

1-2003

## **Mona Lake Watershed Resource Atlas**

Annis Water Resources Institute

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# Mona Lake Watershed Resource Atlas



This Atlas was made possible by a grant from the Charles Stewart Mott Foundation and local support from the Community Foundation for Muskegon County

Charles Stewart Mott Foundation 

 community foundation™  
Muskegon County

Atlas Developed by:



Information Services Center  
January 2003  
MR-2003-1

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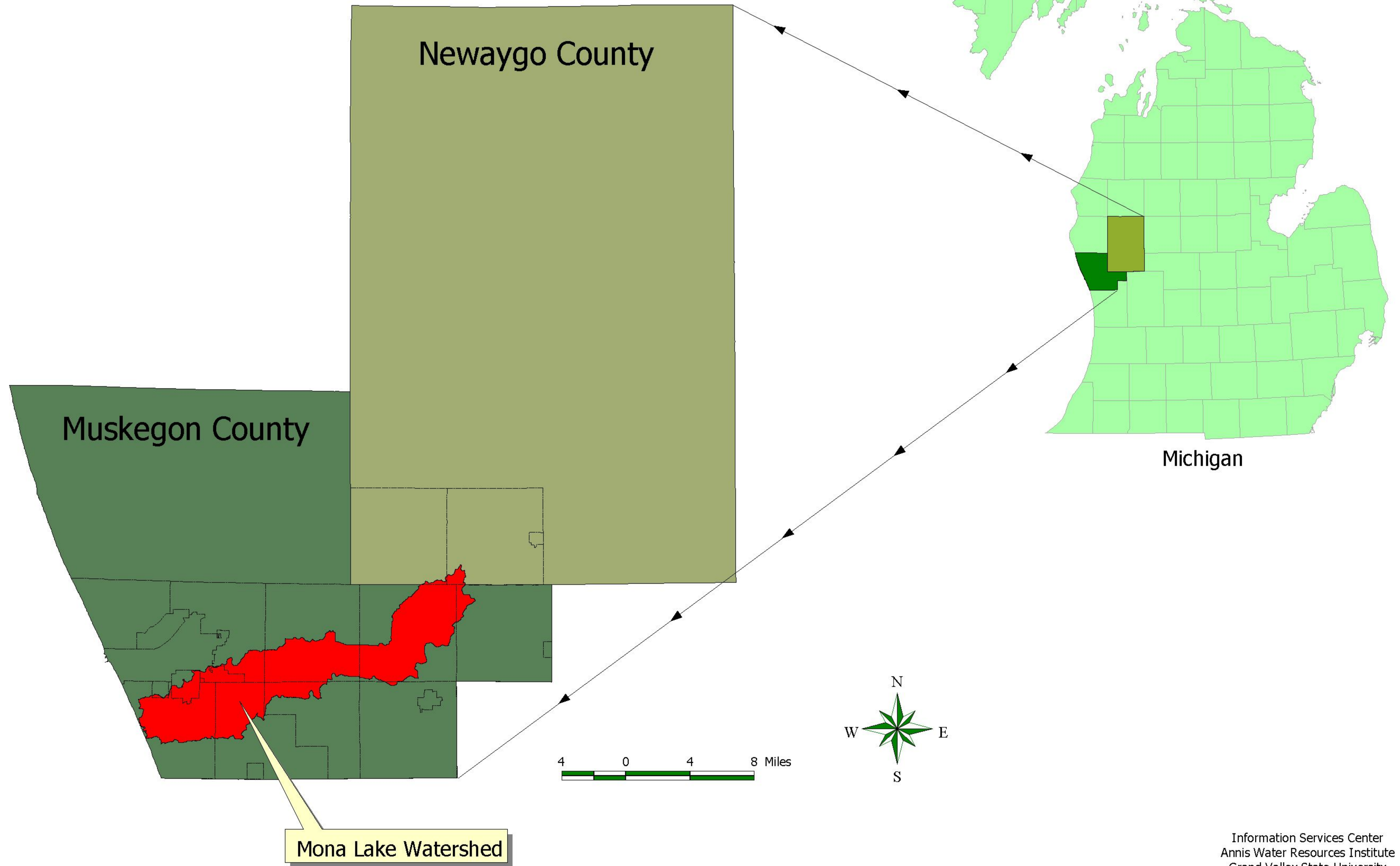
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# Mona Lake Watershed

Muskegon County and Newaygo County, Michigan



# Transportation System

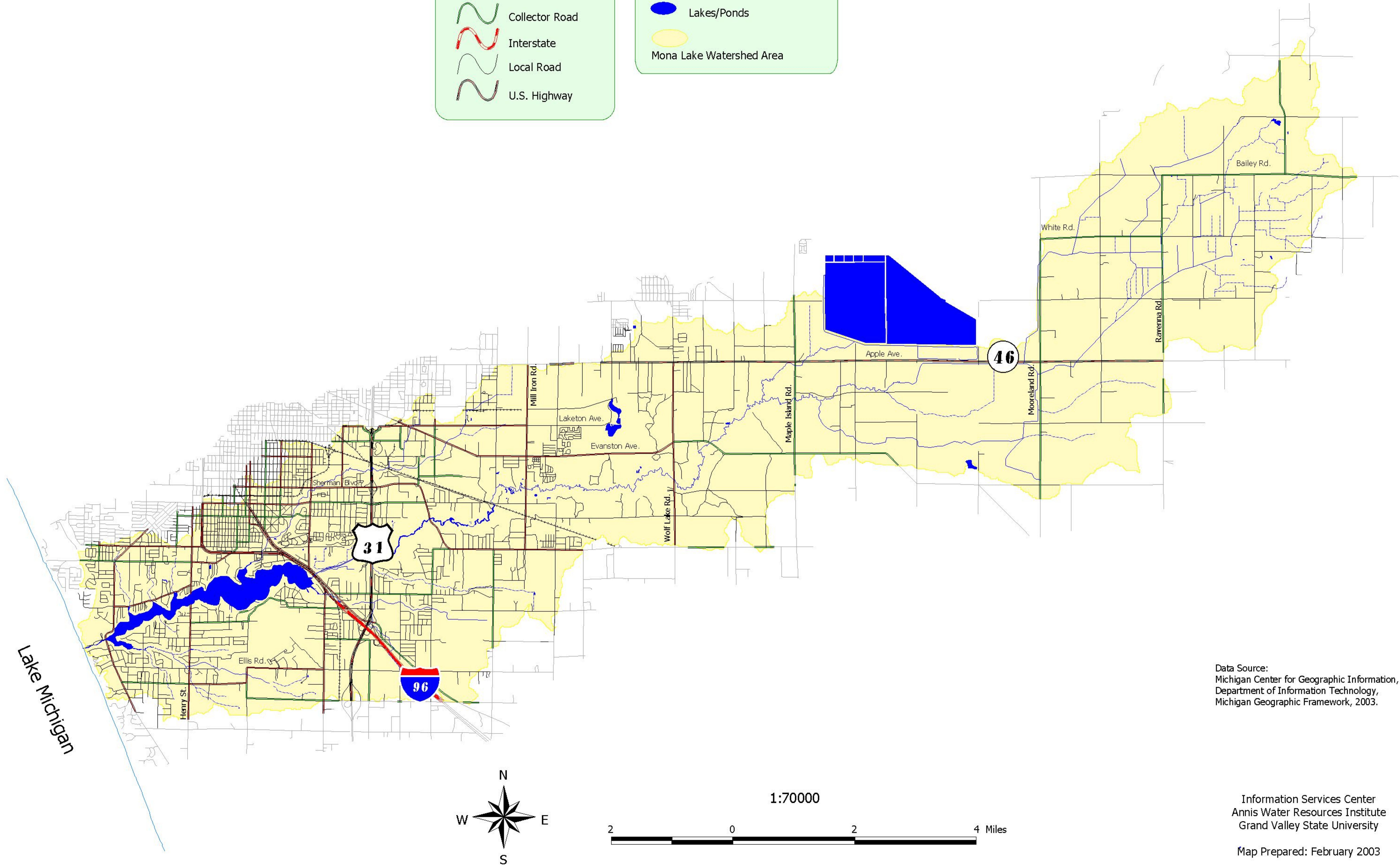
## Mona Lake Watershed

**Transportation Type**

- Railroad
- Roads
  - Arterial Road
  - Collector Road
  - Interstate
  - Local Road
  - U.S. Highway

**Base Information**

- Creek/Stream
- Intermittent Stream/Drain
- Great Lakes Shoreline
- Lakes/Ponds
- Mona Lake Watershed Area



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.

Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003

# Political Boundaries

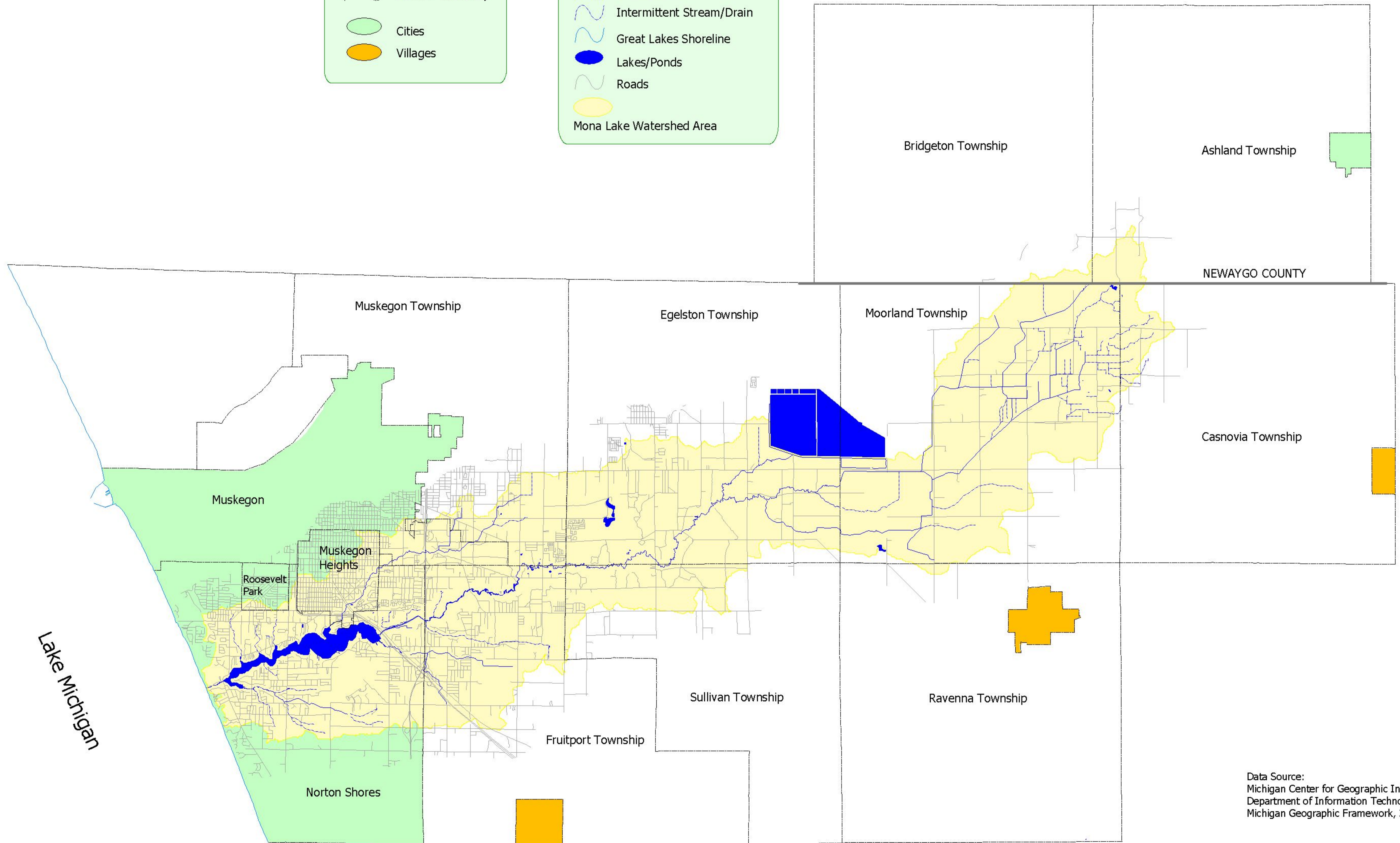
## Mona Lake Watershed

**Political Limits**

- Political Boundary
- Cities
- Villages

**Base Information**

- Creek/Stream
- Intermittent Stream/Drain
- Great Lakes Shoreline
- Lakes/Ponds
- Roads
- Mona Lake Watershed Area



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.



Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003

# Hydrography

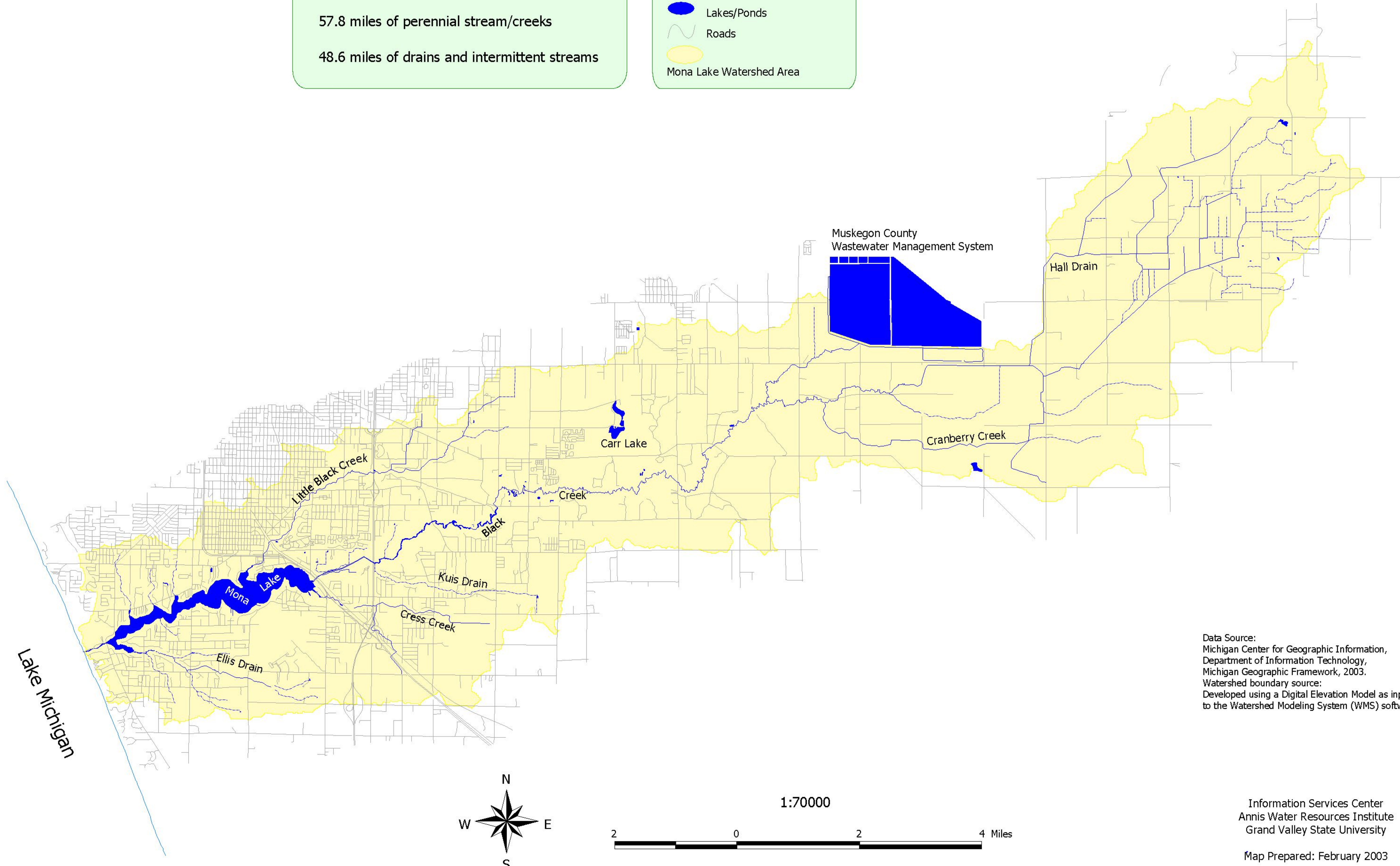
## Mona Lake Watershed

### Statistics

- 45,570 acres in the watershed
- 2425 acres of lake and pond surface area
- 57.8 miles of perennial stream/creeks
- 48.6 miles of drains and intermittent streams

### Base Information

-  Creek/Stream
-  Intermittent Stream/Drain
-  Great Lakes Shoreline
-  Lakes/Ponds
-  Roads
-  Mona Lake Watershed Area



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Watershed boundary source:  
Developed using a Digital Elevation Model as input  
to the Watershed Modeling System (WMS) software.

