Chapter 2

Water Resources in Southwest Ohio

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Chapter 2: *Water Resources in Southwest Ohio*

Introduction and Purpose

The purpose of this chapter is to describe the aquifers, rivers and streams that OKI strives to protect through water quality management planning. The description is from a regional planning perspective, which entails an inter-disciplinary view of the natural characteristics, regulatory framework and scientific assessment of water resources in Butler, Clermont, Hamilton and Warren counties.

A clarification of terms is in order. The phrase "water resources" carries many meanings. For this chapter, the meaning is: *a material source of wealth that occurs in a natural state. The wealth can be actual or potential, but is ultimately supplied by nature.* This definition lays a conceptual foundation for recognizing the value of water resources and using them with care. Regional water quality management planning proceeds from these views. The same can be said for wastewater management planning, which is a major function of water quality management planning because rivers and streams are predominantly the receiving waters for wastewater, treated or untreated.

In accordance with state and federal practices, this analysis is structured by watersheds. The Ohio EPA defines a watershed as an area of land from which surface water drains into a common outlet, such as a river, lake or wetland. Depending on its size and location, a watershed can contain one or many of the following features: streams, ditches, ponds, lakes or wetlands. "Drainage basin" and "hydrologic unit" are synonyms for "watershed." (*A Guide to Developing Local Watershed Action Plans in Ohio*, Ohio EPA, 1997) The U.S. EPA notes "the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point." (*Terms of Environment*: *Glossary, Abbreviations and Acronyms;* U.S. EPA, 2010)

Using watersheds as their geographical framework, planners and others can methodically address the many factors involved in regional water quality management planning. This process follows what is known as the "watershed approach." Federal authorities define the watershed approach as "a coordinated framework for environmental management that focuses public and private efforts on the highest priority problems within hydrologically defined geographic areas taking into consideration both ground and surface water flow." (*Terms of Environment . . . ,*U.S. EPA)

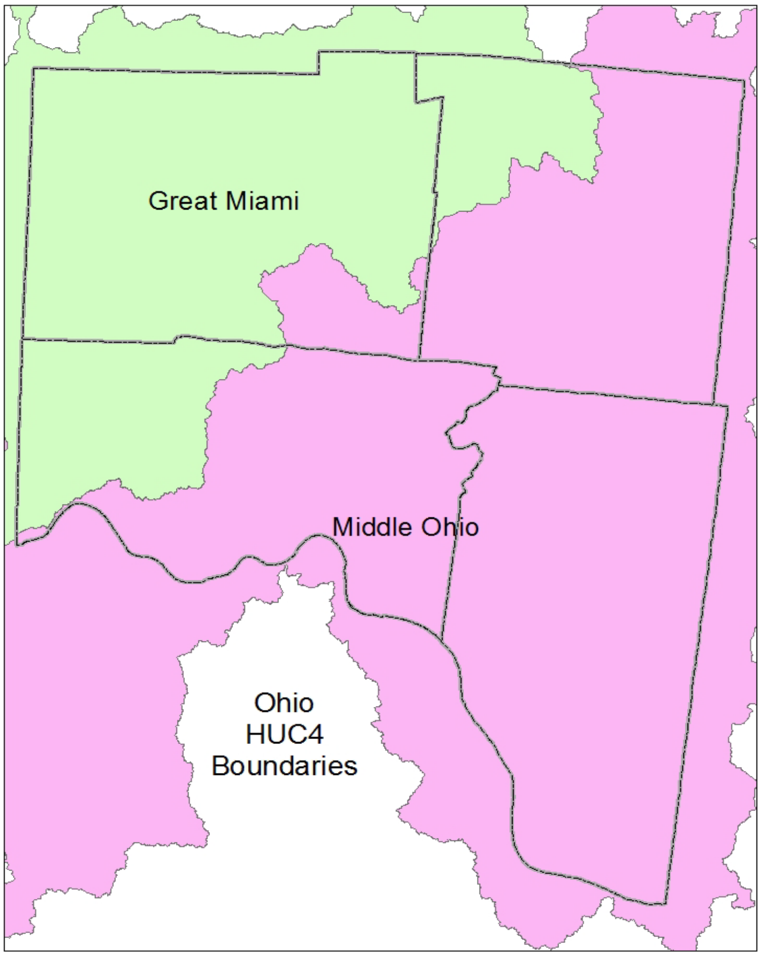
Ohio EPA has adopted the nationwide system of Hydrologic Unit Codes for designating, naming and organizing watersheds throughout the state. OKI is following suit for its planning area. Hydrologic Unit Codes (HUCs) are systematic serial numbers. They denote multiple levels of HUC watersheds, based on size. Each large watershed is divided and subdivided into six levels:

Level 1: Region
A HUC region is a major geographic region that contains the drainage area of a major river or series of rivers. There are 21 HUC regions in the United States. Butler, Clermont, Hamilton and Warren counties are completely within the HUC Ohio Region, which encompasses the drainage area of the Ohio River Basin, excluding the Tennessee River Basin. It bears the HUC code 05.

Level 2: Sub-Region

A HUC sub-region can be the area drained by a river system, a reach of a river and its tributaries, a closed basin, or a group of streams. Butler, Clermont, Hamilton and Warren counties are divided among two sub-regions: Great Miami (0508), and Middle Ohio (0509). They are mapped in Figure 2-1 below:

**Figure 2-1: Sub-Regions (HUC 4)
in Butler, Clermont, Hamilton and Warren Counties**



Level 3: Basin

A HUC basin can subdivide or be the equivalent of a HUC sub-region. Butler, Clermont, Hamilton and Warren counties are divided among two basins: Great Miami (050800), which is equivalent to the Great Miami sub-region, and Middle Ohio-Little Miami (050902), which is a subdivision of the Middle Ohio sub-region. In the OKI region, the basins coincide with the sub-regions, so a separate map of the basins is not necessary.

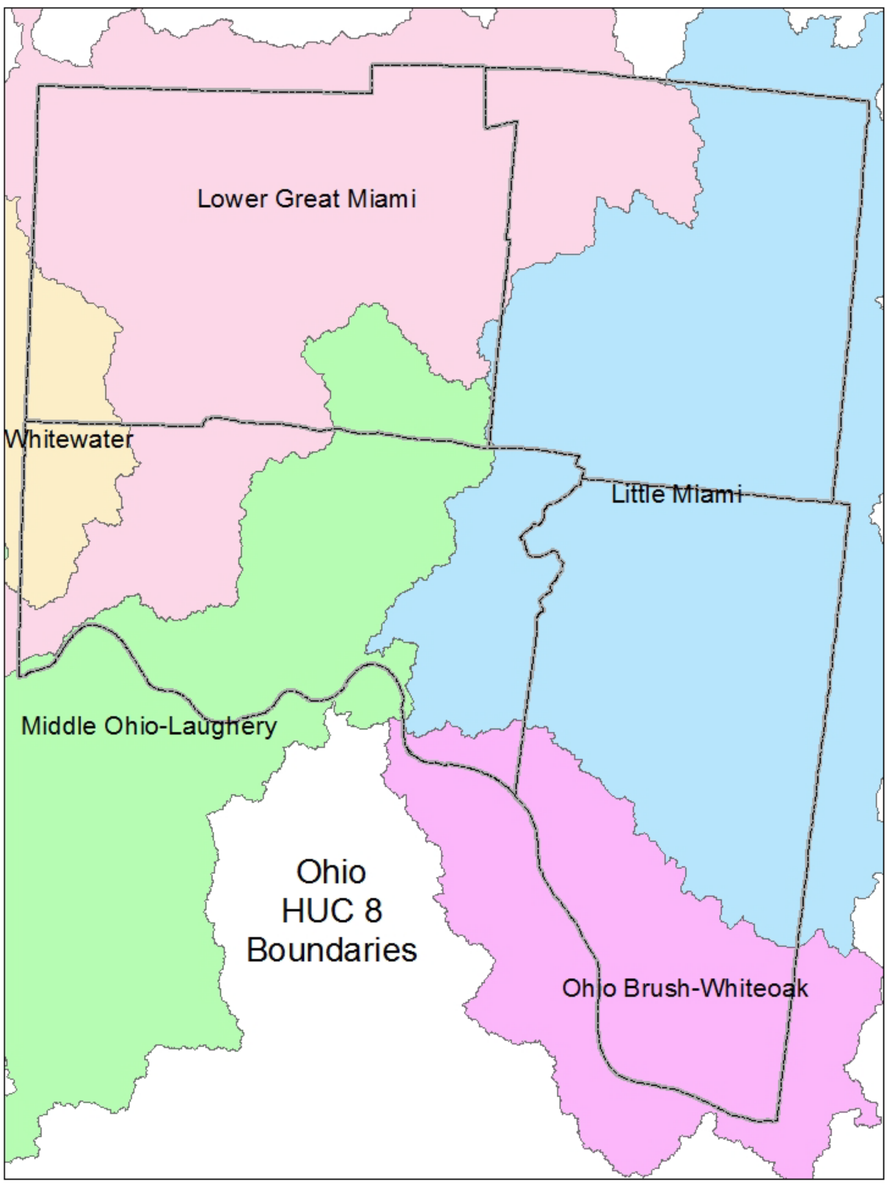
Level 4: Sub-Basin

A HUC sub-basin consists of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. Sub-basins are also known as cataloging units. Butler, Clermont, Hamilton and Warren counties cumulatively have parts of five sub-basins with eight-digit (HUC-8) codes. They are tabulated in Table 2-1 and mapped in Figure 2-2 on the next page:

Table 2-1: Codes and Names for Sub-Basins (HUC 8)
in Butler, Clermont, Hamilton and Warren Counties

8-digit HUC	Sub-Basin Name	County or Counties in OKI Region
05080002	Lower Great Miami	Butler, Hamilton and Warren
05080003	Whitewater	Butler and Warren
05090201	Ohio Brush-Whiteoak	mostly Clermont, partly Hamilton
05090202	Little Miami	Clermont, Hamilton and Warren, marginally in Butler
05090203	Middle Ohio-Laughery	Butler and Hamilton

Figure 2-2: Sub-Basins (HUC 8)
in Butler, Clermont, Hamilton and Warren Counties



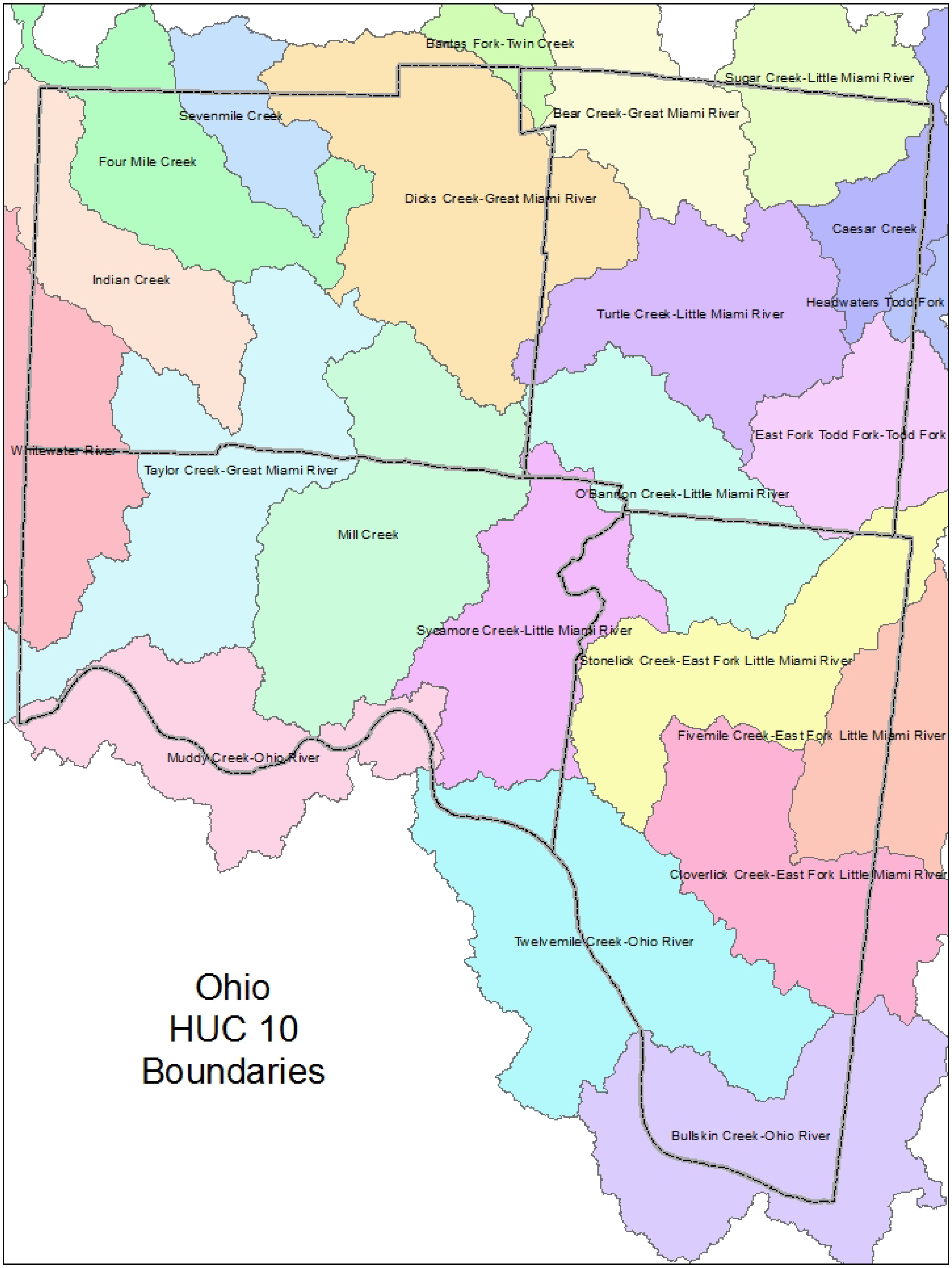
Level 5: Watershed

A HUC watershed is a land area of 40,000 to 250,000 acres that drains to a river or stream. Its boundaries typically follow topographic features such as ridge lines. Butler, Clermont, Hamilton and Warren counties cumulatively have all or part of 22 watersheds with 10-digit (HUC-10) codes. They are tabulated in Table 2-2 below and mapped in Figure 2-3 on the next page:

