-AGRICULTURAL					
25	BREVORT	Severe	Severe	Slight	Slight	Severe	Severe	80	Moderate
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
31	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe	40	Severe
	ST. CLAIR			DRAINAGE NOT NEEDED					
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	MORLEY			DRAINAGE NOT NEEDED					
32	BROOKSTON	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	HOYTVILLE	Moderate	Severe	Severe	Severe	Slight	Severe		
34	MIAMI			DRAINAGE NOT NEEDED				30	Slight
	CONOVER	Slight	Slight	Slight	Slight	Slight	Slight		
43	ORGANIC SOILS						Moderate[1]		
	SOIL ASSOCIATIONS 22, 26, 27, 28, 36 and 39 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–32 Drainage Limitations—Great Lakes Basin, Planning Subarea 4.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
MICHIGAN									
20	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate	90	Moderate
	KAWKAWLIN	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CAPAC	Slight	Slight	Slight	Slight	Slight	Slight		
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
25	BREVORT	Severe	Severe	Slight	Slight	Severe	Severe	80	Moderate
	IOSCO	Severe	Moderate	Moderate	Moderate	Severe	Moderate		
	SIMS	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	PEATS						Moderate[1]		
29	ROSCOMMON	Severe	Severe	Severe	Slight	Severe	Severe	90	Severe
	AU GRES	Severe	Severe	Moderate	Moderate	Severe	Severe		
	PEATS						Moderate[1]		
31	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe	40	Severe
	ST. CLAIR			DRAINAGE	NOT NEEDED				
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	MORLEY			DRAINAGE	NOT NEEDED				
32	BROOKSTON	Slight	Slight	Slight	Slight	Slight	Slight	90	Moderate
	BLOUNT	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	HOYTVILLE	Moderate	Severe	Severe	Severe	Slight	Severe		
33	TOLEDO	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	COLWOOD	Slight	Slight	Severe	Slight	Moderate	Severe		
34	MIAMI			DRAINAGE	NOT NEEDED			30	Slight
	CONOVER	Slight	Slight	Slight	Slight	Slight	Slight		
40	BREMS			DRAINAGE	NOT NEEDED			40	Severe
	WAUSEON	Moderate	Moderate	Severe	Severe	Moderate	Severe		
41	PLAINFIELD			DRAINAGE	NOT NEEDED			30	Severe
	NEWTON	Severe	Severe	Severe	Slight	Severe	Severe		
	OTTAWA			DRAINAGE	NOT NEEDED				
43	ORGANIC SOILS						Moderate[1]	100	Moderate
	SOIL ASSOCIATIONS 22, 27, 36, 37 and 39 DO NOT NEED DRAINAGE.								

[1] Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–33 Drainage Limitations—Great Lakes Basin, Planning Subarea 4.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE TOP-SOIL	TEXTURE SUB-SOIL	TEXTURE SUB-STRATA	PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
OHIO									
1	HOYTVILLE	Slight	Severe	Severe	Severe	Slight	Severe	90	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
3	LATTY	Severe	Severe	Severe	Severe	Slight	Severe	90	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
4	PAULDING	Severe	Severe	Severe	Severe	Slight	Severe	90	Severe
	ROSELMS	Moderate	Severe	Severe	Severe	Slight	Severe		
5	TOLEDO	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	LENAWEE	Moderate	Moderate	Moderate	Moderate	Slight	Moderate		
	FULTON	Slight	Severe	Severe	Severe	Slight	Severe		
6	TUSCOLA			DRAINAGE NOT NEEDED				60	Severe
	KIBBIE	Slight	Slight	Severe	Slight	Moderate	Severe		
	COLWOOD	Slight	Slight	Severe	Slight	Moderate	Severe		
8	MIXED SANDS	Severe	Severe	Severe	Slight	Slight	Severe	30	Severe
9	MILTON			DRAINAGE NOT NEEDED				30	Severe
	MILLSDALE	Slight	Moderate	Severe	Severe	Slight	Severe		
10	WARNERS loam	Slight	Severe	Severe	Slight	Moderate	Severe	100	Severe
11	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe	70	Severe
	PEWAMO	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	MORLEY			DRAINAGE NOT NEEDED					
12	MORLEY			DRAINAGE NOT NEEDED				60	Severe
	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe		
	PEWAMO	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
15	CROSBY	Slight	Slight	Slight	Slight	Slight	Slight	100	Slight
	BROOKSTON	Slight	Slight	Slight	Slight	Slight	Slight		
30	PAINESVILLE			DRAINAGE NOT NEEDED				60	Severe
	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe		
	CANADICE	Slight	Severe	Severe	Severe	Moderate	Severe		
32	ALLIS	Slight	Severe	Severe	Severe	Moderate	Severe	90	Severe
	WICKLIFFE	Slight	Severe	Severe	Severe	Moderate	Severe		
	FRIES	Slight	Severe	Severe	Severe	Moderate	Severe		
33	LORAIN	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	MONROEVILLE	Moderate	Severe	Severe	Severe	Slight	Severe		
36	MAHONING	Slight	Severe	Moderate	Severe	Moderate	Severe	90	Severe
	TRUMBULL	Slight	Severe	Moderate	Severe	Moderate	Severe		
41	ALEXANDRIA			DRAINAGE NOT NEEDED				30	Moderate
	CARDINGTON			DRAINAGE NOT NEEDED					
	BENNINGTON	Slight	Moderate	Moderate	Slight	Moderate	Slight		
42	BENNINGTON	Slight	Moderate	Moderate	Slight	Moderate	Slight	90	Slight
	MARENGO	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
	CONDIT	Slight	Moderate	Moderate	Moderate	Severe	Moderate		
57	ORGANIC SOILS						Moderate[1]		Moderate
	SOIL ASSOCIATION 14 DOES NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–33(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 4.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
INDIANA									
3B	CARLISLE						Moderate[1]		Moderate
11	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe	90	Severe
	PEWAMO	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
11E	HOYTVILLE	Slight	Severe	Severe	Severe	Slight	Severe	90	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
12C	MORLEY			DRAINAGE NOT NEEDED				40	Severe
	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe		
16C	MIAMI			DRAINAGE NOT NEEDED				40	Severe
	CROSBY	Slight	Slight	Slight	Severe	Slight	Severe		
35	RENSSELAER	Slight	Moderate	Severe	Moderate	Slight	Severe	80	Moderate
	WHITAKER	Slight	Slight	Moderate	Slight	Slight	Moderate		
36	LENAWEE	Moderate	Moderate	Moderate	Moderate	Slight	Moderate	80	Severe
	MONTGOMERY	Moderate	Severe	Severe	Severe	Slight	Severe		
	RENSSELAER	Slight	Moderate	Severe	Severe	Slight	Severe		
37	CARLISLE						Moderate[1]	100	Moderate
	WILLET						Moderate[1]		
	SOIL ASSOCIATIONS 1A, 1B, 1C, and 5B DO NOT NEED DRAINAGE.								
MICHIGAN									
31	ST. CLAIR			DRAINAGE NOT NEEDED				40	Severe
	NAPPANEE	Slight	Severe	Severe	Severe	Slight	Severe		
	MORLEY			DRAINAGE NOT NEEDED					
	BLOUNT	Slight	Moderate	Moderate	Severe	Slight	Severe		
34	MIAMI			DRAINAGE NOT NEEDED				30	Slight
	CONOVER	Slight	Slight	Slight	Slight	Slight	Slight		
35	COLDWATER	Slight	Moderate	Severe	Severe	Moderate	Severe	30	Severe
	HILLSDALE			DRAINAGE NOT NEEDED					
	ELMSDALE	Slight	Moderate	Slight	Moderate	Moderate	Moderate		
	SOIL ASSOCIATIONS 36 and 39 DO NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–34 Drainage Limitations—Great Lakes Basin, Planning Subarea 4.3

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
OHIO									
8	MIXED SANDS	Severe	Severe	Severe	Slight	Severe	Severe	30	Severe
30	PAINESVILLE			DRAINAGE NOT NEEDED				60	Severe
	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe		
	CANADICE	Slight	Severe	Severe	Severe	Moderate	Severe		
31	RUGGLES			DRAINAGE NOT NEEDED				60	Severe
	WILMER	Slight	Slight	Severe	Moderate	Moderate	Severe		
	OLMSTEAD	Slight	Slight	Severe	Moderate	Moderate	Severe		
32	ALLIS	Slight	Severe	Severe	Severe	Moderate	Severe	90	Severe
	WICKLIFFE	Slight	Severe	Severe	Severe	Moderate	Severe		
	FRIES	Slight	Severe	Severe	Severe	Moderate	Severe		
33	LORAIN	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	MONROEVILLE	Moderate	Severe	Severe	Severe	Slight	Severe		
34	PLATEA	Slight	Severe	Severe	Severe	Severe	Severe	90	Severe
	FRENCHTOWN	Slight	Severe	Severe	Severe	Severe	Severe		
	SHEFFIELD	Slight	Severe	Severe	Severe	Severe	Severe		
35	CAMBRIDGE			DRAINAGE NOT NEEDED				60	Severe
	VENANGO	Slight	Severe	Slight	Severe	Severe	Severe		
	FRENCHTOWN	Slight	Severe	Slight	Severe	Severe	Severe		
36	MAHONING	Slight	Severe	Severe	Severe	Moderate	Severe	90	Severe
	TRUMBULL	Slight	Severe	Severe	Severe	Moderate	Severe		
37	ELLSWORTH			DRAINAGE NOT NEEDED				40	Severe
	MAHONING	Slight	Severe	Severe	Severe	Moderate	Severe		
38	WAYNE			DRAINAGE NOT NEEDED				30	Moderate
	RITTMAN			DRAINAGE NOT NEEDED					
	WADSWORTH	Slight	Moderate	Moderate	Severe	Moderate	Severe		
40	WOOSTER			DRAINAGE NOT NEEDED				30	Severe
	CANFIELD			DRAINAGE NOT NEEDED					
	RAVENNA	Slight	Severe	Slight	Severe	Moderate	Severe		
44	CHAGRIN			DRAINAGE NOT NEEDED				30	Moderate
	LOBDELL			DRAINAGE NOT NEEDED					
	PAPAKATING	Slight	Moderate	Moderate	Moderate	Slight	Moderate		
45	WHEELING			DRAINAGE NOT NEEDED				30	Moderate
	CHILI			DRAINAGE NOT NEEDED					
	WEINBACH	Slight	Moderate	Slight	Moderate	Moderate	Moderate		
46	MENTOR			DRAINAGE NOT NEEDED				60	Moderate
	FITCHVILLE	Slight	Moderate	Severe	Moderate	Moderate	Moderate		
	LURAY	Moderate	Moderate	Severe	Moderate	Slight	Moderate		
	SOIL ASSOCIATION 39 DOES NOT NEED DRAINAGE.								
PENNSYLVANIA									
CB	CANADICE	Slight	Severe	Severe	Severe	Moderate	Severe	80	Severe
	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe		
	BIRDSALL	Slight	Moderate	Moderate	Moderate	Moderate	Moderate		
CF	CONOTTON			DRAINAGE NOT NEEDED				20	Severe
	OTTAWA			DRAINAGE NOT NEEDED					
	FREDON	Slight	Moderate	Severe	Severe	Moderate	Severe		

TABLE 16–34(continued) Drainage Limitations—Great Lakes Basin, Planning Subarea 4.3

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
PENNSYLVANIA									
EL	ERIE	Slight	Slight	Slight	Severe	Slight	Severe	80	Severe
	LANGFORD	Slight	Slight	Severe	Severe	Slight	Severe		
	ELLERY	Slight	Slight	Slight	Severe	Slight	Severe		
PB	PLATEA	Slight	Severe	Severe	Severe	Severe	Severe	80	Severe
	BIRDSALL	Slight	Slight	Slight	Moderate	Moderate	Moderate		
RB	RIMER	Slight	Slight	Severe	Severe	Moderate	Severe	70	Severe
	WAUSEON	Slight	Slight	Severe	Severe	Moderate	Severe		
	BERRIEN	Slight	Slight	Moderate	Moderate	Moderate	Moderate		
TM	TRUMBULL	Slight	Severe	Severe	Severe	Severe	Severe	100	Severe
	MAHONING	Slight	Severe	Severe	Severe	Moderate	Severe		
	MINER	Moderate	Moderate	Severe	Severe	Moderate	Severe		

TABLE 16–35 Drainage Limitations—Great Lakes Basin, Planning Subarea 4.4

SOIL ASSOCIATIONS	SOIL SERIES	TEXTURE: TOPSOIL	TEXTURE: SUBSOIL	TEXTURE: SUBSTRATA	PERMEABILITY OF MOST RESTRICTED LAYER	NATURAL FERTILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCIATION
NEW YORK									
CC	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe	85	Severe
	CANADICE	Slight	Severe	Severe	Severe	Moderate	Severe		
CD	COLLAMER			DRAINAGE NOT NEEDED				30	Severe
	RHINEBECK	Slight	Severe	Severe	Severe	Slight	Severe		
	WILLIAMSON			DRAINAGE NOT NEEDED					
DR	DARIEN	Slight	Moderate	Moderate	Severe	Slight	Moderate	80	Moderate
	ROMULUS	Slight	Slight	Slight	Severe	Slight	Moderate		
	REMSEM	Slight	Moderate	Moderate	Severe	Slight	Moderate		
	ILION	Slight	Slight	Slight	Severe	Slight	Moderate		
DS	DARIEN	Slight	Moderate	Moderate	Severe	Slight	Moderate	60	Moderate
	DANLEY			DRAINAGE NOT NEEDED					
EL	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe	70	Severe
	LANGFORD			DRAINAGE NOT NEEDED					
ES	ELMWOOD			DRAINAGE NOT NEEDED				50	Severe
	SWANTON	Moderate	Moderate	Severe	Severe	Severe	Severe		
FT	RHINEBECK	Slight	Severe	Slight	Severe	Slight	Severe	90	Severe
	FONDA	Moderate	Severe	Severe	Severe	Slight	Severe		
OS	ODESSA	Slight	Severe	Severe	Severe	Slight	Severe	50	Severe
	SCHOHARIE			DRAINAGE NOT NEEDED					
	FULTON	Slight	Severe	Severe	Severe	Slight	Severe		
	LUCUS			DRAINAGE NOT NEEDED					
T	FONDA	Moderate	Severe	Severe	Severe	Slight	Severe	90	Severe
	CANANDAIGUA	Slight	Slight	Slight	Moderate	Severe	Moderate		
VM	VOLUSIA	Slight	Slight	Slight	Severe	Moderate	Severe	60	Severe
	MARDIN			DRAINAGE NOT NEEDED					
	SOIL ASSOCIATIONS A, BC, CT, F, Hh, HK, Ls, OH, P, and U DO NOT NEED DRAINAGE.								
PENNSYLVANIA									
CB	CANADICE	Slight	Moderate	Severe	Severe	Moderate	Severe	60	Severe
	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe		
	BIRDSALL	Slight	Moderate	Moderate	Moderate	Moderate	Moderate		
CF	CONOTTON			DRAINAGE NOT NEEDED				30	Severe
	OTTAWA			DRAINAGE NOT NEEDED					
	FREDON	Slight	Slight	Severe	Moderate	Moderate	Moderate		
EL	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe	60	Severe
	LANGFORD			DRAINAGE NOT NEEDED					
	ELLERY	Slight	Slight	Slight	Severe	Slight	Severe		
PB	PLATEA	Slight	Severe	Severe	Severe	Severe	Severe	80	Severe
	BIRDSALL	Slight	Slight	Slight	Moderate	Moderate	Moderate		
PH	HOWARD			DRAINAGE NOT NEEDED				40	Moderate
	PHELPS			DRAINAGE NOT NEEDED					
	FREDON	Slight	Slight	Severe	Moderate	Moderate	Moderate		
	HALSEY	Slight	Moderate	Severe	Moderate	Moderate	Severe		
RB	RIMER	Slight	Slight	Severe	Severe	Moderate	Severe	70	Severe
	WAUSEON	Slight	Slight	Severe	Severe	Moderate	Severe		
	BERRIEN			DRAINAGE NOT NEEDED					
TM	TRUMBULL	Slight	Severe	Severe	Severe	Severe	Severe	100	Severe
	MAHONING	Slight	Severe	Severe	Severe	Moderate	Severe		
	MINER	Moderate	Moderate	Severe	Severe	Moderate	Severe		

TABLE 16–36 Drainage Limitations—Great Lakes Basin, Planning Subarea 5.1

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
NEW YORK									
CC	CANEADEA	Slight	Severe	Severe	Severe	Moderate	Severe	85	Severe
	CANADICE	Slight	Severe	Severe	Severe	Moderate	Severe		
CD	COLLAMER			DRAINAGE NOT NEEDED				30	Severe
	RHINEBECK	Slight	Severe	Severe	Severe	Slight	Severe		
	WILLIAMSON			DRAINAGE NOT NEEDED					
CH	CAZENOVIA			DRAINAGE NOT NEEDED				30	Moderate
	OVID	Slight	Slight	Slight	Severe	Slight	Moderate		
CO	CAZENOVIA			DRAINAGE NOT NEEDED				30	Moderate
	OVID	Slight	Slight	Slight	Severe	Slight	Moderate		
DR	DARIEN	Slight	Moderate	Moderate	Severe	Slight	Moderate	80	Moderate
	ROMULUS	Slight	Slight	Slight	Severe	Slight	Moderate		
	REMSEN	Slight	Moderate	Moderate	Severe	Slight	Moderate		
	ILION	Slight	Slight	Slight	Severe	Slight	Moderate		
DS	DARIEN	Slight	Moderate	Moderate	Severe	Slight	Moderate	60	Moderate
	DANLEY			DRAINAGE NOT NEEDED					
EL	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe	70	Severe
	LANGFORD			DRAINAGE NOT NEEDED					
ES	ELMWOOD			DRAINAGE NOT NEEDED				50	Severe
	SWANTON	Moderate	Moderate	Severe	Severe	Severe	Severe		
FT	RHINEBECK	Slight	Severe	Slight	Severe	Slight	Severe	90	Severe
	FONDA	Moderate	Severe	Severe	Severe	Slight	Severe		
L	LOCKPORT	Slight	Severe	Severe	Severe	Slight	Severe	70	Severe
LE	LANGFORD			DRAINAGE NOT NEEDED				30	Severe
	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe		
LV	LORDSTOWN			DRAINAGE NOT NEEDED				30	Severe
	MARDIN			DRAINAGE NOT NEEDED					
	VOLUSIA	Slight	Slight	Slight	Severe	Moderate	Severe		
MU	MUCK						Moderate[1]	100	Moderate
OS	ODESSA	Slight	Severe	Severe	Severe	Slight	Severe	50	Severe
	SCHOHARIE			DRAINAGE NOT NEEDED					
	FULTON	Slight	Severe	Severe	Severe	Slight	Severe		
	LUCUS			DRAINAGE NOT NEEDED					
VM	VOLUSIA	Slight	Slight	Slight	Severe	Moderate	Severe	60	Severe
	MARDIN			DRAINAGE NOT NEEDED					
WH	WAYLAND	Slight	Slight	Slight	Severe	Slight	Moderate	40	Moderate
	TEEL			DRAINAGE NOT NEEDED					
	PAPAKATING	Slight	Slight	Moderate	Moderate	Moderate	Moderate		
	MIDDLEBURY			DRAINAGE NOT NEEDED					
	SOIL ASSOCIATIONS A, Ah, BC, BL, CCM, CT, F, GE, Hh, HK, HL, LC, Ls, Od, OH, OL, P, SI, and U DO NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16-37 Drainage Limitations—Great Lakes Basin, Planning Subarea 5.2

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE TOP-SOIL	TEXTURE SUB-SOIL	TEXTURE SUB-STRATA	PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
NEW YORK									
CD	COLLAMER			DRAINAGE NOT NEEDED				30	Severe
	RHINEBECK	Slight	Severe	Severe	Severe	Slight	Severe		
	WILLIAMSON			DRAINAGE NOT NEEDED					
CM	BURDETT	Slight	Slight	Slight	Severe	Slight	Moderate	75	Moderate
	ILION	Slight	Slight	Slight	Severe	Slight	Moderate		
CO	CAZENOVIA			DRAINAGE NOT NEEDED				30	Moderate
	OVID	Slight	Slight	Slight	Severe	Slight	Moderate		
DR	DARIEN	Slight	Moderate	Moderate	Severe	Slight	Moderate	80	Moderate
	ROMULUS	Slight	Slight	Slight	Severe	Slight	Moderate		
	REMSEN	Slight	Moderate	Moderate	Severe	Slight	Moderate		
	ILION	Slight	Slight	Slight	Severe	Slight	Moderate		
EL	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe	70	Severe
	LANGFORD			DRAINAGE NOT NEEDED					
ES	ELMWOOD			DRAINAGE NOT NEEDED				50	Severe
	SWANTON	Moderate	Moderate	Severe	Severe	Severe	Severe		
FT	RHINEBECK	Slight	Severe	Slight	Severe	Slight	Severe	90	Severe
	FONDA	Moderate	Severe	Severe	Severe	Slight	Severe		
JG	MINOA	Severe	Severe	Severe	Slight	Severe	Moderate	100	Moderate
	LAMSON	Severe	Severe	Severe	Slight	Severe	Moderate		
L	LOCKPORT	Slight	Severe	Severe	Severe	Slight	Severe	70	Severe
LE	LANGFORD			DRAINAGE NOT NEEDED				30	Severe
	ERIE	Slight	Slight	Slight	Severe	Moderate	Severe		
LV	LORDSTOWN			DRAINAGE NOT NEEDED				30	Severe
	MARDIN			DRAINAGE NOT NEEDED					
	VOLUSIA	Slight	Slight	Slight	Severe	Moderate	Severe		
MU	MUCK						Moderate[1]	100	Moderate
OR	OVID	Slight	Slight	Slight	Severe	Slight	Moderate	90	Moderate
	ROMULUS	Slight	Slight	Slight	Severe	Slight	Moderate		
OS	ODESSA	Slight	Severe	Severe	Severe	Slight	Severe	50	Severe
	SCHOHARIE			DRAINAGE NOT NEEDED					
	FULTON	Slight	Severe	Severe	Severe	Slight	Severe		
	LUCUS			DRAINAGE NOT NEEDED					
PT	LANSING			DRAINAGE NOT NEEDED				40	Moderate
	APPLETON	Slight	Slight	Slight	Moderate	Slight	Moderate		
	MOHAWK			DRAINAGE NOT NEEDED					
	MANHEIM	Slight	Slight	Slight	Moderate	Slight	Moderate		
VM	VOLUSIA	Slight	Slight	Slight	Severe	Moderate	Severe	60	Severe
	MARDIN			DRAINAGE NOT NEEDED					
WH	WAYLAND	Slight	Slight	Slight	Severe	Slight	Moderate	40	Moderate
	TEEL			DRAINAGE NOT NEEDED					
	PAPAKATING	Slight	Slight	Moderate	Moderate	Moderate	Moderate		
	MIDDLEBURY			DRAINAGE NOT NEEDED					
	SOIL ASSOCIATIONS A, Ah, C, CT, EW, F, G, GE, Hh, HK, HL, LC, M, NA, Od, P, Rg, SI, U, and WV DO NOT NEED DRAINAGE.								

[1]Organic soils are rated as having moderate restrictions for drainage. Permeability is rapid in all the organic layers. Organic soils are unstable and are subject to settling and compaction, especially on newly developed land and when first drained. Lack of outlet is usually a problem and frost is generally a hazard. Organic soils that are extremely acid in reaction are generally considered non-agricultural land.