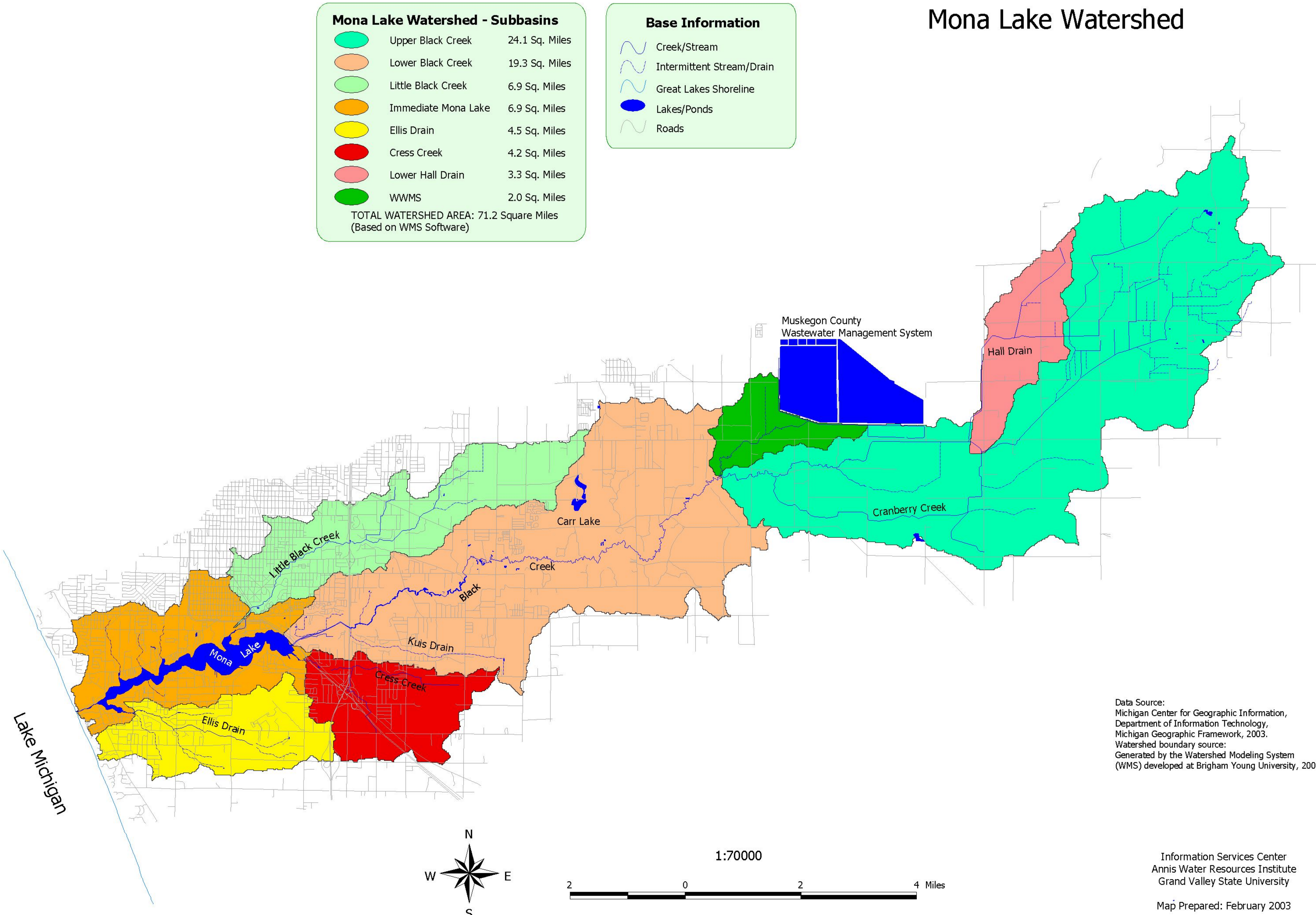
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Annis Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003



# Subbasins

## Mona Lake Watershed



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Watershed boundary source:  
Generated by the Watershed Modeling System  
(WMS) developed at Brigham Young University, 2003.


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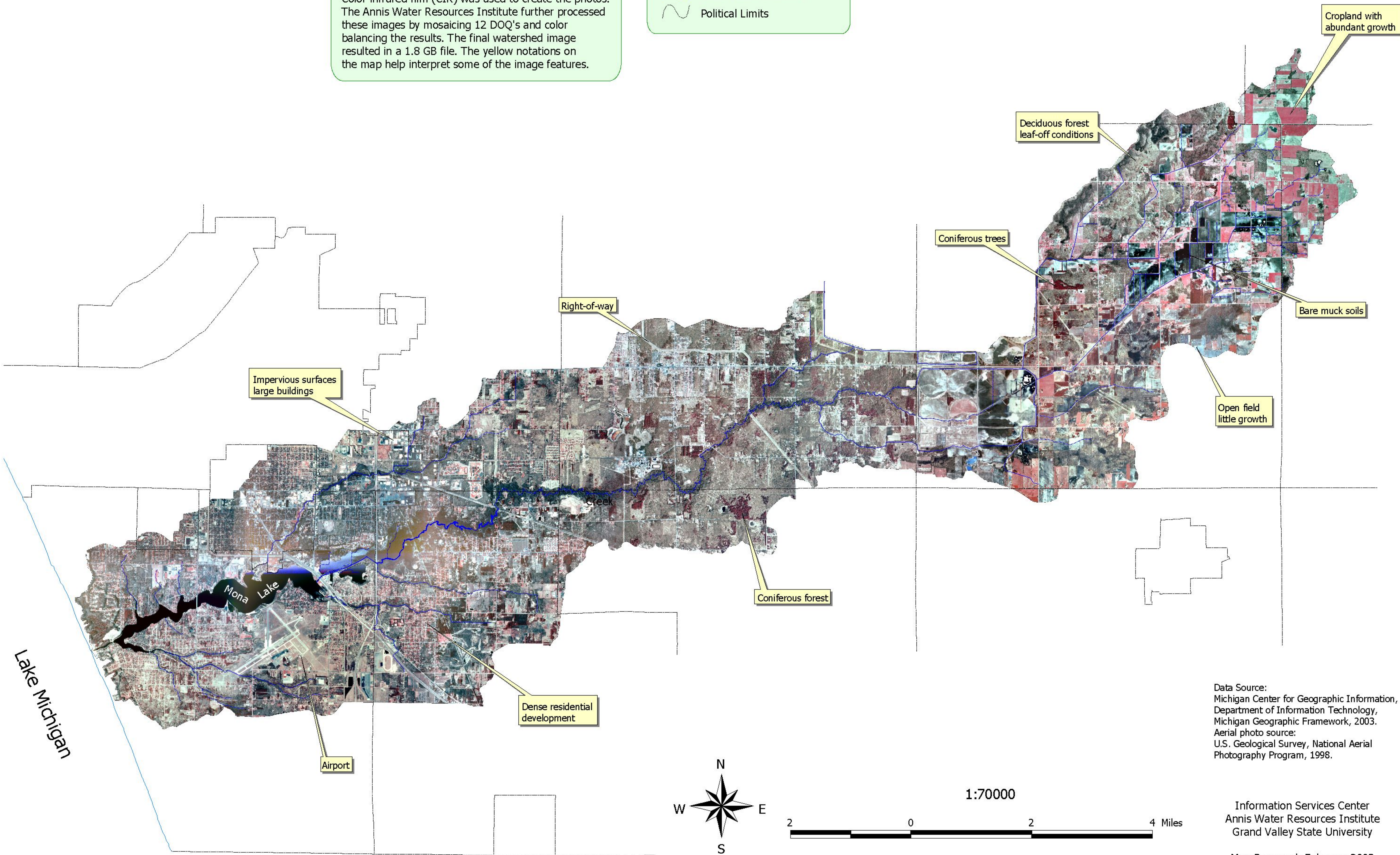
Map Prepared: February 2003

# Aerial Photo Mosaic

## Mona Lake Watershed

**ABOUT THE IMAGERY:**  
 This image is made up of a series of aerial photos taken by the U.S. Geological Survey (USGS) in April, 1998. The USGS orthorectified (removed distortion due to collection geometry and topography) these images into Digital Orthophoto Quadrangles (DOQ). Color infrared film (CIR) was used to create the photos. The Annis Water Resources Institute further processed these images by mosaicing 12 DOQ's and color balancing the results. The final watershed image resulted in a 1.8 GB file. The yellow notations on the map help interpret some of the image features.

- Base Information**
-  Creek/Stream
  -  Intermittent Stream/Drain
  -  Great Lakes Shoreline
  -  Political Limits



Data Source:  
 Michigan Center for Geographic Information,  
 Department of Information Technology,  
 Michigan Geographic Framework, 2003.  
 Aerial photo source:  
 U.S. Geological Survey, National Aerial  
 Photograph Program, 1998.

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Map Prepared: February 2003




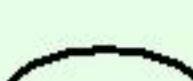
# Total Property Tax Base

## Mona Lake Watershed

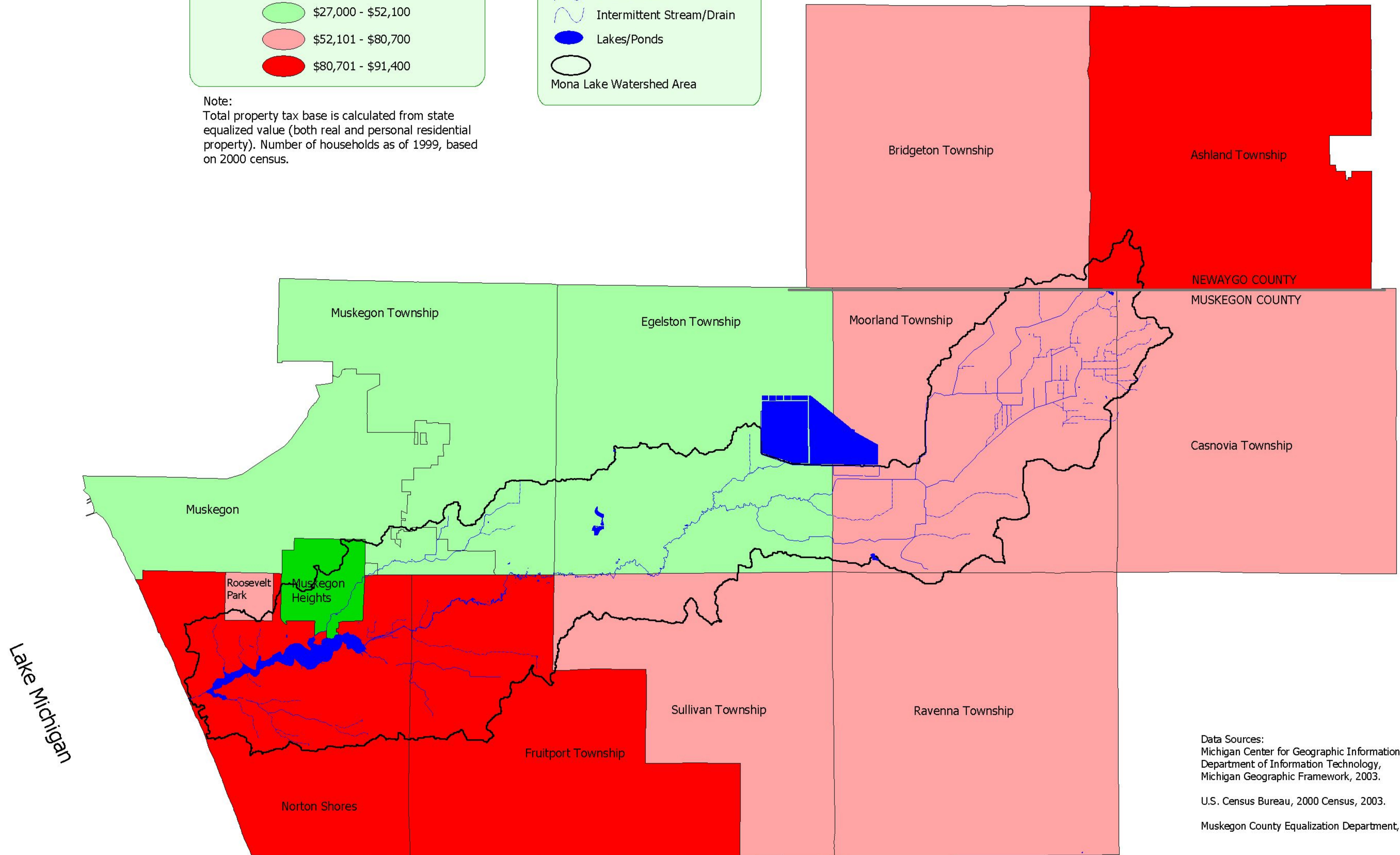
### Per Household - by Municipality

- < \$27,000
- \$27,000 - \$52,100
- \$52,101 - \$80,700
- \$80,701 - \$91,400

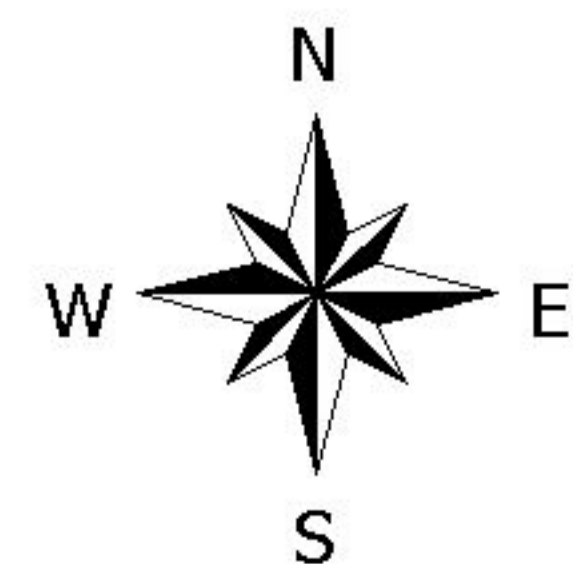
### Base Information

-  Creek/Stream
-  Intermittent Stream/Drain
-  Lakes/Ponds
-  Mona Lake Watershed Area

Note:  
Total property tax base is calculated from state equalized value (both real and personal residential property). Number of households as of 1999, based on 2000 census.



Data Sources:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
U.S. Census Bureau, 2000 Census, 2003.  
Muskegon County Equalization Department, 2003.