Table 2-2: Names for Watersheds (HUC 10)
in Butler, Clermont, Hamilton and Warren Counties

10-digit HUC	Watershed Name	County or Counties in OKI Region
0508000203	Bantas Fork-Twin Creek	marginally in Butler and Warren
0508000204	Bear Creek-Great Miami River	Warren
0508000205	Sevenmile Creek	Butler
0508000206	Fourmile Creek	Butler
0508000207	Dicks Creek	mostly in Butler and partly in Warren
0508000208	Indian Creek	Butler
0508000209	Taylor Creek-Great Miami River	Hamilton
0508000308	Whitewater River	Butler and Hamilton
0509020111	Bullskin Creek-Ohio River	Clermont
0509020112	Twelvemile Creek-Ohio River	mostly in Clermont and partly in Hamilton
0509020204	Caesar Creek	Warren
0509020205	Sugar Creek-Little Miami River	Warren
0509020206	Headwaters Todd Fork	marginally in Warren
0509020207	East Fork Todd Fork-Todd Fork	Warren
0509020208	Turtle Creek-Little Miami River	Butler and Warren
0509020209	O'Bannon Creek-Little Miami River	mostly in Clermont and Warren, marginally in Butler and Hamilton
0509020211	Fivemile Creek-East Fork Little Miami River	Clermont
0509020212	Cloverlick Creek-East Fork Little Miami River	Clermont
0509020213	Stonelick Creek-East Fork Little Miami River	mostly in Clermont, marginally in Warren
0509020214	Sycamore Creek-Little Miami River	mostly in Hamilton, partly in Clermont, marginally in Warren
0509020301	Mill Creek	Butler and Hamilton
0509020302	Muddy Creek-Ohio River	Hamilton

Figure 2-3: Watersheds (HUC 10)
in Butler, Clermont, Hamilton and Warren Counties

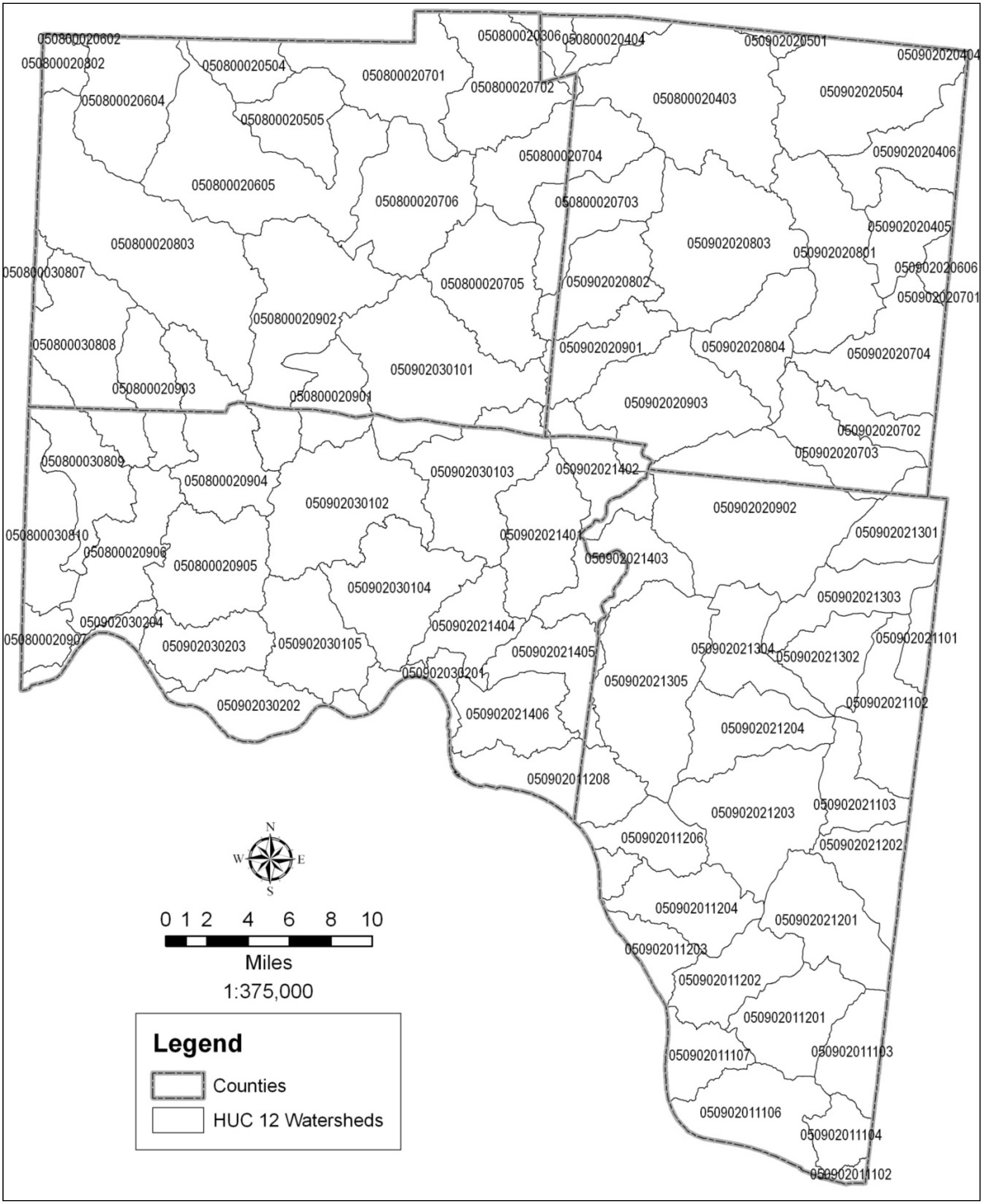


Level 6: Sub-Watershed
A HUC sub-watershed is generally the smallest and most localized layer. Sub-watersheds usually cover 10,000 to 40,000 acres. The four-county study area has all or part of 80 sub-watersheds with 12-digit (HUC-12) codes. They are tabulated on the next page in Table 2-3 and mapped in Figure 2-4:

Table 2-3: Names for Sub-Watersheds (HUC 12) in Butler, Clermont, Hamilton and Warren Counties

12-digit HUC	Watershed Name	12-digit HUC	Watershed Name
050800020306	Town of Germantown-Twin Creek	050902020501	Sugar Creek
050800020403	Clear Creek	050902020504	Newman Run-Little Miami River
050800020404	Dry Run-Great Miami River	050902020606	Little Creek-Todd Fork
050800020504	Rush Run-Sevenmile Creek	050902020701	East Fork Todd Fork
050800020505	Ninemile Creek-Sevenmile Creek	050902020702	Second Creek
050800020602	Little Four Mile Creek	050902020703	First Creek
050800020604	Acton Lake Dam-Four Mile Creek	050902020704	Lick Run-Todd Fork
050800020605	Cotton Run-Four Mile Creek	050902020801	Ferris Run-Little Miami River
050800020701	Elk Creek	050902020802	Little Muddy Creek
050800020702	Browns Run-Great Miami River	050902020803	Turtle Creek
050800020703	Shaker Creek	050902020804	Halls Creek-Little Miami River
050800020704	Dicks Creek	050902020901	Muddy Creek
050800020705	Gregory Creek	050902020902	O'Bannon Creek
050800020706	Town of New Miami-Great Miami River	050902020903	Salt Run-Little Miami River
050800020802	Brandywine Creek-Indian Creek	050902021101	Solomon Run-East Fork Little Miami River
050800020803	Beals Run-Indian Creek	050902021102	Fivemile Creek-East Fork Little Miami River
050800020901	Pleasant Run	050902021103	Todd Run-East Fork Little Miami River
050800020902	Banklick Creek-Great Miami River	050902021201	Poplar Creek
050800020903	Paddys Run	050902021202	Cloverlick Creek
050800020904	Dry Run-Great Miami River	050902021203	Lucy Run-East Fork Little Miami River
050800020905	Taylor Creek	050902021204	Backbone Creek-East Fork Little Miami River
050800020906	Jordan Creek-Great Miami River	050902021301	Headwaters Stonelick Creek
050800020907	Doublelick Run-Great Miami River	050902021302	Brushy Fork
050800030807	Headwaters Dry Fork Whitewater River	050902021303	Moores Fork-Stonelick Creek
050800030808	Howard Creek-Dry Fork Whitewater River	050902021304	Lick Fork-Stonelick Creek
050800030809	Lee Creek-Dry Fork Whitewater River	050902021305	Salt Run-East Fork Little Miami River
050800030810	Jameson Creek-Whitewater River	050902021401	Sycamore Creek
050902011102	Turtle Creek-Ohio River	050902021402	Polk Run-Little Miami River
050902011103	West Branch Bullskin Creek	050902021403	Horner Run-Little Miami River
050902011104	Bullskin Creek	050902021404	Duck Creek
050902011106	Bear Creek-Ohio River	050902021405	Dry Run-Little Miami River
050902011107	Little Indian Creek-Ohio River	050902021406	Clough Creek-Little Miami River
050902011201	Headwaters Big Indian Creek	050902030101	East Fork Mill Creek-Mill Creek
050902011202	North Fork Indian Creek-Big Indian Creek	050902030102	West Fork Mill Creek
050902011203	Boat Run-Ohio River	050902030103	Sharon Creek-Mill Creek
050902011204	Ferguson Run-Twelvemile Creek	050902030104	Congress Run-Mill Creek
050902011206	Tenmile Creek	050902030105	West Fork-Mill Creek
050902011208	Ninemile Creek-Ohio River	050902030201	Town of Newport-Ohio River
050902020404	Middle Caesar Creek	050902030202	Dry Creek-Ohio River
050902020405	Flat Fork	050902030203	Muddy Creek
050902020406	Lower Caesar Creek	050902030204	Garrison Creek-Ohio River

**Figure 2-4: Sub-Watersheds (HUC 12)
in Butler, Clermont, Hamilton and Warren Counties**



The relationship between water quality planning and natural characteristics is explained well in OKI's *Regional Water Quality Management Plan, Summary Report* (OKI, 1977). Time has not lessened the relevance of the report's statement that: "Comprehensive regional water quality planning must account for the dynamic relationship between the man-made and natural environments. The preservation of water quality is not simply a matter of applying treatment technology, but is a complex process that extends to managing the development of land." The process "demands an information base that identifies the region's natural characteristics." In recognition of that need, the next section of this chapter describes the region's geology, physiography and climate.

Natural Characteristics

Natural characteristics largely determine the foundation for most land use activities. As we learn about the configuration of natural features, we gain a better understanding of land use impacts on water quality. This helps answer vital questions about how much and what kinds of development our water resources can support in Butler, Clermont, Hamilton and Warren counties. Certain natural characteristics have a limiting effect on development. It is important to know where the natural features perform functions critical to water quality.