TABLE 16–38 Drainage Limitations—Great Lakes Basin, Planning Subarea 5.3

SOIL ASSOCI-ATIONS	SOIL SERIES	TEXTURE			PERME-ABILITY OF MOST RESTRICT-ED LAYER	NATURAL FER-TILITY	RATING FOR SERIES	PERCENT OF ASSOC. NEEDING DRAINAGE	RATING FOR ASSOCI-ATION
		TOP-SOIL	SUB-SOIL	SUB-STRATA					
NEW YORK									
BM	BRAYTON	Slight	Moderate	Moderate	Severe	Severe	Severe	50	Severe
	MOIRA			DRAINAGE NOT NEEDED					
CD	COLLAMER			DRAINAGE NOT NEEDED				30	Severe
	RHINEBECK	Slight	Severe	Severe	Severe	Slight	Severe		
	WILLIAMSON			DRAINAGE NOT NEEDED					
CM	BURDETT	Slight	Slight	Slight	Severe	Slight	Moderate	75	Moderate
	ILION	Slight	Slight	Slight	Severe	Slight	Moderate		
CV	COVEYTOWN	Severe	Severe	Moderate	Moderate	Severe	Moderate	80	Severe
	COOK	Severe	Severe	Moderate	Moderate	Severe	Moderate		
ES	ELMWOOD			DRAINAGE NOT NEEDED				50	Severe
	SWANTON	Moderate	Moderate	Severe	Severe	Severe	Severe		
GP	GRENVILLE			DRAINAGE NOT NEEDED				30	Severe
	KINGSBURY	Severe	Severe	Severe	Severe	Slight	Severe		
GS	GRENVILLE			DRAINAGE NOT NEEDED				30	Severe
	SWANTON	Moderate	Moderate	Severe	Severe	Severe	Severe		
LG	LIVINGSTON	Slight	Severe	Severe	Severe	Slight	Severe	50	Severe
	GRENVILLE			DRAINAGE NOT NEEDED					
OS	ODESSA	Slight	Severe	Severe	Severe	Slight	Severe	50	Severe
	SCHOHARIE			DRAINAGE NOT NEEDED					
	FULTON	Slight	Severe	Severe	Severe	Slight	Severe		
	LUCUS			DRAINAGE NOT NEEDED					
PR	KINGSBURY	Slight	Severe	Severe	Severe	Slight	Severe	40	Severe
	ROCKLAND			NON-AGRICULTURAL					
PT	LANSING			DRAINAGE NOT NEEDED				40	Moderate
	APPLETON	Slight	Slight	Slight	Moderate	Slight	Moderate		
	MOHAWK			DRAINAGE NOT NEEDED					
	MANHEIM	Slight	Slight	Slight	Moderate	Slight	Moderate		
PV	KINGSBURY	Slight	Severe	Severe	Severe	Slight	Severe	80	Severe
	VERGENNES	Slight	Severe	Severe	Severe	Slight	Severe		

SOIL ASSOCIATIONS Ah, C, EW, F, G, M, NA, Rg, SI, SN, and WV DO NOT NEED DRAINAGE.

Section 4

PROJECTED DRAINAGE NEEDS

4.1 Types of Drainage Needs

The term drainage problem only denotes condition. It does not indicate the potential to drain or a need to drain. There are several conditions and reasons why drainage may be needed.

4.1.1 Cropland

Drainage may be needed on agricultural land when it is limited in order to increase crop yields and to produce enough food to meet Basin demands. Urban expansion and other uses severely limit the land available for agricultural uses. Every acre may be needed to produce at its maximum economic potential.

The cost of producing a given allocation of food may be reduced through drainage. By increasing the value of per-acre yield, one can offset the drainage cost and achieve a lower production cost than achieved on less productive land that does not need drainage. There are areas where small amounts of drainage would affect many acres, facilitating large crop yields. Both the reduction of production cost and the need to use limited available land wisely are reasons for requiring drainage, based upon the region's needs and its share of national food production. Neither subregional conditions nor local ownership is considered.

The ownership of land and the economics of the individual farm unit may indicate a need for agricultural drainage. To operate a farm unit economically, drainage of some fertile but wet land may be necessary to improve per-acre yields. Drainage of wet cropland will produce higher yields and increase net income, allowing the farmer in some cases to retire less productive cropland. Improvement may also allow more efficient use of equipment. Drainage would be less expensive to the farm operator than buying or leasing more land. Drainage of farm areas would provide public benefit through increased land values and tax base. Other indirect benefits, such as increased buying power and lower food prices, would enhance the general economy.

Drainage on agricultural land requires periodic maintenance. Soil conditions can reduce the effectiveness of installed drainage if the land is used for row crops. Vegetation growing in the drainage channel can reduce channel capacity. Sediment will often fill the channel, even with the use of good land treatment practices. Subsurface drainage installations may need to be replaced or periodically increased.

Much of the drainage being done is actually renewal or maintenance of previous drainage works. Renewal or maintenance can cause significant problems on organic soils because these soils will settle and are subject to considerable oxidation after they are drained. This subsidence may result in a need to lower or renew ditches and buried drains.

Water level control is a reason for drainage on agricultural or nonagricultural lands. A controlled, variable water level is desirable for some land uses. A lower water level is needed to establish and grow a crop, while a higher water level is desirable during winter and spring. This proceduure is often used in muck farming areas, particularly in sod production. The ground-water level has to remain low enough for the crop to become established, but should be high enough so that the soil will not be too arid in dry periods. A relatively high water table will also reduce the rate of subsidence indicated above.

Water level regulation is sometimes used to improve the productivity of wildlife areas. The "green pool" concept improves waterfowl habitat. Wetlands are drained to produce the desired amount and quality of food and cover. Wetlands are flooded during spring and fall to provide resting areas for migrating waterfowl.

If a land owner wishes to manage his wetland for timber production, a water level regulation plan can be prepared to maximize those benefits. By changing the soil-water-air environment through drainage during the growing season, the growth of some tree species can

be improved. Regeneration of some forest species can also be enhanced through water level regulation.

Multiple objectives can be fulfilled through water level regulation. By lowering the water level during the growing season plant growth is improved. The same land area can be used for floodwater retardation before, after, and for brief periods during the growing season. Ground-water recharge can be increased by maintaining a higher hydrostatic head.

4.1.2 Forests

Of the approximately 15 million acres of commercial forest wetland in the Basin, 12 million acres have a high capability of production and potential for site amelioration through water regulation. Table 16–39 shows the breakdown of forest wetlands by planning subarea. The remaining acres have other factors that limit the potential for increased forest growth through water regulation. The management of lands in the higher capability classes in terms of forest products and water is a part of the Basinwide land and water management program.

Most potential commercial forest wetland that would benefit by drainage in the northern Basin is the spruce-fir forest type, consisting of black spruce, northern white cedar, and tamarack trees. The remainder consists mainly of the elm-ash-cottonwood type and maple-beech-birch type and some aspen-birch. Research data and tree habitat requirements indicate a potential for increasing growth through water regulation in the spruce-fir, beech-birch-maple, and aspen-birch forest types. Water regulation on the other types is improbable or questionable.

4.1.3 Urban Development

Agricultural land is often the first to be converted as urban areas expand. When development occurs without proper allowance for drainage, water problems may become critical. Urban drainage is practiced either to lower ground-water levels or to carry off storm waters. Lowering the ground water is very often needed to stabilize structures and to prevent basement flooding, which may be critical to building uses. Installation of proper drainage before construction would save much time and future expense. Development in areas with acute and difficult water problems should be restricted.

TABLE 16–39 Commercial Forest Wetlands and the Potential for Water Regulation (1,000 Acres)

Planning Subarea	Commercial Forest Wetland	Commercial Forest Wetland Potential for Water Regulation
1.1	3,709.3	2,528.4
1.2	2,006.8	1,743.4
2.1	1,743.6	1,226.3
2.2	114.9	88.1
2.3	868.3	815.2
2.4	1,804.2	1,562.6
3.1	904.4	800.4
3.2	812.0	774.2
4.1	408.5	408.5
4.2	363.4	360.5
4.3	327.6	327.1
4.4	483.9	457.1
5.1	369.5	324.3
5.2	531.9	419.3
5.3	606.0	364.8
Total	15,054.3	12,200.2

Source: CNI and U.S. Forest Service

Removal of storm waters in urban areas is a drainage problem. Provisions for removal and disposal of storm runoff are major expenses in developing areas. An urban area has less pervious ground surface and, therefore, a high amount of runoff. This runoff has higher flow rates than in natural conditions. Without proper storm drainage, much damage and inconvenience results. Problems of storm water removal, although widespread, are generally local in nature and affect the individual urban area. This is probably the largest drainage problem in terms of dollars expended for correction.

Proper design and construction procedures need to be followed in any drainage program. Channel improvements must include sediment control measures such as prompt seed-

TABLE 16–40 Drainage by Project Action (1,000 Acres)

Planning Subarea	1970--1980 Field Crops	1970--1980 Specialty Crops	1980--2000 Field Crops	1980--2000 Specialty Crops	2000--2020 Field Crops	2000--2020 Specialty Crops	Total
1.1	-----	----	-----	----	-----	----	-----
1.2	-----	----	-----	----	-----	----	-----
2.1	7.8	3.5	15.6	7.0	5.8	2.6	42.3
2.2	1.3	1.5	2.6	3.0	1.0	1.1	10.5
2.3	11.8	6.0	23.6	12.0	8.8	4.5	66.7
2.4	-----	0.4	-----	0.8	-----	0.3	1.5
3.1	3.0	0.5	6.0	1.0	2.3	0.4	13.2
3.2	46.7	2.4	93.4	4.8	35.0	1.8	184.1
4.1	45.0	12.1	90.0	24.2	33.8	9.0	214.1
4.2	185.8	22.5	312.1	45.0	250.8	16.9	833.1
4.3	17.7	4.2	29.5	8.4	18.1	3.1	81.0
4.4	2.8	1.5	5.6	3.0	2.1	1.1	16.1
5.1	2.6	2.3	5.2	4.6	2.0	1.7	18.4
5.2	0.5	0.5	1.0	1.0	0.4	0.4	3.8
5.3	2.5	----	5.0	----	1.8	----	9.3
Total	327.5	57.4	589.6	114.8	361.9	42.9	1,494.1

ing of disturbed areas, berms, and spoil areas. Improvements must be designed to control sediment transport to downstream areas in order to eliminate stream damage. Through good design, construction, and maintenance, much of the adverse impact on fish and wildlife can be eliminated. The areas considered for drainage improvement in this report are presently in agricultural use and have seasonal water problems or poor movement of water through the soil. Areas that have aquatic vegetation and high water table for most of the year are considered wetlands and should not be drained.

4.2 Future Project Action

A proposed program of project measures suggests improving drainage on approximately 1.5 million acres of cropland by the year 2020. Project action will be needed to carry out this program. Operators of adjoining farms would need to cooperate during improvement action in order to gain the desired level of drainage. Drainage projects will require on-farm drainage measures as well as channel improvements. This project action can be undertaken through any of the existing Federal, State, or local drainage programs. Improvements are projected for field and specialty crop acreages only. Drainage that will improve pasture, forest, or other land is not recommended. The projections are listed in Table 16–40 by planning subarea and time frame.

This program would improve drainage conditions on nearly 400,000 acres of cropland by 1980. An additional 800,000 acres would be improved from 1980 to 2000, with 300,000 in the last 20 years. More than half of this acreage is in Planning Subarea 4.2. It is projected that over 80,000 acres are to be drained in Planning Subareas 3.2, 4.1, and 4.3. These four planning subareas contain 88 percent of all the land to be improved. Approximately 14 percent of the programmed acreage is expected to be applied to land producing high-value specialty crops

with the remainder in field crops. Land improvement through project action will require both the application of land treatment measures and drainage in order to reach full production potential on these acres. This drainage is a part of the program outlined in Section 4.3.

The projected drainage represents a constant rate of application from 1970 through 2000. Approximately 34,000 field crop acres and 6,000 acres of specialty crops are expected to be drained per year during this 30-year period. This rate of drainage is less than half the past rate of drainage installation. The projected rate of drainage between 2000 and 2020 was reduced to approximately 13,000 acres of field crops and 2,000 acres of specialty crops per year.

This projection was developed by the Drainage Work Group. The estimated rate of drainage through project action is not constrained by an allocation of food production requirements, nor does it represent a speedup of drainage to obtain maximum development. The analysis of watersheds most favorable for project action was used in developing the projections. It was assumed that 24 percent of the field crop acres and 60 percent of the specialty crop acres in these watersheds would be improved between 1970 and 2000. An additional six percent of the field crop acres and 15 percent of specialty crop acres would obtain project action by 2020.

The amount of drainage previously installed was determined by using SCS annual reports on county acres of land where drain tile had been installed. This is the most prevalent drainage measure. Drained acres that require only ditching and no subsurface drainage were not included in this analysis. Tiling figures from 1964 to 1969 were averaged to get the past rate. The rates are given in Table 16–41 by planning subarea.

The table also lists the projected rates of drainage installation. The projected rate as compared to past records varies between planning subareas, but for the Basin it is less than half the past rate. Many areas can obtain adequate drainage with tile alone and no project measures. This comparison of the projected rate versus the past rate indicates that the projected program is reasonable.

The projected measures will be needed primarily to develop and maintain economical farm units. Farm units, which may have to be increased in size if farmers are to remain in business, will have to produce the optimum on each acre of cropland. This program will increase farm income. The average value of farm products sold per farm was $9,800 in the Great Lakes Basin in 1964. At the same time, 60 percent of the farms in Michigan had sales of less than $5,000 per year, and 75 percent had an annual income of less than $10,000. Drainage on these farms will increase the amount and value of farm products sold, and will also allow for more efficient use of equipment.

Drainage of land with high productive potential will also allow some farmers to retire poor cropland. Production of the same or higher yield on fewer total acres will increase net farm income. Wet or poor upland soils would be available for purposes other than cropping, such as recreation and wildlife habitat.

Developing urban areas will also need drainage improvement. Where and how much will be needed has not been estimated.

TABLE 16–41 Drainage Installation Rates (1,000 Acres per Year)

Planning Subarea	Tile Installation[1] 1964–1969	Group Action Drainage Projection 1970–2000
1.1	----	----
1.2	----	----
2.1	2.4	1.1
2.2	0.8	0.3
2.3	3.4	1.8
2.4	1.5	0.1
3.1	1.8	0.4
3.2	18.1	4.9
4.1	7.9	5.7
4.2	42.4	22.3
4.3	1.3	0.4
4.4	1.5	0.4
5.1	1.4	0.5
5.2	----	0.1
5.3	0.2	0.2
Total	82.7	40.0

[1] SCS Records

TABLE 16–42 Projected Acres With Improved Drainage Through Land Treatment Programs (1,000 Acres)

Planning Subarea	1980	2000	2020	Total
1.1	11.1	19.1	12.4	42.6
1.2	4.1	7.6	4.6	16.3
2.1	111.0	104.0	85.3	300.3
2.2	82.9	154.6	94.2	331.7
2.3	144.5	269.3	164.1	577.9
2.4	10.8	11.0	6.7	28.5
3.1	9.5	17.7	10.8	38.0
3.2	76.3	113.5	115.2	305.0
4.1	71.3	115.5	74.1	260.9
4.2	208.3	357.1	267.7	833.1
4.3	21.9	37.9	27.8	87.6
4.4	30.0	55.9	34.1	120.0
5.1	24.3	45.3	27.6	97.2
5.2	41.5	77.4	47.2	166.1
5.3	33.9	63.2	38.5	135.6
Total	881.4	1,449.1	1,010.3	3,340.8

TABLE 16–43 Drainage Installation Costs, Projected Regional Economic Development Program ($1,000,000)

Planning Subarea	Project Year 1980	2000	2020	Total Cost
1.1	1.7	2.9	1.9	6.5
1.2	0.6	1.1	0.7	2.4
2.1	14.6	14.4	11.2	40.2
2.2	12.6	23.7	14.3	50.6
2.3	24.6	46.2	26.8	97.6
2.4	1.7	1.8	1.1	4.6
3.1	1.8	3.4	1.9	7.1
3.2	14.2	23.5	14.9	52.6
4.1	20.3	36.5	18.3	75.1
4.2	33.3	57.1	42.9	133.3
4.3	4.1	7.2	5.1	16.4
4.4	4.1	7.7	4.6	16.4
5.1	4.1	7.9	4.5	16.5
5.2	6.5	12.2	7.4	26.1
5.3	2.6	5.1	2.8	10.5
Total	146.8	250.7	158.4	555.9

4.3 Projected Accelerated Growth (ACC) Program

The Land Use and Management Work Group has developed a projected program of land treatment measures. These measures are to be applied to the land on an individual farm basis and include on-farm drainage measures, such as tiling and field ditching. This program was based upon the latest conservation needs inventory for practices to be applied. It includes a current program rate of installation of these measures plus a recommended accelerated program. This program is considered to be a regional development plan.

Table 16–42 outlines by planning subarea the acres that are included in the land treatment program. Most of the elements of this on-farm drainage program are considerably larger than the project action figured by acreage. The project action program would be within this on-farm treatment program. The acres in project action are equal to or less than the land treatment acres for each time period. Each acre affected by the project would need local land treatment in addition to project action. This table shows that Planning Subareas 2.3 and 4.2 have the largest program of drainage measures because the two areas contain more than 40 percent of the total projection. Other planning subareas with significant amounts of projected drainage are Planning Subareas 2.1, 2.2, 3.2, and 4.1. Basin totals indicate that the land treatment drainage program encompasses over twice the number of acres of the project action program.

Estimated installation costs of the developmental program (Table 16–43) include the cost of land treatment measures plus the cost of project measures at the rate indicated in the previous section. For this estimate, the unit cost of land treatment measures is $150 per acre. The cost of the project measures was determined for each planning subarea by dividing the installation cost (Table 16–19) by the total acres in field and specialty crops. This gives an average Basin cost of $70 per acre benefitted. Planning subarea costs range from $35 to more than $300 per acre. This program includes expenditures of more than $500 million in a 50-year period. Nearly $150 million would be needed prior to 1980. The highest cost for improvements is $133 million for Planning Subarea 4.2. An expenditure of more than $75 million is needed for Planning Subareas 2.3 and 4.1.

4.4 Projected Normal Growth (NOR) Program

The economic base study projected a need for some drainage of agricultural land. These projections were based upon an allocation of national needs for food and fibers. The economic potential for agricultural drainage was identified using an economic budgeting model (linear programming). The main objective of the analysis is to organize resources in

TABLE 16–44 Projected Agricultural Drainage[1] (1,000 Acres)

Planning Subarea	Cumulative Total of New Drainage 1980	2000	2020
1.1	11.1	15.9	15.9
1.2	-----	-----	-----
2.1	111.1	134.6	154.1
2.2	18.7	32.5	88.7
2.3	15.6	32.0	174.9
2.4	10.8	21.8	24.5
3.1	4.7	10.2	15.7
3.2	47.0	55.0	170.2
4.1	71.3	163.4	180.6
4.2	61.0	251.0	518.6
4.3	4.1	7.2	35.0
4.4	15.1	15.1	15.1
5.1	18.5	18.5	18.5
5.2	41.0	86.7	86.7
5.3	18.6	38.8	38.8
Total[2]	448.5	882.6	1,537.3

[1] The above estimates would contribute to the national income objective through the reduction of the total cost of producing the Great Lakes Basin's share of national food and fiber requirements, as specified in Appendix 19, Economic and Demographic Studies, Table 19-85.

[2] Values may not add due to rounding.

order to provide Basin requirements at the lowest possible cost, thus contributing to the national income objective. In this framework, drainage has economic potential when it minimizes costs.

In identifying the areas with potential for development, the following assumptions were made.

(1) Planning subareas within the Great Lakes Basin were analyzed as part of a single region. Resources were shifted interregionally in order to best use the comparative advantage of a planning subarea. Each planning subarea should specialize in the products for which it has a comparative advantage (greatest relative efficiency measured by least cost).

(2) The basic comparison for each target year is between a benchmark projection and a development projection. The benchmark projection represents the optimal organization of 1970 resources to meet requirements for 1980, 2000, and 2020. It assumes that no new drainage development would be undertaken and that present drainage systems would be properly maintained. The model development run evaluates the economic potential for additional drainage.

(3) The Great Lakes Basin share of national food and fiber production requirements for each projection year is the same for both the benchmark and the development situation.

(4) The optimal organization of resources resulting from the budgeting procedure represents a constrained efficiency in the sense that factors other than economics affect agricultural activity. Shifts to the most efficient use of resources are hampered by the constraints of custom, institutions, and interdependence of crop and livestock activities. These factors are assumed to diminish in time by allowing resources to shift between planning subareas more freely according to comparative advantage.

The projection of agricultural land drainage from these model runs is given in Table 16–44. This table shows that nearly a half-million

TABLE 16–45 Drainage Installation Costs, Projected National Income Program ($1,000,000)

Planning Subarea	Project Year 1980	2000	2020	Total Cost
1.1	2.4	1.0	----	3.4
1.2	----	----	----	-----
2.1	24.3	6.1	4.6	35.0
2.2	3.0	3.6	12.0	18.6
2.3	5.4	5.5	28.4	39.3
2.4	3.1	3.3	0.7	7.1
3.1	1.1	2.6	1.9	5.6
3.2	14.4	0.8	26.3	41.5
4.1	24.9	33.3	6.6	64.8
4.2	15.0	46.5	66.8	128.3
4.3	1.0	0.8	6.8	8.6
4.4	3.4	----	----	3.4
5.1	5.3	----	----	5.3
5.2	8.9	10.2	----	19.1
5.3	3.1	3.6	----	6.7
Total	115.3	117.3	154.1	386.7

acres are to be drained by 1980, and a total of 1.5 million acres is to be drained by 2020. This drainage program would reduce the cost of producing the required allocation of the national food and fibers. These projected acres are less than the regional development projections in most planning subareas. The total program involves approximately one-half the acres of the developmental program. Both programs include application of field drainage and project action measures. The project action would be part of the acreage given in Section 4.2, but not to exceed the national development projection for any planning subarea or time frame.

Economic base projection would be a part of the total drainage program and would represent the portion most advantageous to the national economic development objective.

Installation costs for this program have been estimated at $285 million, which includes project measures and on-farm treatment measures. Expenditures by time frame for each planning subarea are given in Table 16–45. Unit costs equal those of the regional economic development plan. In order to implement this plan more than $85 million would be required before 1980. Planning Subarea 4.2 has the highest cost for drainage under this plan with $83 million in 50 years. More than $55 million is projected for Planning Subarea 4.1.

Section 5

ALTERNATIVE PROGRAMS AND IMPACTS

The programs of drainage improvement discussed in the previous section are limited to measures on active agricultural lands, primarily cropland. These acres are now farmed, but production is limited by high water table and/or seasonal surface flooding. Drainage would increase productive capacity. A program confined to agricultural acreage would minimize the possible adverse effects on nonagricultural lands. Drainage that would put new land into crop production is not proposed nor supported by the Drainage Work Group.

Projected acres of drainage through project action can be developed from watershed data (Section 1). This information indicates watersheds and areas that appear to be favorable for project action. The projected program represents improvement on approximately 30 percent of the field crop acreage and 75 percent of the specialty crop acreage in the favorable watersheds. Alternative locations for improvement are available in these watersheds. As needs of a group of farmers grow, development may progress on those watersheds. Approximately 30 percent of the listed watersheds would need to be improved to meet the projected program. A large selection of alternatives for development is available.

If acres are drained, this program will improve yield and increase returns to the farmer. Throughout the Basin the net value of increased production of field crops varies from $6 to $10 per acre with an average increase of $7.25 per acre with drainage. Drainage of specialty crop acres will increase the value of crops produced on an average of $35 per acre. The projected program would result in a net increase in production of more than $4.5 million in 1980.

The regional economic development program can be applied through the current and an accelerated land treatment program with the project action increment. These are a part of the projected land treatment program of Appendix 13, *Land Use and Management*. Current programs will result in the application of 48 percent of the projected program. The remainder would be accomplished through a recommended accelerated program of installation. These measures would be needed on the areas receiving project action in addition to project measures. The projected program of project action is equal to or less than the acreage indicated for land treatment projections.

This program would improve the production of crops on these acres and provide optimum use of land for agricultural purposes. Drainage improvements would provide higher yields and increase net income for farmers. The public would benefit through increased land values and tax base for the improved land. Efficient food production would lower prices and enhance the general economy. Further benefits are discussed in Appendix 13, *Land Use and Management*.