1:100000

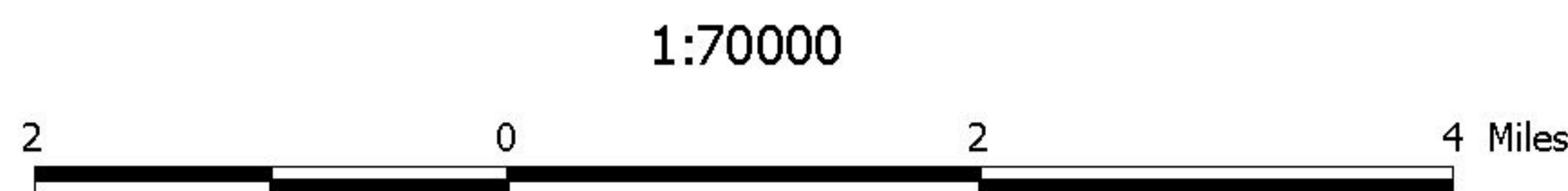
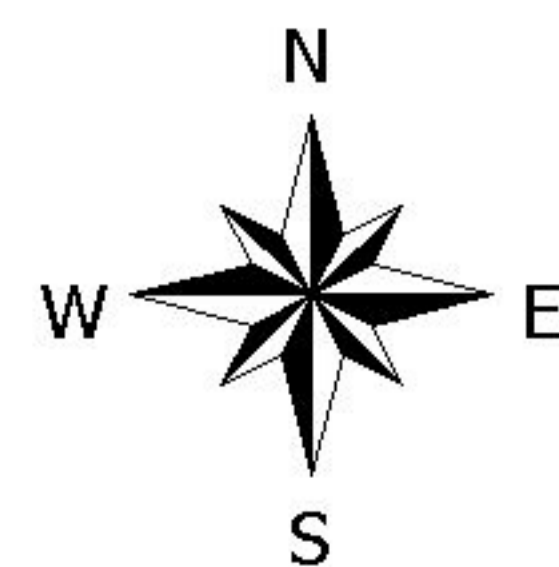
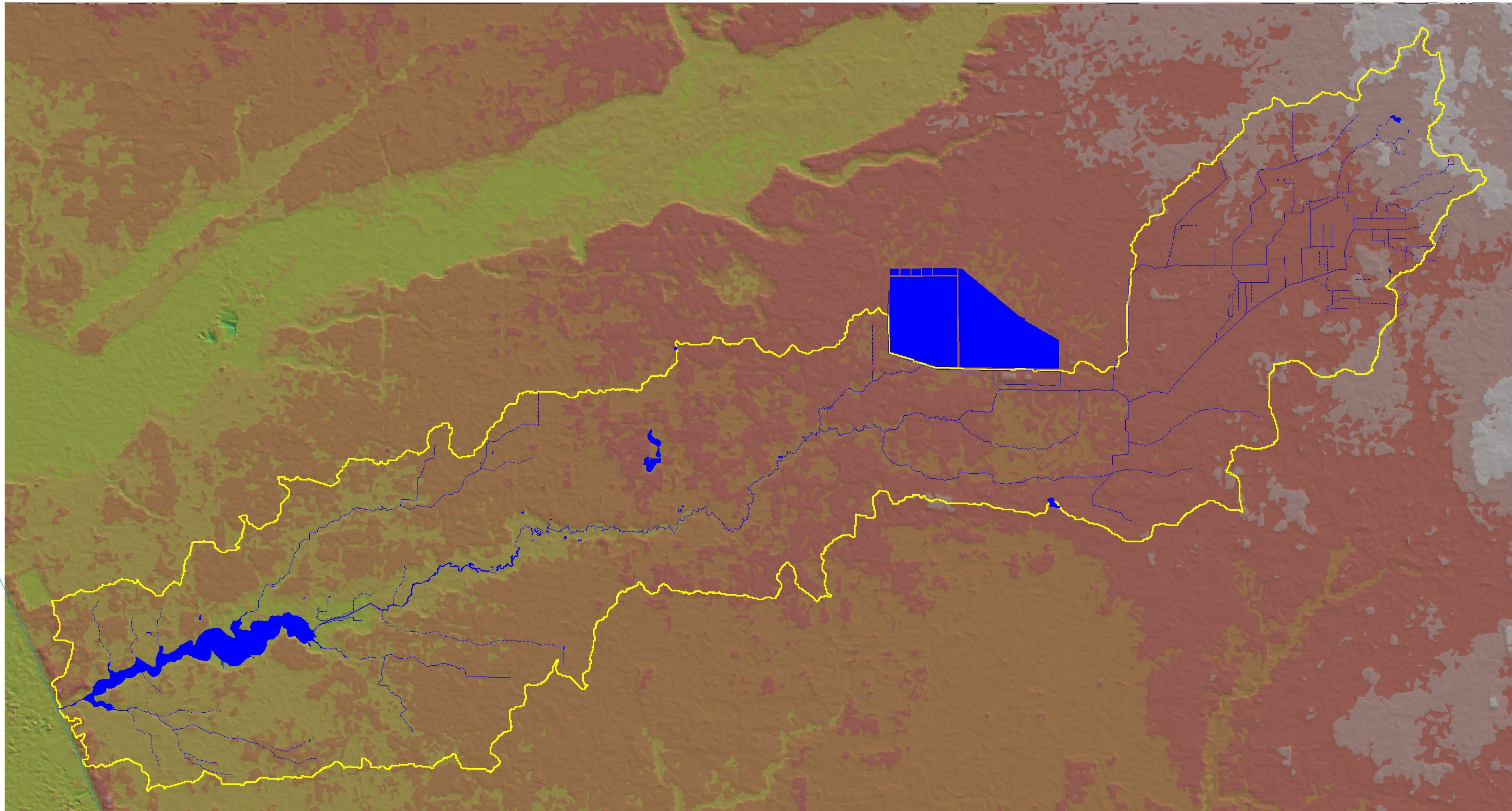
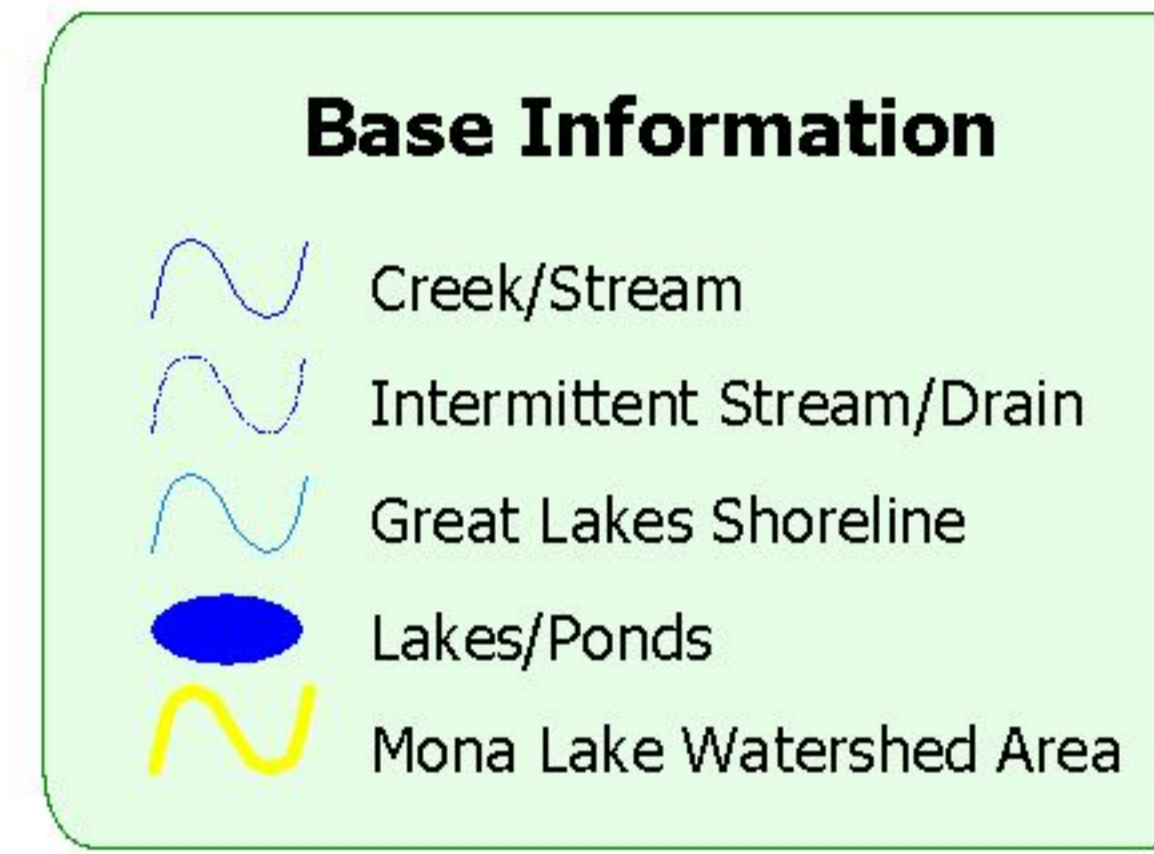
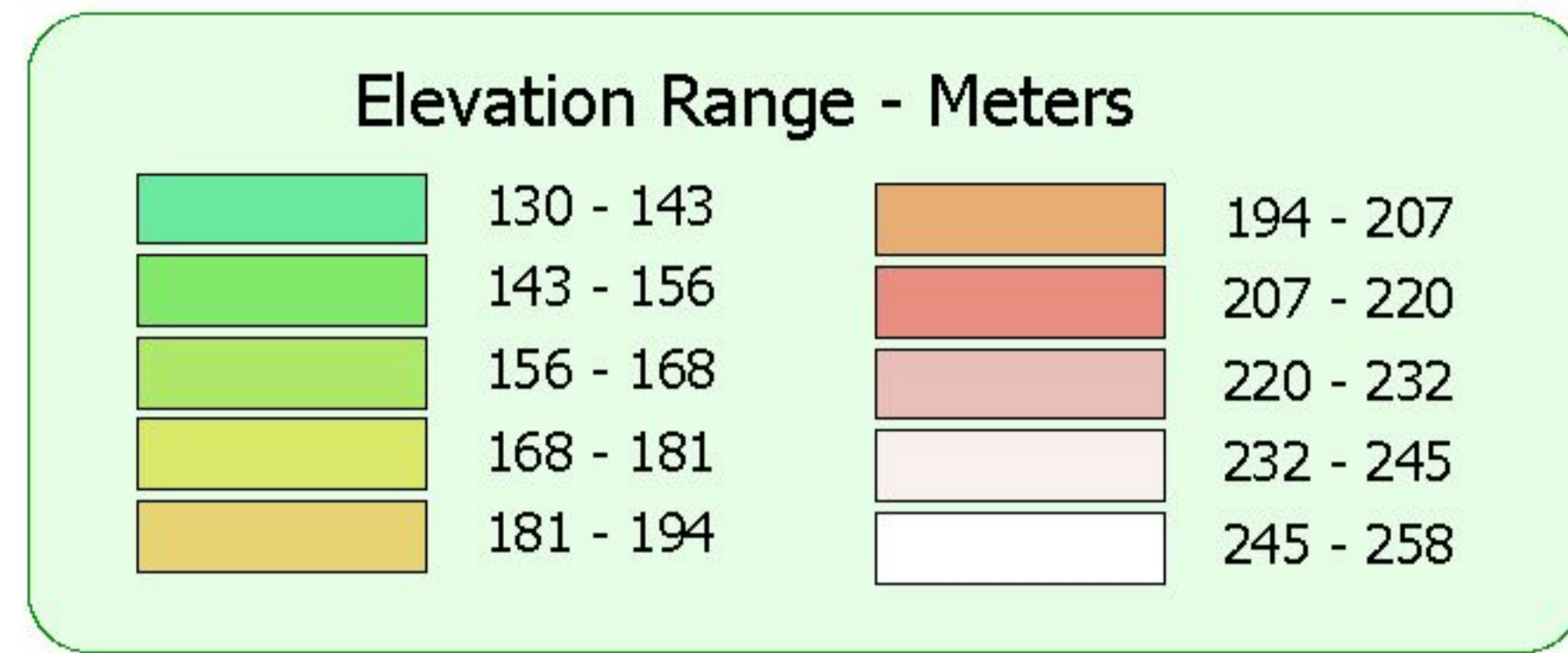


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Map Prepared: October 2003

# Digital Elevation Model

## Mona Lake Watershed



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Elevation source:  
Shuttle Radar Topography Mission (SRTM)  
aboard the Space Shuttle Endeavour, launched  
on Feb. 11, 2000. Obtained from the U.S.  
Geological Survey, EROS Data Center, 2003.

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# Land Use and Cover Classification System

## RESIDENTIAL

Residential land uses range from high density, multiple-unit structures of urban cores, to low density, where houses are on lots of more than one acre on the periphery of urban expansion. Included in this category are multi-family units, single family units, duplex units, and mobile home parks.

## COMMERCIAL/INSTITUTIONAL

Commercial land uses are those used predominantly for the sale of products and services. The main buildings, secondary structures, and areas supporting the basic use are all included -- office buildings, warehouses, driveways, sheds, parking lots, landscaped areas, and waste disposal areas. Education, religious, health, correctional, and military facilities are considered institutional. All buildings, grounds, and parking lots that compose the facility are included within the institutional unit.

## INDUSTRIAL

Industrial areas include a wide array of uses from light manufacturing and industrial parks to heavy manufacturing plants.

## OTHER DEVELOPED AREA

This land use includes areas used for transportation, communication, utilities infrastructure, extractive operations such as sand pits, and open land such as recreation facilities and cemeteries.

## CROPLAND

Land used to produce crops such as small grains, hay, or row crops including vegetables.

## ORCHARD OR OTHER SPECIALTY CROP

This land use includes orchards, vineyards, and bush fruits. Horticultural areas include nurseries, floricultural producers, and seed/sod producers.

## CONFINED FEEDING AND PERMANENT PASTURE

Feeding operations are large, specialized livestock production facilities, chiefly beef cattle feedlots and large poultry farms. Hog and fur-bearing animal farms also are included. Permanent pasture is land that produces grasses and certain types of legumes, which are grazed by animals.

## OTHER AGRICULTURAL LAND

Other agricultural land not included in the preceding three categories or combinations of agricultural land that cannot be clearly defined are included here. Land with greenhouses or land associated with agricultural production such as barns, out buildings, grain storage buildings, and the family farmhouse are in this category.

## OPEN FIELD

Areas of open field support early stages of plant succession consisting of plant communities characterized by grasses or shrubs. In cases where there is obvious evidence of seeding, fertilizing, or other cultural practices, these areas are mapped as permanent pasture.

## FOREST

Forest lands are lands that are at least ten percent stocked by deciduous and/or coniferous tree species.

## WATER

This category includes all areas that are predominantly or persistently covered with water.

## WETLAND

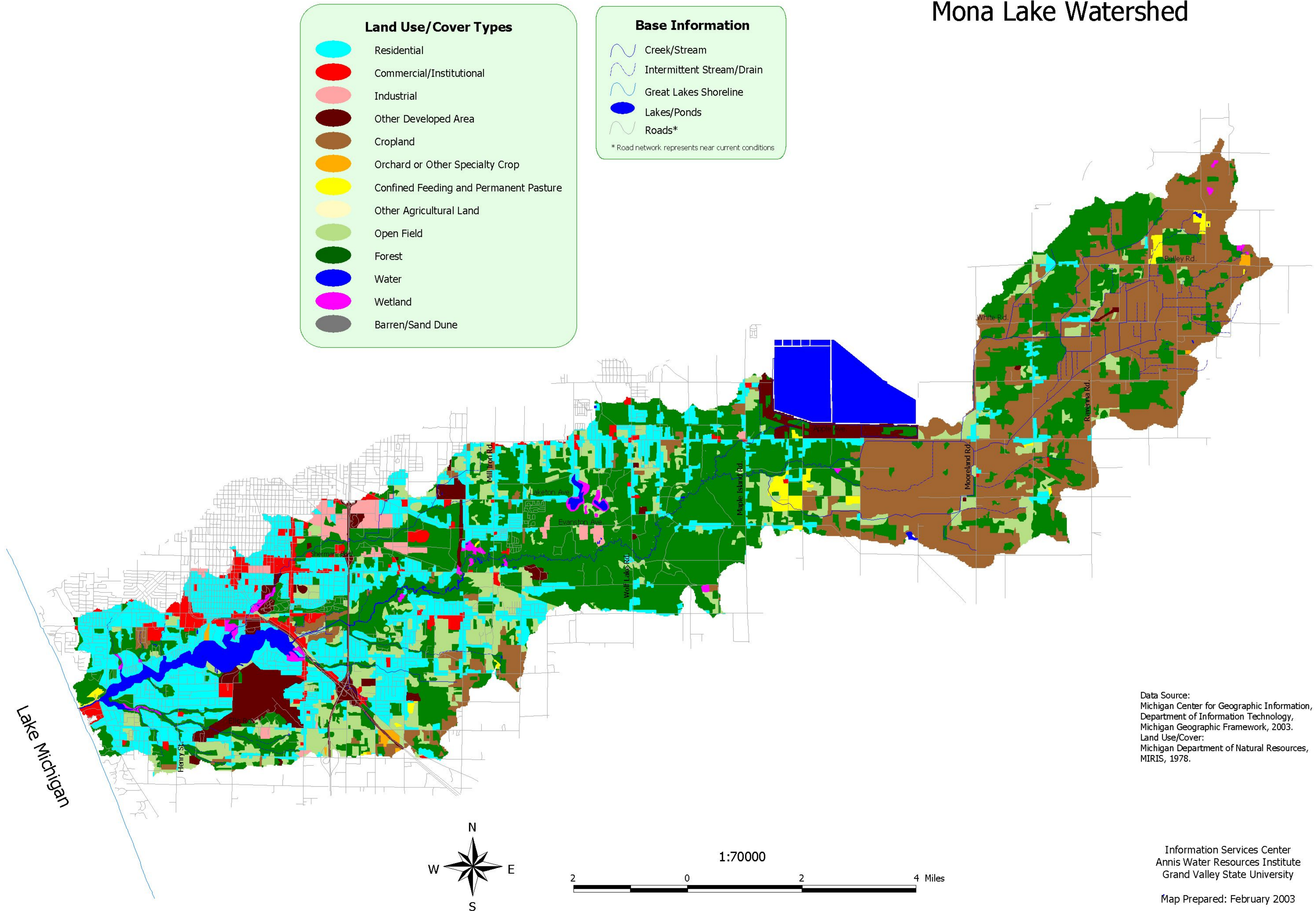
Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation is established.

## BARREN/SAND DUNE

Barren land (non-vegetated) is land that has little or no vegetation. Types of land use/cover considered in this category include beaches, riverbanks, sand dunes, and bare exposed rock.

# Land Use/Cover - 1978

## Mona Lake Watershed



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Land Use/Cover:  
Michigan Department of Natural Resources,  
MIRIS, 1978.