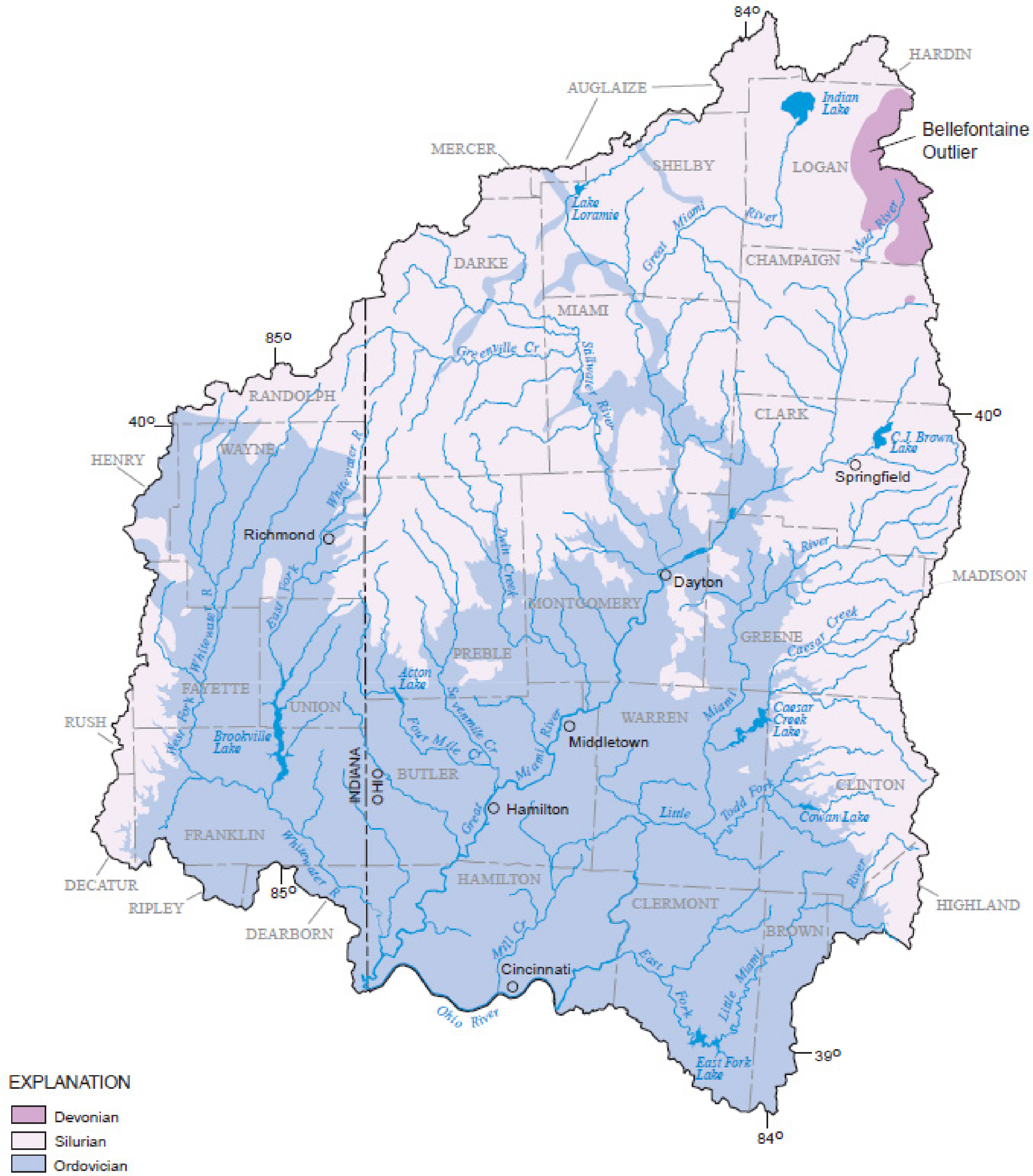
Geology

Geology is a good starting point to describe natural characteristics because it influences watershed management in several ways. As an example, different bedrock materials and overlying soils have different levels of susceptibility to erosion by water (erodibility). Also, the composition of the bedrock material and soils are primary natural factors governing the shape and slope of the stream bed and, ultimately, the depth and velocity of water running through the channel. In addition, porous material such as sand, gravel or limestone can act as a conduit and/or reservoir for ground water, whereas solid bedrock, clays and shales serve as barriers to subsurface water flow (*Middle East Fork Watershed Action Plan*, East Fork Watershed Collaborative, 2009). Ultimately, regional geology influences the quality of surface and groundwater resources. The distribution of various types of geologic materials in the sub-surface governs the transport and storage of groundwater in aquifers. Chemical reactions between water, soil and aquifer materials can influence the concentration of major ions, trace elements, radionuclides and synthetic organic chemicals in groundwater and surface water (*Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. Geological Survey, 2000).

As noted in the *Regional Water Quality Management Plan* (OKI, 1977), the geologic history of the OKI region begins with the formation of the earth and its hard core of igneous (fire-formed) rock. This forms the area's "basement complex," which has an average depth below the surface of 3,400 feet. The most important rock layers are the sedimentary rocks that formed in shallow seas covering the region during the Ordovician Period of 520 to 440 million years ago. Clays, silts, sands and lime settled to the bottom as sediments, and later hardened into rock. Successive deposition, with some intermittent uplift and erosion, gave this region a geologic profile with these layers: Pre-Cambrian (at least 560 million years ago), Cambrian (at least 520 million years ago), Ordovician (at least 440 million years ago) and Silurian (at least 410 million years ago).

With a few exceptions, the region's exposed bedrock is of Ordovician Age. The exceptions are small Silurian Age outliers in northern Warren County, as illustrated in Figure 2-5 on the next page.

Figure 2-5: Ordovician and Silurian Geology



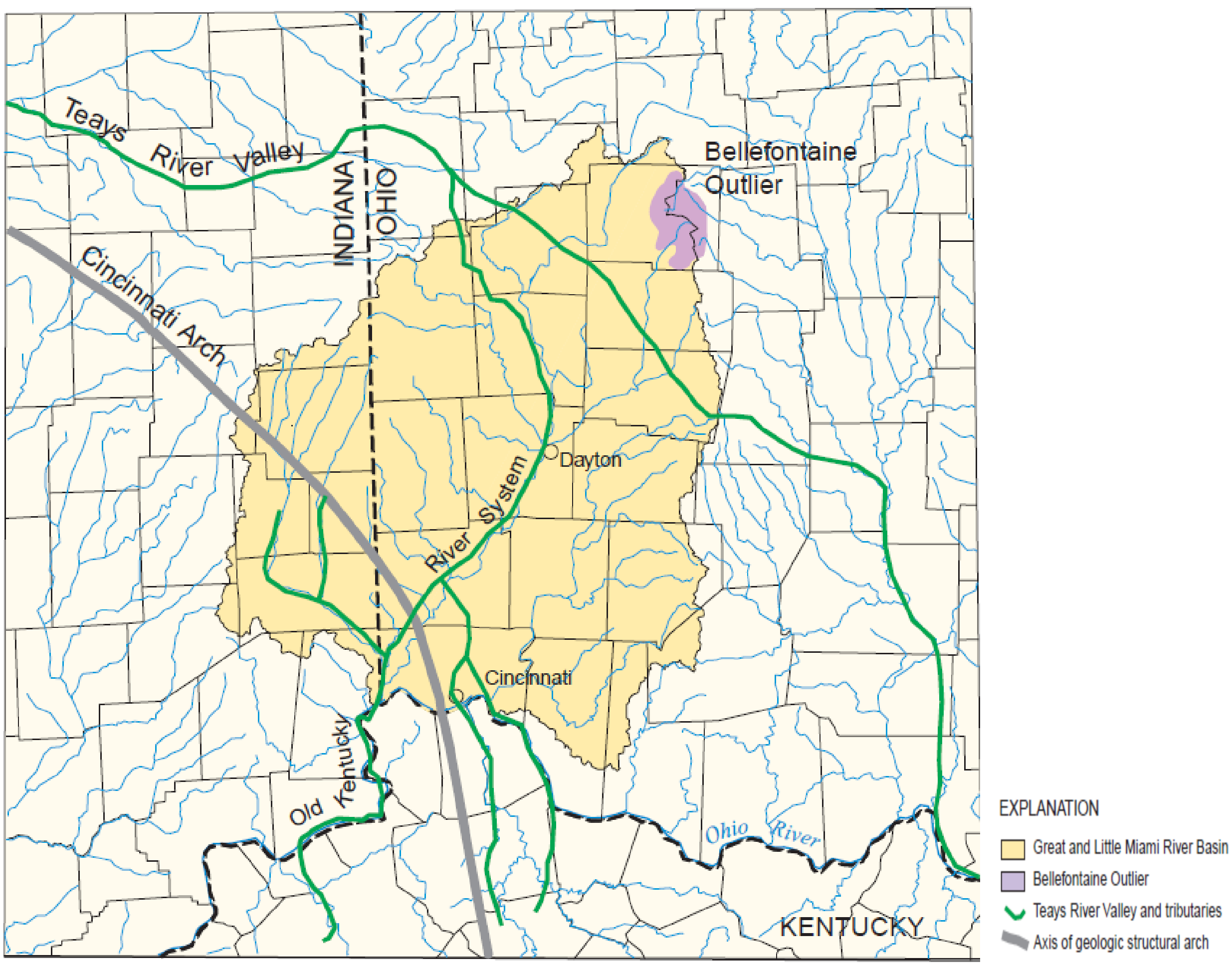
NOTE: The southeastern tip of Hamilton County and the southern part of Clermont County have Ordovician geology.

Limestones and shales alternate through most of the region's geologic profile. Age of rock is not the important factor, but parent material and its relationship with surface character, when decomposed and eroded, is of major consideration.

Toward the end of the Ordovician Period, the earth's crust began to warp and a large part of the surface began to rise in relation to the area around its margin. This uplift continued for several hundred million years, forming the domal structure called the Cincinnati Arch. Along the arch axis, bedrock is nearly horizontal but overall dips 5 to 10 feet per mile towards the north-northwest. The crest of the Cincinnati Arch is about 75 miles wide. Figure 2-6 below shows how the axis of the arch passes through Butler and Hamilton counties. During the Paleozic Era, the arch was an area of emergent land in shallow seas, and it flanks were the sites of extensive sediment deposition. Near the end of the Paleozoic Era the shallow seas receded and a long episode of erosion occurred, forming a flat erosional surface that later was dissected by stream. Because of this post-depositional erosion, older rocks are found in the center of the arch; younger rocks outcrop along the margins (*Environmental Setting and Effects on Water Quality,* U.S. Geological Survey, 2000).

Figure 2-6: Cincinnati Arch

(from *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)



After the final emergence of land from the water of the region's shallow seas, the process of erosion began. This continued until the eroded surface was reduced to a peneplain, an almost flat surface. Pre-glacial rivers and streams flowed at about the same elevation as the present hilltops, but the drainage pattern was wholly different. Before glacial disruption, the region's river system was the Teays, which had its headwaters in the Appalachian highlands of what are now North Carolina and Virginia. From this source, the Teays flowed northwestward across present-day West Virginia and entered Ohio near Portsmouth (*The Ice Age in Ohio*, Ohio Department of Natural Resources, Division of Geological Survey, 1997) In southern Ohio, the Teays took a northward route and, in a classic interpretation, swung westward across central Ohio into Indiana. Continuing its westward path across Indiana and Illinois, the Teays eventually joined the ancestral Mississippi River in western Illinois. Figure 2-6 on the preceding page shows the general location of Teays River Valley and its tributaries in the Ohio-Kentucky-Indiana region.

About one million years ago, the first glacial advance (pre-Illinoian, formerly Kansan) to influence the region created an ice dam across the Teays drainage basin. This natural impoundment formed a system of connected fingerlakes in southern Ohio and adjacent parts of Kentucky and West Virginia. The 7,000-square-mile lake system eventually spilled over low drainage divides and established new drainage patterns. These new drainage channels cut 250 feet below the elevation of the Teays. This Deep Stage Valley System later formed the bedrock floor that underlies the region's deep deposits of glacial outwash and alluvium (flowing water deposits). The region still bears drainage features formed by the Illinoian ice age (130,000 to 300,000 years old) and the Wisconsian ice invasion (14,000 to 24,000 years old).

In its 2000 report titled *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana*, the United States Geological Survey (U.S.G.S.) summarized the study area's geologic history by describing three episodes of Pleistocene glaciation. Each glaciation left behind a distinct mixture of unconsolidated deposits.