Drainage needed as projected for the national income objective will meet the allocation of food and fiber production for the Basin. Some of the needed measures can be a part of the land treatment program, but project action may also be needed.

This drainage would reduce the cost of producing Basin food requirements by $12.3 million in 1980, $4.5 million in 2000, and $1.0 million in 2020, based upon 1970 indices. This is a reduction of 1.5, 0.5, and 0.1 percent of the production cost.

As a result of additional drainage and the concomitant shifts of cropping patterns on existing cropland, acreage in the idled cropland category will change. For the entire Basin these changes will affect approximately 156,000 acres in 1980, 408,000 acres in 2000, and 623,000 acres in 2020 (Table 16–46). According to this study, an acre of cropland can be retired from use for each 2.5 acres drained. These idled acres can be made available for recreation, wildlife, urban, and other uses.

The initial amount of idled cropland as indicated by the benchmark projections and the changes associated with drainage development are shown in Table 16–46. As time passes acreage in idled cropland generally declines because demands for food production increase

TABLE 16–46 Benchmark Projections of Acreage in Idled Cropland and Changes Associated With Drainage Development Projections (1,000 Acres)

Planning Subarea	1980		2000		2020	
	Benchmark	Change	Benchmark	Change	Benchmark	Change
1.1	225.9	10.5[1]	281.2	- 15.8	281.4	8.7
1.2	172.2	16.5	199.6	4.4	201.0	1.5
2.1	1,002.1	-106.7	1,131.8	- 83.3	1,134.9	2.3
2.2	310.5	- 37.1	161.0	96.1	54.7	8.8
2.3	1,775.5	112.7	1,505.4	21.0	817.2	211.3
2.4	903.3	5.7	870.4	- 9.8	748.6	8.0
3.1	295.9	12.7	304.4	- 9.1	249.9	1.2
3.2	610.3	59.0	493.3	120.7	216.9	213.3
4.1	642.1	- 98.0	558.1	-149.9	198.0	32.5
4.2	463.0	102.3	221.2	403.1	92.6	51.8
4.3	314.0	26.4	248.7	45.5	152.3	3.7
4.4	435.0	-----	464.7	8.9	461.4	2.1
5.1	545.4	16.1	587.1	11.1	557.7	24.3
5.2	748.5	71.7	853.9	- 26.6	791.3	52.1
5.3	370.6	-----	416.4	- 8.5	413.9	1.0
Total	8,814.3	191.8	8,297.2	407.8	6,371.8	622.6

[1] E.g., idled cropland in PSA 1.1 was increased by 10,500 acres for 1980 because drainage would cause cropping pattern shifts.

and the land base shrinks as urban areas expand.

The projected program of on-farm drainage emphasizes local and regional development aspects and considers the optimum use of each acre within its capabilities without regard to total food production needs. The projected program considers that drainage will meet food and fiber needs at the lowest production cost. This emphasizes the national income objective.

Alternatives to drainage must obtain equivalent benefits to be considered. If there were no drainage measures, additional cropland would be needed to produce the same yields, and farmers would not gain a higher net income unless a subsidy or other compensation were offered. Some yield increases may be possible through land management that includes more fertilization and irrigation, but these measures usually raise production and food costs.

Any alternative that includes less than the projected amount of drainage would produce benefits in proportion to the size of the program.

SUMMARY

Studies summarized in this appendix define the scope and magnitude of drainage problems on agricultural and urban lands in the Great Lakes Basin. A drainage problem is considered to exist if production within its present use is reduced or limited by excess water in the soil profile. Information is presented to indicate degree of potential drainage problems in developing urban areas and degree of limitation for agricultural drainage. Some problem acres of woodland are inventoried, but no drainage is projected or recommended for woodland or other noncropland.

Approximately 12 million of the 32 million acres of agricultural land in the Great Lakes Basin have drainage problems. Seven and one-half million of these acres are in cropland, 1.5 million are in pasture, and the remainder are in woodland or other use. Lake Erie region has 5.5 million acres with excess soil water, or more than 45 percent of the 12 million acres reported. The other 6.5 million acres with drainage problems are spread fairly evenly between Lakes Michigan, Huron, and Ontario. Table 16–47 shows the acreage with water problems by Lake basin and percent distribution. Group or project action is needed in many areas to gain adequate drainage. Lake Erie basin has the greatest need for project action. Fourteen percent of its acreage has problems, which represents approximately 40 percent of the total acres needing project action in the Basin.

More than three million acres of crop and pastureland have severe problems and have no drainage improvement installations. Nearly five million acres with drainage problems have some drainage improvement installations. Many of these drainage installations have not been maintained and cannot provide needed cropland drainage. The Lake Michigan area has nearly 900,000 acres with severe drainage problems and 1.4 million with less severe problems. Lake Erie region has the most intense drainage problem in the Basin. Approximately 40 percent of its agricultural land reports a drainage problem. Approximately 25 percent of the crop and pastureland in the Lakes Huron and Ontario region has a drainage problem of one variety or another.

A study showed a total of 217 watersheds, nearly 18 million acres, which may be favorable for project action. A drainage problem is reported on 6.4 million acres within these watersheds. Approximately 4.5 million acres are in cropland. Net annual benefits that could be obtained from drainage on these 6.4 million acres would be $34 million. This was a survey of the potential for project action. A watershed that is favorable indicates potential, but not necessarily recommended project action. The location of watersheds favorable for project action is indicated in the text.

Portions of the SMSAs not presently urbanized have wet soils that will create problems for future development. Internal drainage will be necessary. In Saginaw-Bay City, Michigan; Toledo, Ohio; Fort Wayne, Indiana; and Lima, Ohio, more than 80 percent of the nonurban land has a wet soil condition. Metropolitan areas that have 50 to 80 percent of the soil with natural wetness include Gary-Hammond, Indiana; Cleveland-Lorain-Elyria, Ohio; Erie, Pennsylvania; and Buffalo, New York. Other metropolitan areas have lesser degrees of wetness problems.

Projected demands for urban development indicate shortages in available land base by 2020 in the Chicago and Detroit metropolitan areas. Soil wetness conditions will cause serious problems as 10 metropolitan areas develop. Three areas, Saginaw-Bay City, Detroit-Ann Arbor, and Cleveland-Lorain-Elyria, will have large areas of development on wet soils. Before future urban development begins on wet soil, zoning and proper land use planning will be necessary.

Interpretative maps (Figures 16–21 through 16–35) for each planning subarea indicate the relative limitation for soil drainage under the natural condition. The drainage limitations are either severe, moderate, or slight. A severe limitation would indicate severe difficulties in draining the soil profile. These maps should be useful in determining the generalized drainage conditions within any area.

Three projections of drainage programs are

TABLE 16–47 Location of Drainage Problems

Lake Drainage Basin	Agricultural Land (1,000 Acres)		Percent of Total Agricultural Problem Acres		
				Crop and Pasture	
	Total	With Problem	Agricultural Land	With Problem	Needing Project Action
Superior	859	753	6	1	1
Michigan	14,413	2,427	20	19	10
Huron	3,251	1,681	14	8	6
Erie	9,261	5,457	46	34	14
Ontario	4,308	1,656	14	9	5
Total	32,092	11,974	100	71	36

given. First is a projection of project action to be carried out as part of two other programs. The second program is the projection for the Regional Economic Development Program, which includes acreages needing on-farm drainage measures. Project action will be needed in some areas in order to gain full potential. The third projection includes drainage needs that meet the allocation of national food production and includes on-farm measures and some project action.

Project action for a drainage program would improve drainage on 400,000 acres of cropland in the Basin by 1980. Nearly 60,000 acres would be used for specialty crops (vegetables) and the rest for field crops. This drainage would increase the crop yield on these acres, help meet the food production needs of the Basin, and provide more income per farm unit. Some of this drainage would restore former productivity to the land, and some would achieve higher soil productivity. This program would reduce total land needed for food production. Some of the less productive land or areas not drained could be dropped from crop production and made available for other uses. From 1970 to 2020 the drainage of 1.3 million field crop acres and 215,000 specialty crop acres would be improved. Only five percent of all Basin cropland, or 20 percent of all cropland with a wetness condition, would be drained.

More than half of the project action drainage is in Planning Subarea 4.2 (Table 16–40), northwestern Ohio. Considerable amounts are also recommended for Planning Subareas 3.2, 4.1, and 4.3. Drainage is projected in lesser amounts for the other planning subareas. The project action drainage would be accomplished through programs available at the Federal, State, or local levels. No new programs would be necessary to carry out these projects. Project areas to be drained would be chosen from the watersheds most favorable for project action. In the 50-year period, these programs would improve the drainage for agriculture on approximately 25 percent of the field crop problem acres in the potential watersheds. Three-quarters of the specialty crop problem acres in these watersheds would be improved through the recommended program.

The Regional Economic Development Program projects application of drainage measures to 3.3 million acres in the 50-year period. Lake Michigan and Lake Erie basins each have approximately 38 percent of the projected land treatment program. The 1.5 million acres under project action would be a part of this treatment program. The installation cost for this program is estimated to be $556 million. These measures would benefit farmers and the region by increasing production capacity and by operating more efficiently.

Studies show that production of the Basin food allocation to meet the national income

objective will require 1.5 million acres of new drainage by 2020. Approximately 950,000 of these acres will require project action as well as on-farm measures. Forty-nine percent of the program is in the Lake Erie basin. Nearly 500,000 acres are projected to be drained by 1980 with an additional 433,000 acres treated by 2000. Approximately $387 million would be required to install this program. It will reduce the cost to produce the allocation of food by $12.3 million in 1980, $4.4 million in 2000, and $1.0 million in 2020. The acreage needed for crop production would be reduced by 156,000 in 1980, 408,000 in 2000, and 623,000 in 2020. Much of this acreage would be available for other uses.

GLOSSARY

agricultural land—land used for the production of crops or pasture feed. Also includes land used for these purposes in the past and not dedicated to other purposes such as forest or urban use.

alluvial soil—soil of unconsolidated material recently deposited by streams, generally stratified, varying widely in texture, and subject to frequent flooding.

benchmark projection—optimal organization of 1970 resources to meet requirements for 1980, 2000, and 2020.

commercial forest wetland—forest wetland capable of producing industrial wood.

Conservation Needs Inventory—a study made by the U. S. Department of Agriculture to determine the amount of land needing conservation treatment to preserve long term values. The report was prepared in 1958 and revised in 1968.

degree of limitation—relative difficulty in providing adequate drainage within each of the soil series.

drainage problem—excess water on lands where naturally high water table, normal precipitation, or seepage limits agricultural production or urban use.

forest wetland—forest land where excess water is the dominant hazard or limitation in its use.

fragipan—a dense and brittle pan or layer in soils. Its hardness results mainly from extreme density or compactness. Fragments that are removed are friable, but in place the material is so dense that it cannot be penetrated by roots. Water moves through it very slowly.

project action—cooperative action for improvement of agricultural land that can be effected only through formal organizations having the authority to raise funds and allocate monies to install, operate, and maintain works of improvement.

severe drainage problem area—land being used for crop production or pasture feed that has a drainage problem and little or no prior installation of drainage measures.

soil association—grouping of two or more similar or dissimilar soil series and land units that occur together in the landscape in a characteristic pattern.

soil resource group—combination of land capability units and soil types arranged according to similarities of texture and management problems.

Standard Metropolitan Statistical Area—a county or group of contiguous counties that contains at least one city with 50,000 or more inhabitants or contiguous cities with a combined population of at least 50,000.

watershed—an area comprising all land and water within the confines of a drainage divide, or a water problem area consisting in part of land needing drainage.

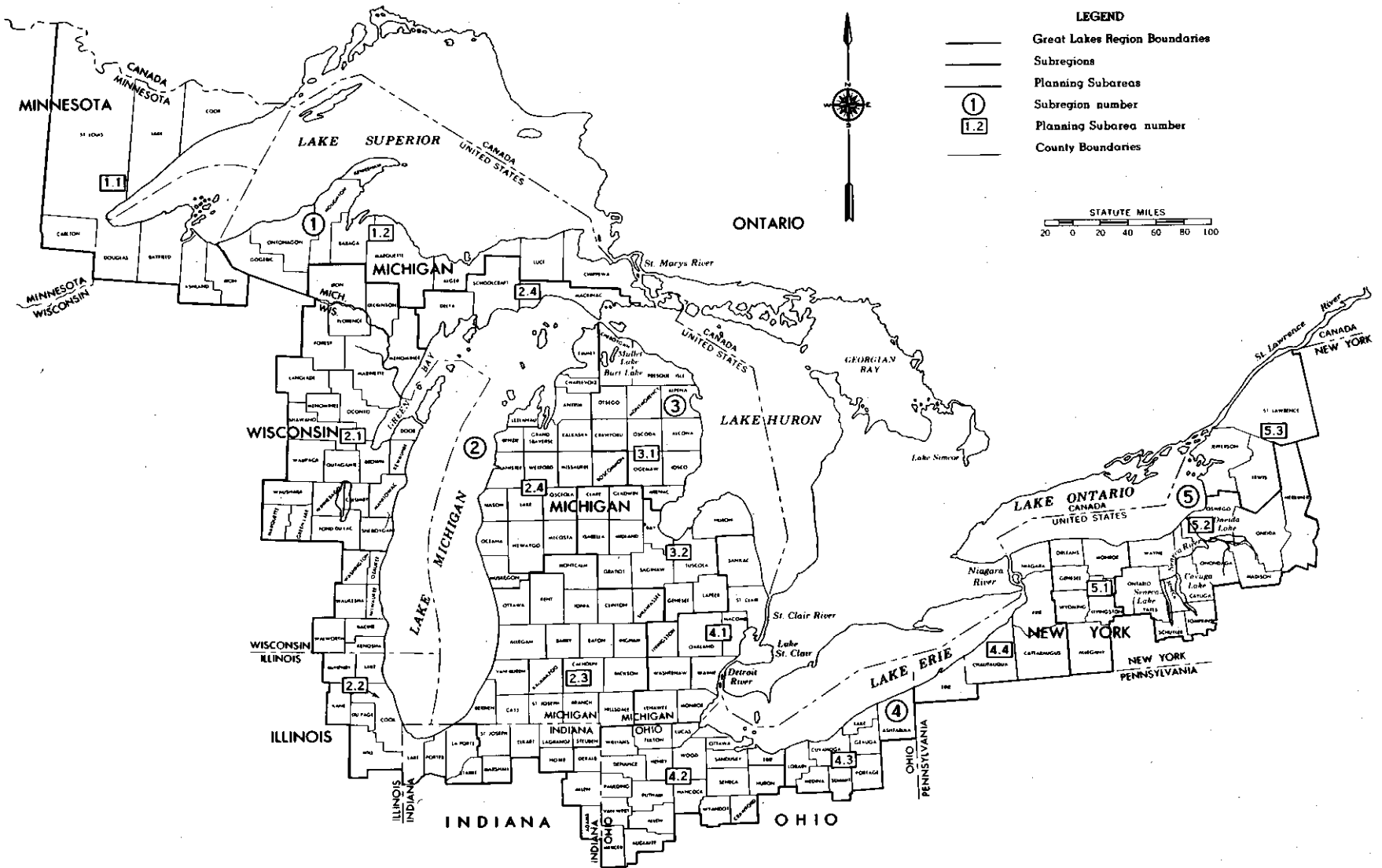

FIGURE 16–1 Great Lakes Region Planning Subareas

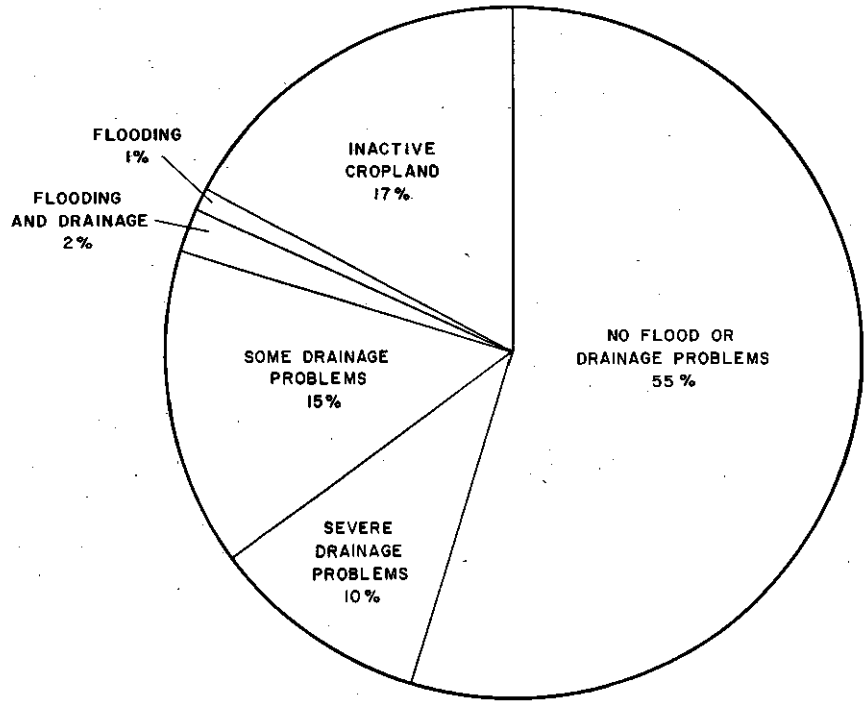

FIGURE 16–2 Agricultural Land Problems (Basin Totals)

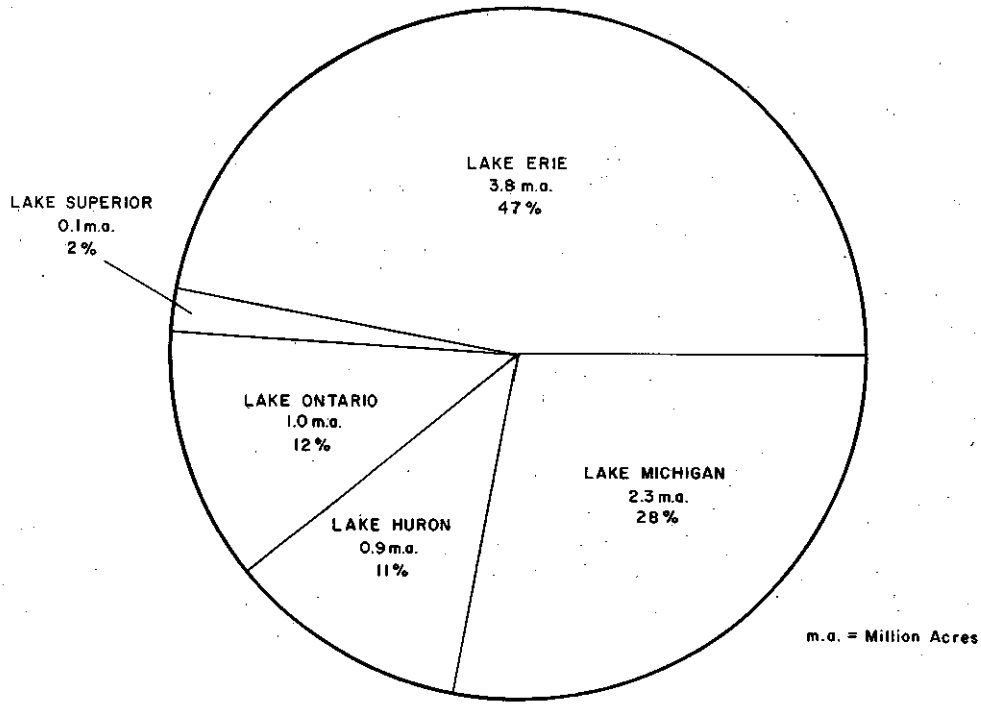

FIGURE 16–3 Drainage Problems (By Lake)