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# Land Use/Cover - 1997

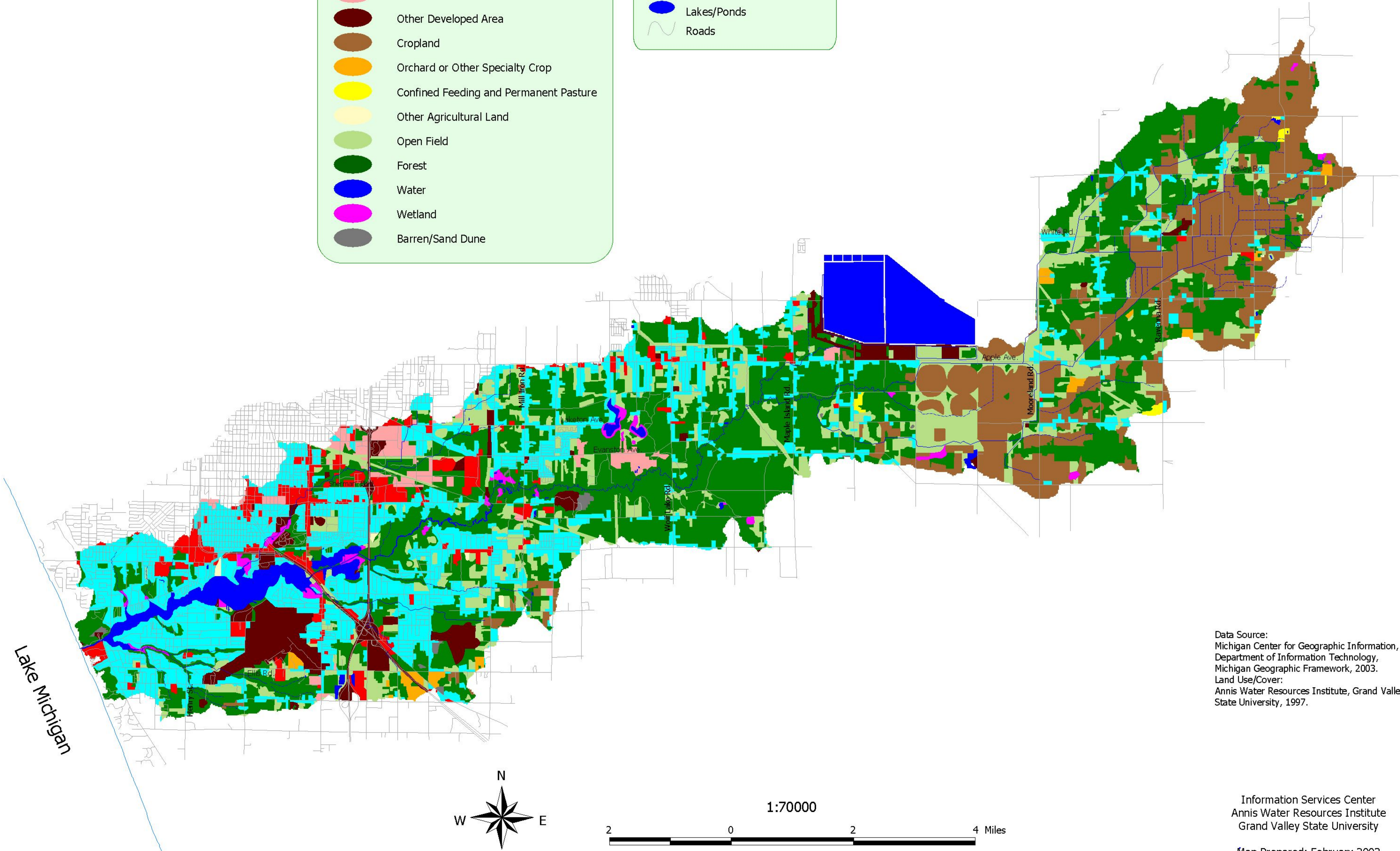
## Mona Lake Watershed

### Land Use/Cover Types

-  Residential
-  Commercial/Institutional
-  Industrial
-  Other Developed Area
-  Cropland
-  Orchard or Other Specialty Crop
-  Confined Feeding and Permanent Pasture
-  Other Agricultural Land
-  Open Field
-  Forest
-  Water
-  Wetland
-  Barren/Sand Dune

### Base Information

-  Creek/Stream
-  Intermittent Stream/Drain
-  Great Lakes Shoreline
-  Lakes/Ponds
-  Roads



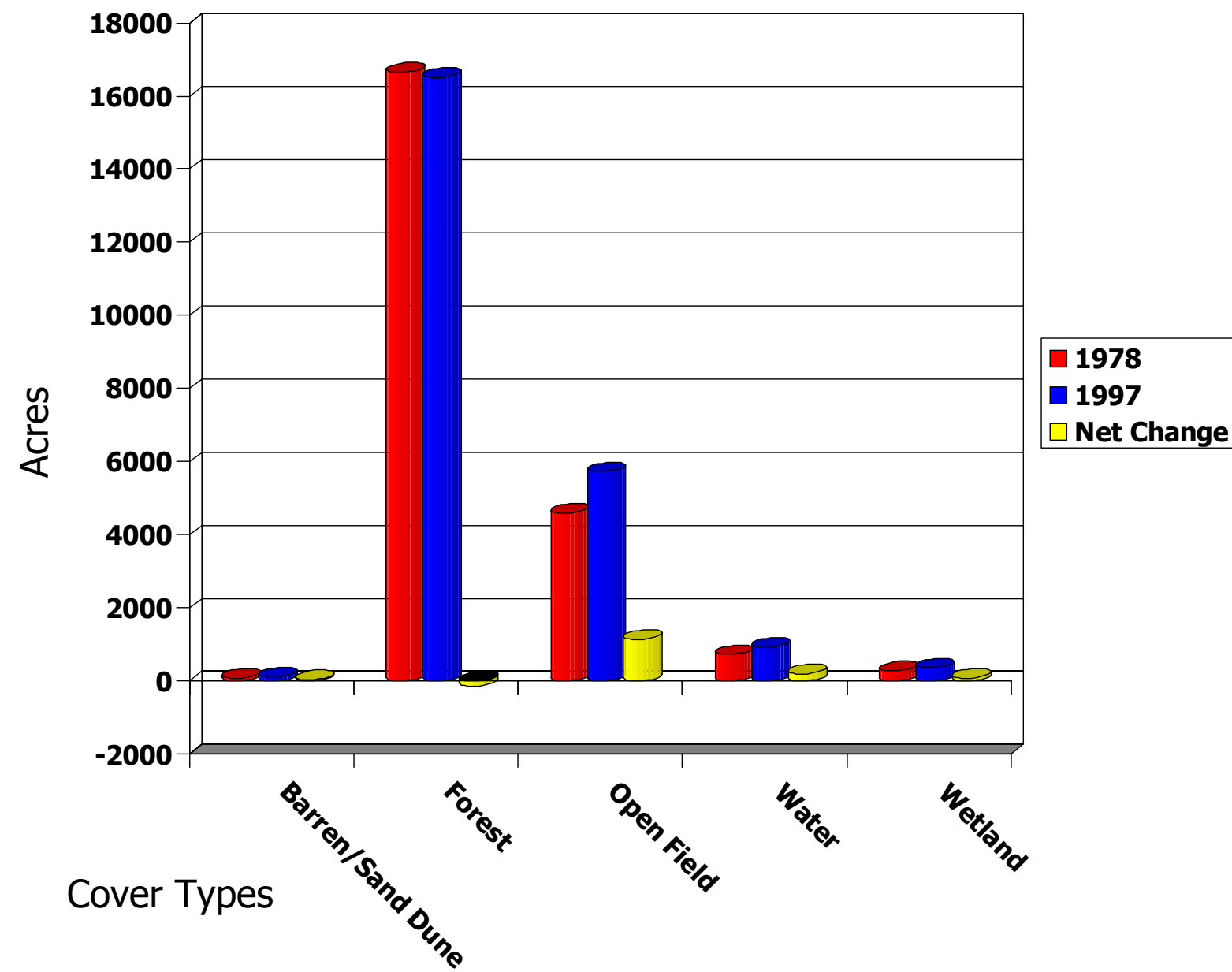
Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Land Use/Cover:  
Annis Water Resources Institute, Grand Valley  
State University, 1997.

Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

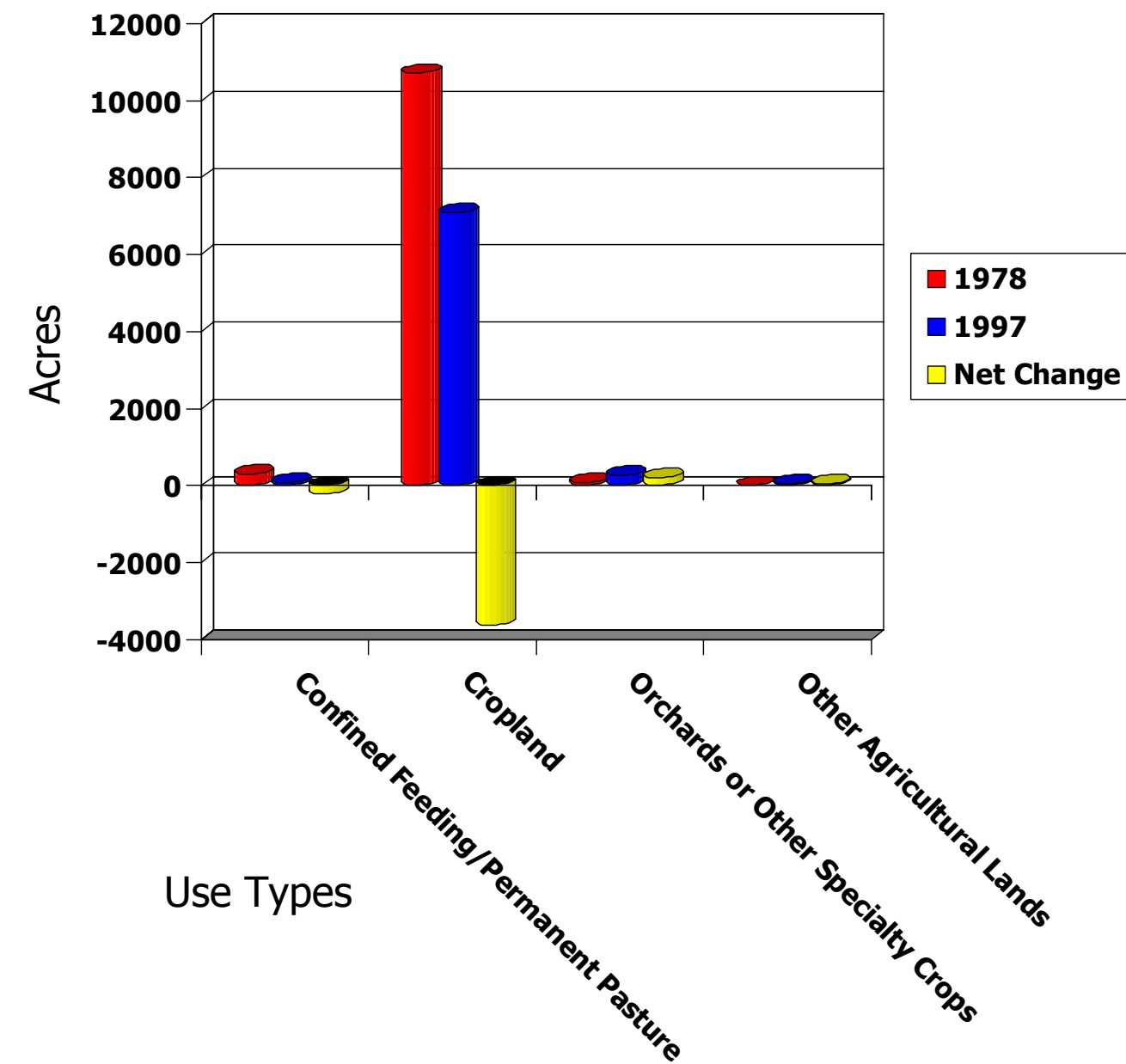
Map Prepared: February 2003

# Land Use and Cover Change Analysis

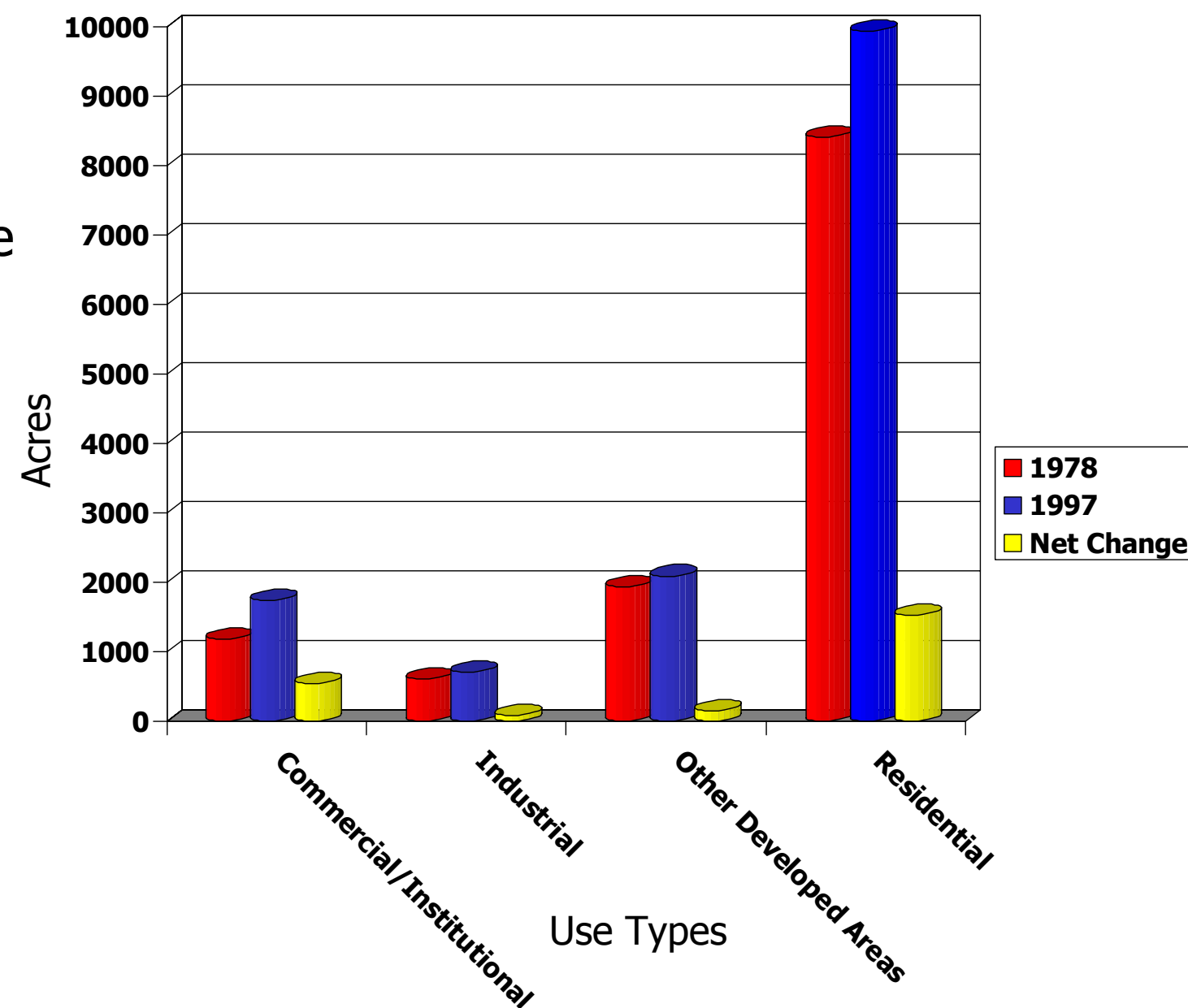
## Natural Cover Change 1978 to 1997



## Agricultural Use Change 1978 to 1997



## Developed Use Change 1978 to 1997



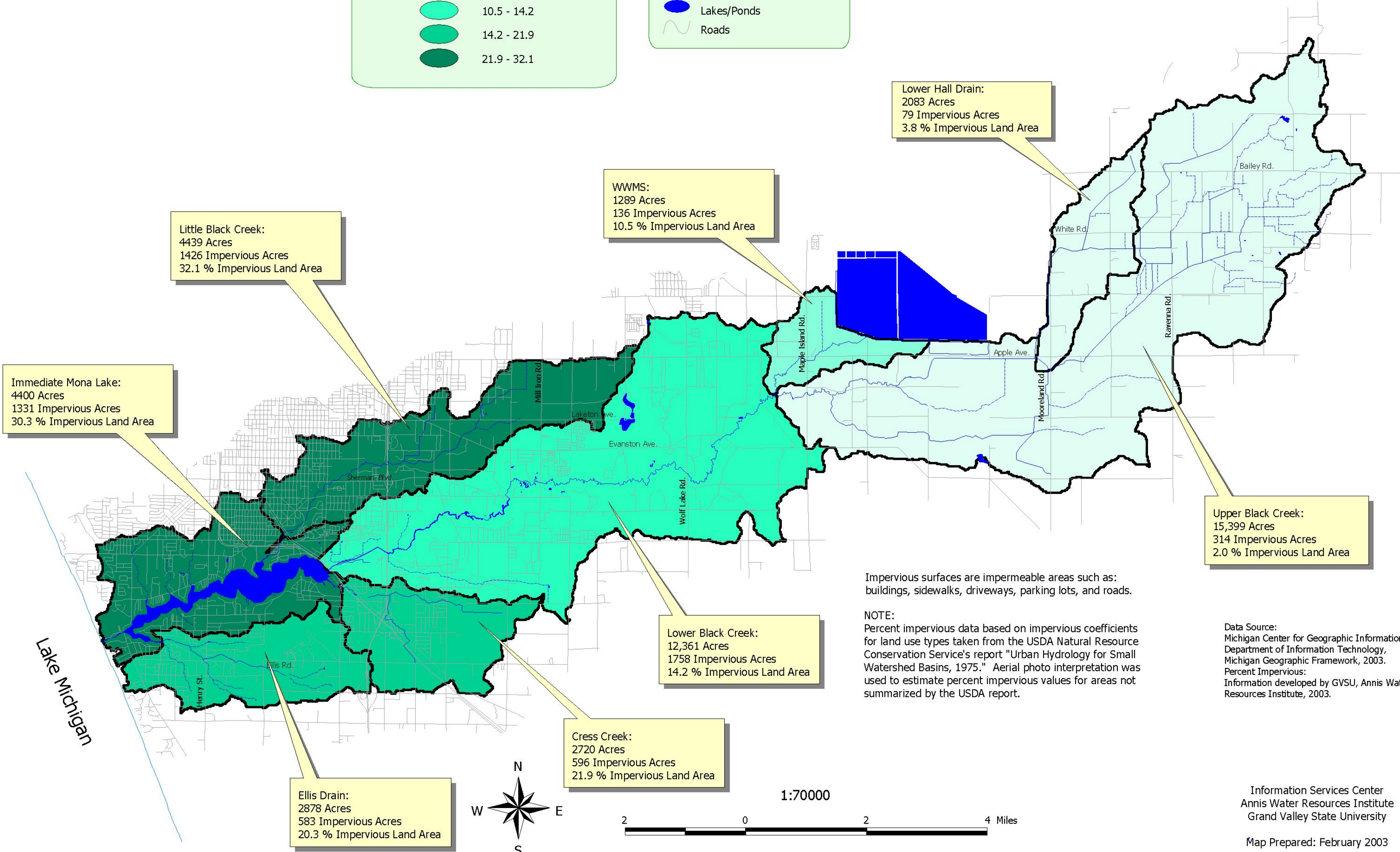
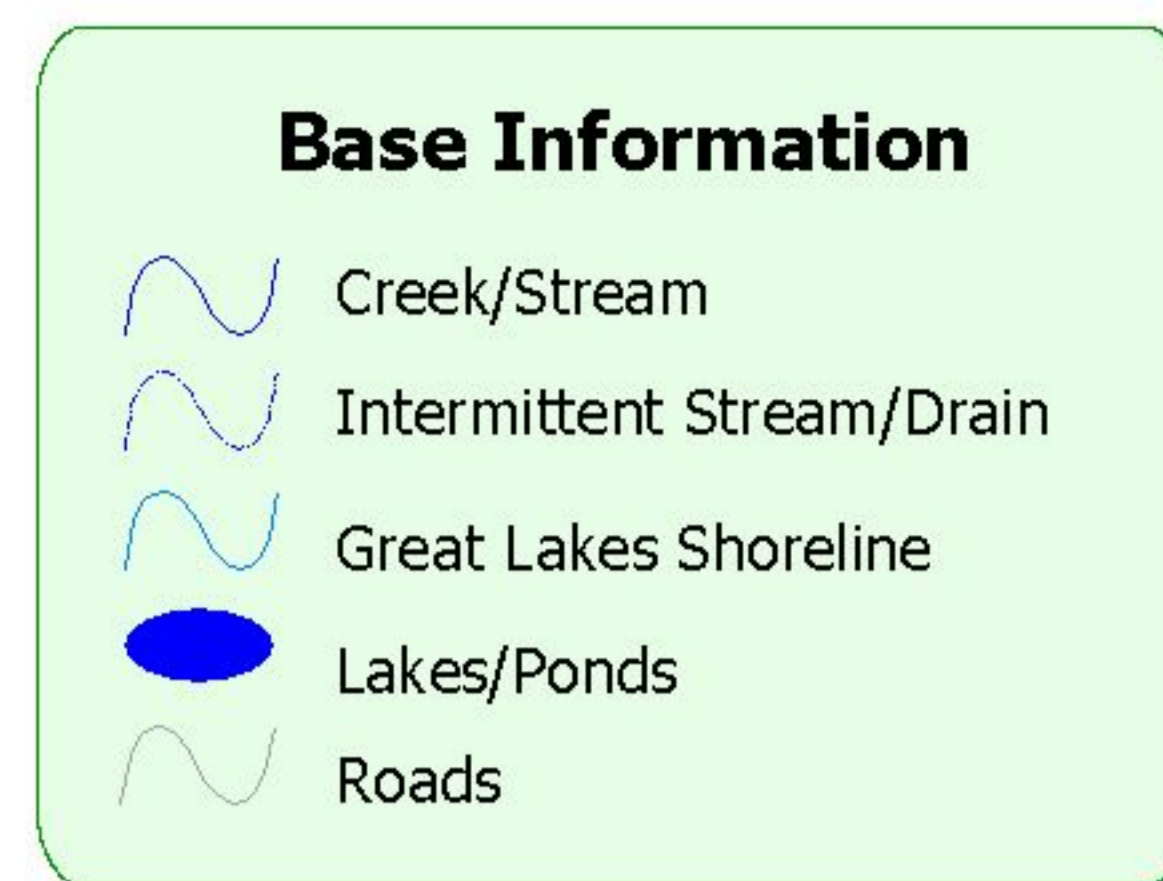
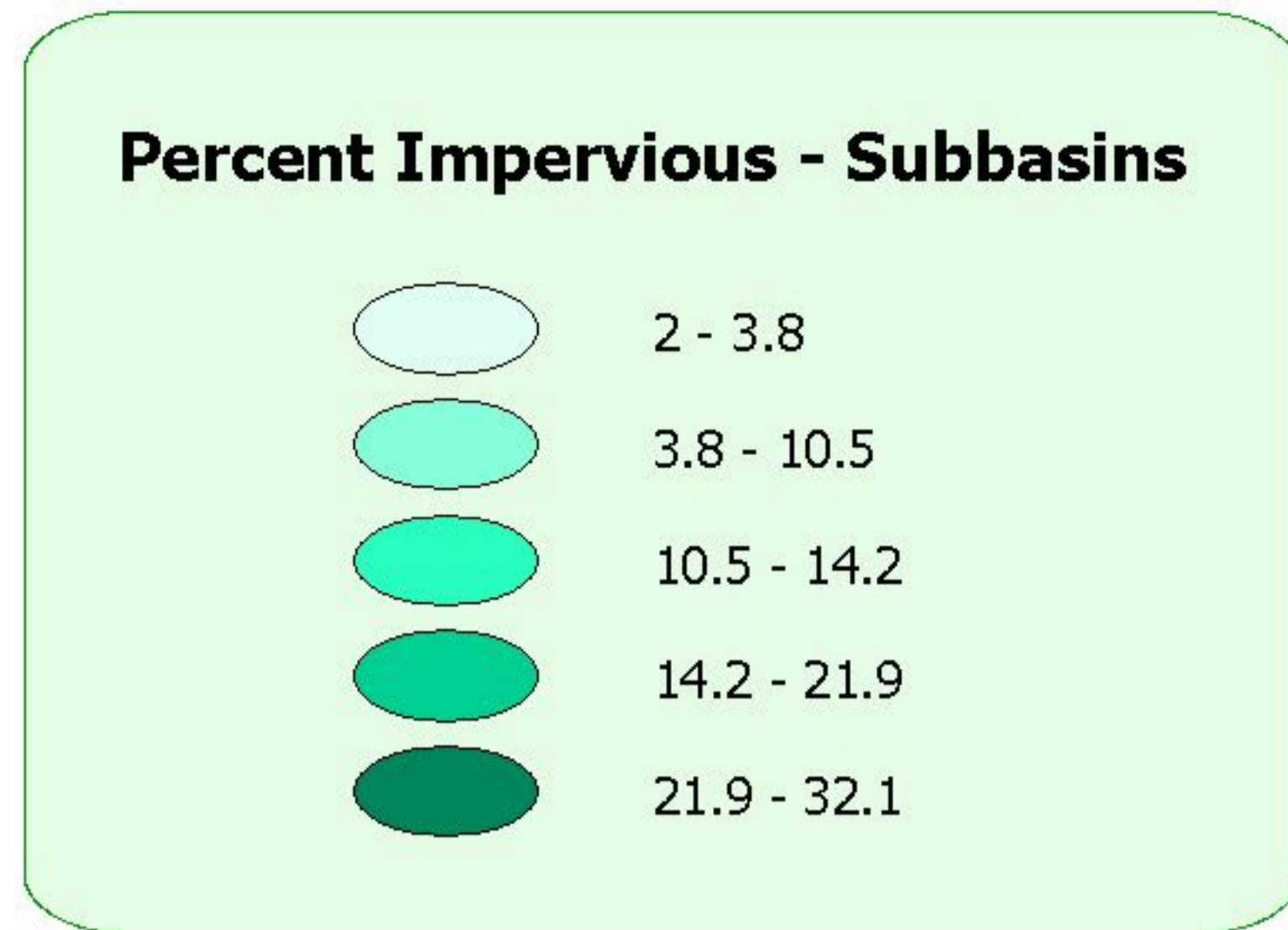
## Change Statistics

	Acres - 1978	% of Total - 1978	Acres - 1997	% of Total - 1997	Net Change (Acres)	Net Change (%)
<b>Natural Cover</b>						
Barren/Sand Dune	70	0.2	99	0.2	29	41
Forest	16655	36.5	16511	36.2	-144	-1
Open Field	4591	10.1	5726	12.6	1135	25
Water	725	1.6	917	2.0	192	26
Wetland	279	0.6	349	0.8	70	25
	22320	49.0	23602	51.8	1282	
<b>Agricultural Use</b>						
Confined Feeding or Permanent Pasture	305	0.7	82	0.2	-223	-73
Cropland	10711	23.5	7098	15.6	-3613	-34
Orchard or Other Specialty Crops	88	0.2	283	0.6	195	222
Other Agricultural Lands	0	0.0	40	0.1	40	100
	11104	24.4	7503	16.5	-3601	
<b>Developed Use</b>						
Commercial/Institutional	1184	2.6	1733	3.8	549	46
Industrial	614	1.3	706	1.5	92	15
Other Developed Areas	1935	4.2	2092	4.6	157	8
Residential	8413	18.5	9935	21.8	1522	18
	12146	26.6	14466	31.7	2320	
<b>TOTAL WATERSHED ACRES</b>						
	45570		45570			



# Percent Impervious

## Mona Lake Watershed



Little Black Creek:  
4439 Acres  
1426 Impervious Acres  
32.1 % Impervious Land Area

WWMS:  
1289 Acres  
136 Impervious Acres  
10.5 % Impervious Land Area

Lower Hall Drain:  
2083 Acres  
79 Impervious Acres  
3.8 % Impervious Land Area

Upper Black Creek:  
15,399 Acres  
314 Impervious Acres  
2.0 % Impervious Land Area

Immediate Mona Lake:  
4400 Acres  
1331 Impervious Acres  
30.3 % Impervious Land Area

Lower Black Creek:  
12,361 Acres  
1758 Impervious Acres  
14.2 % Impervious Land Area

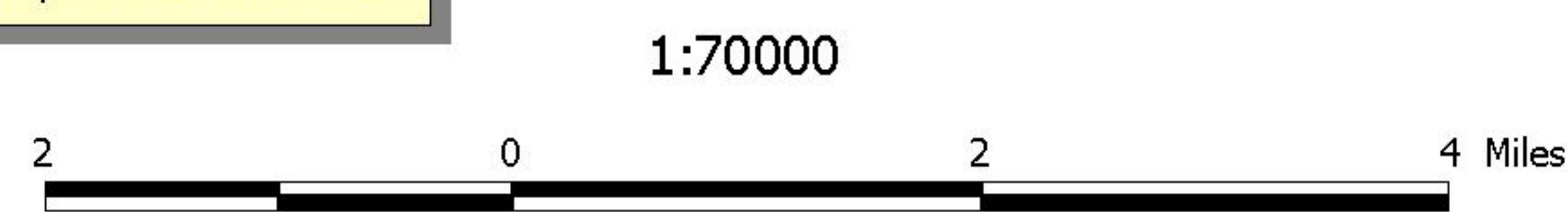
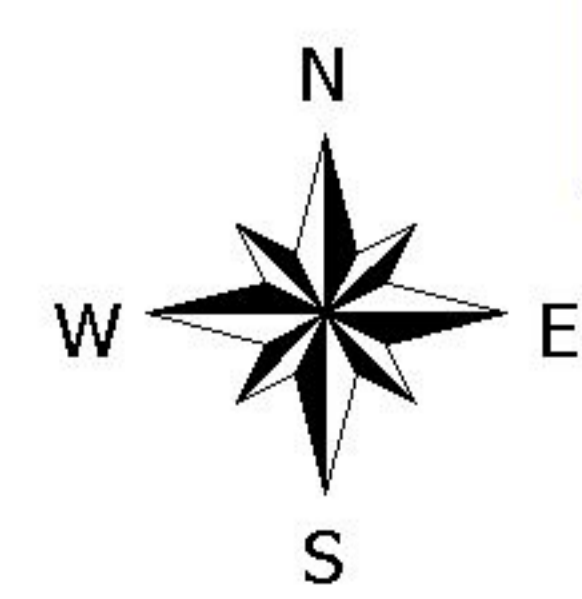
Cress Creek:  
2720 Acres  
596 Impervious Acres  
21.9 % Impervious Land Area

Ellis Drain:  
2878 Acres  
583 Impervious Acres  
20.3 % Impervious Land Area

Impervious surfaces are impermeable areas such as: buildings, sidewalks, driveways, parking lots, and roads.

NOTE:  
Percent impervious data based on impervious coefficients for land use types taken from the USDA Natural Resource Conservation Service's report "Urban Hydrology for Small Watershed Basins, 1975." Aerial photo interpretation was used to estimate percent impervious values for areas not summarized by the USDA report.

Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Percent Impervious:  
Information developed by GVSU, Annis Water  
Resources Institute, 2003.



Information Services Center  
Annis Water Resources Institute  
Grand Valley State University





Map Prepared: February 2003

# Wetlands

National Wetlands Inventory

## Mona Lake Watershed

### Wetland Types

	Aquatic Bed	3 Acres
	Emergent	520 Acres
	Scrub-Shrub	258 Acres
	Forested	3227 Acres

### Base Information

	Creek/Stream
	Intermittent Stream/Drain
	Great Lakes Shoreline
	Lakes/Ponds
	Roads
	Watershed Boundary

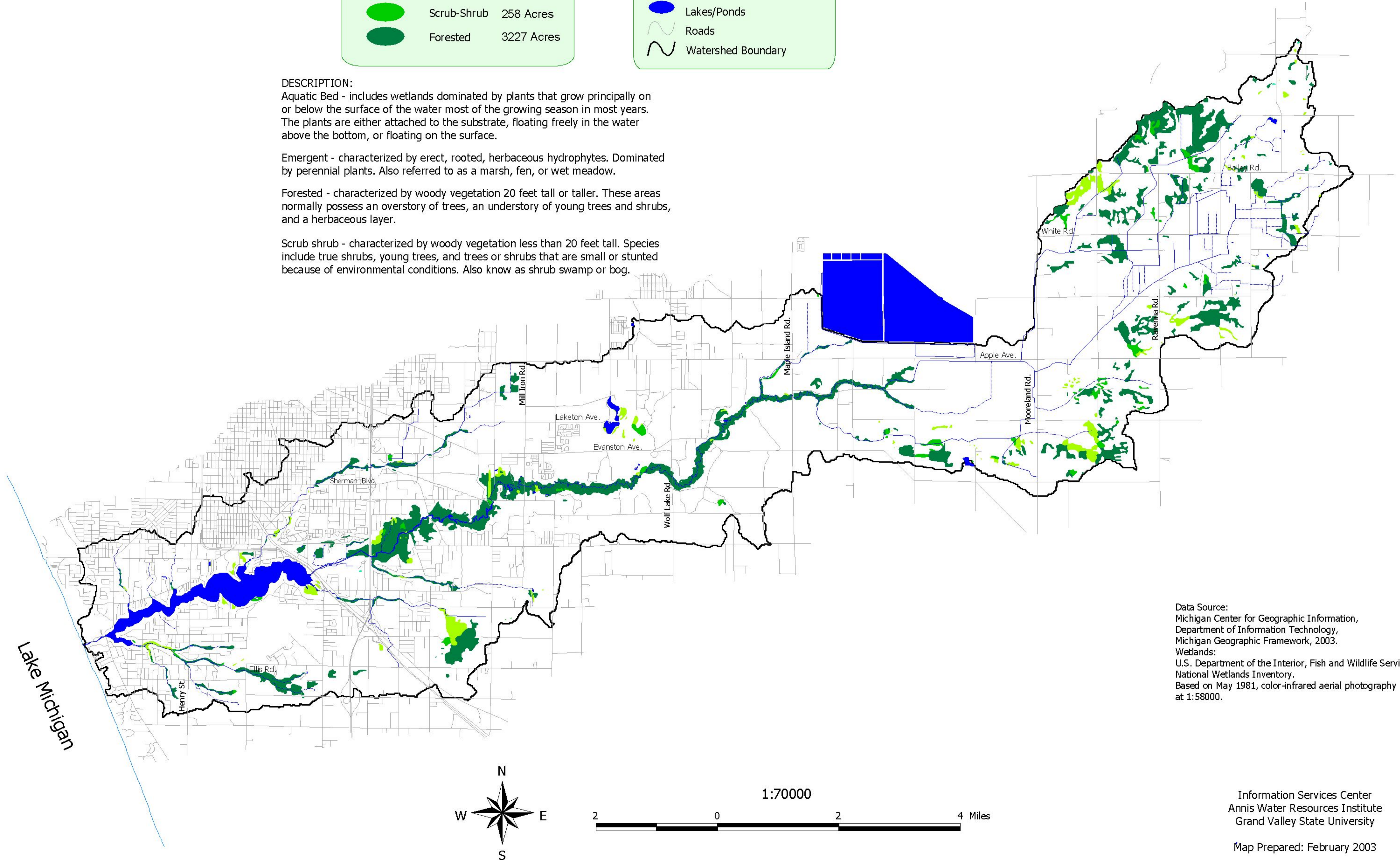
#### DESCRIPTION:

**Aquatic Bed** - includes wetlands dominated by plants that grow principally on or below the surface of the water most of the growing season in most years. The plants are either attached to the substrate, floating freely in the water above the bottom, or floating on the surface.