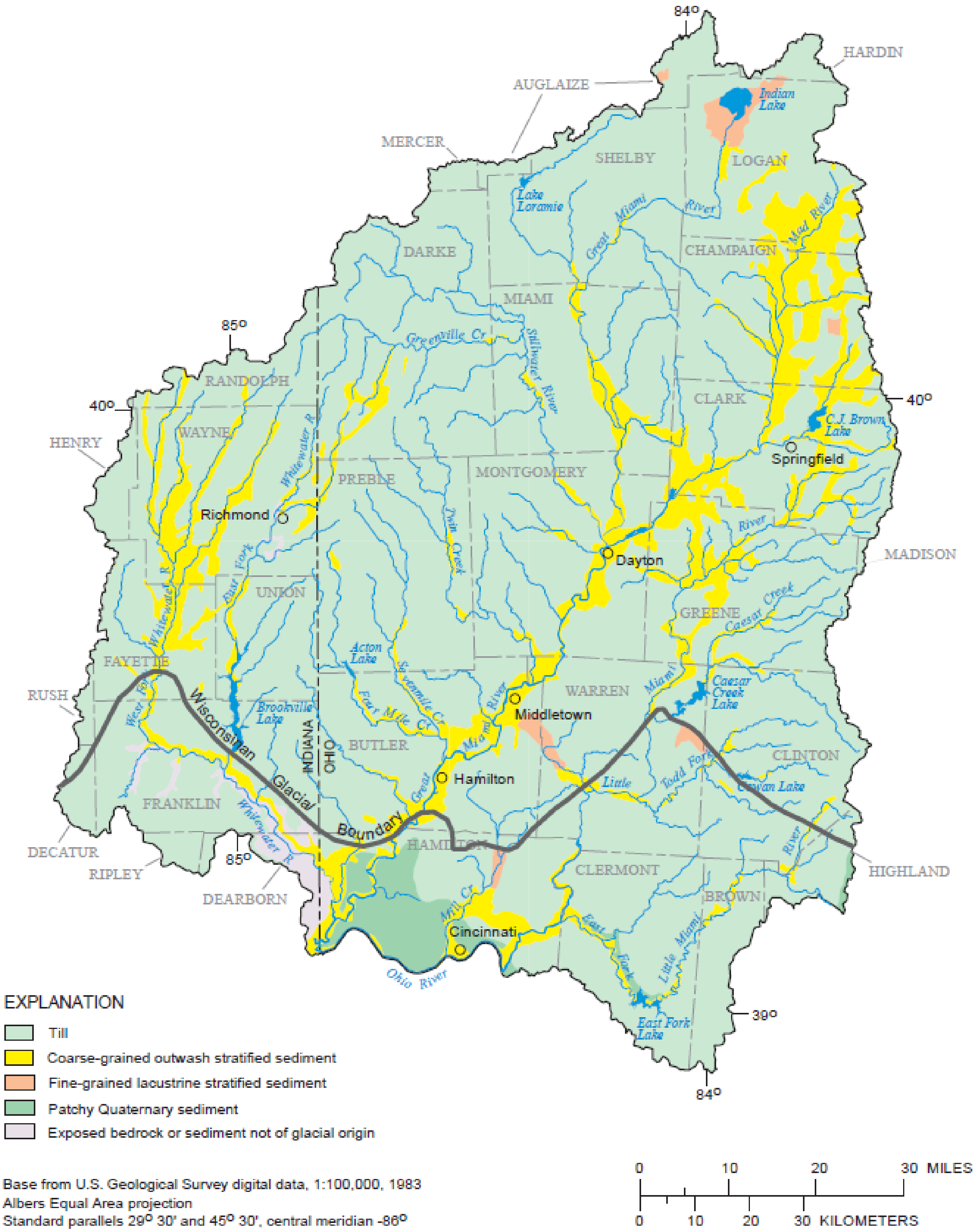
The oldest deposits are undifferentiated drift associated with pre-Illinoian glaciations that occurred more than 300,000 years ago. These deposits are exposed along the Ohio River in southern Hamilton and Clermont counties.

Glacial drift deposited during the Illinoian glaciations (130,000 to 300,000 years ago) is confined mostly to the Todd Fork and East Fork Little Miami River watersheds, which overlap the study area in Clermont County.

The most recent glaciations, the Wisconsian, occurred between 14,000 and 24,000 years ago. Unconsolidated deposits from the Wisconsinan ice sheets cover nearly all of Butler County, roughly the northwestern half of Warren County and small parts of Hamilton County. Figure 2-7 on the next page shows the southern extent of the Wisconsinan glacial boundary in the study area. Created by the U.S.G.S., the map in Figure 2-7 also illustrates the generalized glacial geology of Butler, Hamilton and Warren counties and northern Clermont County in relation to other counties with water resources that ultimately flow through the four-county study area.

Figure 2-7: Generalized Glacial Geology of the Great and Little Miami River Basins

(from *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)



The five geological map units shown on the previous page in Figure 2-7 were summarized by U.S.G.S. as follows:

1. Till, which is unconsolidated glacial sediment consisting of an unsorted mixture of clay, silt, sand and gravel. Till was deposited by advancing glaciers or by melting stagnant ice.
2. Outwash, which is coarse-grained, stratified sediment consisting of well-sorted sand and gravel. Outwash was deposited by glacial meltwater. When the ice sheets melted, large volumes of meltwater flowed through stream valleys carved out by previous erosional events and filled them with well-sorted sand and gravel. Such outwash deposits are found beneath most major stream valleys in Butler, Clermont, Hamilton and Warren counties. Since the Pleistocene Epoch (Ice Age), these outwash deposits have been covered by recent alluvial deposits.
3. Lacustrine deposits, which are fine-grained stratified sediments consisting of alternating well-sorted silt and clay layers. They were accumulated in lake environments formed in basins or valleys dammed by glacial ice.
4. Quaternary sediments, which are composed of glacial and recently deposited alluvium. Quaternary sediment is absent or sparse near the limit of glaciations and in the dissected area within the glaciated region.
5. Exposed bedrock or non-glacial sediments, which occupy the western extreme of Hamilton County, next to the west bank of the Whitewater River.

Glacial deposits cover most of the study area. Thick till and outwash deposits are found in the buried valleys created by tributaries to the ancient Teays River. Clay and silt confining units and sand and gravel sediments are complexly distributed throughout the region.

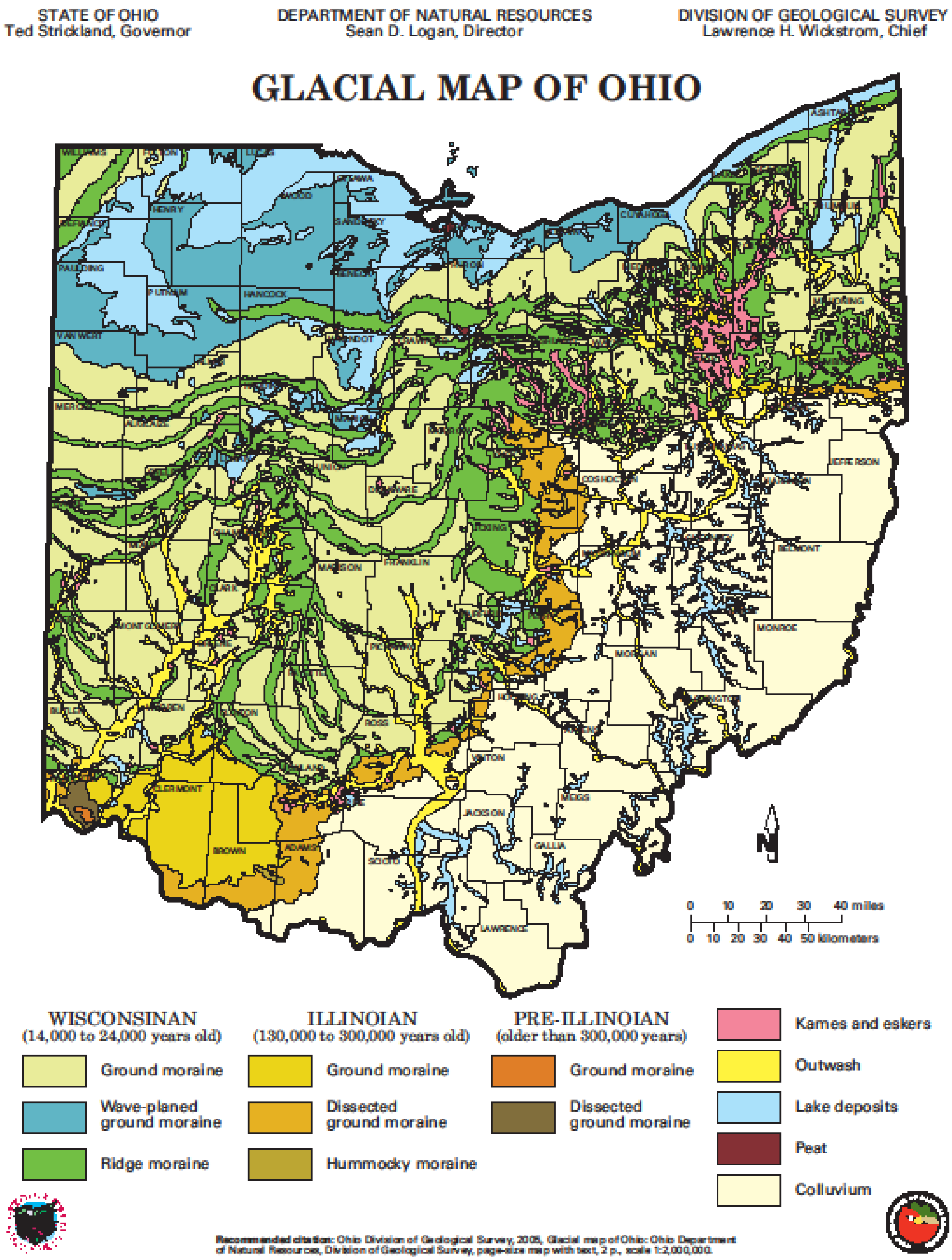
Since the retreat of the last glacier, weathering and erosional forces have developed our current landforms from the glacial materials. The many types of Ice Age deposits can be broadly classified into two distinct groups: (1) water-laid glacial outwash and sediments, or (2) ice-laid glacial till. Glacial outwash is sorted and stratified by differences in meltwater velocity and volumes. Glacial till is a mechanical mixture of varied particle sizes that are transported in the advancing ice and deposited on the old surface.

The Division of Geological Survey at the Ohio Department of Natural Resources (ODNR) mapped the glacial geology of the four-county study area in generally the same fashion as the U.S.G.S. with one distinct difference in terminology: moraine. The ODNR's *Glacial Map of Ohio* shows seven types of moraine, which is a mound, ridge or other distinct accumulation of unconsolidated and unsorted glacial debris (soil and rock) deposited chiefly by the direct action of glacial ice. Of those seven types of moraine, six are found in the four-county study area:

- Wisconsinan ground moraine
- Wisconsinan ridge moraine
- Illinoian ground moraine
- Illinoian dissected ground moraine
- Pre-Illinoian ground moraine
- Pre-Illinoian dissected ground moraine

Figure 2-8 on the next page illustrates the glacial deposits of Butler, Clermont, Hamilton and Warren counties in relation to glacial geology for the entire state of Ohio, as mapped by ODNR.

Figure 2-8: Glacial Map of Ohio



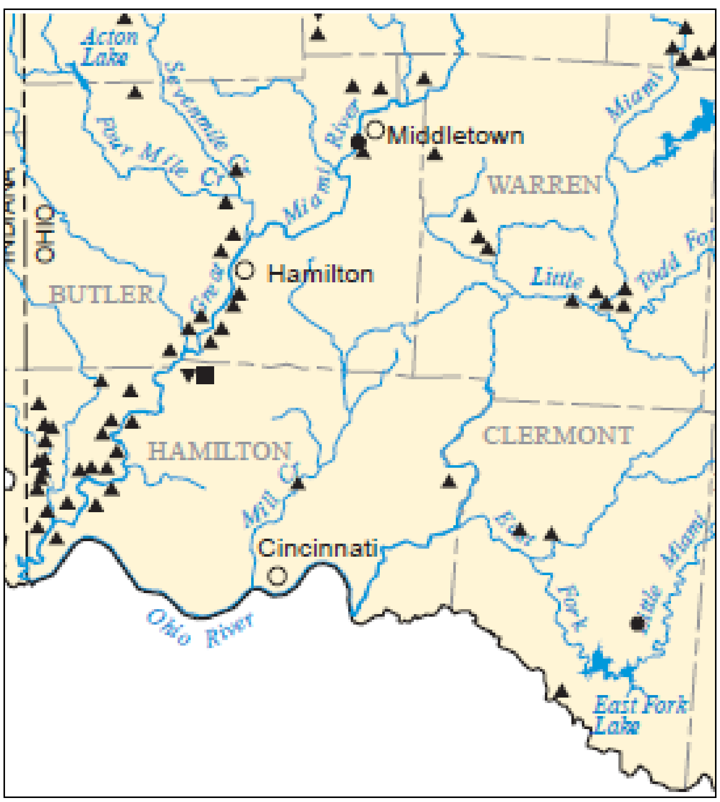
Ultimately, the surficial geology of Butler, Clermont, Hamilton and Warren counties is diverse and complex. This is evident on detailed, smaller scale maps such as *Surficial Geology of the Ohio Portions of the Cincinnati and Falmouth 30 X 60 Minute Quadrangles*, which the Ohio Division of Geological Survey published in 2004. The map designates 26 surficial units for the four-county study area and shows much greater topographic detail. It can be accessed online at:
ftp://ftp.dnr.state.oh.us/Geological_Survey/SurficialPDF_Drafts/CincinattiFallmouth_Surficial_v4.pdf

Economically, Ice Age legacies benefit the OKI region every day. The rich agricultural soils formed on glacial deposits produce a bounty of plant and animal products. The Ohio River, which formed in association with the ice sheets, serves as a major transportation route. The region's glacial deposits of sand and gravel constitute a significant value in mineral wealth.

Butler and Hamilton counties are prolific sand and gravel producers in a state that traditionally ranks among the top five for such mineral production. Sand and gravel are low-cost natural resources. Their widespread distribution in the OKI region lowers transportation costs to construction sites and road projects. Each black triangle on Figure 2-9 below shows the location of a sand and gravel mining operation in of the four-county study area.