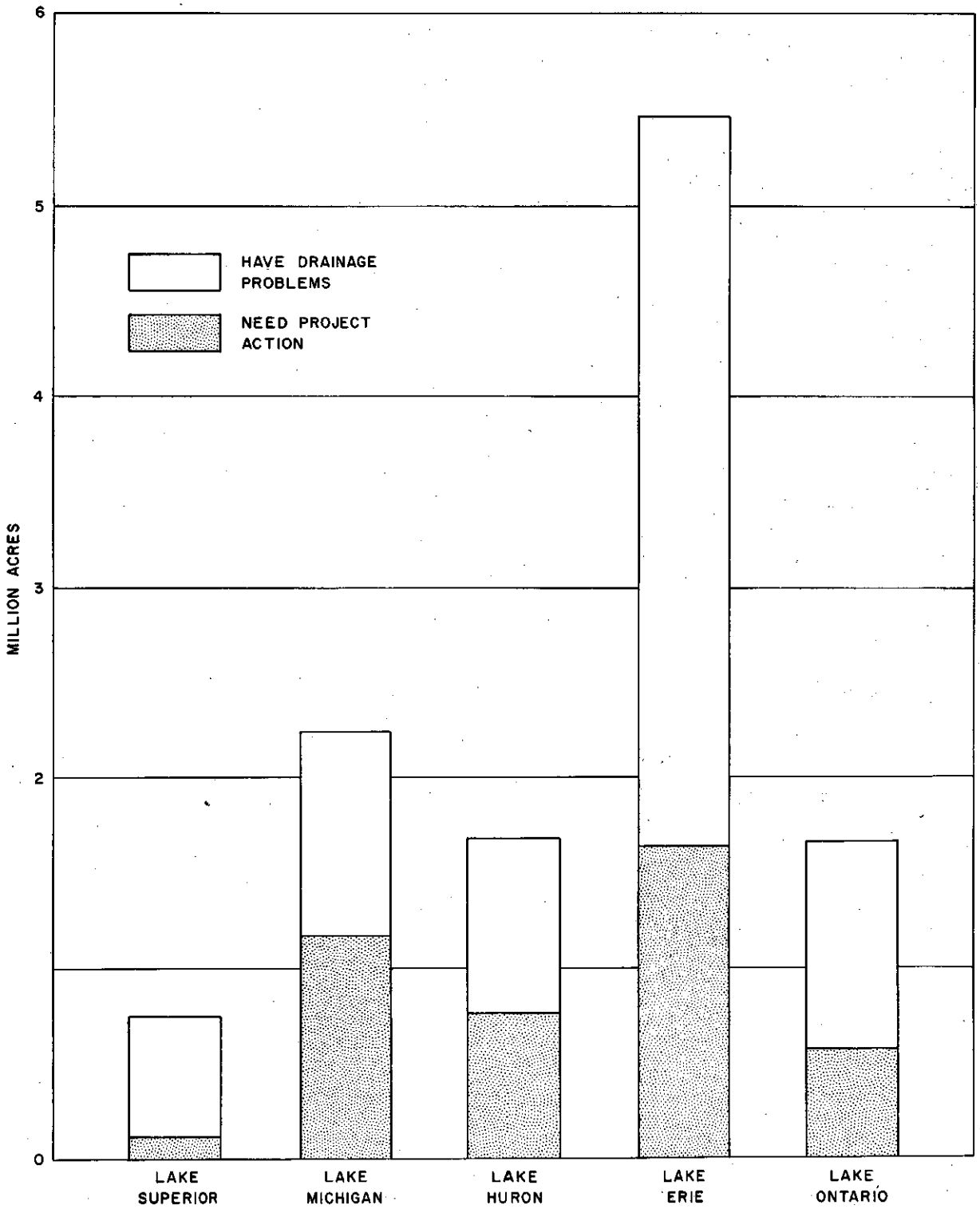

FIGURE 16–4 Distribution of Watershed Drainage Problems

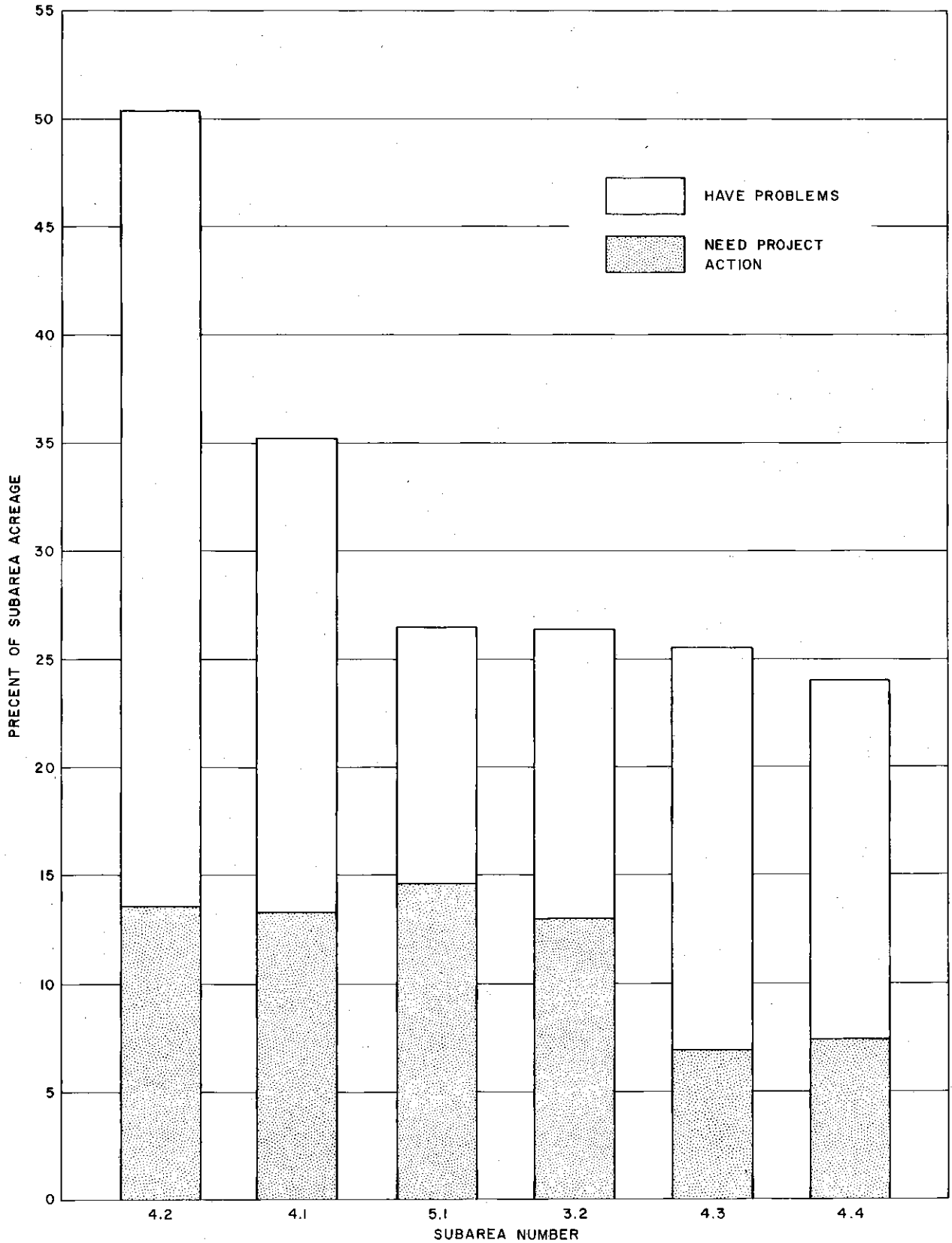

FIGURE 16–5 Magnitude of Drainage Problems by River Basin Group

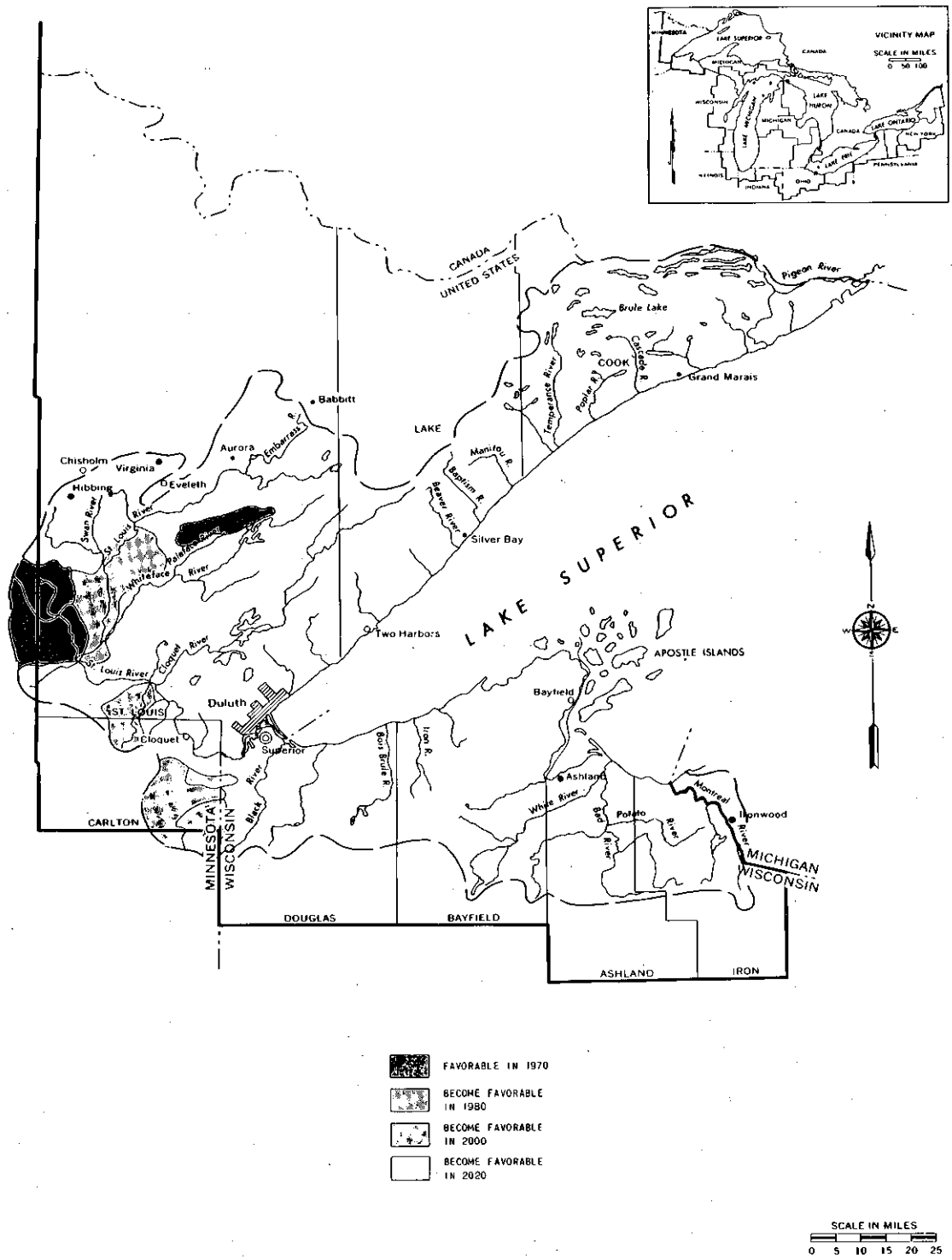

FIGURE 16–6 Watersheds Most Favorable for Project Action, Planning Subarea 1.1

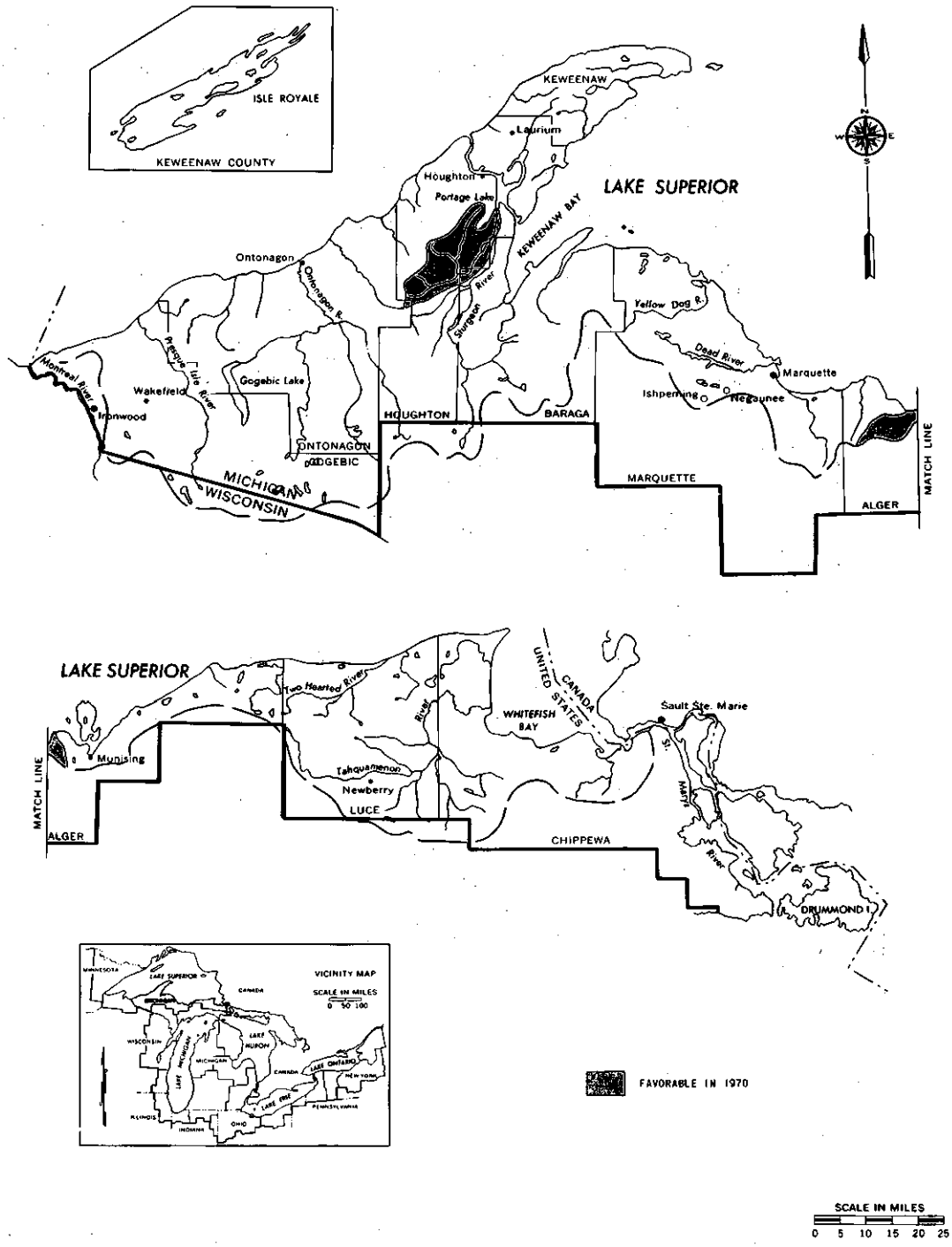

FIGURE 16–7 Watersheds Most Favorable for Project Action, Planning Subarea 1.2

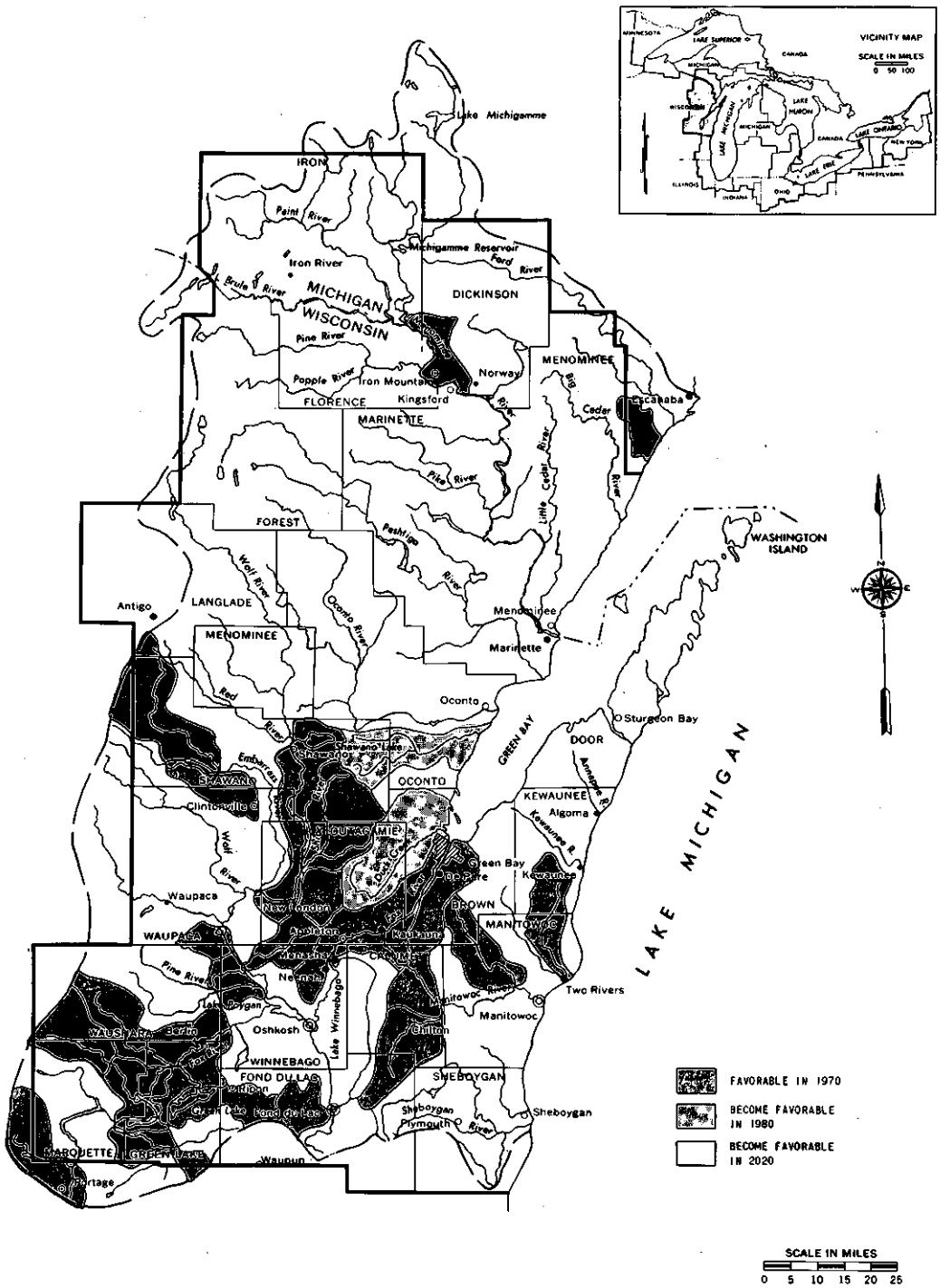

FIGURE 16–8 Watersheds Most Favorable for Project Action, Planning Subarea 2.1

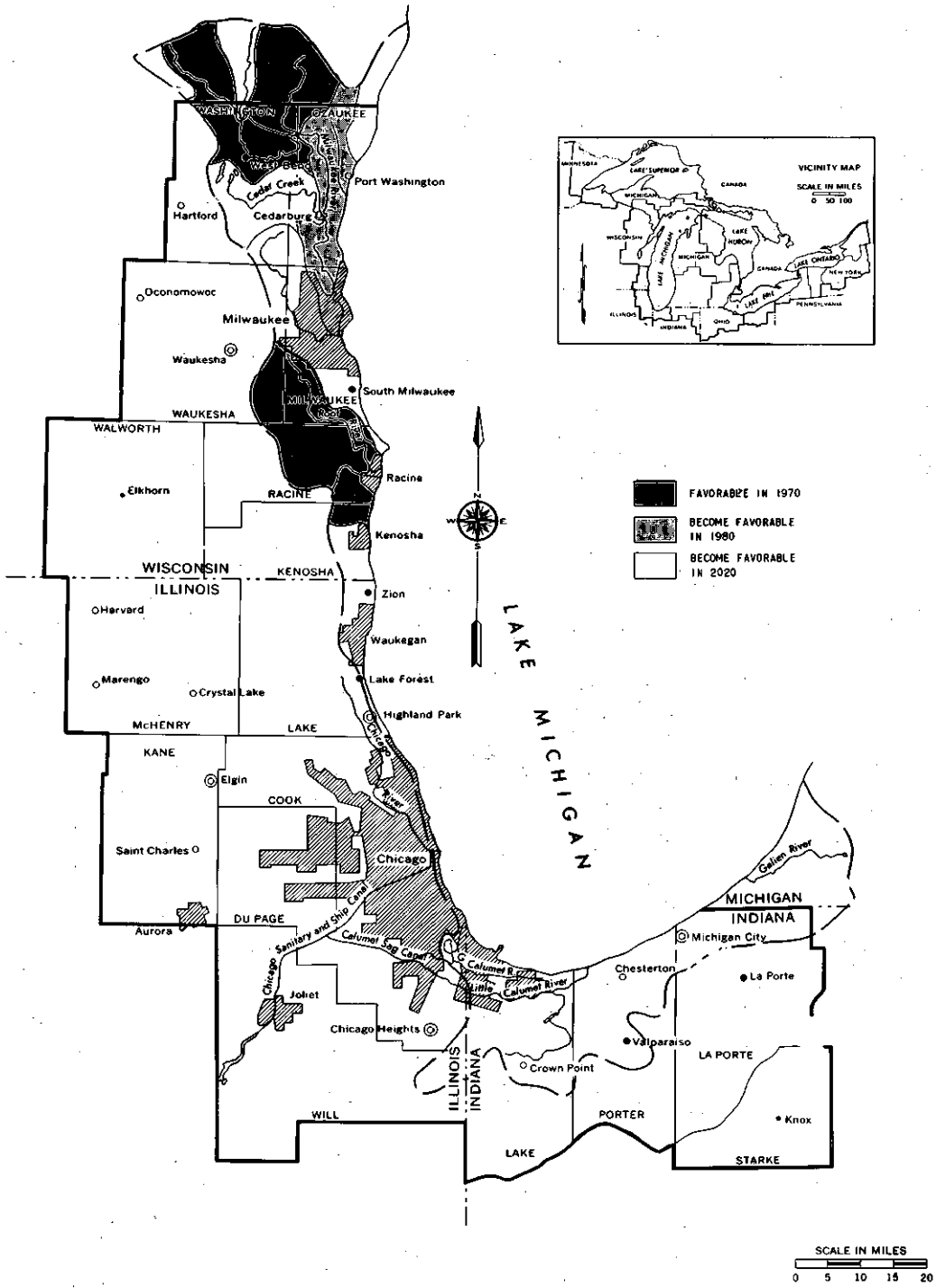

FIGURE 16–9 Watersheds Most Favorable for Project Action, Planning Subarea 2.2

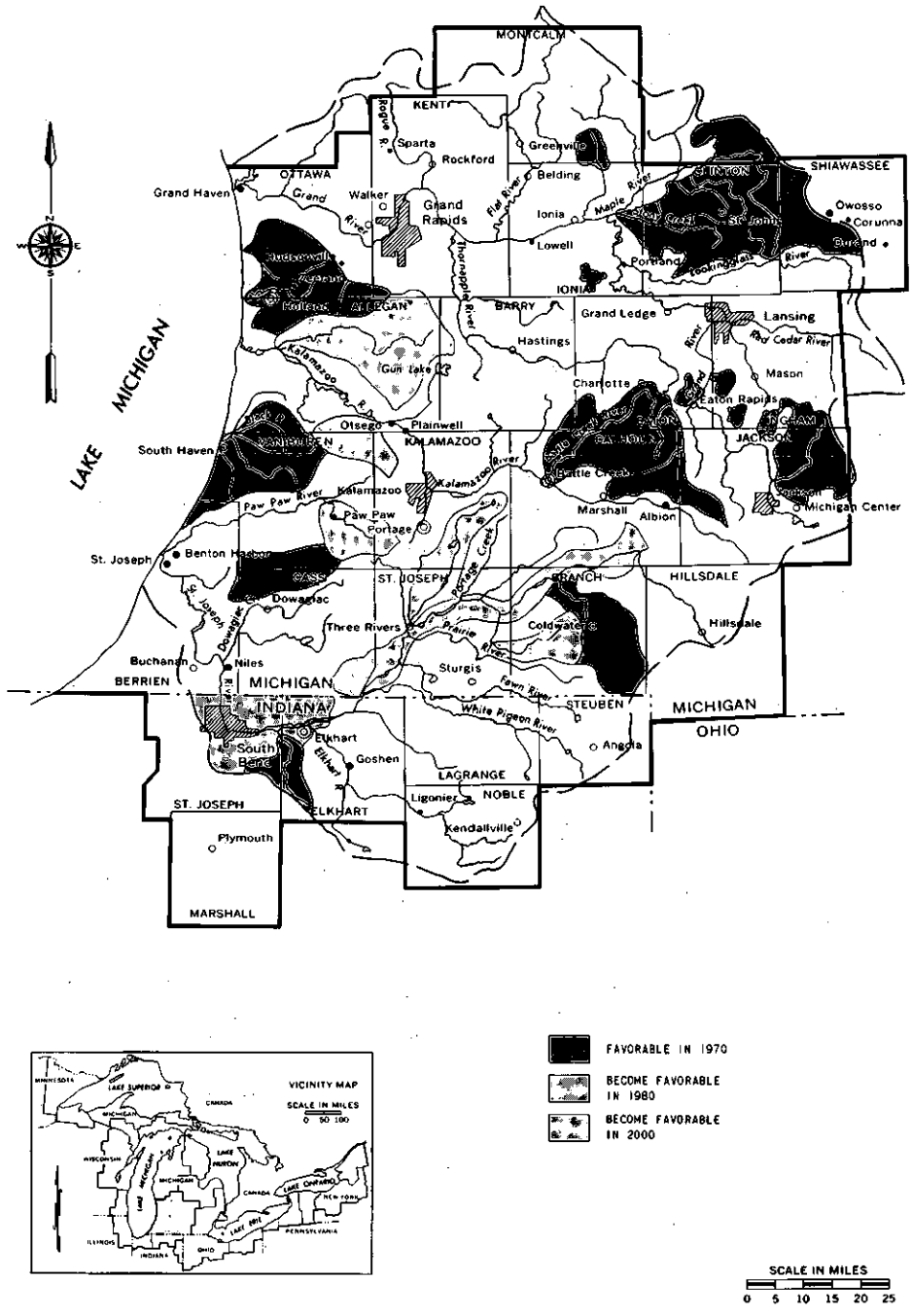

FIGURE 16–10 Watersheds Most Favorable for Project Action, Planning Subarea 2.3