**Emergent** - characterized by erect, rooted, herbaceous hydrophytes. Dominated by perennial plants. Also referred to as a marsh, fen, or wet meadow.

**Forested** - characterized by woody vegetation 20 feet tall or taller. These areas normally possess an overstory of trees, an understory of young trees and shrubs, and a herbaceous layer.

**Scrub shrub** - characterized by woody vegetation less than 20 feet tall. Species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Also known as shrub swamp or bog.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Wetlands:  
U.S. Department of the Interior, Fish and Wildlife Service,  
National Wetlands Inventory.  
Based on May 1981, color-infrared aerial photography  
at 1:58000.

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Ann Arbor Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003






# Presettlement Landscape

## Mona Lake Watershed

### Vegetation Types

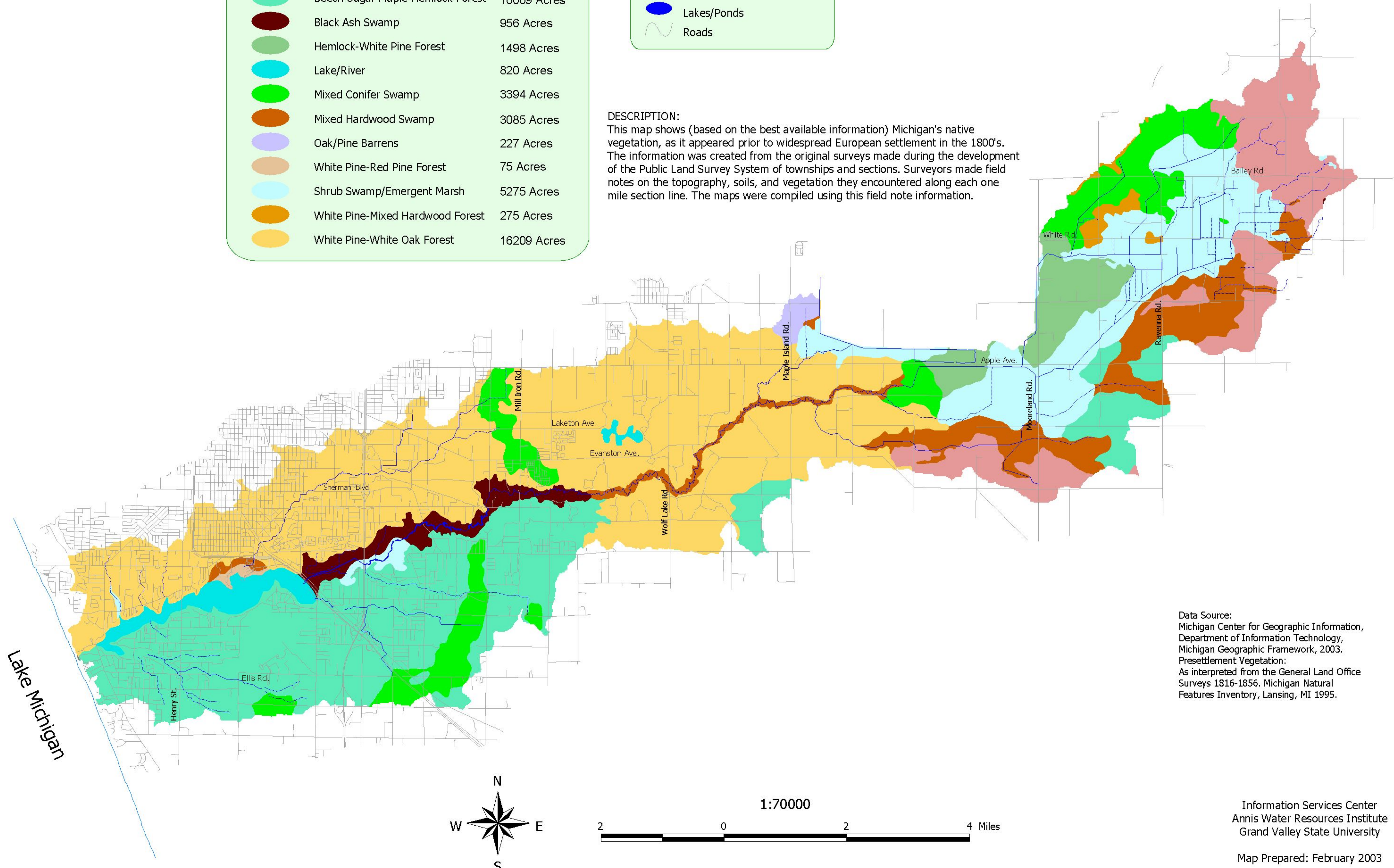
	Beach, Riverbank	1 Acre
	Beech-Sugar Maple Forest	3745 Acres
	Beech-Sugar Maple-Hemlock Forest	10009 Acres
	Black Ash Swamp	956 Acres
	Hemlock-White Pine Forest	1498 Acres
	Lake/River	820 Acres
	Mixed Conifer Swamp	3394 Acres
	Mixed Hardwood Swamp	3085 Acres
	Oak/Pine Barrens	227 Acres
	White Pine-Red Pine Forest	75 Acres
	Shrub Swamp/Emergent Marsh	5275 Acres
	White Pine-Mixed Hardwood Forest	275 Acres
	White Pine-White Oak Forest	16209 Acres

### Base Information

	Creek/Stream
	Intermittent Stream/Drain
	Great Lakes Shoreline
	Lakes/Ponds
	Roads

### DESCRIPTION:

This map shows (based on the best available information) Michigan's native vegetation, as it appeared prior to widespread European settlement in the 1800's. The information was created from the original surveys made during the development of the Public Land Survey System of townships and sections. Surveyors made field notes on the topography, soils, and vegetation they encountered along each one mile section line. The maps were compiled using this field note information.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Presettlement Vegetation:  
As interpreted from the General Land Office  
Surveys 1816-1856. Michigan Natural  
Features Inventory, Lansing, MI 1995.

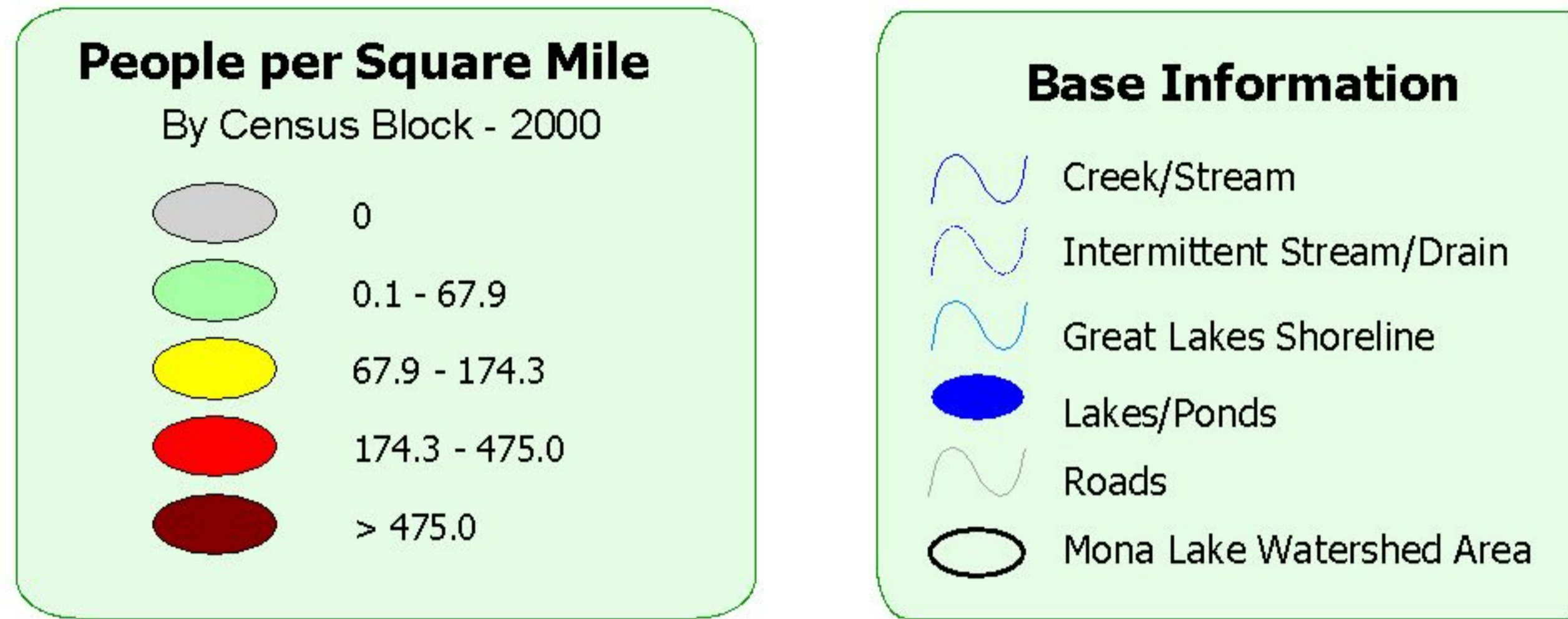
Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003

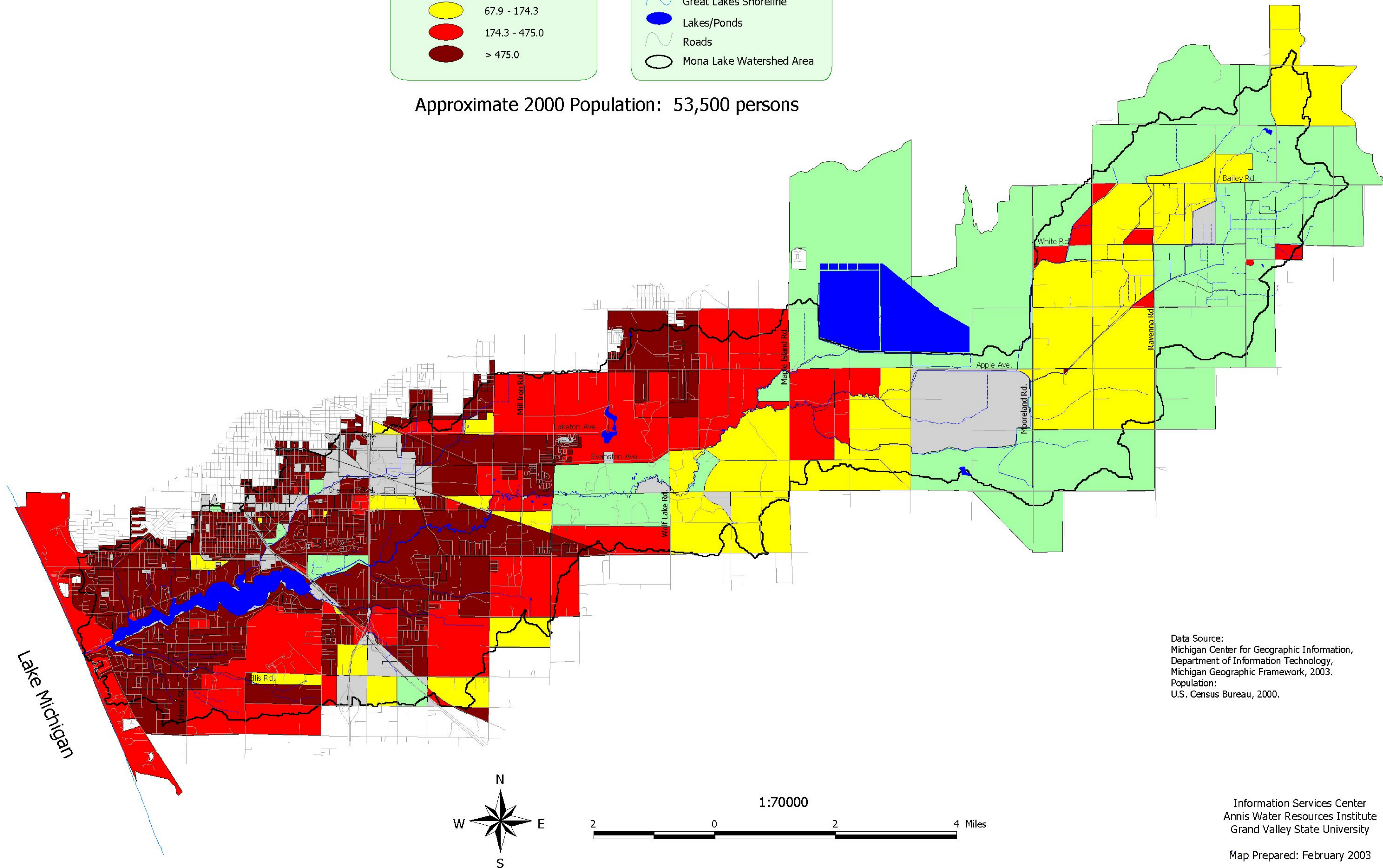
# Population Density

2000 Census

Mona Lake Watershed



Approximate 2000 Population: 53,500 persons



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Population:  
U.S. Census Bureau, 2000.



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Annis Water Resources Institute  
Grand Valley State University

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# Trout Streams and Lakes

## Mona Lake Watershed

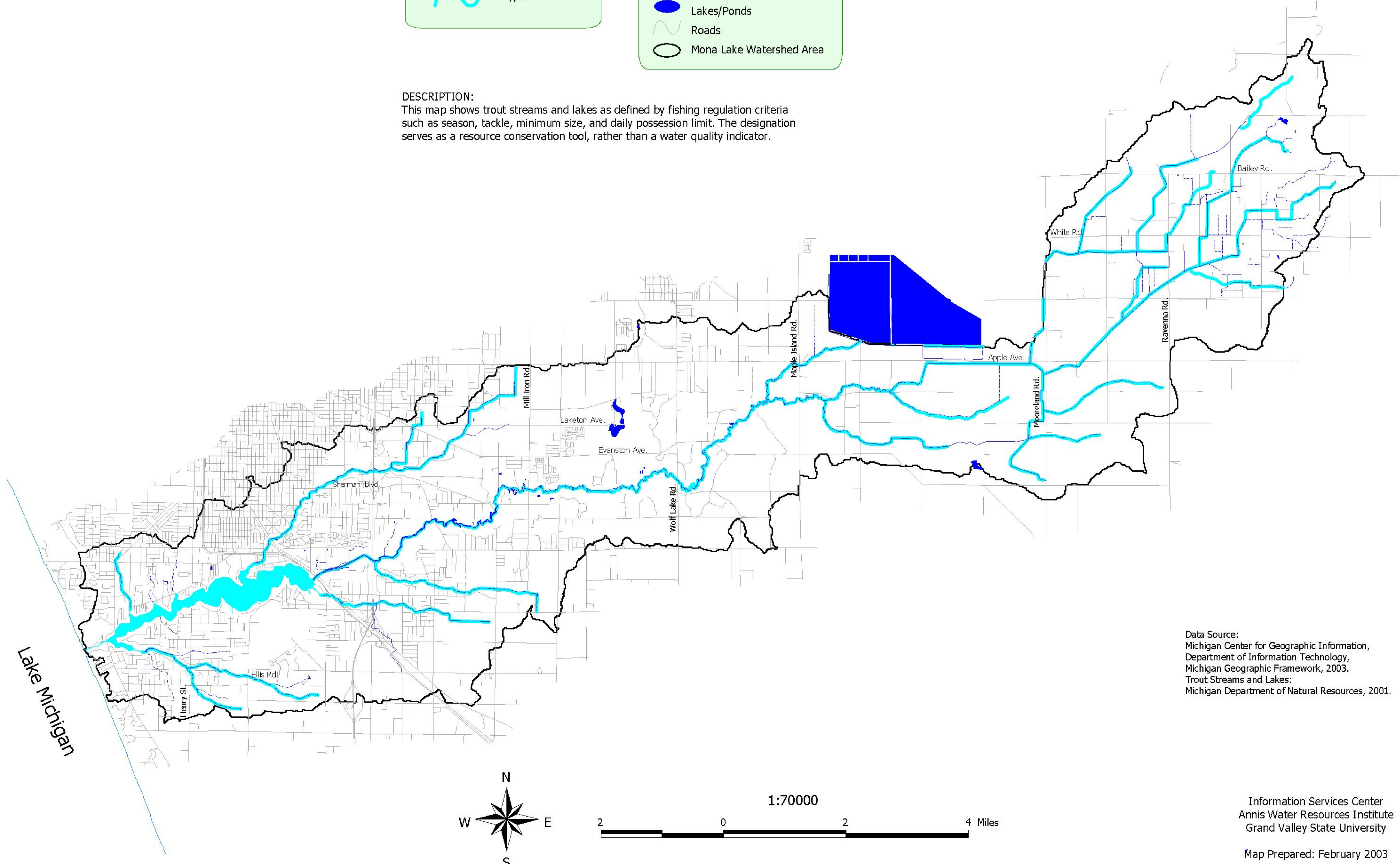
**Designation**

-  Trout Lake
-  Type I Stream

**Base Information**

-  Creek/Stream
-  Intermittent Stream/Drain
-  Great Lakes Shoreline
-  Lakes/Ponds
-  Roads
-  Mona Lake Watershed Area

**DESCRIPTION:**  
This map shows trout streams and lakes as defined by fishing regulation criteria such as season, tackle, minimum size, and daily possession limit. The designation serves as a resource conservation tool, rather than a water quality indicator.