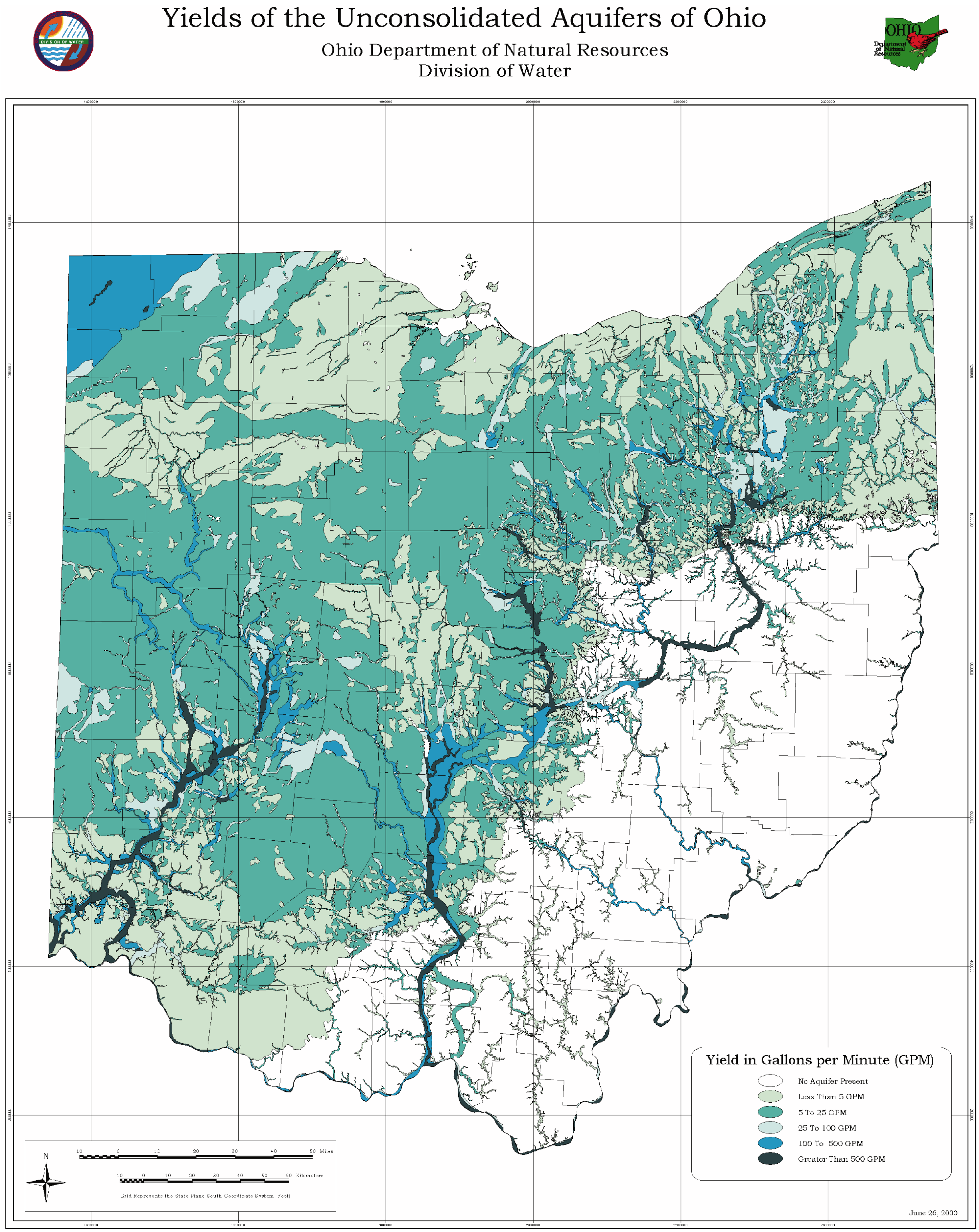
Figure 2-9: Sand and Gravel Mining Locations
in Butler, Clermont, Hamilton and Warren Counties

(from *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)



The region's unconsolidated aquifers, which were formed by melting glaciers, abundantly provide fresh water for domestic and industrial use. Figure 2-10 on the next page shows the region's buried valley aquifers in relation to other groundwater resources throughout Ohio.

Figure 2-10: Yields of the Unconsolidated Aquifers of Ohio



Buried valley aquifers derive their name from their location in the pre-glacial bedrock river valleys that have been left buried beneath unconsolidated glacial deposits. The ancient valleys received sand and gravel washing out from melting glaciers. Unconsolidated sand and gravel are ideal for holding groundwater because of the relatively large pore spaces between their particles.

Environmentally, Ice Age features can either broaden or limit the region's land use options. Thick, impermeable deposits of clay-rich glacial till provide good sites for landfills because the clays prevent landfill fluids from leaching into groundwater supplies. Glacial deposits of sand and gravel provide excellent, well-drained sites for development. These same sand and gravel areas, however, are highly vulnerable to groundwater contamination. And some of the clay-rich deposits are subject to landslide problems.

Ecoregions

For any given area, geology has a major influence on that area's ecoregion designation. The U.S. EPA states that ecoregions "are identified by similarities in geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology." Ohio EPA's *Guide to Developing Local Watershed Action Plans* states that "ecoregions are land-surface areas that are grouped based on similarities in land use, potential natural vegetation, land surface form and soils. These underlying factors determine the character of watersheds and have a profound influence on background water quality and the type and composition of the biological communities in a stream or river and the manner in which human impacts are exhibited." The U.S. Geological Survey concurs, saying: "Ecoregion characteristics influence surface- and ground-water quality, biological communities, and the types of human activities that will occur in an area." (*Environmental Setting and Effects . . .,* U.S.G.S., 2000*)*

In Ohio, ecoregions are also significant to water resource assessments and regulations. Ohio EPA partly bases its water quality standards, especially biocriteria, on the five types of ecoregions that had been designated for the state when the standards were set. More specifically, ecoregions influence the criteria to be applied for warmwater habitat, which is the predominant aquatic life use designation for streams in Butler, Clermont, Hamilton and Warren counties. When Ohio EPA assesses whether the region's streams attain their warmwater habitat potential, ecoregion influences the application of these biological indices:

- index of biological integrity (IBI)
- invertebrate health. community index (ICI)
- modified index of well being (MIwB).

Several ecoregional classification systems exist. This chapter describes the classification system referenced by the Ohio EPA in its *Guide to Developing Local Watershed Action Plans* as well as the U.S. Geological Survey in its National Water Quality Assessment of the drainage basin encompassing watersheds of the Whitewater River, Great Miami River, Mill Creek and Little Miami River. Both Ohio EPA and U.S. Geological Survey rely on the U.S. EPA's Omernik ecoregion system, which is hierarchical and considers the spatial patterns of both the living and non-living components, such as geology, physiography, vegetation, climate, soils, land use, wildlife, water quality, and hydrology. The Omernik hierarchy has four nested levels, with Level I being subdivided into smaller regions for Level II and so on.

All of the OKI region lies within the Level I ecoregion known as Eastern Temperate Forests, which is distinguished by its moderate to mildly humid climate, its relatively dense and diverse forest cover, and its high density of human inhabitants.

The OKI region straddles two Level II ecoregions known as the Central USA Plains and the Southeastern USA Plains
The Central USA Plains are distinguished by smooth plains with glacial moraines and lacustrine (lake) deposits as the surface materials. The ecoregion's pre-settlement vegetation was oak, hickory, elm, ash, beech and maple.

The Southeastern USA Plains are distinguished by irregular plains with low hills and surface materials of residium and loess (soils deposited by winds). The pre-settlement vegetation was mostly oak and hickory.

Two Level III ecoregions split the OKI planning area: (1) Interior Plateau, and (2) Eastern Corn Belt Plains. In the area, the Level III boundaries and Level II boundaries are the same.

The Interior Plateau is found along the Ohio River corridor of Clermont and Hamilton counties. This ecoregion bulges northward to include most of Hamilton County's western half. It is a diverse ecoregion with open hills and irregular plains in Clermont and Hamilton counties. Fish community diversity is a distinguishing feature of the Interior Plateau.

The Eastern Corn Belt Plains cover all of Butler and Warren counties, most of Clermont County and the eastern half of Hamilton County, except for the Ohio River corridor. This ecoregion is typified by gently rolling glacial till plains with moraines, kames and outwash features (Omernik and Gallant 1988, as cited in Ohio EPA 1997) Before settlement, the area had plentiful natural tree cover. Many of its soils are relatively loamy, rich and well-drained. Glacial deposits of Wisconsian age are extensive. Areas with pre-Wisconsian till are more dissected and leached. Originally, beech forests were common on the Wisconsinan soils while beech forests and elm-ash swamp forests dominated the wetter pre-Wisconsinan soils. Today, extensive corn, soybean, and livestock production affect stream chemistry and turbidity.

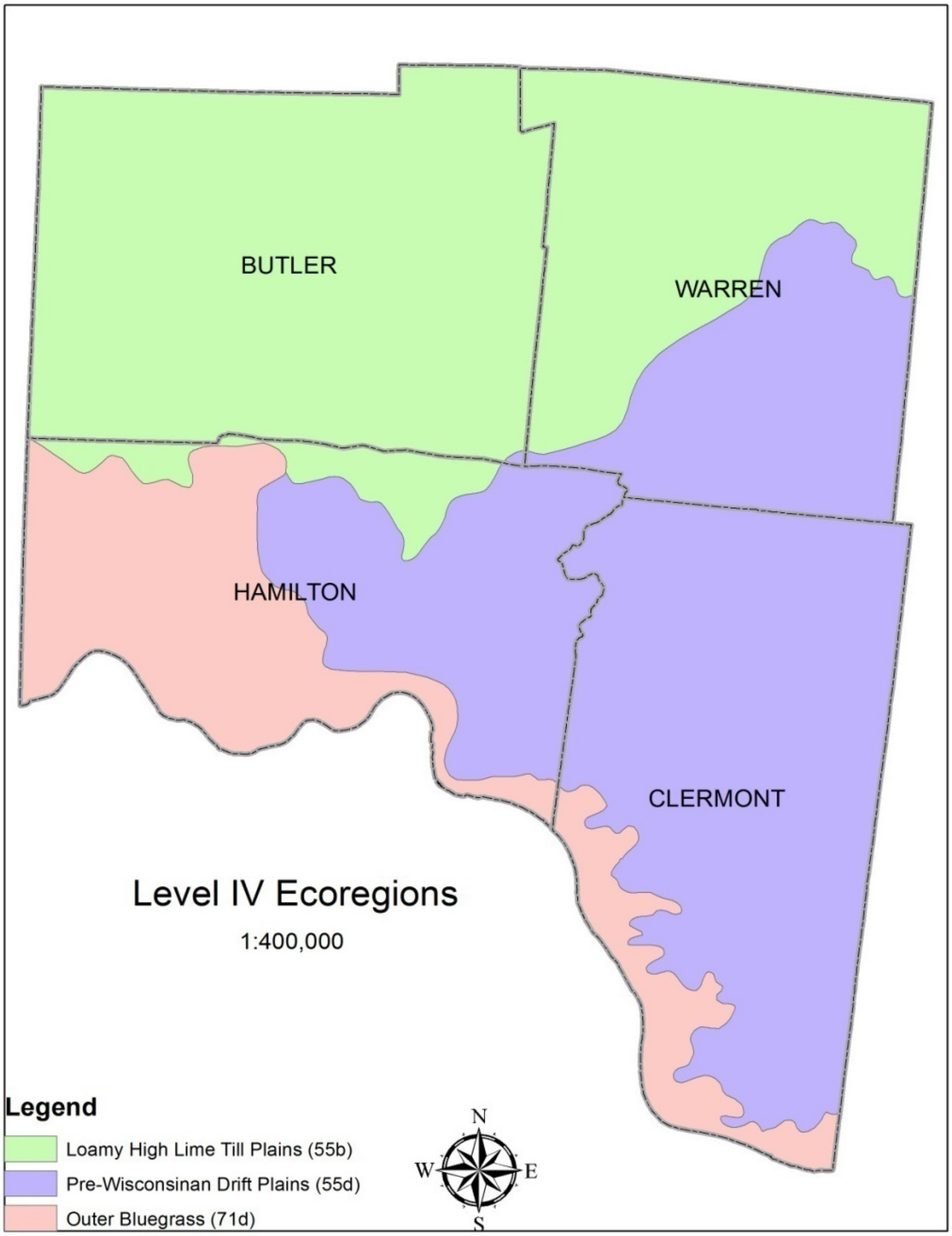
Three Level IV ecoregions are found in the OKI planning area:

1. Loamy High Lime Till Plains (ecoregion map unit 55b): This ecoregion covers nearly all of Butler County, a little more than half of Warren County and a small part of northern Hamilton County. As part of the Till Plains, this subecoregion drains from north to south-southwest toward Cincinnati. It is characterized by high lime, late Wisconsian glacial till with a well-developed drainage network and fertile soils. Before settlement, the ecoregion flourished in beech forests and elm/ash swamp forests. Oak/sugar-maple forests were also present. The forests have been replaced by corn, soybean, wheat, livestock and dairy farming on artificially drained clayey soils.
2. Pre-Wisconsian Drift Plains (ecoregion map unit 55d): This ecoregion covers much of eastern Hamilton County, a little less than half of Warren County and all parts of Clermont County north of the Ohio River Valley. It is characterized by dissected, deeply leached, acidic, clay-loam glacial till and thin loess. The soils in this region are poorly drained. Historically, beech forests and elm/ash swamp forests were common. Soybean, corn, tobacco and livestock are common in non-urbanized parts of this ecoregion. (*Environmental Setting . . .,* U.S. Geological Survey, 2000)

3. Outer Bluegrass (ecoregion map unit 71d): This ecoregion covers all but the northern edge of western Hamilton County and all of the Ohio River Valley in Hamilton and Clermont counties. It is characterized by rugged terrain and woodlands. Much of the land is farmed for hay, grain, cattle, hogs and poultry. Unlike the soils in the Eastern Corn Belt Plains (Level III ecoregion), Outer Bluegrass soils are derived predominantly from sandstone, siltstone, shale and limestone bedrock. Outer Bluegrass has a mixture of glaciated and unglaciated soils and is characterized by limestone bedrock, flat rubble streambeds and high relief near the Ohio River. This ecoregion is also known as the Northern Bluegrass.