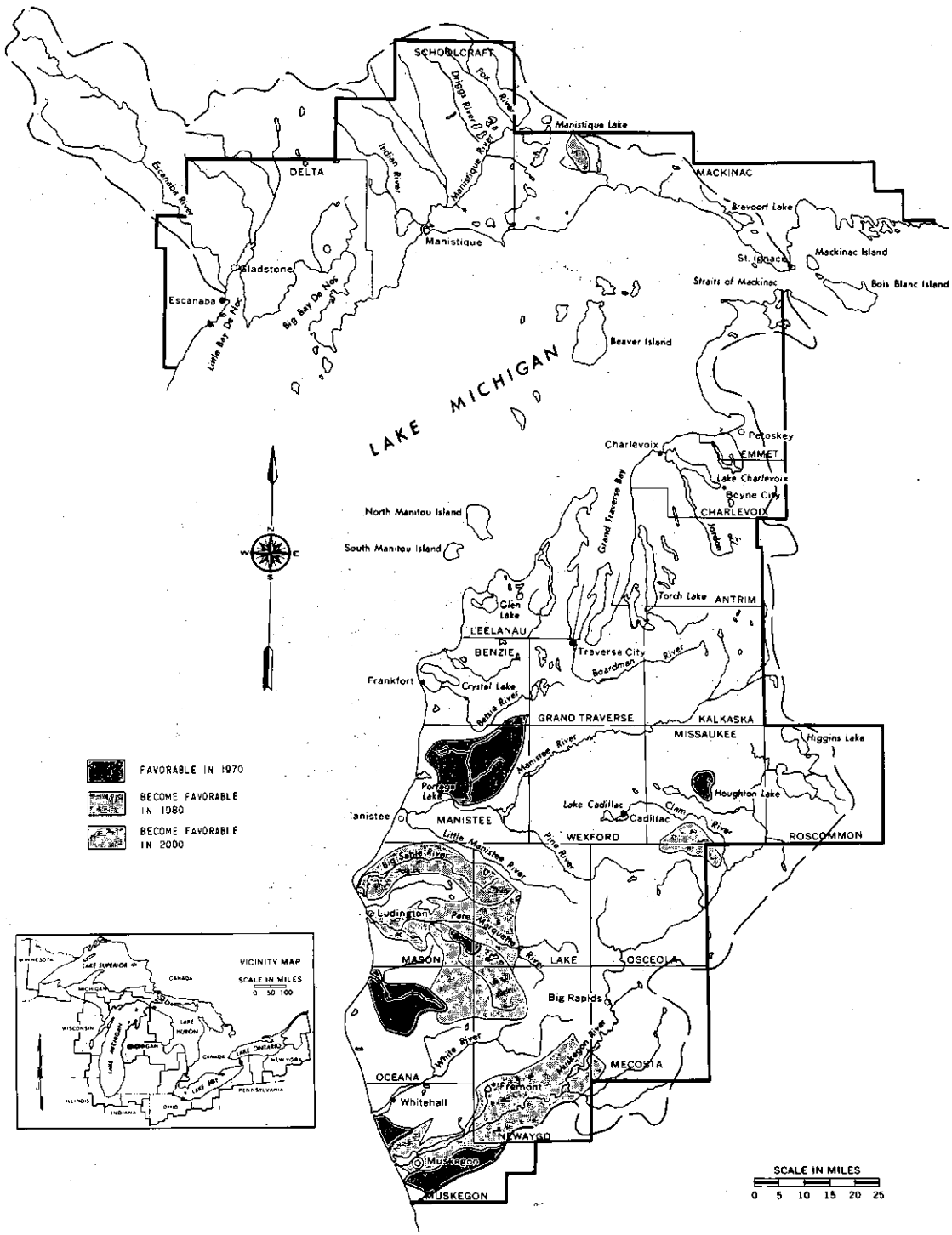

FIGURE 16–11 Watersheds Most Favorable for Project Action, Planning Subarea 2.4

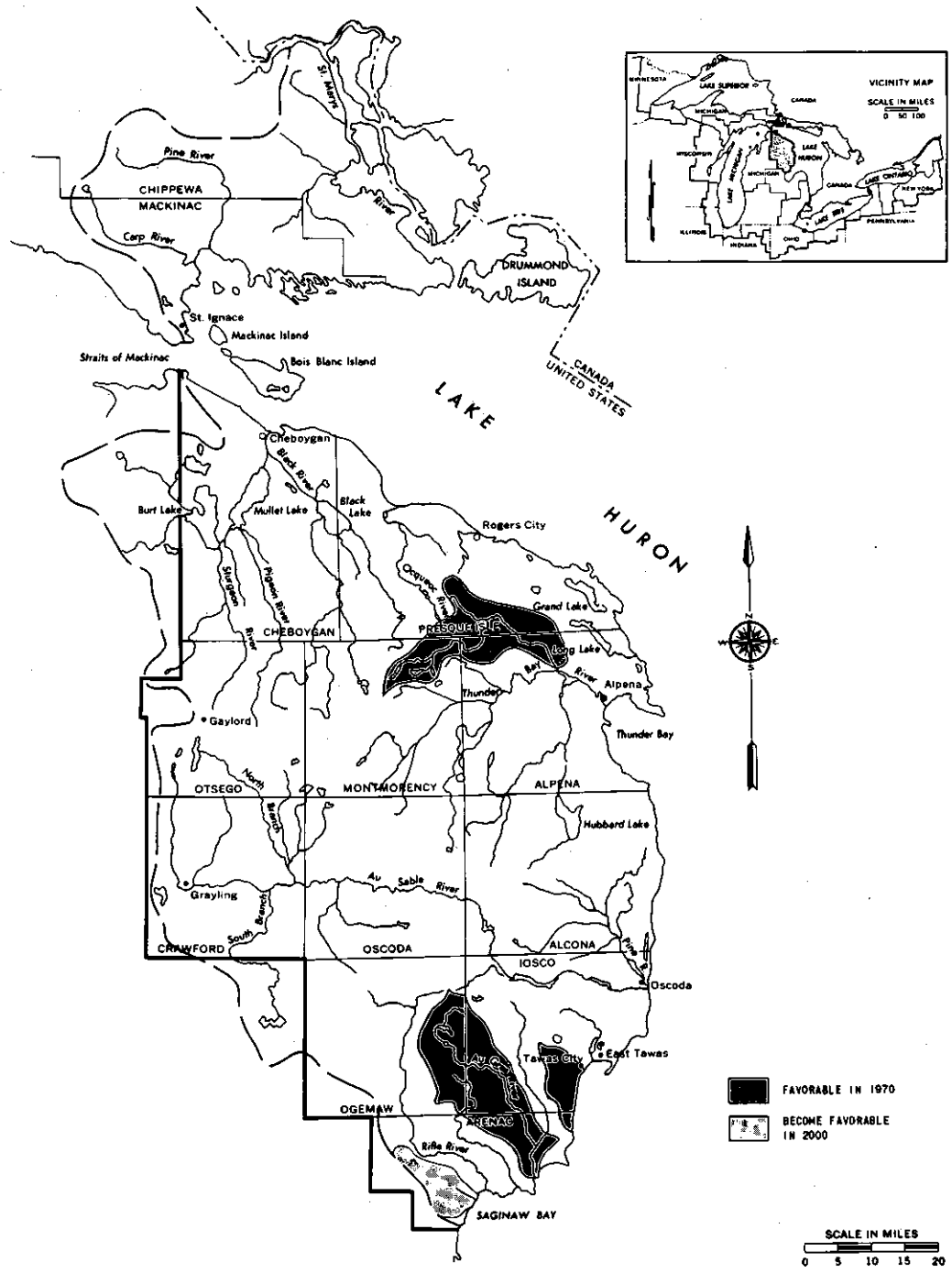

FIGURE 16–12 Watersheds Most Favorable for Project Action, Planning Subarea 3.1

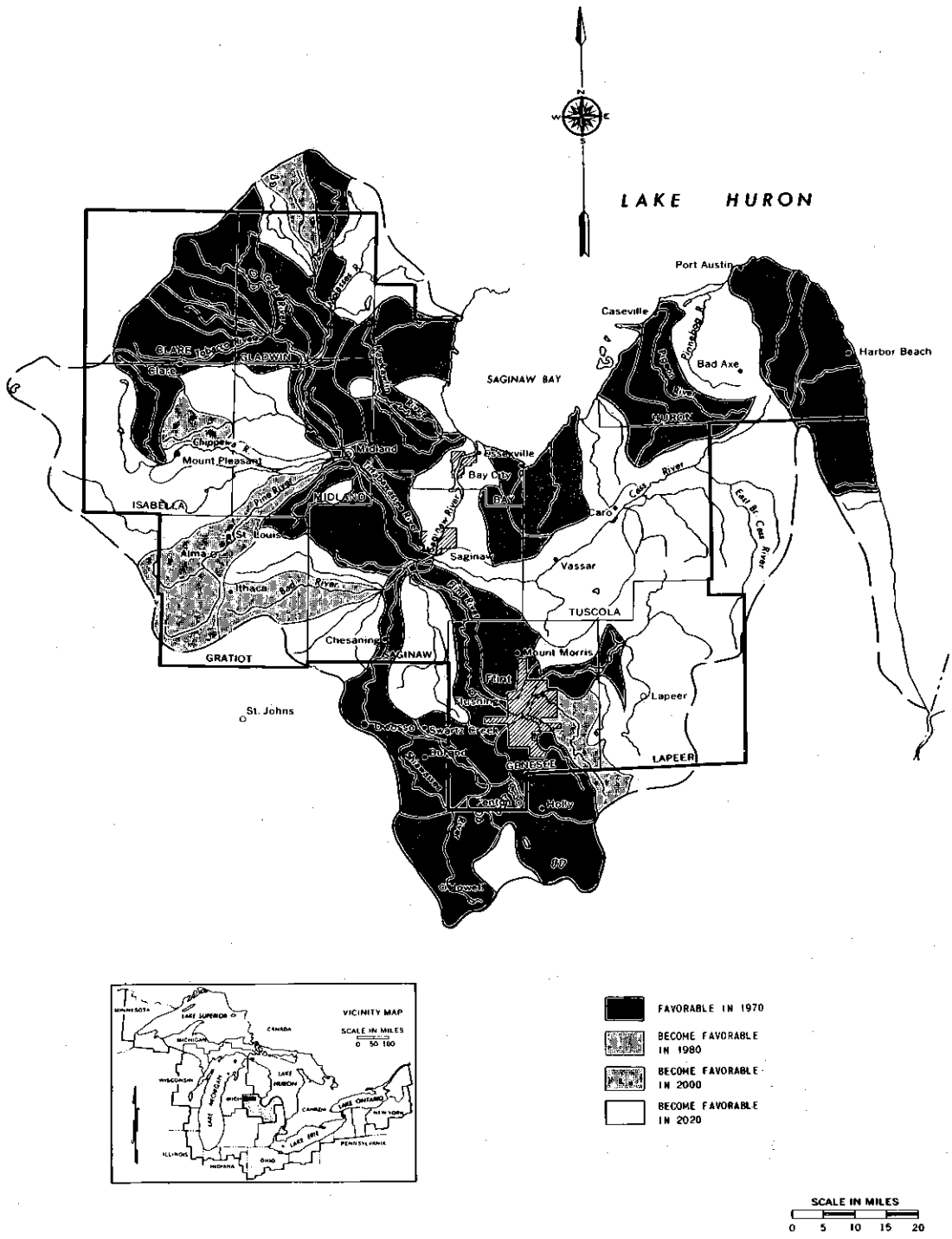

FIGURE 16–13 Watersheds Most Favorable for Project Action, Planning Subarea 3.2

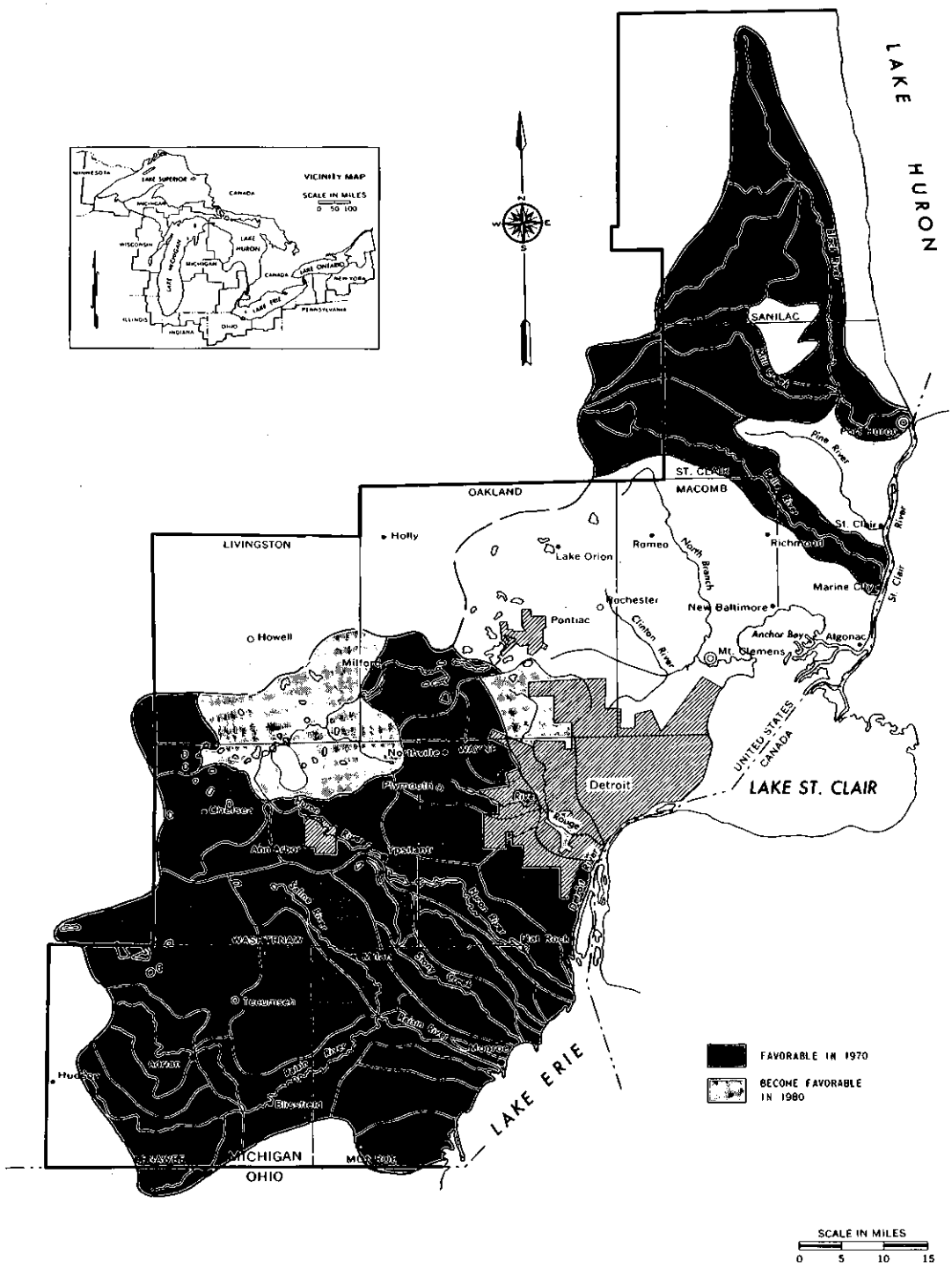

FIGURE 16–14 Watersheds Most Favorable for Project Action, Planning Subarea 4.1

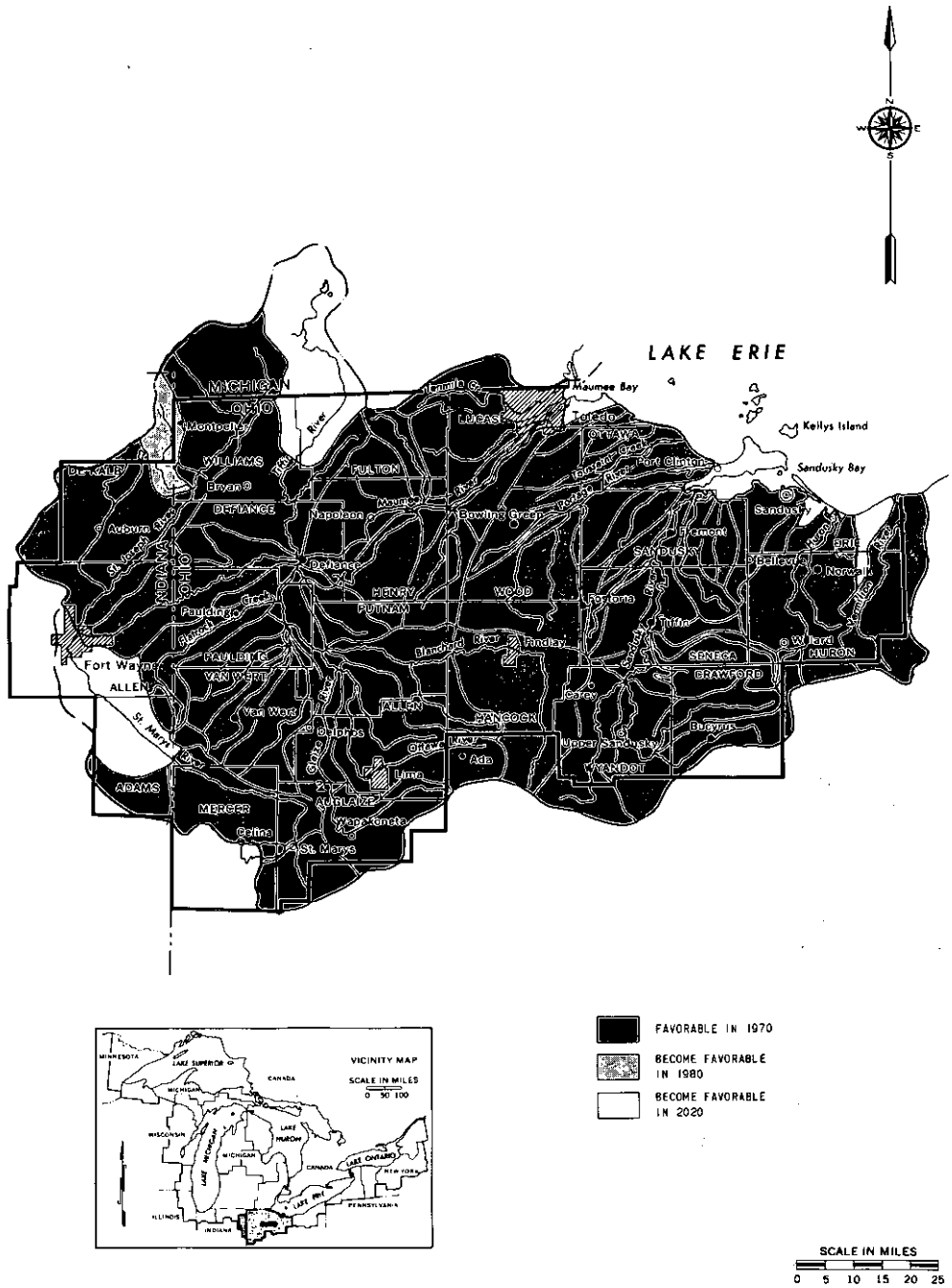

FIGURE 16–15 Watersheds Most Favorable for Project Action, Planning Subarea 4.2

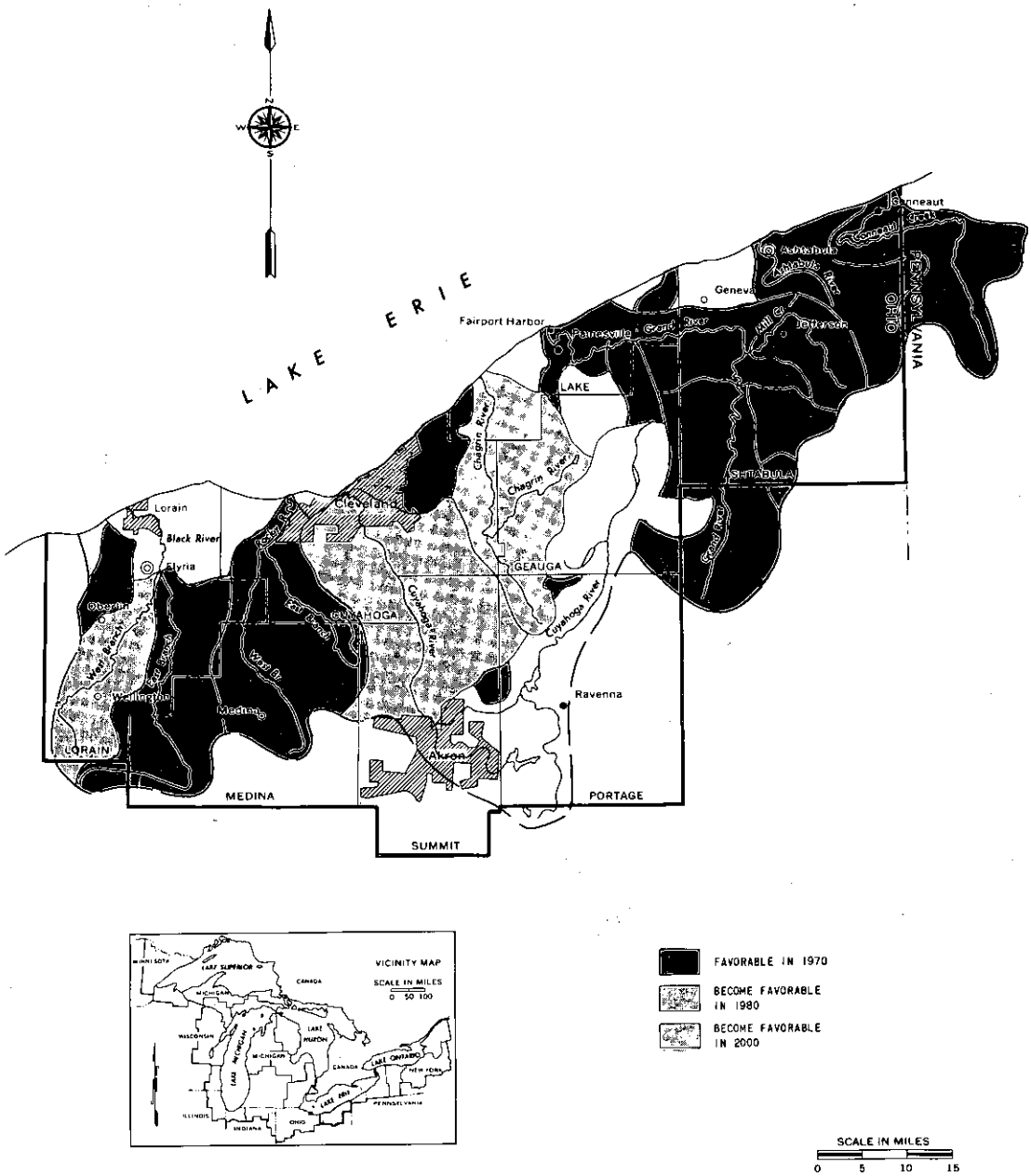

FIGURE 16–16 Watersheds Most Favorable for Project Action, Planning Subarea 4.3

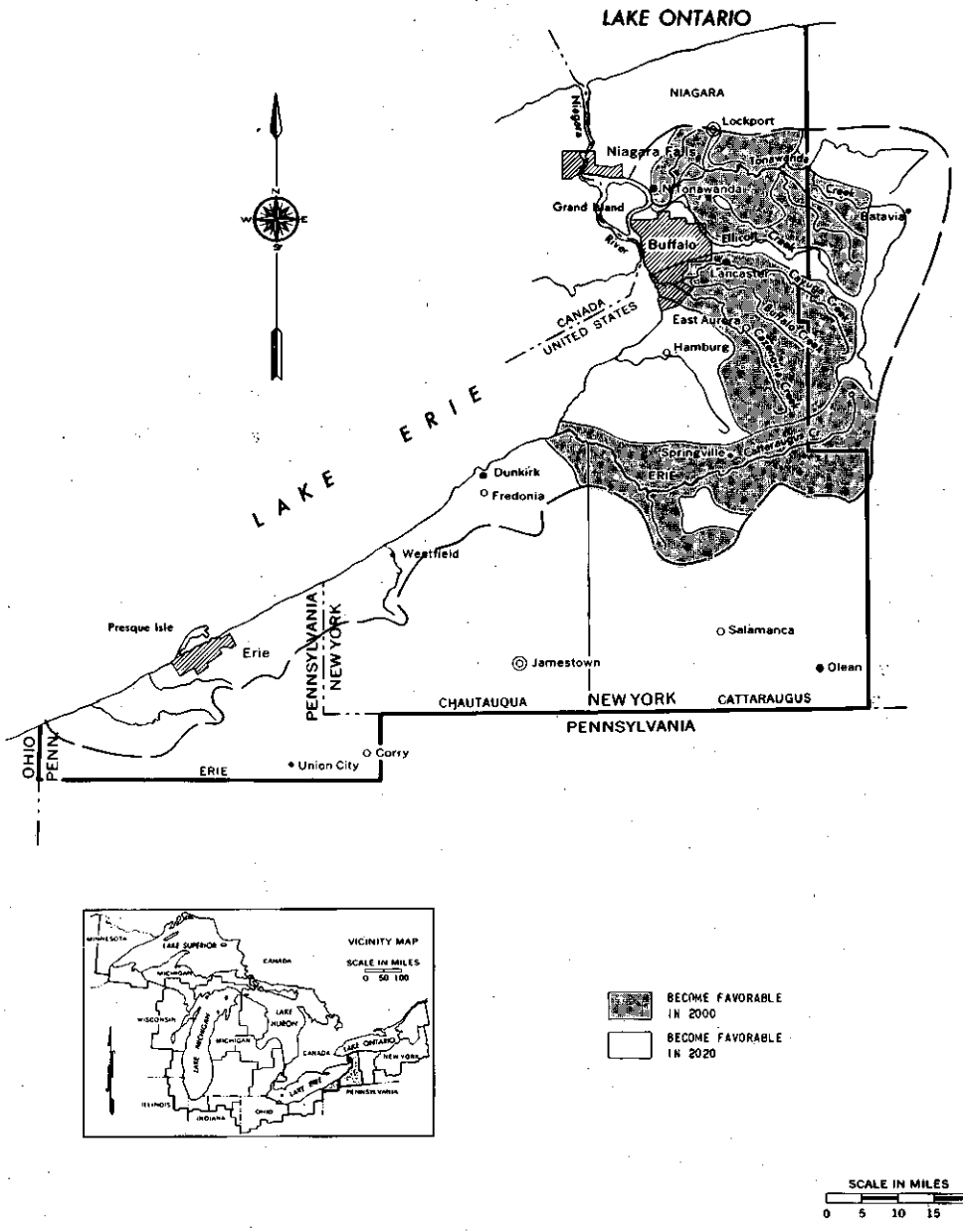

FIGURE 16–17 Watersheds Most Favorable for Project Action, Planning Subarea 4.4