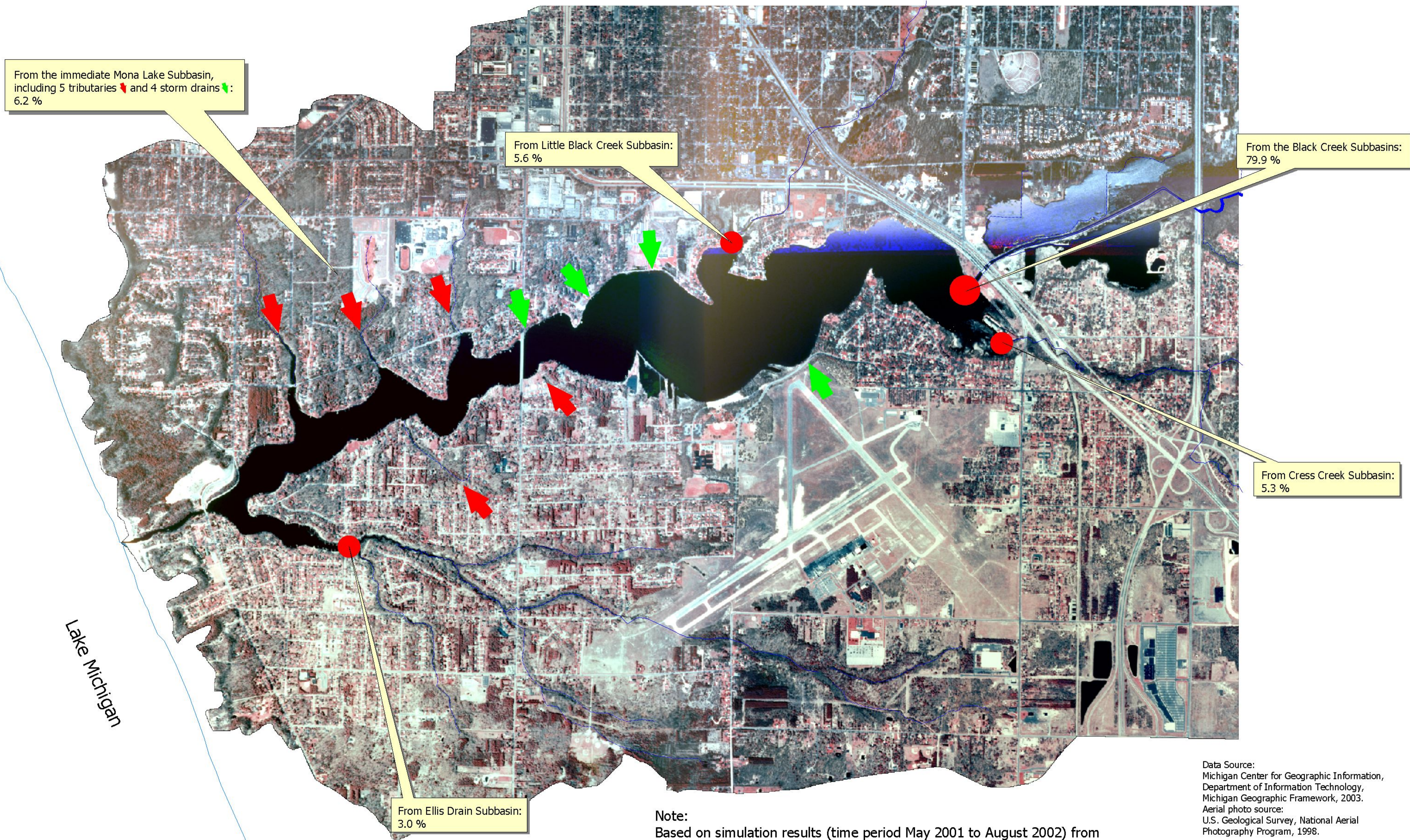
Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Trout Streams and Lakes:  
Michigan Department of Natural Resources, 2001.

Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

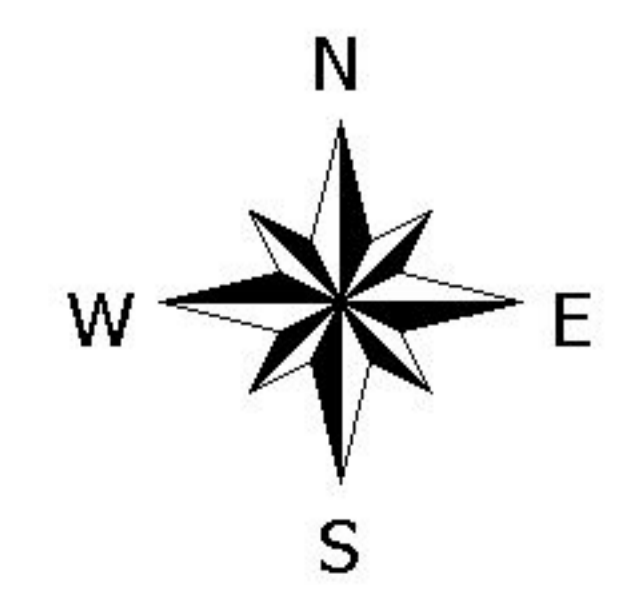
Map Prepared: February 2003

# Water Sources of Mona Lake

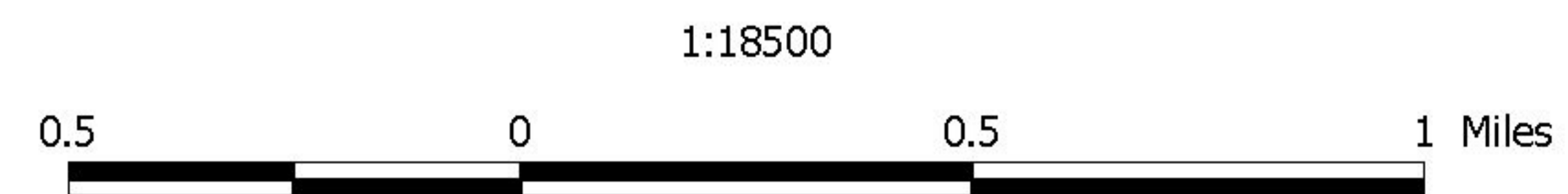
Mona Lake Watershed



Lake Michigan



**Note:**  
Based on simulation results (time period May 2001 to August 2002) from the Watershed Modeling System, the percentages represent the amount of water discharged into Mona Lake from the various subbasins.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Aerial photo source:  
U.S. Geological Survey, National Aerial  
Photography Program, 1998.

Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

Map Prepared: February 2003

# Groundwater Stream Base Flow

## Mona Lake Watershed

### Percent of Base Flow From Groundwater

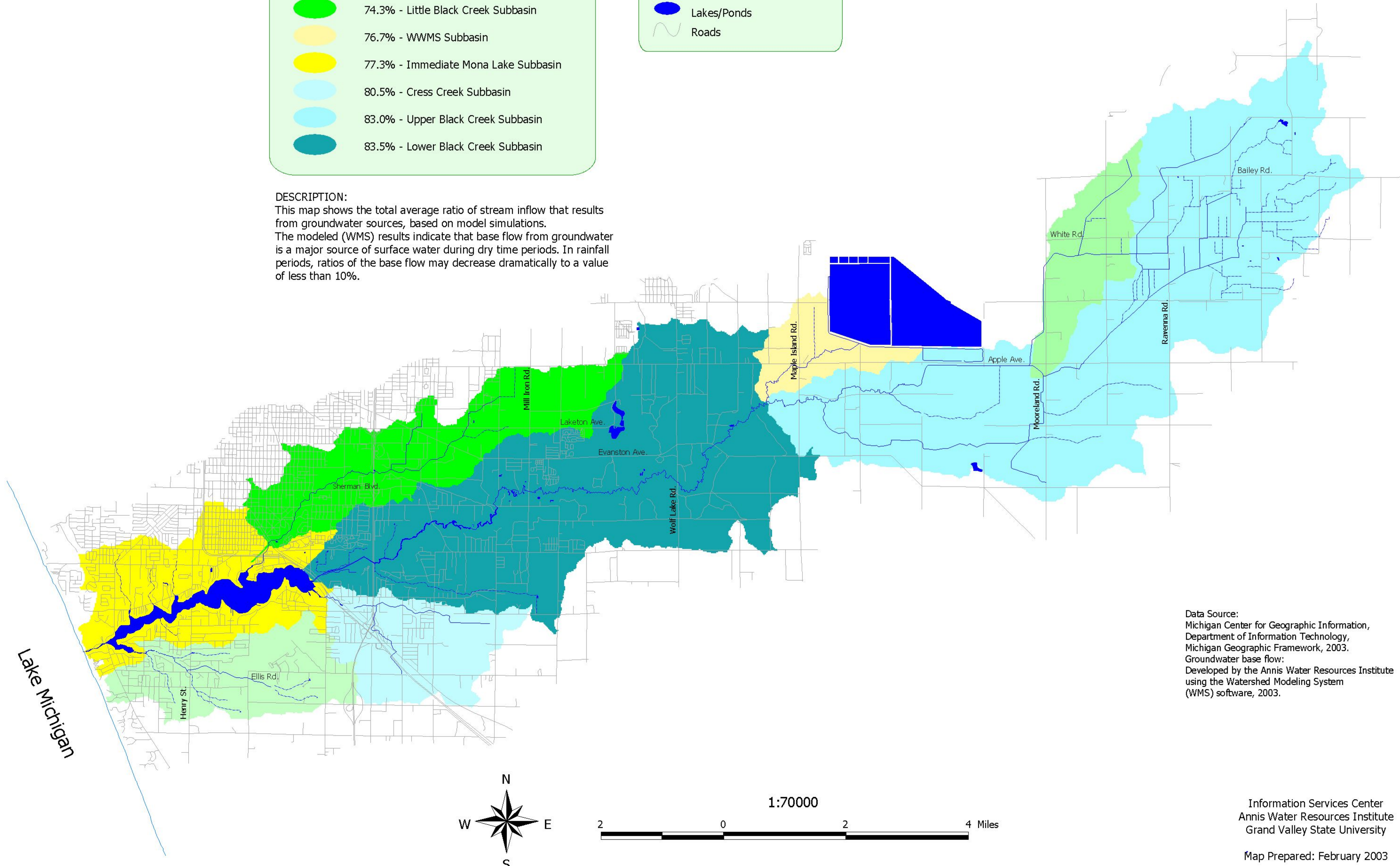
- 74.0% - Lower Hall Drain Subbasin
- 74.1% - Ellis Drain Subbasin
- 74.3% - Little Black Creek Subbasin
- 76.7% - WWMS Subbasin
- 77.3% - Immediate Mona Lake Subbasin
- 80.5% - Cress Creek Subbasin
- 83.0% - Upper Black Creek Subbasin
- 83.5% - Lower Black Creek Subbasin

### Base Information

- Creek/Stream
- Intermittent Stream/Drain
- Great Lakes Shoreline
- Lakes/Ponds
- Roads

#### DESCRIPTION:

This map shows the total average ratio of stream inflow that results from groundwater sources, based on model simulations. The modeled (WMS) results indicate that base flow from groundwater is a major source of surface water during dry time periods. In rainfall periods, ratios of the base flow may decrease dramatically to a value of less than 10%.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Groundwater base flow:  
Developed by the Annis Water Resources Institute  
using the Watershed Modeling System  
(WMS) software, 2003.



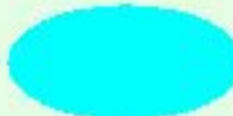





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# Natural Runoff Potential






## Mona Lake Watershed

### Hydrologic Soil Groups

	A - High infiltration potential, low runoff potential	22690 Acres
	A/D - Artificially drained condition versus natural condition	12344 Acres
	B	4935 Acres
	B/D	1347 Acres
	C	2162 Acres
	C/D	483 Acres
	D - Low infiltration potential, high runoff potential	90 Acres
	Not Rated	1520 Acres

 Increasing runoff potential  


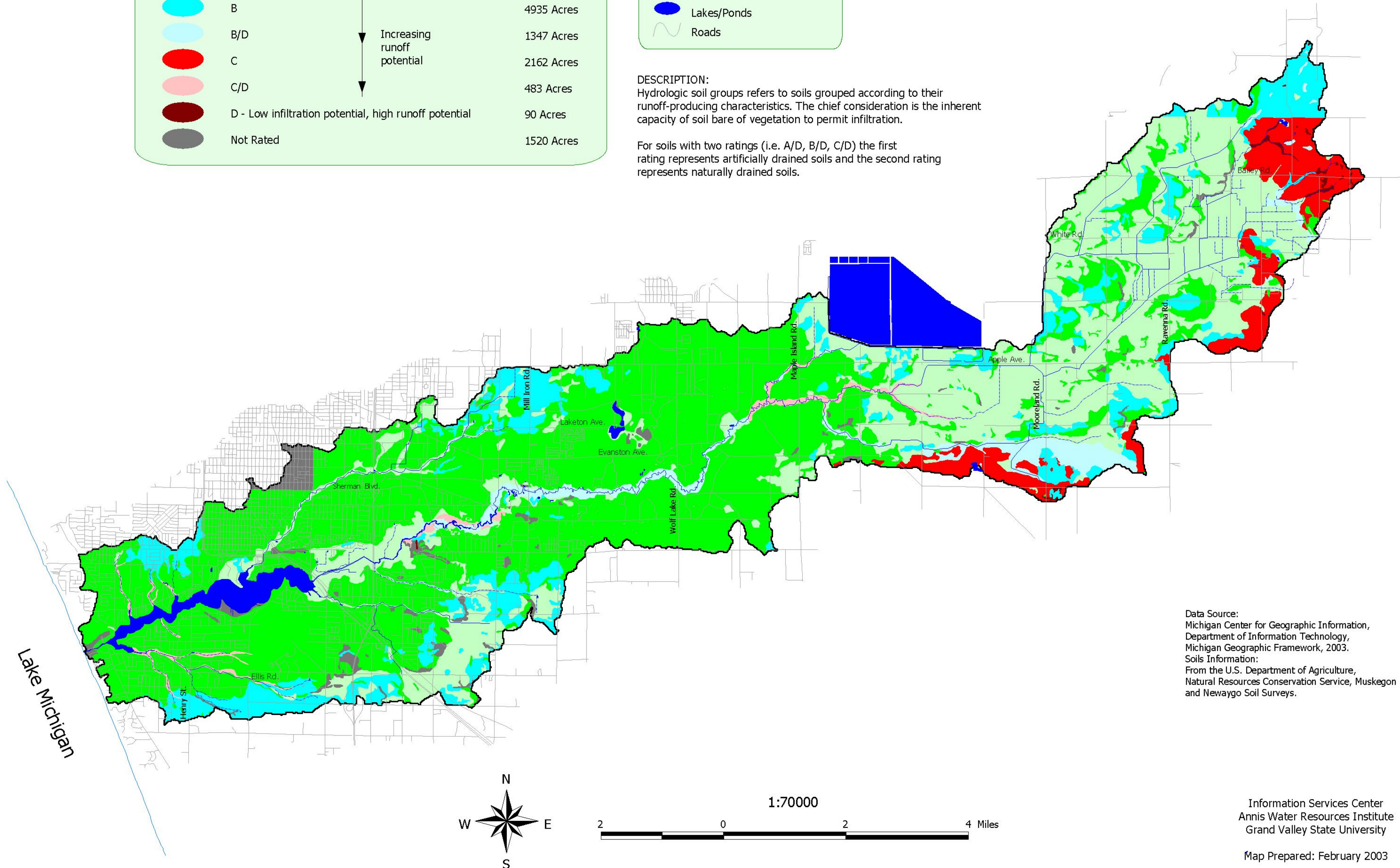
### Base Information

-  Creek/Stream
-  Intermittent Stream/Drain
-  Great Lakes Shoreline
-  Lakes/Ponds
-  Roads

#### DESCRIPTION:

Hydrologic soil groups refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration.

For soils with two ratings (i.e. A/D, B/D, C/D) the first rating represents artificially drained soils and the second rating represents naturally drained soils.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Soils Information:  
From the U.S. Department of Agriculture,  
Natural Resources Conservation Service, Muskegon  
and Newaygo Soil Surveys.