Figure 2-11 below shows the Level IV ecoregions of the four-county study area.

Figure 2-11: Level IV Ecoregions in Butler, Clermont, Hamilton and Warren Counties



Physiography

Most of the four-county study area is within the Till Plains of the Central Lowland physiographic province. The province is characterized by Pleistocene glaciations. Advance and retreat of the glacial ice sheets produced a flat to gently rolling land surface that is cut by steep-walled river valleys of low to moderate relief. Towards the south, glacial deposits are thin or absent, and erosion of less-resistant shale has produced a dissected hilly terrain of higher stream density. The general topographic gradient is from north to south. The study area includes the lowest elevation in the State of Ohio, which occurs along the banks of the Ohio River in southwestern Hamilton County. The spot is 451 feet above sea level. (*Setting and Effects . . .,* U.S.G.S., 2000)

The *Soil Survey of Hamilton County, Ohio* (U.S. Department of Agriculture, 1982) states the Till Plains of the Central Lowland are characterized by structural and sedimentary basins, domes and arches that came into existence throughout the Paleozoic times of 550 to 250 million years ago. Among these features is the Cincinnati Arch, which is described above in the geology section.

In its groundwater pollution potential reports of the 1990s, the Ohio Department of Natural Resources described the physiography of the study area's four counties as follows:

Butler County is characterized by steeply rolling uplands dissected by broad, flat-bottomed valleys. The uplands are composed of late Ordovician shale and limestone bedrock covered by varying thicknesses of till deposits.

Clermont County is characterized by broad, level to rolling uplands dissected by steep-sided stream valleys. The topography in the upland areas primarily reflects the bedrock surface due to the thin glacial cover in these areas.

Hamilton County is characterized by rolling uplands dissected by broad valleys. The uplands are composed of Late Ordovician shale and limestone bedrock and are covered by thin till deposits. The valleys are filled with thick deposits of glacial and fluvial origin.

Warren County is characterized by relatively flat-lying upland areas that have been dissected by streams. Valley sides are generally steep, particularly where bedrock is near the surface. The major rivers have broad, flat-bottomed valleys. The uplands are composed primarily of Ordovician shale and limestone bedrock covered by varying thicknesses of glacial till deposits.

Within the four-county study area, the Till Plains of the Central Lowland divide into three Ohio subunits and one Indiana subunit. Topographic variations in each Ohio subunit depend largely on the bedrock geology and glacial history of the region. The one Indiana subunit is distinguished by the thickness of glacial till. The four physiographic subunits are:

1. Southern Ohio Loamy Till Plain − This Ohio physiographic subunit is characterized by end and recessional moraines between relatively flat-lying ground moraine. The morainal features are cut by steep volleyed streams, with alternating broad and narrow flood plains. Buried valleys filled with glacial-outwash deposits are common. This subunit also contains interlobate areas characterized by extensive outwash deposits, outwash terraces, and border moraines; as such they are areas of focused groundwater discharge in the form of cold, perennial, groundwater-fed springs and streams. Nearly all of the glacial deposits are underlain by Ordovician shale and limestone. In small parts of northern Butler and Warren counties, glacial deposits are underlain by Silurian carbonates.

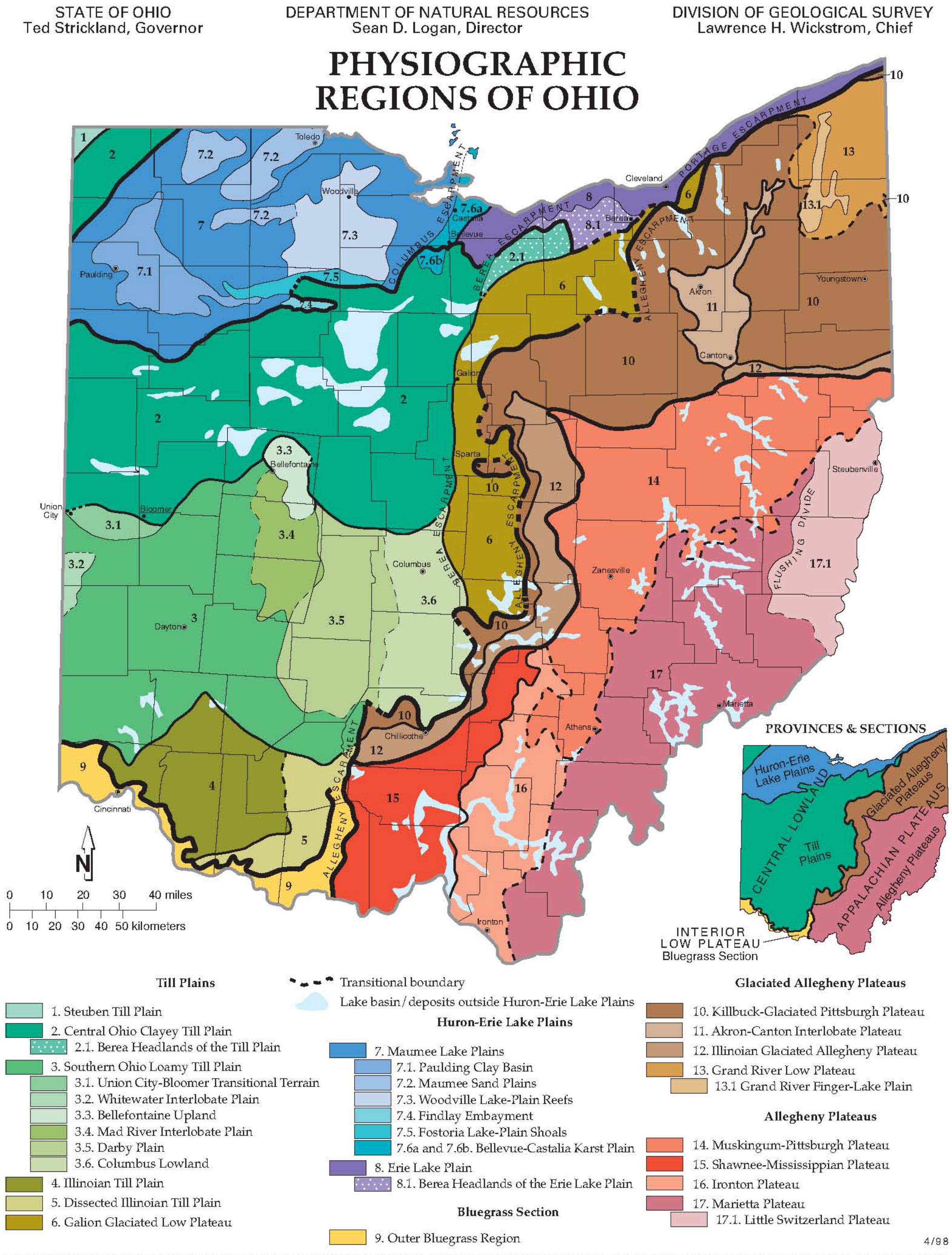
2. Illinoian Till Plain – This Ohio physiographic subunit is characterized by rolling ground moraines of older till and numerous buried valleys. Its streams typically flow over exposed Ordovician shale and limestone.
3. Dissected Illinoian Till Plain – This Ohio physiographic subunit is former glacial till plain where glacial deposits have been eroded from valley sides, resulting in a hilly topography and higher stream density. Like the Illinoian Till Plain, this area's streams typically flow over exposed Ordovician shale and limestone.
4. Dearborn Upland – This Indiana physiographic subunit is a bedrock plateau with rugged relief covering the southern two-thirds of the Whitewater River Basin, which is mostly in neighboring Indiana but has 7.3 river miles in western Hamilton County. The plateau is overlain by 15 to 50 feet of glacial till. Bedrock in Ohio's part of the Dearborn Upland consists of Ordovician shale and limestone.

Part of the study area, namely western Hamilton County and the Ohio River corridor at the southern extremities of Hamilton and Clermont counties, is located within the Interior Low Plateau physiographic province. More specifically, the described area is entirely within in the Outer Bluegrass Region of the Interior Low Plateau Province.

The Outer Bluegrass is characterized by a dissected plateau of carbonate rocks with moderately high relief (300 feet). The physiographic region's geology consists of Ordovician-age dolomites, limestones and calcareous shales. Ridges show pre-Wisconsian drift. The colluvium is typically silt-loam. The region's boundaries are distinguished by Ohio River bluffs and bounded by three types of till plain (from west to east: Southern Ohio Loamy Till Plain, Illinoian Till Plain and Dissected Illinoian Till Plain).

Outer Bluegrass soils lack the high lime content of the Wisconsian till soils predominant in Butler County and the northwestern half of Warren County. Figure 2-12 on the next page is a map by the Ohio Department of Natural Resources showing the physiographic regions of Butler, Clermont, Hamilton and Warren counties in relation to the entire State of Ohio.

Figure 2-12: Physiographic Regions of Ohio



Soils

Soil characteristics influence the quality of surface water and groundwater. Soils are classified by composition of parent material, native vegetation, texture, color, structure, depth, arrangement of soil horizons and thickness of soil horizons. The physical properties of soils influence a variety of water-related processes, including runoff, infiltration, sedimentation and erosion rates. The chemical properties of soils influence the chemical processes of dissolution, precipitation, adsorption and oxidation-reduction reactions. Soil chemical properties are influenced by organic material, microorganisms and gases available. (*Environmental Setting . . .,*U.S.G.S., 2000)

Soils affect vegetation cover, farming practices, rainfall infiltration, pollution runoff rates, erosion and sedimentation. Among the soil characteristics relevant to water quality management planning are: erosion control, nutrient management, suitability for septic systems, and construction of wetlands in hydric soils for wastewater treatment. Soil characteristics also help estimate the volume of runoff and suspended sediment loads to receiving streams. (*A Guide to Developing Local Watershed Action Plans in Ohio*, Ohio EPA, 1997)

As noted by Dr. Paul Edwin Potter in *Exploring the Geology of the Cincinnati/Northern Kentucky Region* (Kentucky Geological Survey, 1996), Southwest Ohio has an unusually wide spectrum of soils. This is attributable to significant variations in:

- ages of the region's glacial deposits, from less than 17,000 years ago (Wisconsinan age) to more than 300,000 years ago (Illinoian age)
- types of the region's parent materials--till, loess, colluviums, alluvium, ancient bedrock
- slopes of the region's land surfaces, which range from steep hillsides to flat uplands

Comparison of soils formed on Illinoian drift in southeastern Warren County with those formed on nearby Wisconsinan drift illustrates how much time affects soil properties. Topography is as important as parent materials, yet depth of leaching, productivity and drainage are strikingly different because the weathering process has operated 15 to 20 times longer on Illinoian drift than on Wisconsinan drift, so that Illinoian soils are tight and poorly drained, creating a shorter growing season and lower crop yields. The active weathering process is the alteration of parent material by water, organic acids and plants. Water dissolves soluble minerals such as calcium carbonated, transforms other minerals such as feldspar into clay minerals, and along with freezing and thawing and plant activity, converts coarse material into finer material. Accordingly, extended time and poor drainage produce a tight, water-logged, clay-rich, dense, deeply leached Clermont/Avonburg soil in comparison to a less leached, better drained, less dense Russell/Miamian soil. (Potter, 1996)

Soil classification systems have been launched at the national, regional, state and county levels. This discussion covers the regional, state and county classification system. The State Soil Geographic (STATSGO) Data Base was designed primarily for regional, multistate, river basin, state and multicounty resource planning, management and monitoring. Soil maps for STATSGO are compiled by generalizing more detailed soil survey maps. Soils of like areas are studied, and their probable classifications are determined. (*State Soil Geographic Data Base, Data Use Information*, U.S. Department of Agriculture, 1994). Figure 2-13 on the next page shows the STATSGO map units for Butler, Clermont, Hamilton and Warren counties. Separate descriptions are unavailable for the 12 general soil associations mapped in Figure 2-10. Instead, their characteristics must be deduced from the properties of the local soil series named in each association. Accordingly, the map below is followed by eight pages of tabular data on the 400 most prevalent soil types in the four-county study area, starting with the most common soil type.