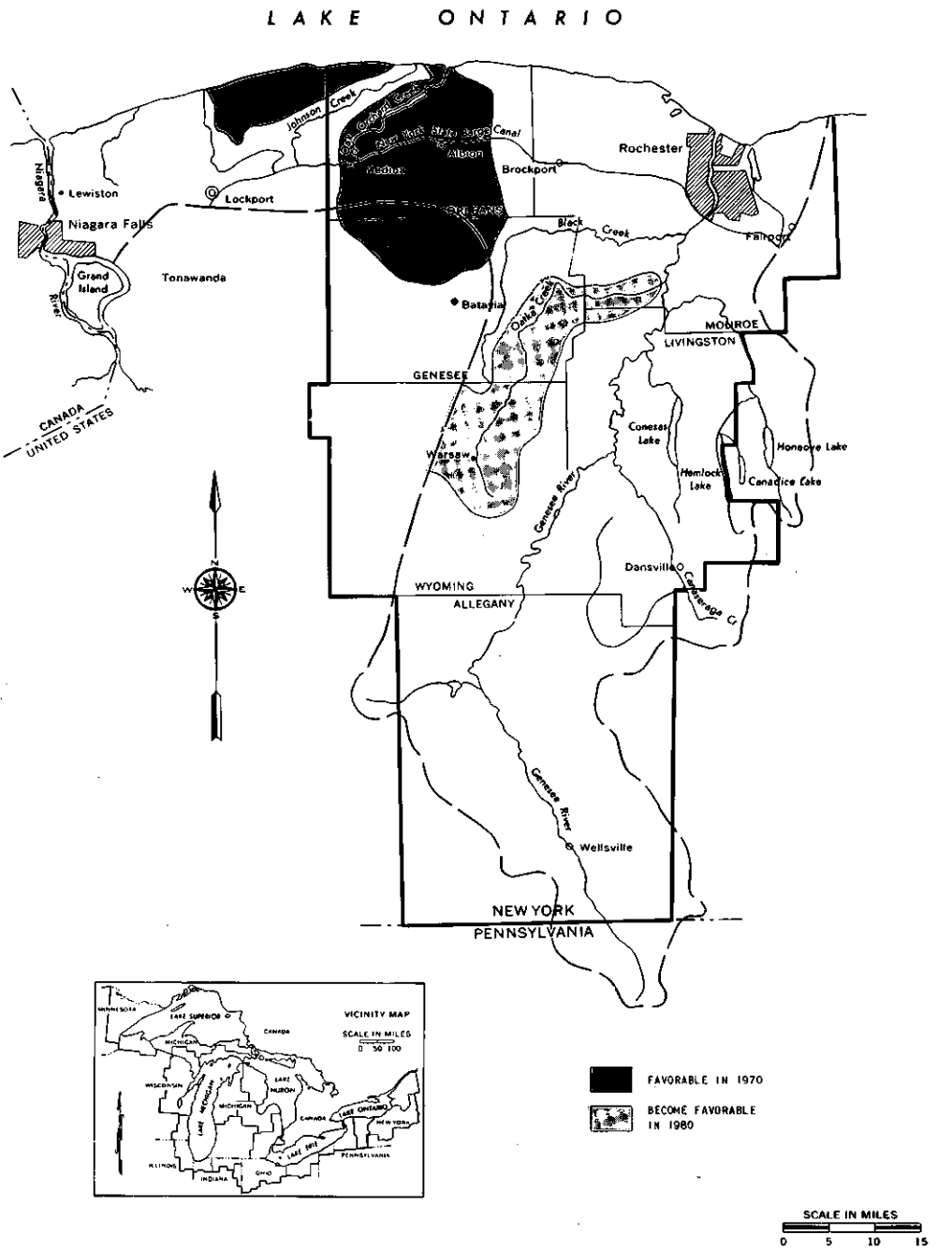

FIGURE 16–18 Watersheds Most Favorable for Project Action, Planning Subarea 5.1

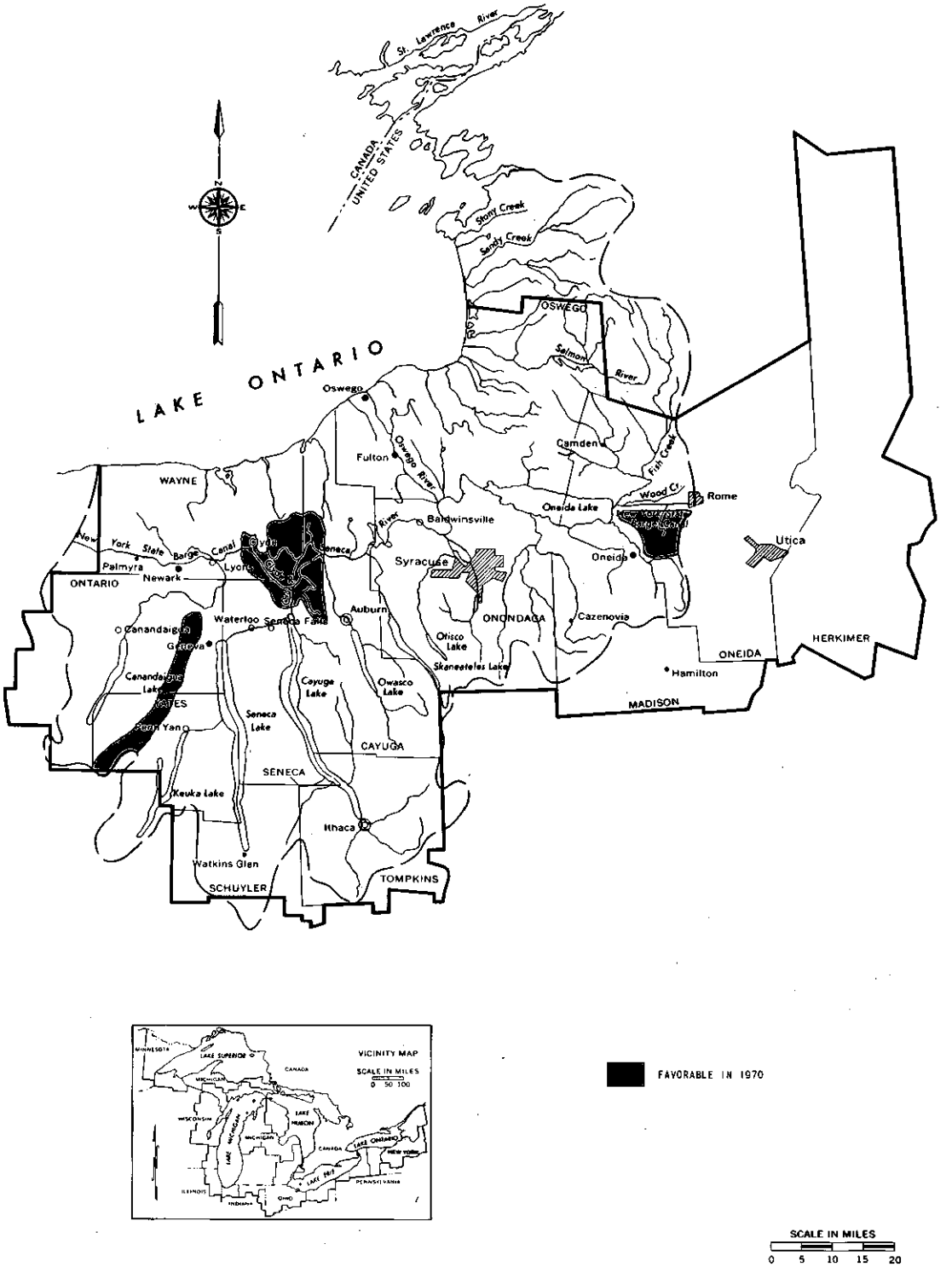

FIGURE 16–19 Watersheds Most Favorable for Project Action, Planning Subarea 5.2

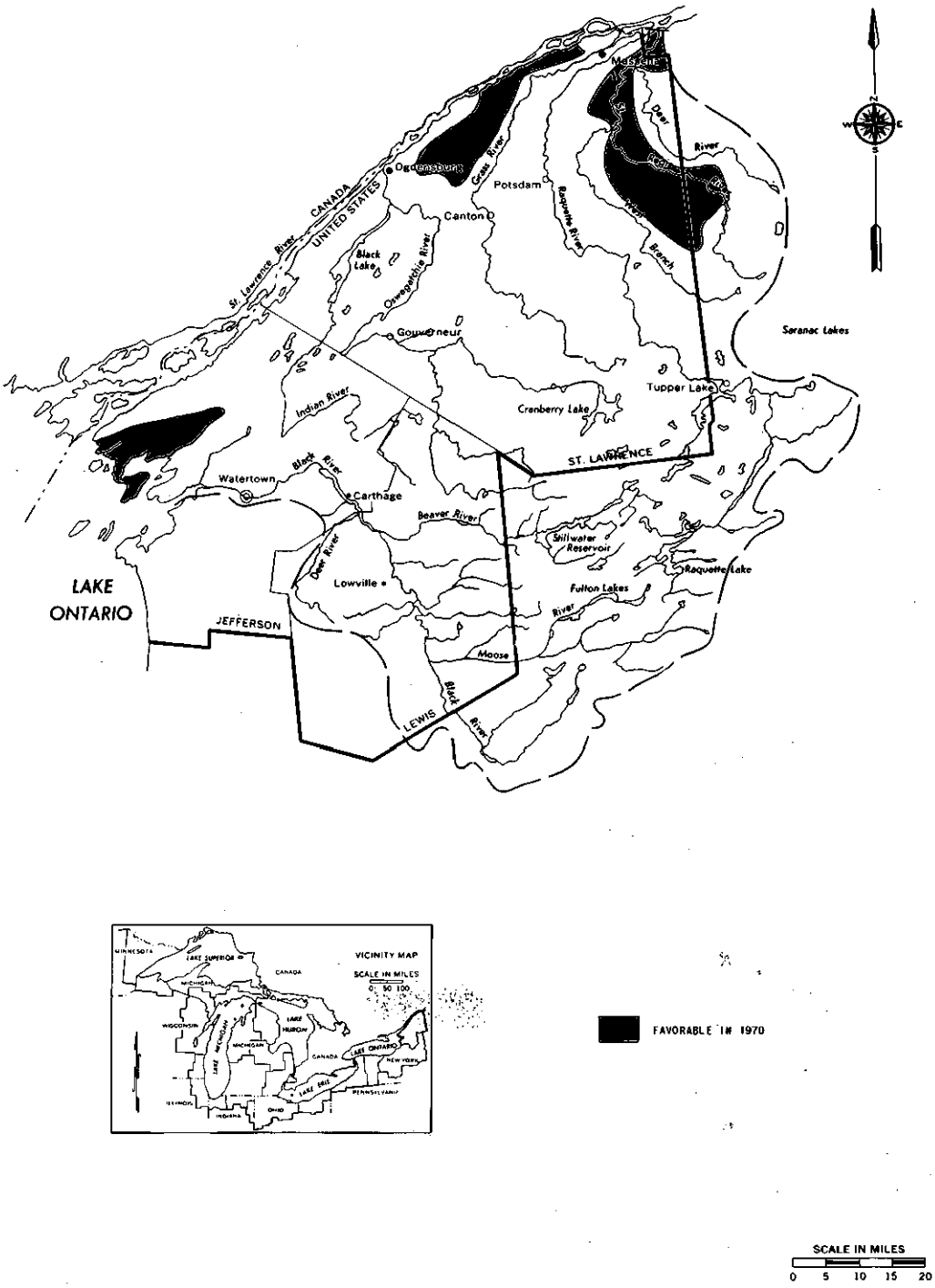

FIGURE 16–20 Watersheds Most Favorable for Project Action, Planning Subarea 5.3

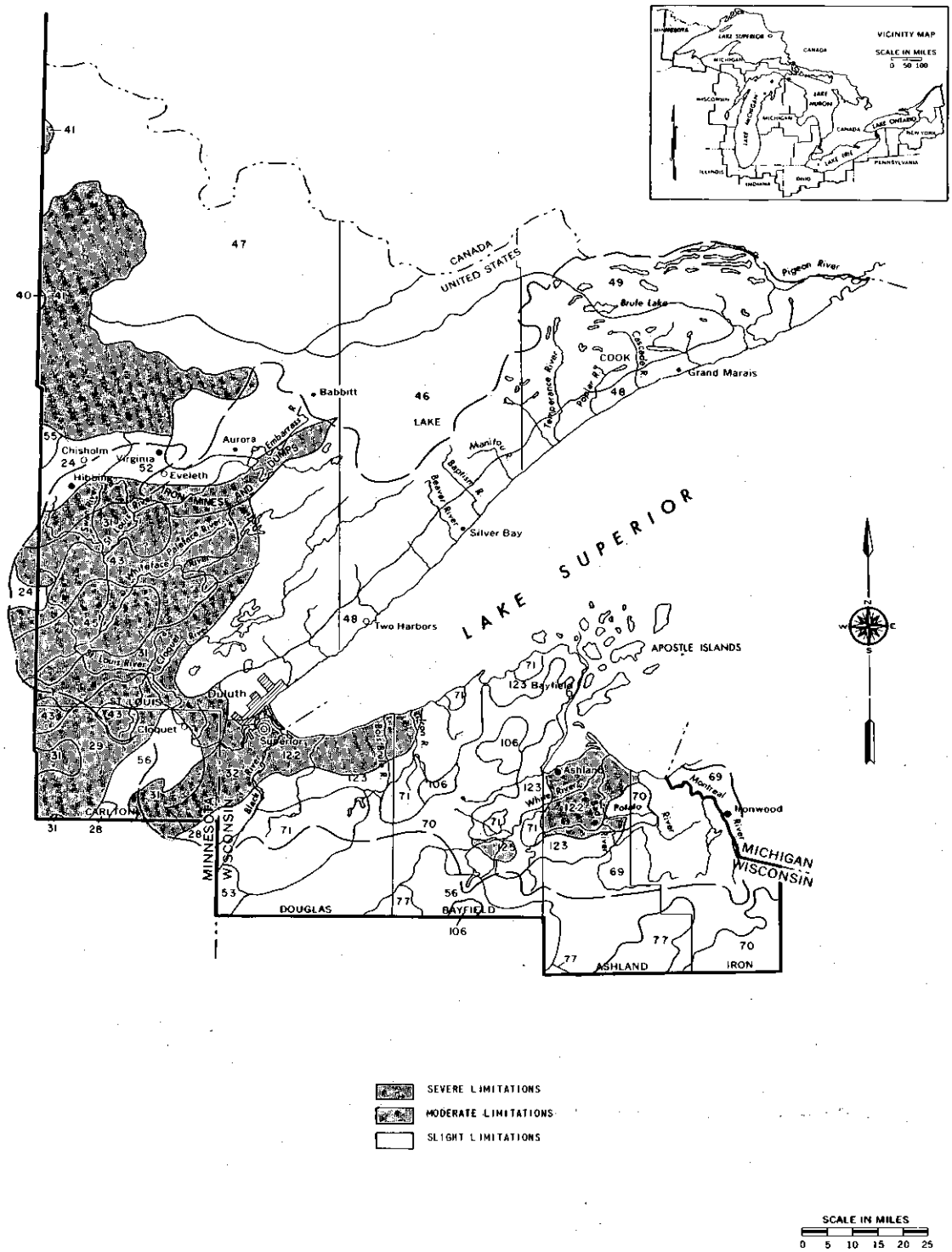

FIGURE 16–21 Soil Drainage Limitations, Planning Subarea 1.1 (Numbers are soil association codes, Table 16–24).

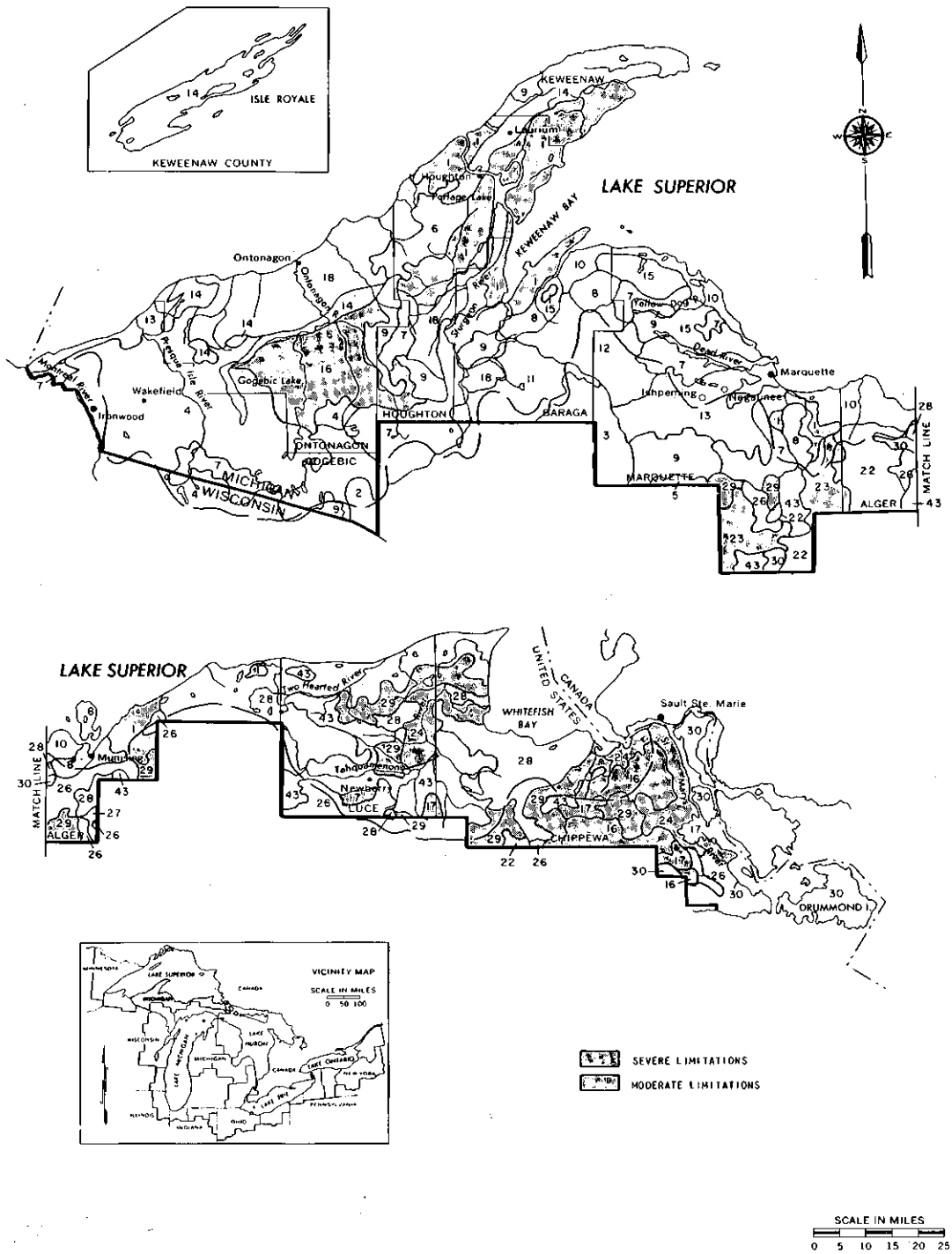

FIGURE 16–22 Soil Drainage Limitations, Planning Subarea 1.2. (Numbers are soil association codes, Table 16–25).

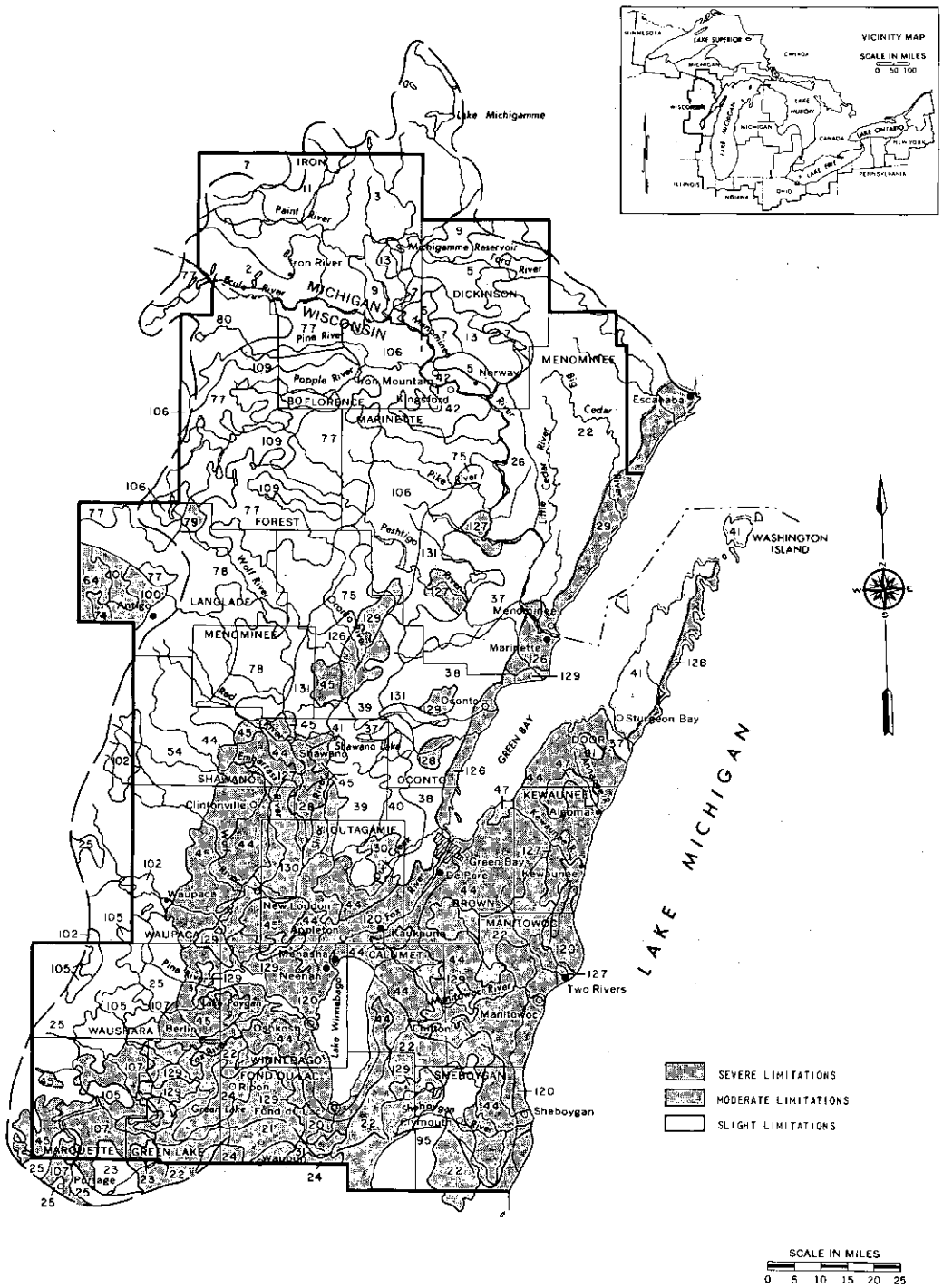

FIGURE 16–23 Soil Drainage Limitations, Planning Subarea 2.1. (Numbers are soil association codes, Table 16–26).