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# Sheet and Rill Erosion Potential

## Mona Lake Watershed

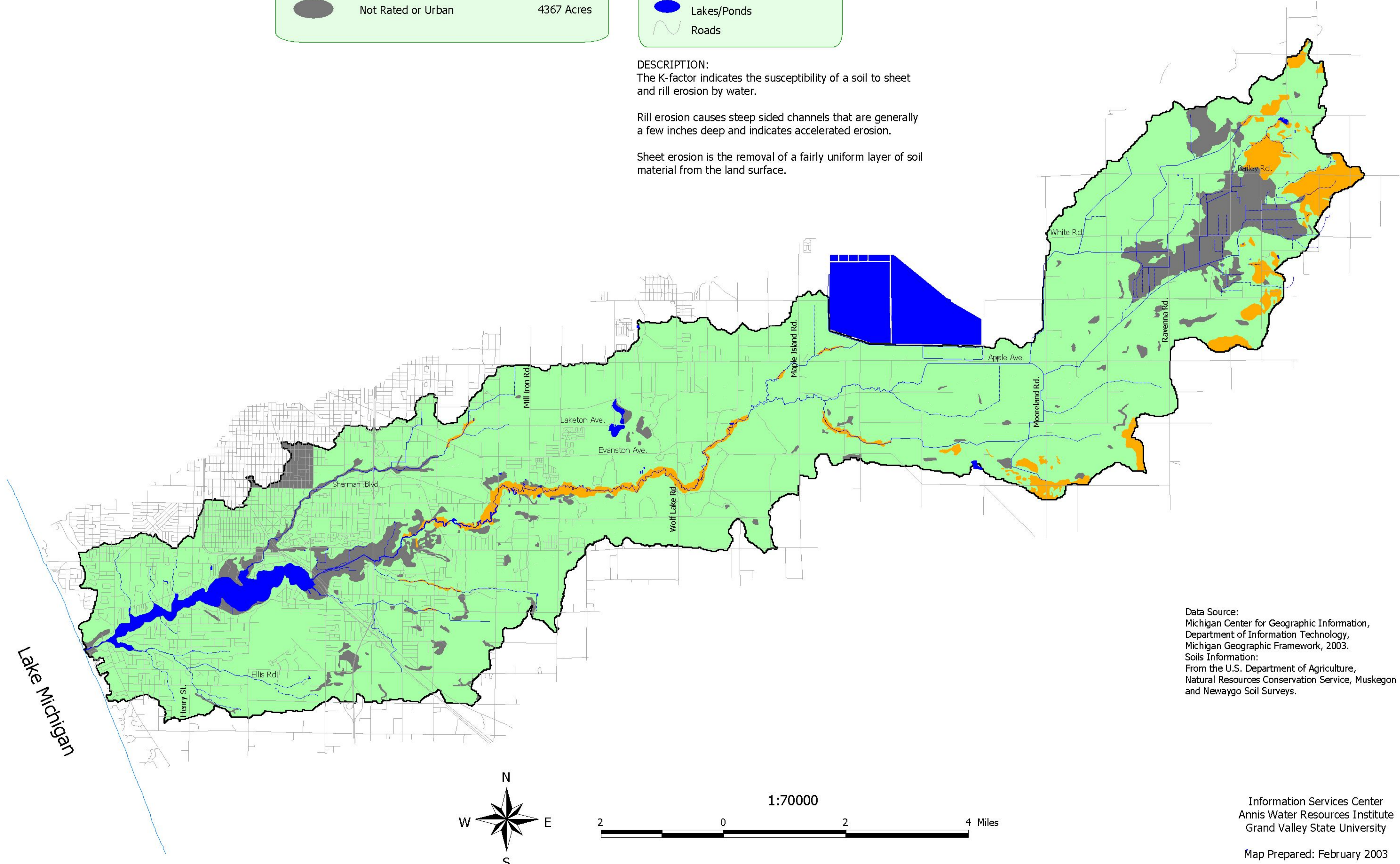
K - Factor		
	0.05 - 0.26 - Low Potential	39356 Acres
	0.27 - 0.48 - Moderate Potential	1848 Acres
	Not Rated or Urban	4367 Acres

Base Information	
	Creek/Stream
	Intermittent Stream/Drain
	Great Lakes Shoreline
	Lakes/Ponds
	Roads

**DESCRIPTION:**  
The K-factor indicates the susceptibility of a soil to sheet and rill erosion by water.

Rill erosion causes steep sided channels that are generally a few inches deep and indicates accelerated erosion.

Sheet erosion is the removal of a fairly uniform layer of soil material from the land surface.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Soils Information:  
From the U.S. Department of Agriculture,  
Natural Resources Conservation Service, Muskegon  
and Newaygo Soil Surveys.

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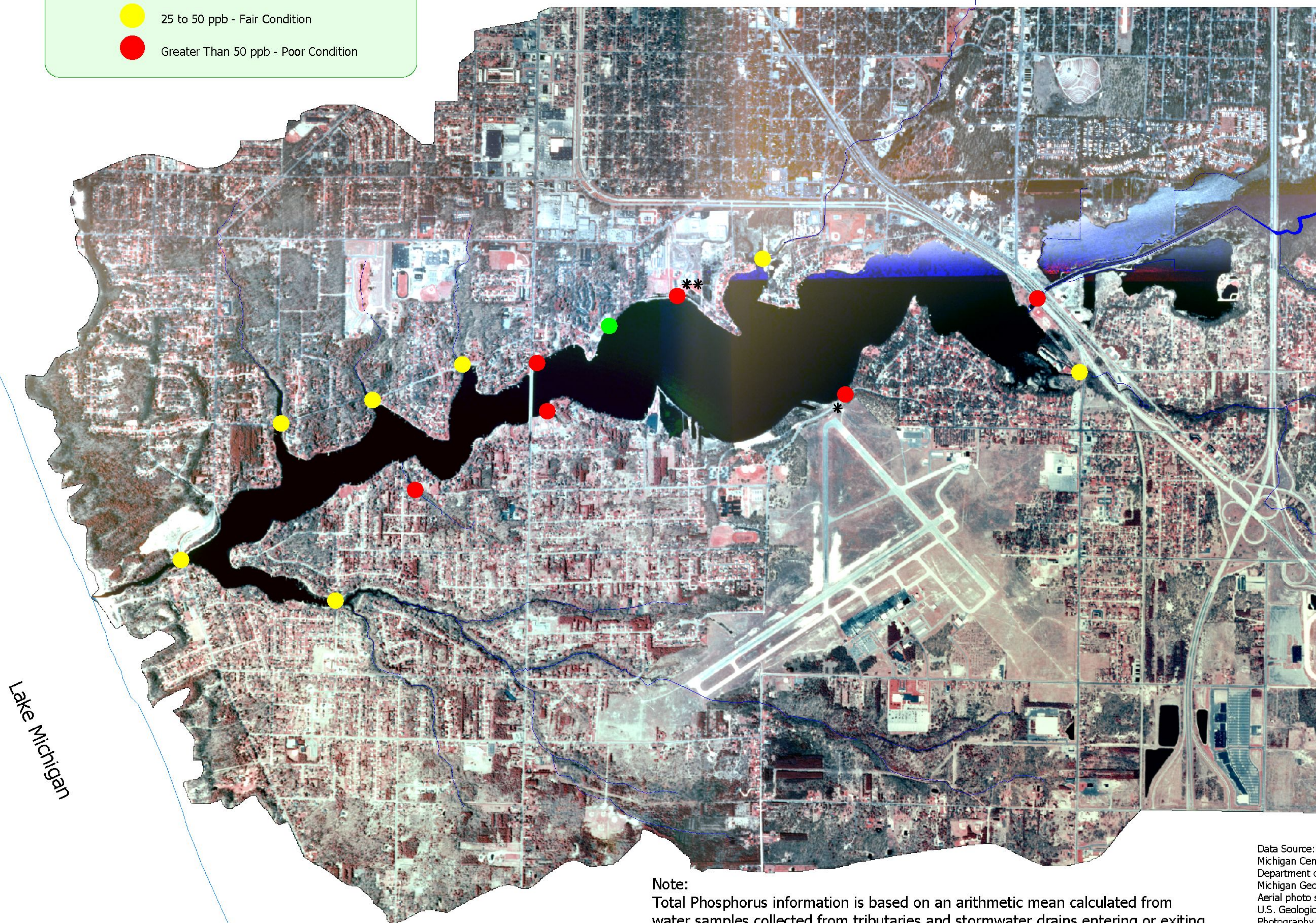
Map Prepared: February 2003

# Total Phosphorus Concentration

## Mona Lake Watershed

### Phosphorus Concentration (Parts Per Billion)

- 1 to 24 ppb - Good Condition
- 25 to 50 ppb - Fair Condition
- Greater Than 50 ppb - Poor Condition



Lake Michigan

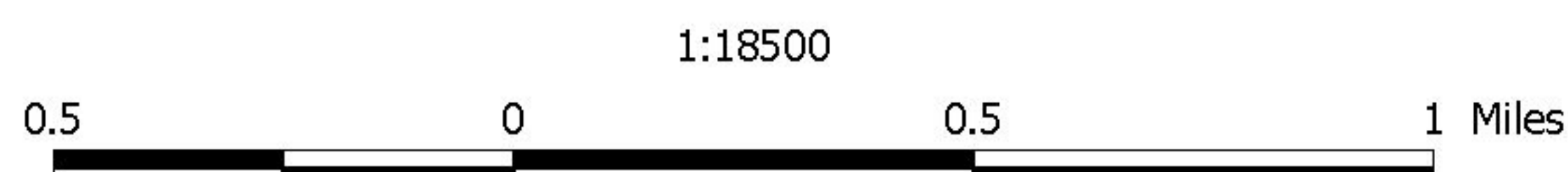
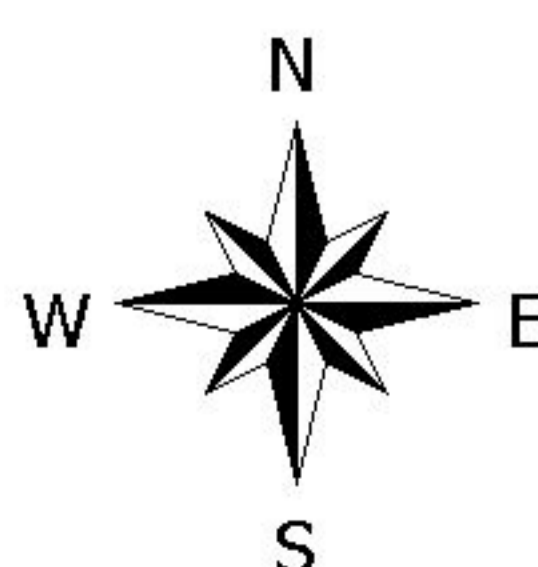
Note:  
Total Phosphorus information is based on an arithmetic mean calculated from water samples collected from tributaries and stormwater drains entering or exiting (channel only) Mona Lake. Period of record was June 2002 to August 2003.

- \* Site had detectable flow on only one sampling date.
- \*\* Site had detectable flow on only four sampling dates.

Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Aerial photo source:  
U.S. Geological Survey, National Aerial  
Photography Program, 1998.  
Phosphorus data source:  
GVSU, Annis Water Resources Institute, 2003.

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Map Prepared: October 2003

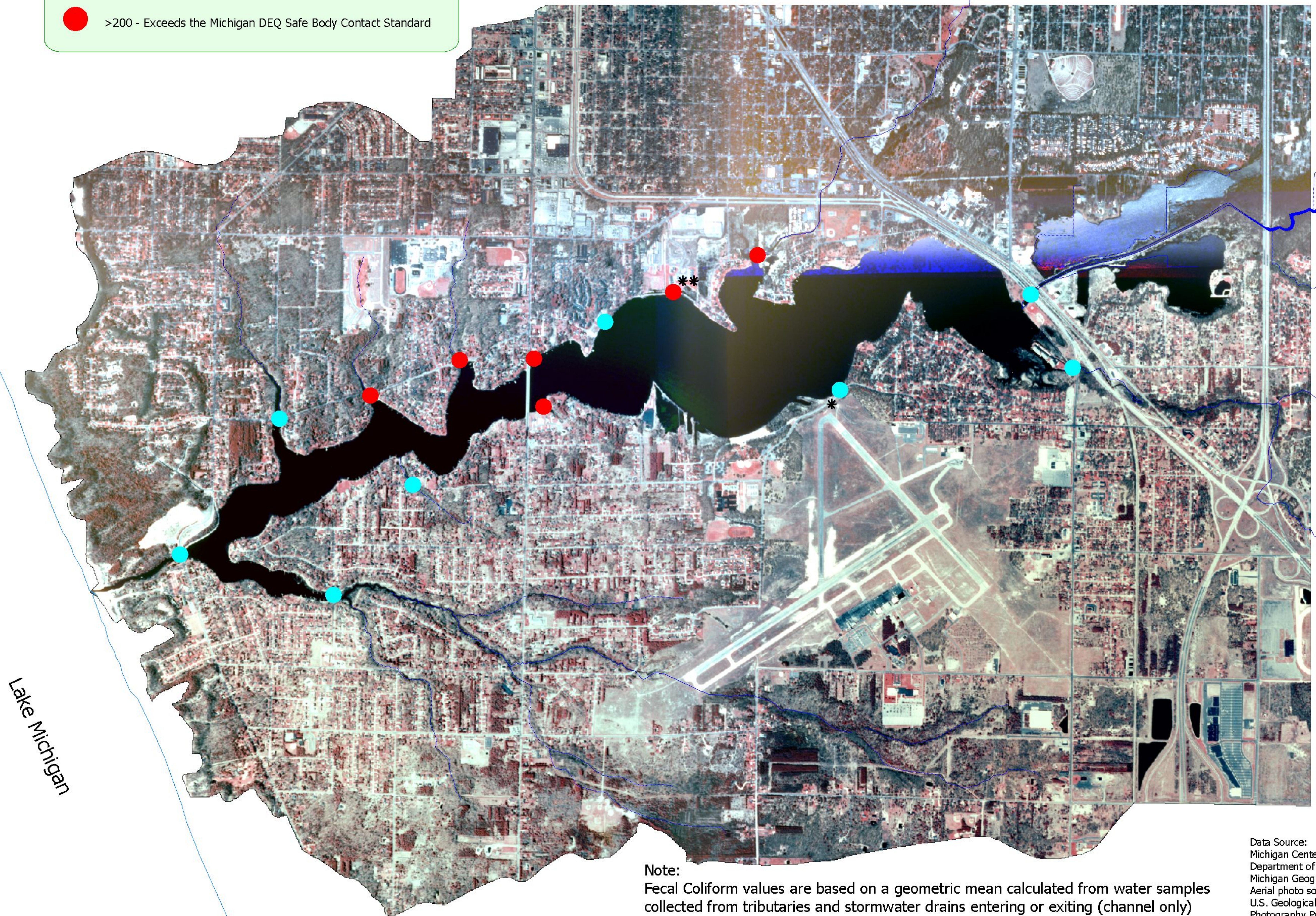


# Bacterial Contamination

## Mona Lake Watershed

### Fecal Coliform Concentration (# of colonies/100 ml)

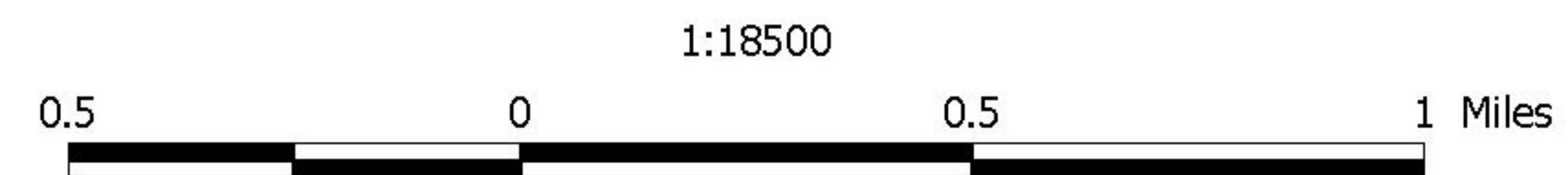
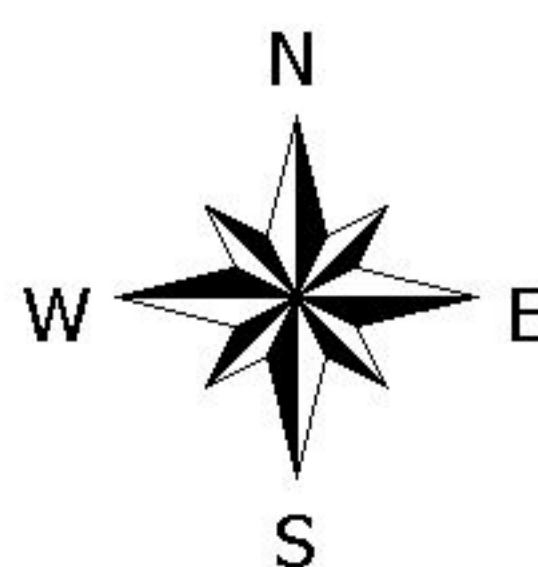
-  < 200 - Under the Michigan DEQ Safe Body Contact Standard
-  >200 - Exceeds the Michigan DEQ Safe Body Contact Standard



Lake Michigan

Note:  
Fecal Coliform values are based on a geometric mean calculated from water samples collected from tributaries and stormwater drains entering or exiting (channel only) Mona Lake. Period of record was June 2002 to August 2003. The standard used in the legend is based on the Pre-1996 Michigan DEQ 200 colonies per 100 ml threshold.

- \* Site had detectable flow on only one sampling date.
- \*\* Site had detectable flow on only four sampling dates.



Data Source:  
Michigan Center for Geographic Information,  
Department of Information Technology,  
Michigan Geographic Framework, 2003.  
Aerial photo source:  
U.S. Geological Survey, National Aerial  
Photography Program, 1998.  
Bacteria data source:  
GVSU, Annis Water Resources Institute, 2003.

Information Services Center  
Annis Water Resources Institute  
Grand Valley State University

Map Prepared: October 2003