Figure 2-13: State Soil Geographic Data Base Map Units for Southwest Ohio

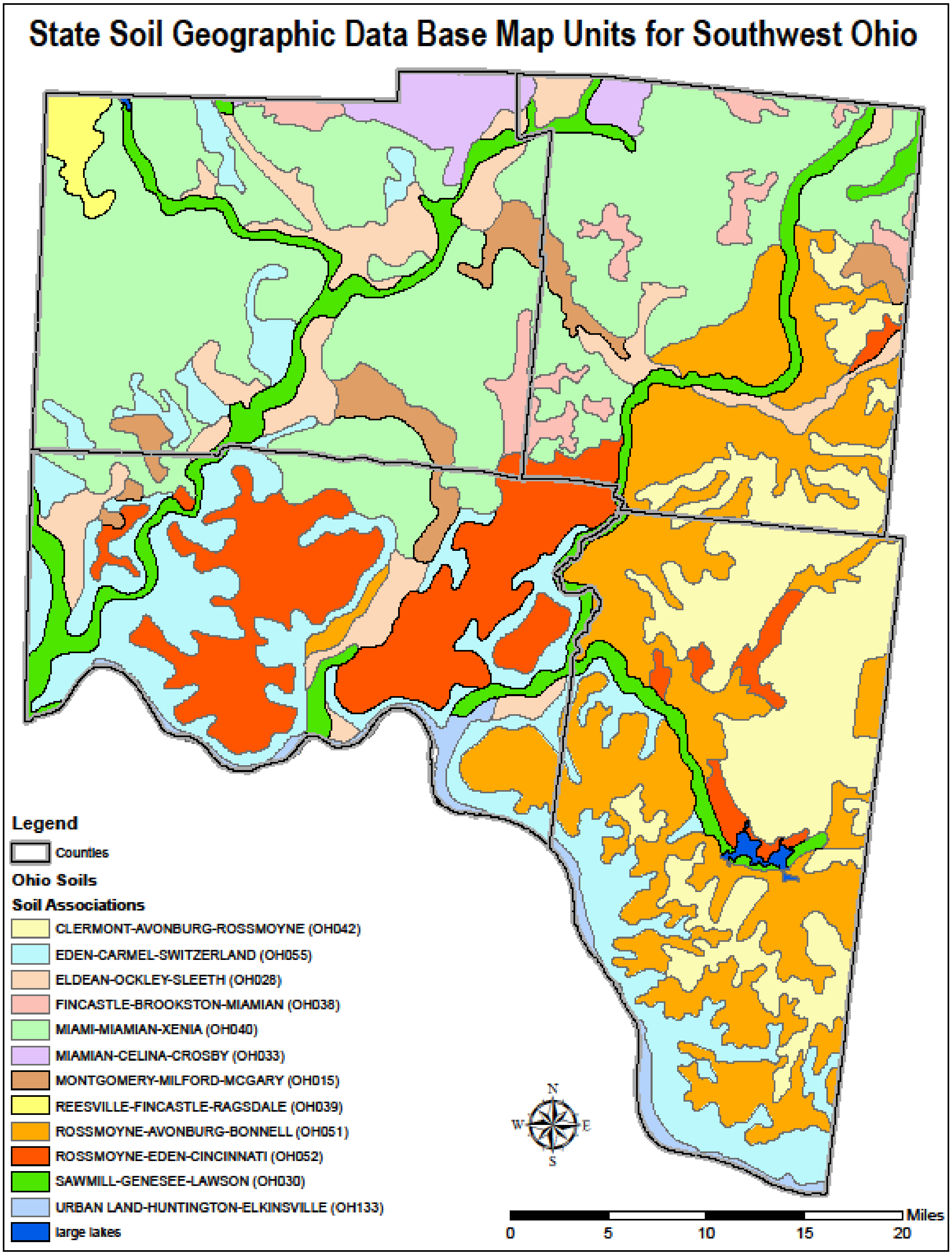


Table 2-4: Most Prevalent Soil Types in Butler, Clermont, Hamilton and Warren Counties

#	County	Symbol	Soil Type (may include water area)	Acres
1	Clermont	Cle1A	Clermont silt loam, 0 to 1% slopes	45,784
2	Clermont	AvA	Avonburg silt loam, 0 to 2% slopes	42,887
3	Hamilton	RtB	Rossmoyne-Urban land complex, 3 to 8% slopes	34,068
4	Clermont	RpB	Rossmoyne silt loam, 2 to 6% slopes	32,385
5	Hamilton	EcE	Eden silty clay loam, 25 to 40% slopes	31,182
6	Butler	WyC2	Wynn silt loam, 6 to 12% slopes, moderately eroded	26,918
7	Clermont	CcC2	Cincinnati silt loam, 6 to 12% slopes, moderately eroded	22,590
8	Warren	Cle1A	Clermont silt loam, 0 to 1% slopes	19,011
9	Clermont	RpB2	Rossmoyne silt loam, 2 to 6% slopes, moderately eroded	18,235
10	Warren	RvB2	Russell-Miamian silt loams, 2 to 6% slopes, moderately eroded	16,936
11	Butler	EcE2	Eden silty clay loam, 15 to 25% slopes, moderately eroded	16,776
12	Butler	RwB2	Russell-Miamian silt loams, bedrock substratum, 2 to 6% slopes, moderately eroded	15,984
13	Warren	RpB	Rossmoyne silt loam, 2 to 6% slopes	15,646
14	Warren	RvB	Russell-Miamian silt loams, 2 to 6% slopes	15,431
15	Warren	AvA	Avonburg silt loam, 0 to 2% slopes	14,300
16	Clermont	EaF2	Eden flaggy silty clay loam, 25 to 50% slopes, moderately eroded	14,228
17	Butler	RvB2	Russell-Miamian silt loams, 2 to 6% slopes, moderately eroded	13,560
18	Warren	FhA	Fincastle silt loam, 0 to 2% slopes	13,104
19	Warren	XeB	Xenia silt loam, 2 to 6 % slopes	13,101
20	Butler	XfB	Xenia silt loam, bedrock substratum, 2 to 6% slopes	12,393
21	Butler	WyB2	Wynn silt loam, 2 to 6% slopes, moderately eroded	11,904
22	Hamilton	EcD	Eden silty clay loam, 15 to 25 %slopes	11,304
23	Hamilton	RtC	Rossmoyne-Urban land complex, 8 to 15% slopes	11,029
24	Clermont	EbG2	Edenton loam, 25 to 50% slopes, moderately eroded	11,025
25	Butler	XeB	Xenia silt loam, 2 to 6% slopes	11,017
26	Warren	RpB2	Rossmoyne silt loam, 2 to 6% slopes, moderately eroded	10,742
27	Clermont	EbE2	Edenton loam, 18 to 25% slopes, moderately eroded	10,731
28	Clermont	RpC2	Rossmoyne silt loam, 6 to 12% slopes, moderately eroded	10,525
29	Butler	MsC2	Miamian-Russell silt loams, 6 to 12% slopes, moderately eroded	9,853
30	Butler	FcA	Fincastle silt loam, 0 to 2% slopes	9,718
31	Hamilton	EdF	Eden flaggy silty clay loam, 40 to 60% slopes	9,511
32	Hamilton	AsB	Ava-Urban land complex, 3 to 8% slopes	9,456
33	Warren	MrC2	Miamian-Russell silt loams, 6 to 12% slopes, moderately eroded	9,212
34	Butler	Gn	Genesee loam	9,161
35	Warren	Br	Brookston silty clay loam	8,835
36	Butler	EuA	Eldean-Urban land complex, nearly level	8,811
37	Hamilton	RtA	Rossmoyne-Urban land complex, 0 to 3% slopes	8,341
38	Hamilton	SxC	Switzerland-Urban land complex, 8 to 15% slopes	8,151
39	Clermont	Gn	Genesee silt loam	8,144
40	Butler	HeE2	Hennepin-Miamian silt loams, 18 to 25% slopes, moderately eroded	7,906
41	Warren	HtF2	Hickory-Fairmount complex, 25 to 50% slopes, moderately eroded	7,662
42	Butler	MtC2	Miamian-Russell silt loams, bedrock substratum, 6 to 12% slopes, moderately eroded	7,538
43	Hamilton	RxB	Russell-Urban land complex, 3 to 8% slopes	7,189
44	Warren	DaB	Dana silt loam, 2 to 6% slopes	7,135
45	Clermont	HkF2	Hickory loam, 18 to 35% slopes, moderately eroded	6,959
46	Butler	RxB	Russell-Urban land complex, gently sloping	6,940
47	Hamilton	RpB2	Rossmoyne silt loam, 3 to 8% slopes, eroded	6,058
48	Butler	ElA	Eldean loam, 0 to 2% slopes	5,865
49	Hamilton	SwC2	Switzerland silt loam, 8 to 15% slopes, eroded	5,823
50	Clermont	RpA	Rossmoyne silt loam, 0 to 2% slopes	5,804

#	County	Symbol	Soil Type (may include water area)	Acres
51	Hamilton	Ju	Jules silt loam, occasionally flooded	5,635
52	Butler	RvB	Russell-Miamian silt loams, 2 to 6% slopes	5,585
53	Butler	MlB2	Miamian silt loam, 2 to 6% slopes, moderately eroded	5,563
54	Warren	WyB2	Wynn silt loam, 2 to 6% slopes, moderately eroded	5,334
55	Butler	Rn	Ross loam	5,304
56	Hamilton	CnC2	Cincinnati silt loam, 8 to 15% slopes, eroded	5,075
57	Butler	RwB	Russell-Miamian silt loams, bedrock substratum, 2 to 6% slopes	4,969
58	Butler	Pa	Patton silty clay loam	4,928
59	Butler	DaB	Dana silt loam, 2 to 6% slopes	4,841
60	Clermont	W	Water	4,788
61	Warren	Gn	Genesee loam	4,612
62	Butler	Lg	Lanier fine sandy loam	4,599
63	Butler	St	Stonelick fine sandy loam	4,566
64	Warren	Gd	Genesee fine sandy loam	4,515
65	Hamilton	W	Water	4,473
66	Hamilton	UmB	Urban land-Martinsville complex, 3 to 8% slopes	4,467
67	Clermont	AvB	Avonburg silt loam, 2 to 6% slopes	4,466
68	Butler	FdA	Fincastle silt loam, bedrock substratum, 0 to 2% slopes	4,368
69	Butler	HeF	Hennepin-Miamian silt loams, 25 to 50% slopes	4,191
70	Hamilton	BoE	Bonnell silt loam, 25 to 35% slopes	4,156
71	Clermont	EbD2	Edenton loam, 12 to 18% slopes, moderately eroded	4,125
72	Hamilton	Uh	Urban land-Huntington complex, frequently flooded	4,084
73	Warren	RpA	Rossmoyne silt loam, 0 to 2% slopes	4,066
74	Hamilton	Gn	Genesee loam, occasionally flooded	3,912
75	Clermont	CkD3	Cincinnati and Hickory soils, 12 to 25% slopes, severely eroded	3,862
76	Butler	XfB2	Xenia silt loam, bedrock substratum, 2 to 6% slopes, moderately eroded	3,850
77	Butler	Ra	Ragsdale silty clay loam	3,829
78	Warren	HrD2	Hickory silt loam, 12 to 18% slopes, moderately eroded	3,725
79	Warren	WyC2	Wynn silt loam, 6 to 12% slopes, moderately eroded	3,611
80	Warren	Rn	Ross loam	3,598
81	Butler	XeB2	Xenia silt loam, 2 to 6% slopes, moderately eroded	3,561
82	Clermont	CcD2	Cincinnati silt loam, 12 to 18% slopes, moderately eroded	3,523
83	Hamilton	St	Stonelick fine sandy loam, frequently flooded	3,520
84	Warren	FaF2	Fairmount-Eden flaggy silty clay loams, 25 to 50% slopes, moderately eroded	3,392
85	Hamilton	PfD	Pate silty clay loam, 15 to 25% slopes	3,338
86	Hamilton	EeD	Eden-Urban land complex, 15 to 25% slopes	3,251
87	Hamilton	BoD	Bonnell silt loam, 15 to 25% slopes	3,225
88	Warren	RpC2	Rossmoyne silt loam, 6 to 12% slopes, moderately eroded	3,221
89	Hamilton	ErA	Eldean-Urban land complex, 0 to 2% slopes	3,219
90	Warren	Pc	Patton silty clay loam	3,134
91	Butler	XeA	Xenia silt loam, 0 to 2% slopes	3,077
92	Hamilton	ArB2	Ava silt loam, 3 to 8% slopes, eroded	3,037
93	Warren	MnD2	Miamian-Hennepin silt loams, 12 to 18% slopes, moderately eroded	3,030
94	Butler	RdA	Raub silt loam, 0 to 2% slopes	2,948
95	Warren	HrC2	Hickory silt loam, 6 to 12% slopes, moderately eroded	2,902
96	Warren	Sec3A	Secondcreek silty clay loam, 0 to 1% slopes	2,854
97	Warren	XeA	Xenia silt loam, 0 to 2% slopes	2,807
98	Hamilton	Po	Pits, gravel	2,771
99	Warren	FlA	Fox loam, 0 to 2% slopes	2,749
100	Butler	MlC2	Miamian silt loam, 6 to 12% slopes, moderately eroded	2,678
101	Hamilton	PhD	Pate-Urban land complex, 15 to 25% slopes	2,669
102	Butler	ElB2	Eldean loam, 2 to 6% slopes, moderately eroded	2,650