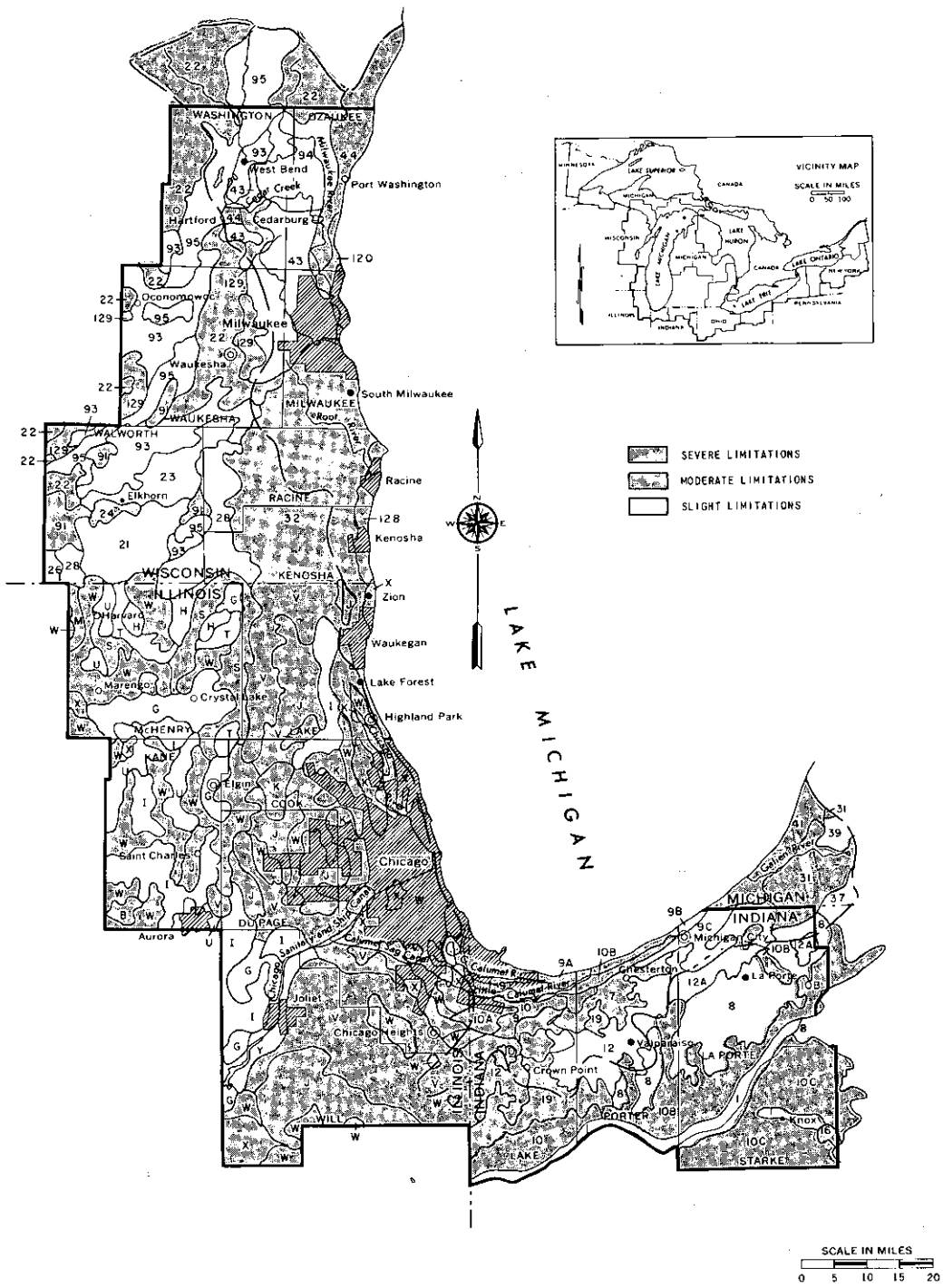

FIGURE 16–24 Soil Drainage Limitations, Planning Subarea 2.2. (Numbers and letters are soil association codes, Table 16–27).

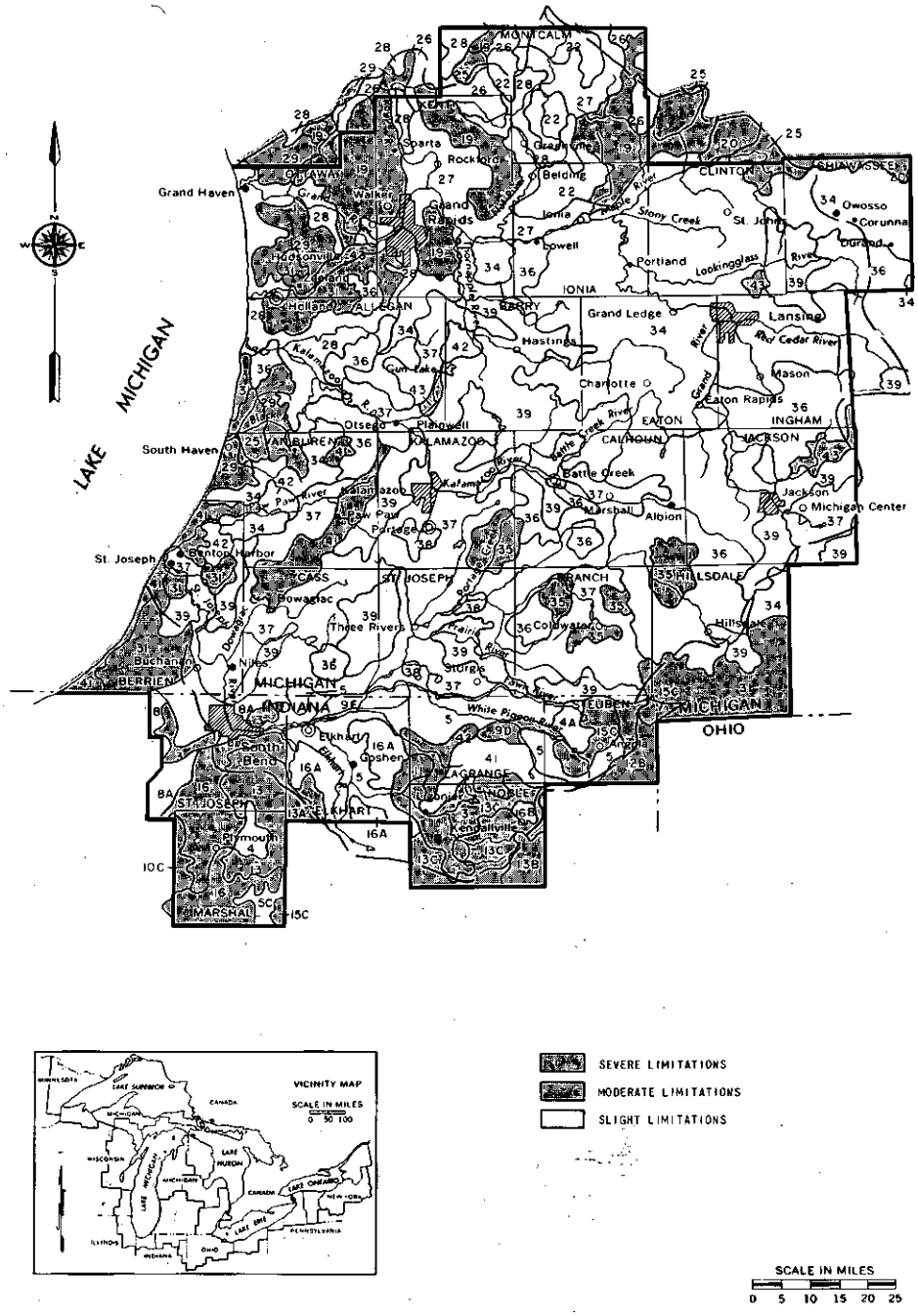

FIGURE 16–25 Soil Drainage Limitations, Planning Subarea 2.3. (Numbers and letters are soil association codes, Table 16–28).

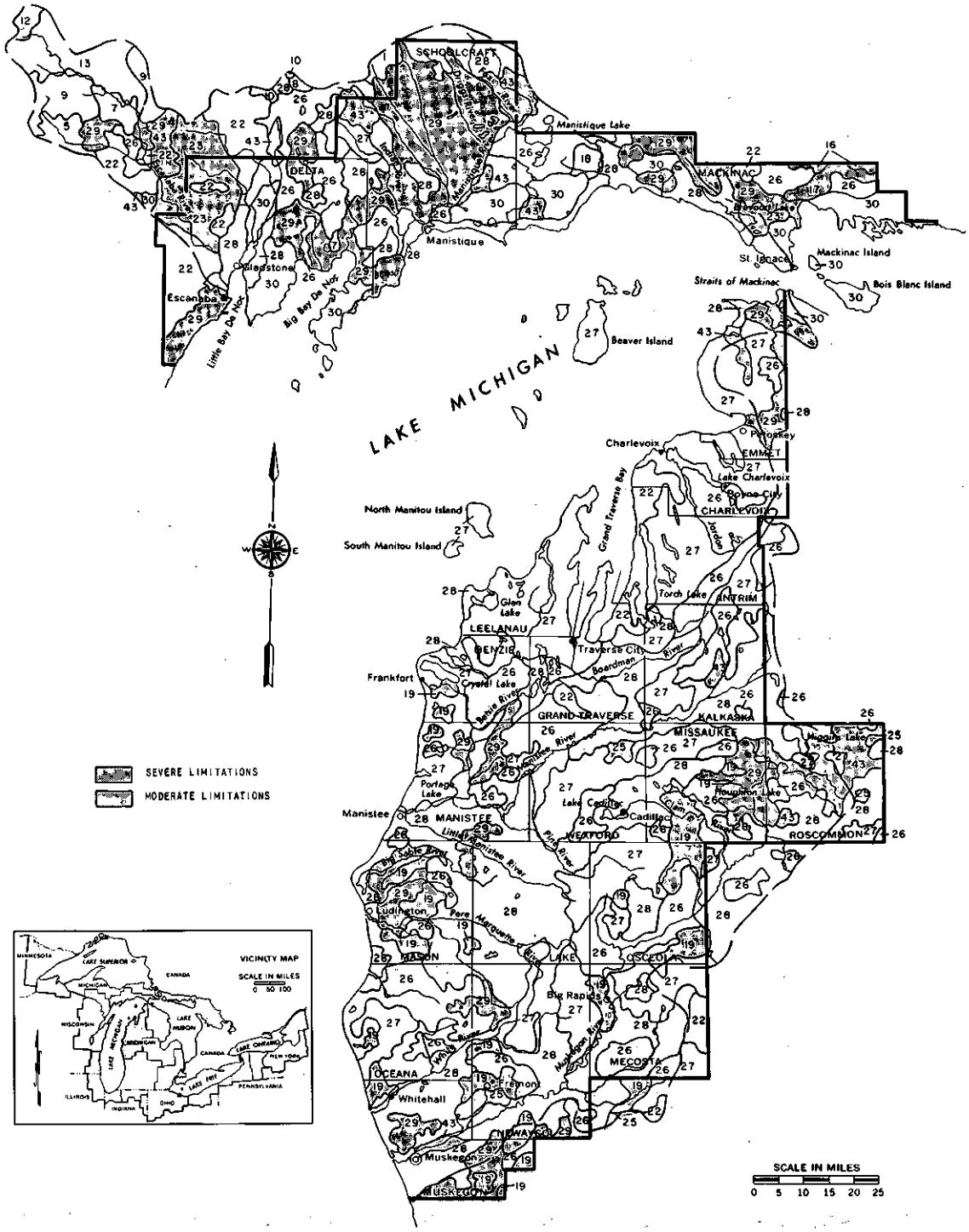

FIGURE 16–26 Soil Drainage Limitations, Planning Subarea 2.4. (Numbers are soil association codes, Table 16–29).

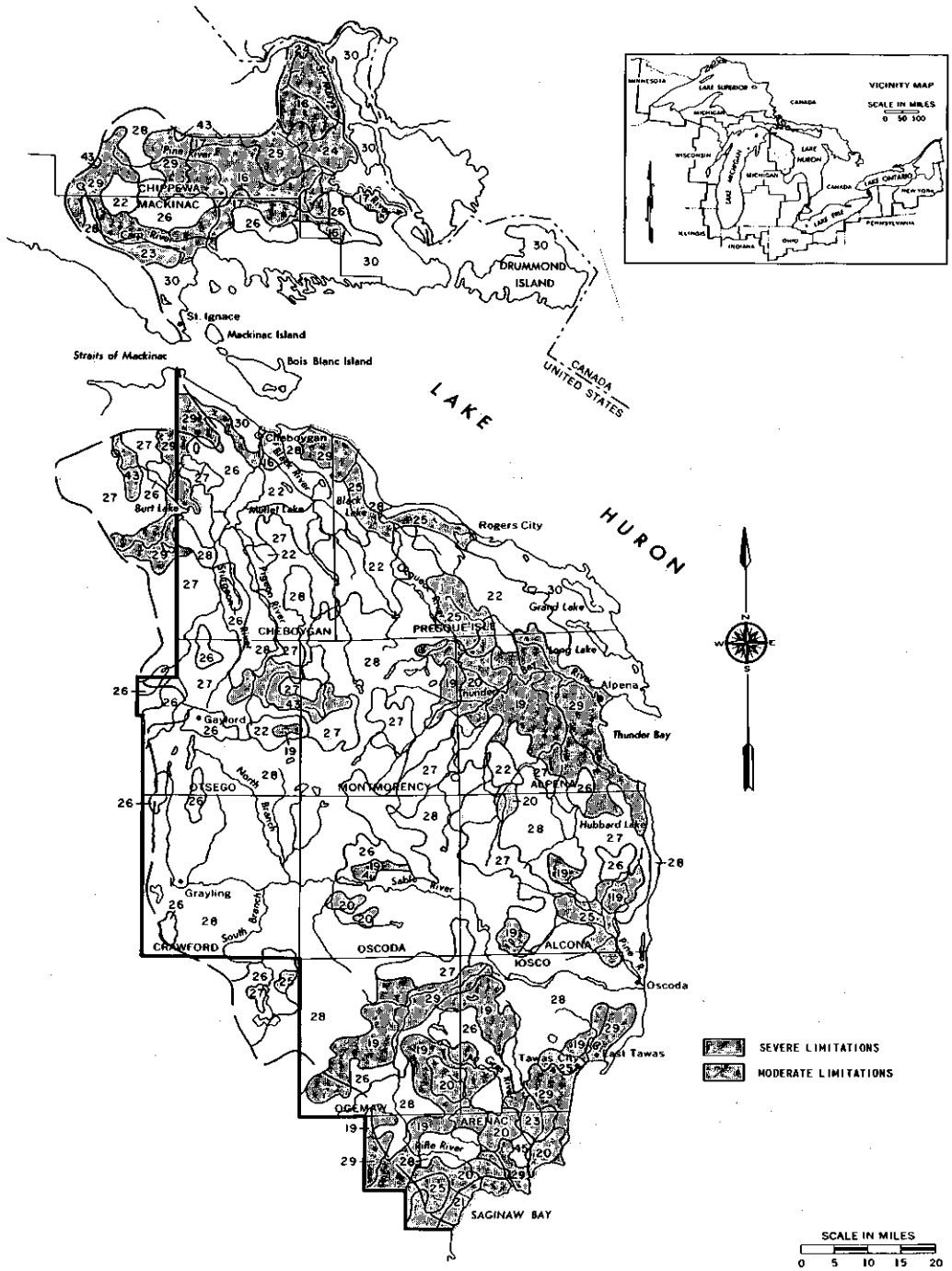

FIGURE 16–27 Soil Drainage Limitations, Planning Subarea 3.1. (Numbers are soil association codes, Table 16–30).

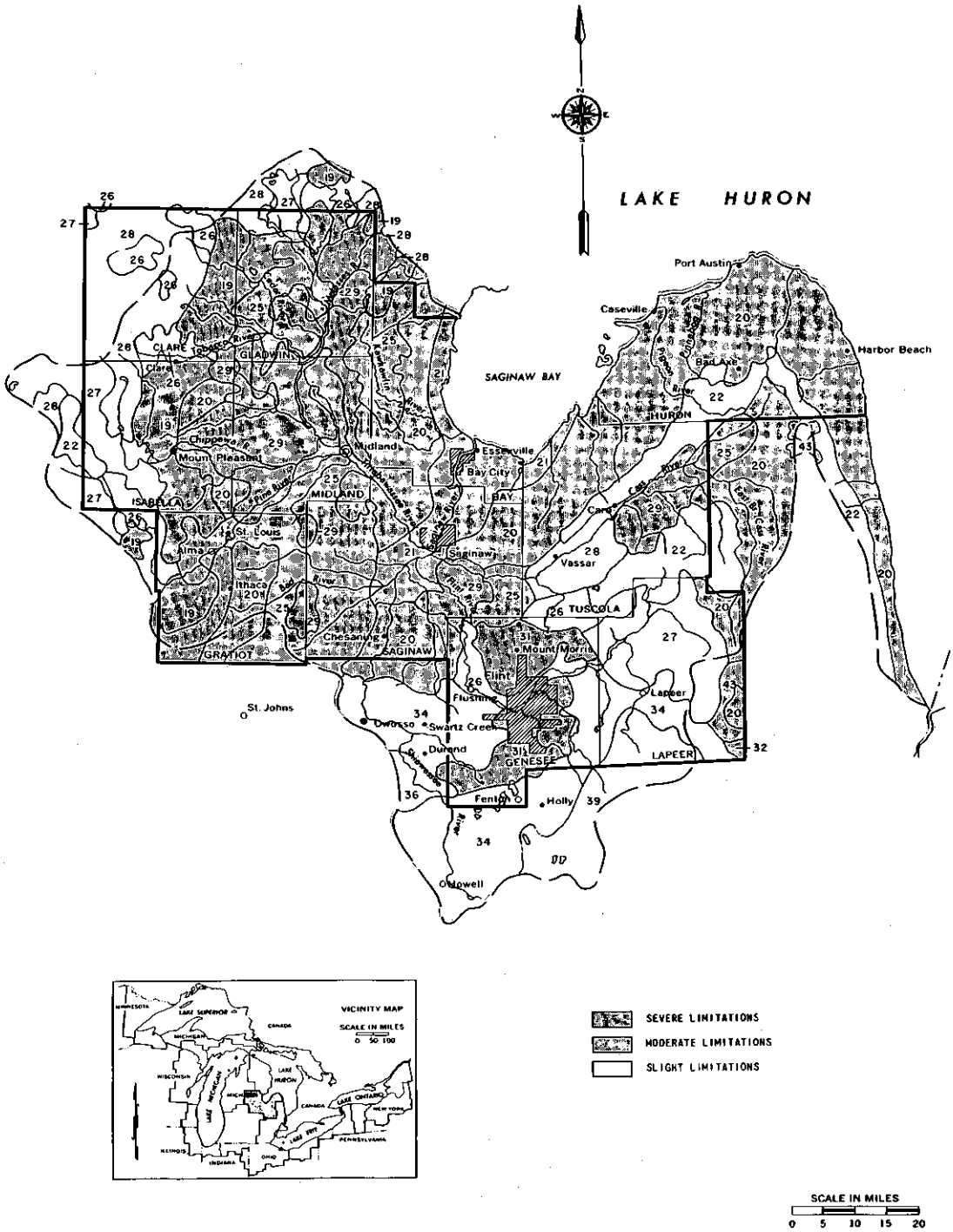

FIGURE 16–28 Soil Drainage Limitations, Planning Subarea 3.2. (Numbers are soil association codes, Table 16–31).

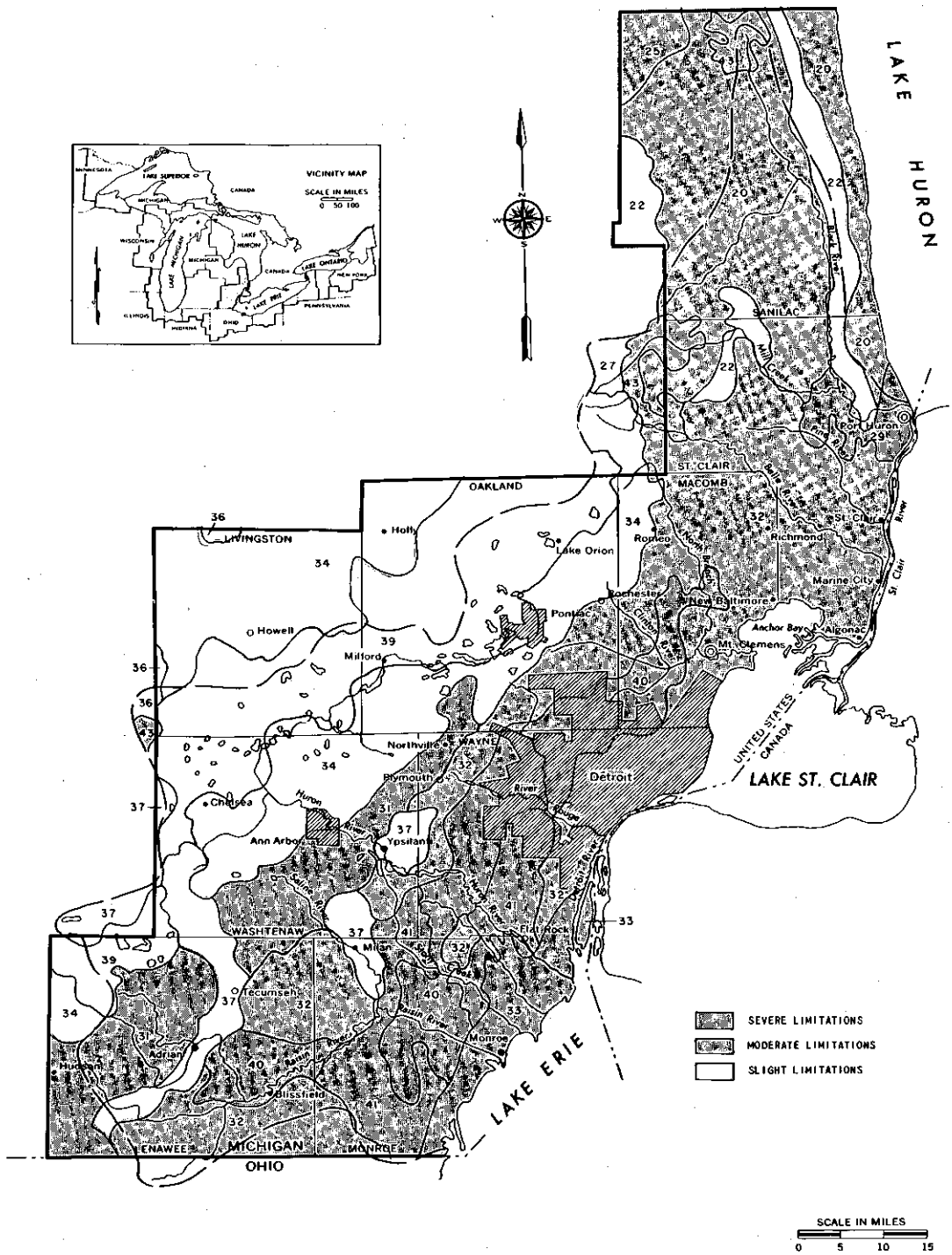

FIGURE 16–29 Soil Drainage Limitations, Planning Subarea 4.1. (Numbers are soil association codes, Table 16–32).

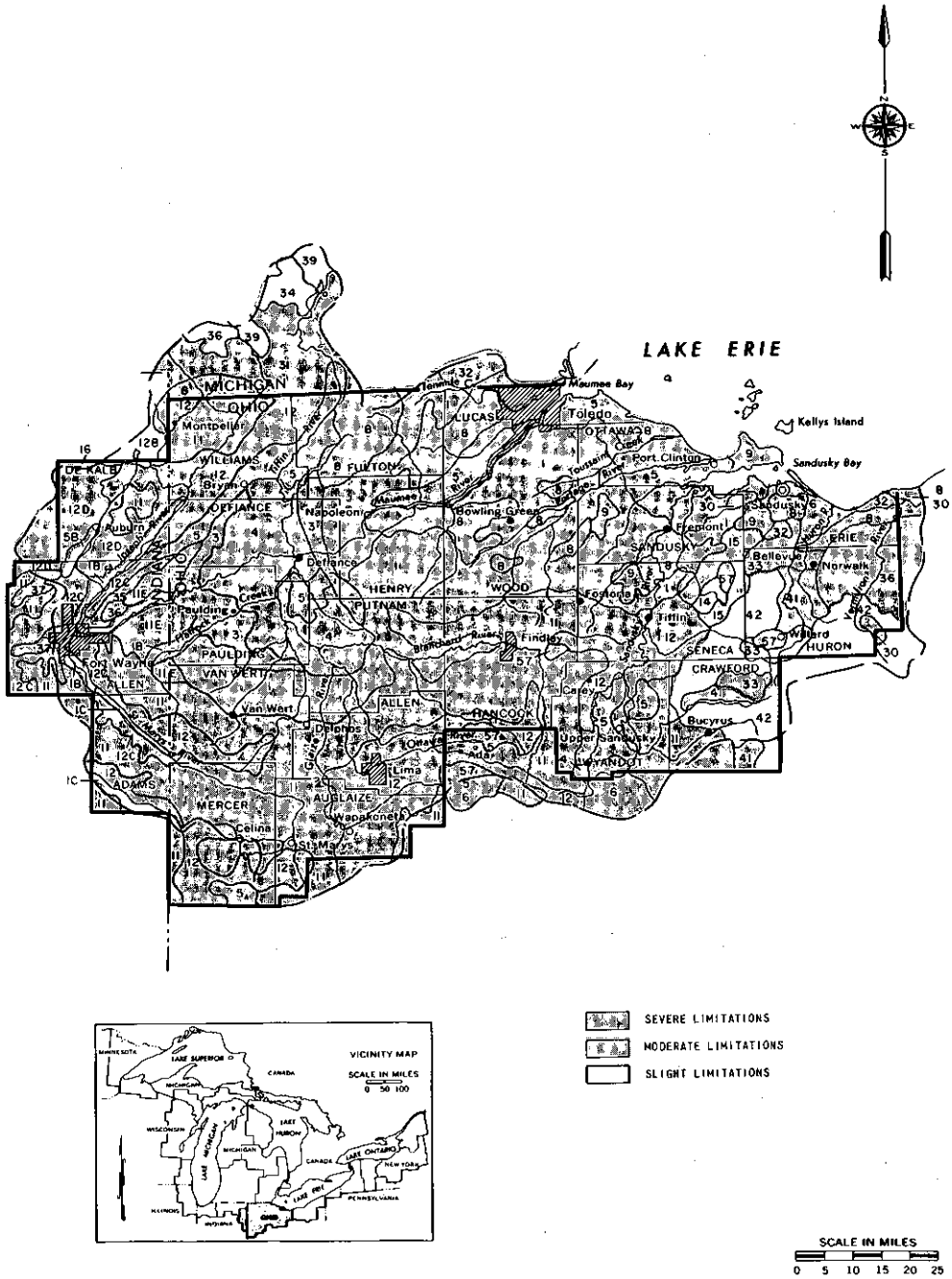

FIGURE 16–30 Soil Drainage Limitations, Planning Subarea 4.2. (Numbers and letters are soil association codes, Table 16–33).

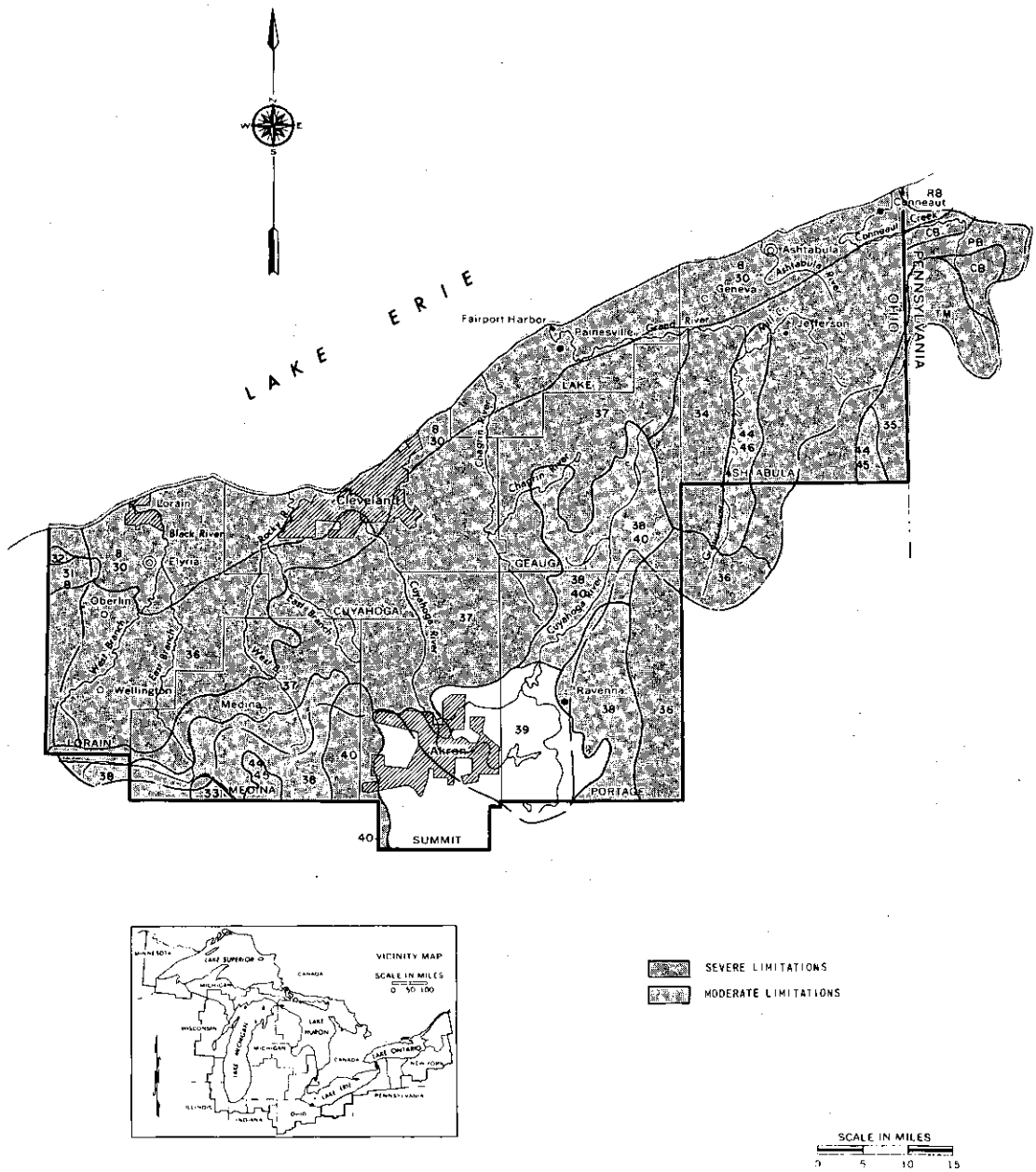

FIGURE 16–31 Soil Drainage Limitations, Planning Subarea 4.3. (Numbers and letters are soil association codes, Table 16–34).

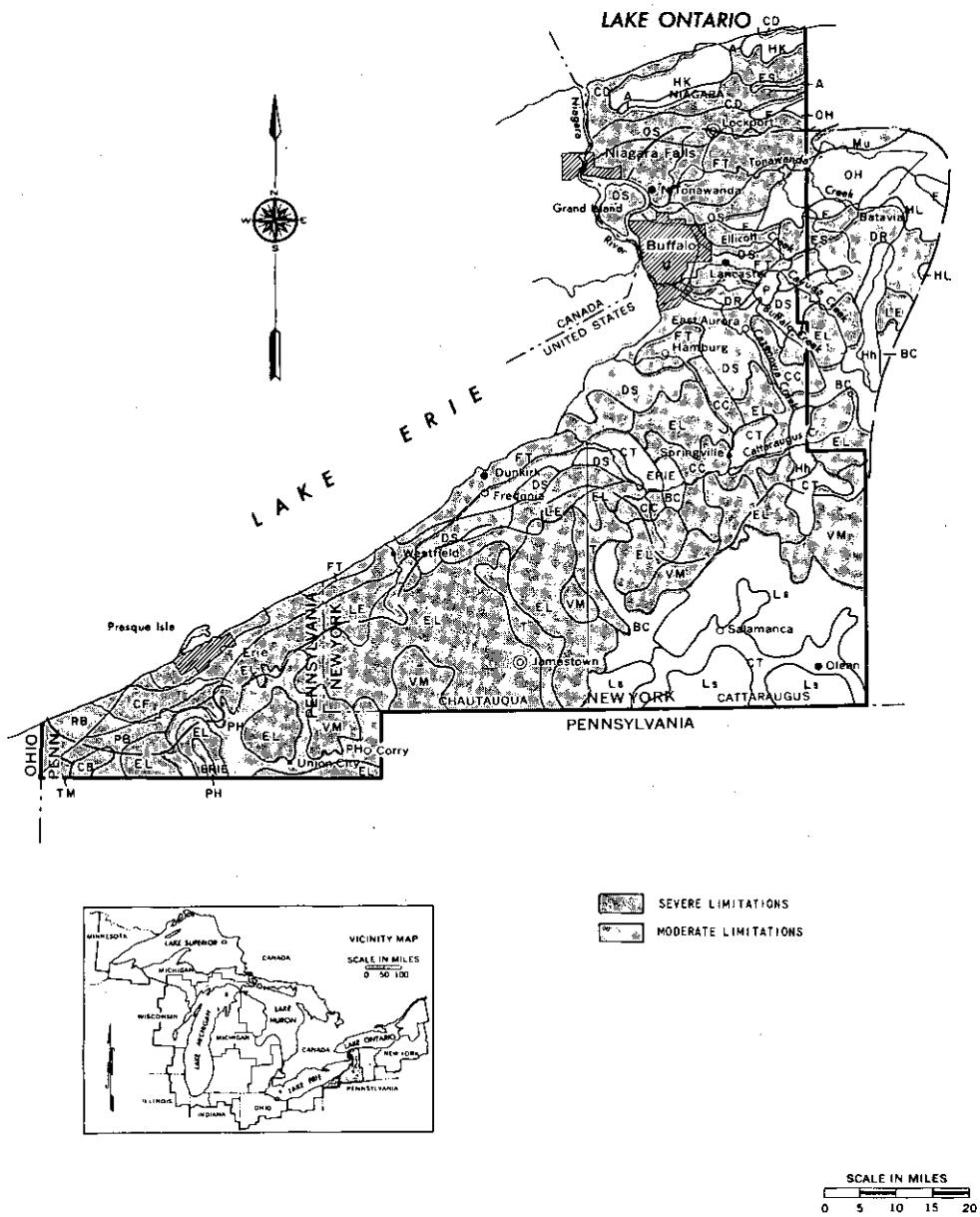

FIGURE 16–32 Soil Drainage Limitations, Planning Subarea 4.4. (Letters are soil association codes, Table 16–35).

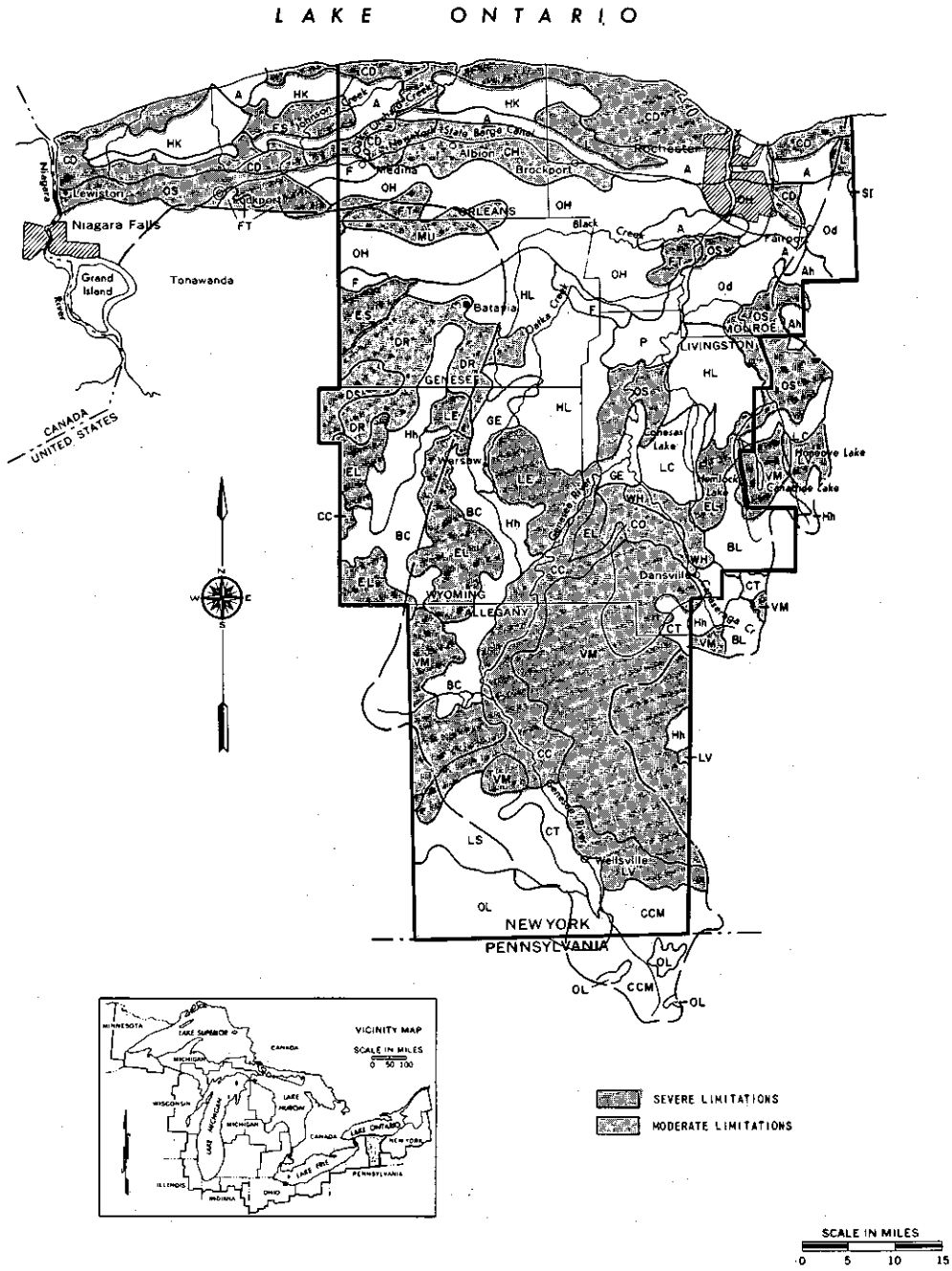

FIGURE 16–33 Soil Drainage Limitations, Planning Subarea 5.1. (Letters are soil association codes, Table 16–36).

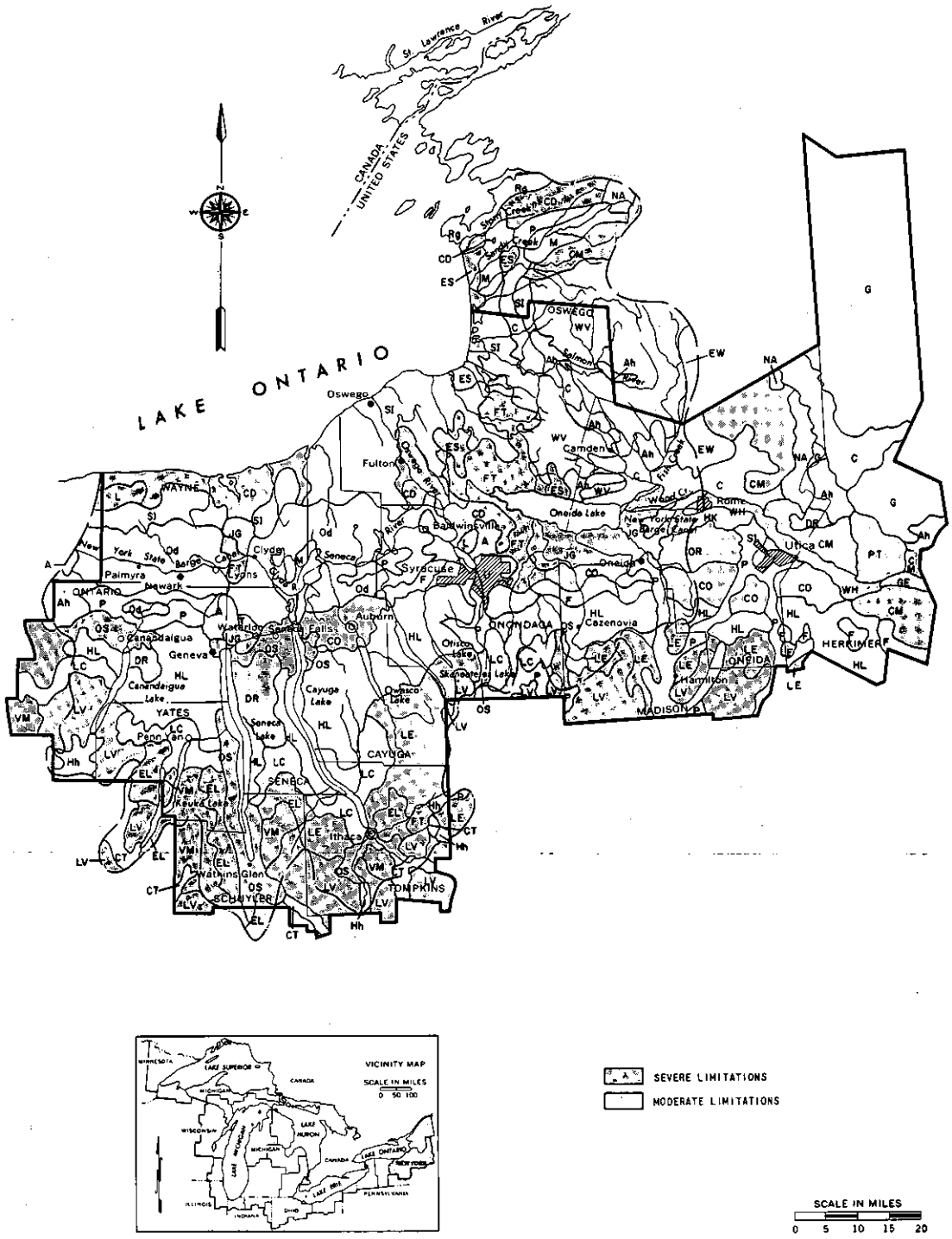

FIGURE 16–34 Soil Drainage Limitations, Planning Subarea 5.2. (Letters are soil association codes, Table 16–37).

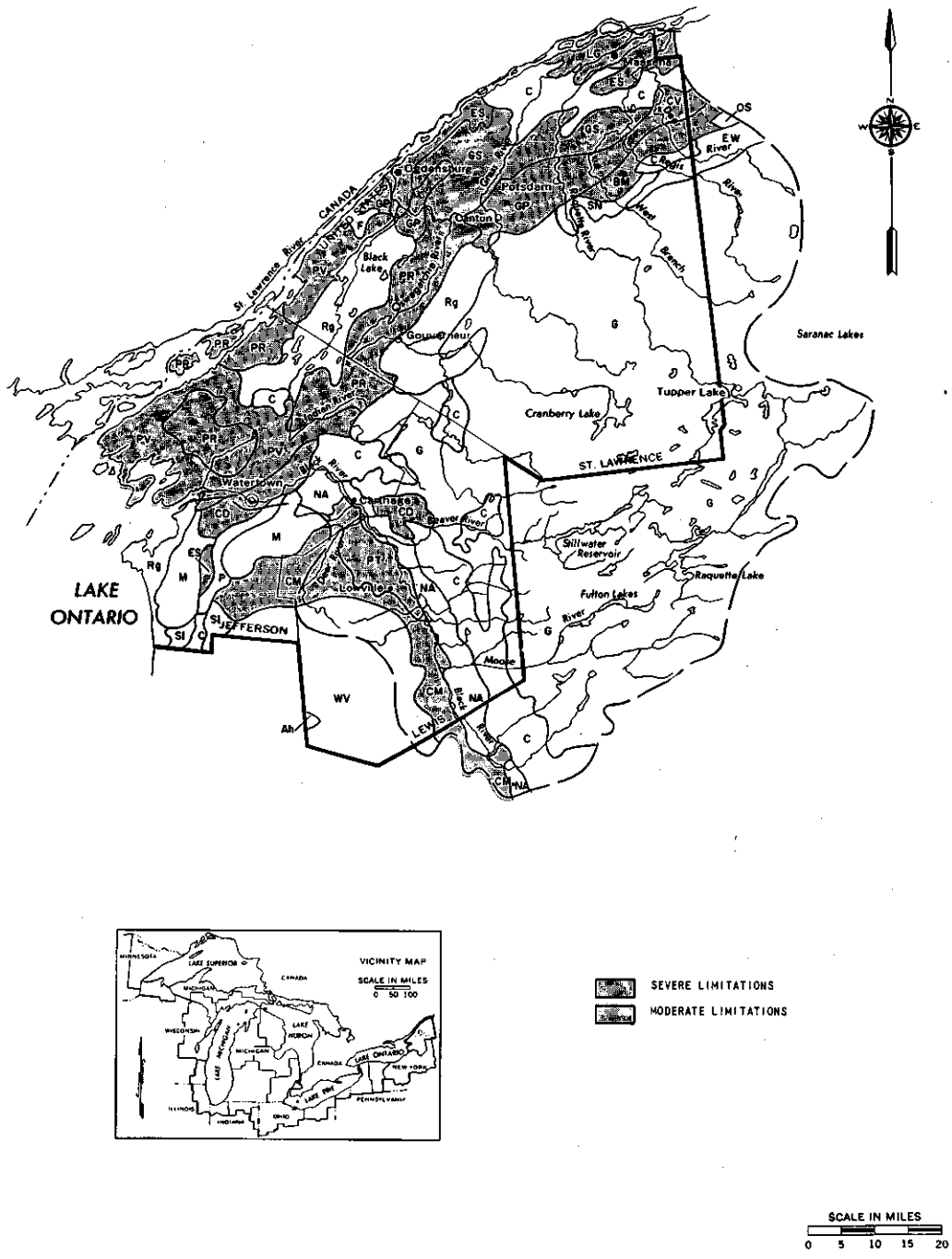

FIGURE 16–35 Soil Drainage Limitations, Planning Subarea 5.3. (Letters are soil association codes, Table 16–38).

GREAT LAKES BASIN FRAME-
WORK STUDY - APPENDIX 16

AUTHOR

TITLE GREAT LAKES BASIN FRAMEWORK STUDY - APPENDIX 16

DATE DUE	BORROWER'S NAME

GREAT LAKES BASIN COMMISSION
Frederick O. Rouse, Chairman

Members

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