#	County	Symbol	Soil Type (may include water area)	Acres
103	Clermont	RsC3	Rossmoyne silty clay loam, 6 to 12% slopes, severely eroded	2,495
104	Hamilton	Ux	Urban land-Stonelick complex, frequently flooded	2,486
105	Warren	CnC2	Cincinnati silt loam, 6 to 12% slopes, moderately eroded	2,431
106	Butler	OcA	Ockley silt loam, 0 to 2% slopes	2,411
107	Warren	FlB	Fox loam, 2 to 6% slopes	2,379
108	Hamilton	ArC2	Ava silt loam, 8 to 15% slopes, eroded	2,244
109	Butler	FcB	Fincastle silt loam, 2 to 6% slopes	2,211
110	Butler	EcF2	Eden silty clay loam, 25 to 50% slopes, moderately eroded	2,210
111	Clermont	EaE2	Eden flaggy silty clay loam, 18 to 25% slopes, moderately eroded	2,205
112	Hamilton	CnB2	Cincinnati silt loam, 3 to 8% slopes, eroded	2,192
113	Clermont	CcB2	Cincinnati silt loam, 2 to 6% slopes, moderately eroded	2,174
114	Hamilton	UrB	Urban land-Rossmoyne complex, 0 to 8% slopes	2,172
115	Warren	AvB	Avonburg silt loam, 2 to 6% slopes	2,151
116	Butler	TpA	Tippecanoe silt loam, 0 to 2% slopes	2,145
117	Clermont	FaG2	Fairmount very flaggy silty clay loam, 25 to 50% slopes, moderately eroded	2,127
118	Clermont	Ee	Eel silt loam	2,124
119	Butler	FdB	Fincastle silt loam, bedrock substratum, 2 to 6% slopes	2,099
120	Butler	MsD2	Miamian-Russell silt loams, 12 to 18% slopes, moderately eroded	2,086
121	Hamilton	McA	Martinsville silt loam, 0 to 2% slopes	2,073
122	Warren	HeF2	Hennepin silt loam, 25 to 35% slopes, moderately eroded	2,041
123	Warren	EdF2	Eden complex, 25 to 35% slopes, moderately eroded	2,022
124	Butler	MuC	Miamian-Urban land complex, sloping	2,014
125	Clermont	AvB2	Avonburg silt loam, 2 to 6% slopes, moderately eroded	2,003
126	Clermont	RtB	Rossmoyne-Urban land complex, gently sloping	1,970
127	Butler	Ud	Udorthents	1,936
128	Hamilton	EpA	Eldean loam, 0 to 2% slopes	1,933
129	Warren	HeF	Hennepin silt loam, 25 to 35% slopes	1,933
130	Butler	WyB	Wynn silt loam, 2 to 6% slopes	1,901
131	Hamilton	Go	Genesee-Urban land complex, occasionally flooded	1,888
132	Hamilton	Uo	Urban land-Patton complex	1,846
133	Hamilton	AsC	Ava-Urban land complex, 8 to 15% slopes	1,799
134	Clermont	Hu	Huntington silt loam	1,777
135	Butler	UpA	Urban land-Eldean complex, nearly level	1,764
136	Warren	HtE2	Hickory-Fairmount complex, 18 to 25% slopes, moderately eroded	1,751
137	Butler	EuB	Eldean-Urban land complex, gently sloping	1,747
138	Butler	Go	Genesee-Urban land complex	1,727
139	Warren	HmE2	Hennepin-Miamian silt loams, 18 to 25% slopes, moderately eroded	1,654
140	Hamilton	RwB2	Russell silt loam, 3 to 8% slopes, eroded	1,621
141	Hamilton	AwA	Avonburg-Urban land complex, 0 to 2% slopes	1,618
142	Hamilton	RpA	Rossmoyne silt loam, 0 to 3% slopes	1,607
143	Butler	WeA	Wea silt loam, 0 to 2% slopes	1,606
144	Hamilton	XfB2	Xenia silt loam, 2 to 6% slopes, eroded	1,593
145	Warren	MmC3	Miamian clay loam, 6 to 12% slopes, severely eroded	1,570
146	Hamilton	AvA	Avonburg silt loam, 0 to 2% slopes	1,567
147	Warren	FhB	Fincastle silt loam, 2 to 6% slopes	1,563
148	Warren	XeB2	Xenia silt loam, 2 to 6% slopes, moderately eroded	1,557
149	Butler	WbA	Warsaw loam, 0 to 3% slopes	1,552
150	Warren	W	Water	1,538
151	Warren	FlC2	Fox loam, 6 to 12% slopes, moderately eroded	1,504
152	Butler	OcB	Ockley silt loam, 2 to 6% slopes	1,490
153	Hamilton	Lg	Lanier sandy loam, occasionally flooded	1,477
154	Clermont	HkD2	Hickory loam, 12 to 18% slopes, moderately eroded	1,442

#	County	Symbol	Soil Type (may include water area)	Acres
155	Warren	WyB	Wynn silt loam, 2 to 6% slopes	1,434
156	Clermont	HlG3	Hickory clay loam, 25 to 50% slopes, severely eroded	1,423
157	Hamilton	SwD2	Switzerland silt loam, 15 to 25% slopes, eroded	1,405
158	Clermont	CcB	Cincinnati silt loam, 2 to 6% slopes	1,389
159	Warren	RkE2	Rodman and Casco gravelly loams, 18 to 25% slopes, moderately eroded	1,377
160	Clermont	AwA	Avonburg-Urban land complex, nearly level	1,375
161	Clermont	OcA	Ockley silt loam, 0 to 2% slopes	1,364
162	Clermont	Lg	Lanier sandy loam	1,362
163	Hamilton	RpC2	Rossmoyne silt loam, 8 to 15% slopes, eroded	1,293
164	Butler	XfA	Xenia silt loam, bedrock substratum, 0 to 2% slopes	1,289
165	Butler	Pg	Pits, gravel	1,279
166	Warren	EdD2	Eden complex, 12 to 18% slopes, moderately eroded	1,230
167	Hamilton	ErB	Eldean-Urban land complex, 2 to 6% slopes	1,218
168	Clermont	WvB	Williamsburg and Martinsville silt loams, 2 to 6% slopes	1,218
169	Butler	DbB	Dana silt loam, bedrock substratum, 2 to 8% slopes	1,214
170	Butler	HoA	Henshaw silt loam, 0 to 2% slopes	1,208
171	Butler	Ee	Eel silt loam	1,202
172	Clermont	EcE3	Edenton clay loam, 12 to 25% slopes, severely eroded	1,193
173	Clermont	EbC2	Edenton loam, 6 to 12% slopes, moderately eroded	1,188
174	Clermont	EdG3	Edenton and Fairmount soils, 25 to 50% slopes, severely eroded	1,186
175	Warren	OcB	Ockley silt loam, 2 to 6% slopes	1,167
176	Warren	FlB2	Fox loam, 2 to 6% slopes, moderately eroded	1,118
177	Hamilton	UgB	Urban land-Elkinsville complex, 3 to 8% slopes	1,117
178	Butler	DaA	Dana silt loam, 0 to 2% slopes	1,099
179	Warren	WaA	Warsaw loam, 0 to 2% slopes	1,081
180	Warren	Ag	Algiers silt loam	1,069
181	Clermont	OcB	Ockley silt loam, 2 to 6% slopes	1,029
182	Warren	HoB	Henshaw silt loam, 1 to 4% slopes	1,012
183	Hamilton	PfE	Pate silty clay loam, 25 to 35% slopes	992
184	Butler	Uf	Udorthents and Dumps	986
185	Hamilton	FdA	Fincastle silt loam, 0 to 2% slopes	947
186	Butler	W	Water	940
187	Clermont	Sh	Shoals silt loam	932
188	Hamilton	EeC	Eden-Urban land complex, 8 to 15% slopes	922
189	Warren	Ud	Udorthents	922
190	Hamilton	PbC2	Parke silt loam, 8 to 15% slopes, eroded	914
191	Warren	CnB2	Cincinnati silt loam, 2 to 6% slopes, moderately eroded	909
192	Hamilton	EcC2	Eden silty clay loam, 8 to 15% slopes, eroded	905
193	Butler	La	Landes sandy loam	896
194	Butler	RtB	Russell silt loam, 2 to 6% slopes	895
195	Hamilton	PrA	Princeton sandy loam, 0 to 2% slopes	890
196	Hamilton	EpB2	Eldean loam, 2 to 6% slopes, eroded	882
197	Butler	MnD3	Miamian clay loam, 12 to 18% slopes, severely eroded	879
198	Hamilton	Hu	Huntington silt loam, occasionally flooded	875
199	Clermont	AdC	Alluvial land, sloping	864
200	Hamilton	MuC	Miamian-Urban land complex, 8 to 15% slopes	857
201	Hamilton	CdE	Casco loam, 25 to 35% slopes	853
202	Hamilton	MnC2	Miamian silt loam, 8 to 15% slopes, eroded	847
203	Clermont	WvC2	Williamsburg and Martinsville silt loams, 6 to 12% slopes, moderately eroded	843
204	Warren	CnB	Cincinnati silt loam, 2 to 6% slopes	815
205	Clermont	Ne	Newark silt loam	813
206	Clermont	Ln	Lindside silt loam	789

#	County	Symbol	Soil Type (may include water area)	Acres
207	Warren	Pb	Patton silt loam, silted	783
208	Warren	AbA	Abscota sand, calcareous variant	776
209	Warren	OcA	Ockley silt loam, 0 to 2% slopes	769
210	Hamilton	Rn	Ross loam, rarely flooded	763
211	Butler	WuC	Wynn-Urban land complex, sloping	756
212	Warren	EdE2	Eden complex, 18 to 25% slopes, moderately eroded	748
213	Hamilton	FpA	Fox-Urban land complex, 0 to 3% slopes	744
214	Hamilton	SwB2	Switzerland silt loam, 3 to 8% slopes, eroded	734
215	Hamilton	UgC	Urban land-Elkinsville complex, 8 to 15% slopes	722
216	Butler	Bt	Brenton silt loam	709
217	Butler	CrA	Crosby silt loam, 0 to 2% slopes	709
218	Clermont	FnB	Fox silt loam, 2 to 6% slopes	702
219	Butler	ElC2	Eldean loam, 6 to 12% slopes, moderately eroded	699
220	Hamilton	HoA	Henshaw silt loam, 0 to 2% slopes	694
221	Hamilton	Pn	Patton silty clay loam	679
222	Butler	MnC3	Miamian clay loam, 6 to 12% slopes, severely eroded	662
223	Butler	UsA	Urban land-Patton complex, nearly level	659
224	Hamilton	XfA	Xenia silt loam, 0 to 2% slopes	639
225	Clermont	EaD2	Eden flaggy silty clay loam, 12 to 18% slopes, moderately eroded	639
226	Warren	Ee	Eel loam	639
227	Hamilton	MaB	Markland silty clay loam, 2 to 6% slopes	629
228	Hamilton	McB	Martinsville silt loam, 2 to 6% slopes	616
229	Hamilton	FeA	Fincastle-Urban land complex, 0 to 2% slopes	614
230	Butler	UnB	Uniontown silt loam, 2 to 6% slopes	612
231	Warren	WeA	Wea silt loam, 0 to 2% slopes	612
232	Warren	WyC3	Wynn silt loam, 6 to 12% slopes, severely eroded	608
233	Clermont	St	Stonelick sandy loam	606
234	Butler	WuB	Wynn-Urban land complex, gently sloping	605
235	Clermont	FuB	Fox-Urban land complex, gently sloping	580
236	Hamilton	EeB	Eden-Urban land complex, 3 to 8% slopes	577
237	Hamilton	PbB2	Parke silt loam, 3 to 8% slopes, eroded	575
238	Clermont	SaB	Sardinia silt loam, 2 to 6% slopes	558
239	Butler	EnB2	Eldean gravelly loam, 2 to 6% slopes, moderately eroded	555
240	Clermont	EaF	Eden flaggy silt loam, 40 to 70% slopes	551
241	Hamilton	EcE2	Eden silty clay loam, 15 to 25% slopes, moderately eroded	541
242	Hamilton	FoA	Fox loam, 0 to 2% slopes	541
243	Warren	WlB	Williamsburg silt loam, 2 to 6% slopes	529
244	Butler	RdB	Raub silt loam, 2 to 6% slopes	527
245	Hamilton	PrC2	Princeton sandy loam, 6 to 12% slopes, eroded	520
246	Hamilton	PcB	Parke-Urban land complex, 3 to 8% slopes	519
247	Hamilton	Ua	Udorthents	519
248	Hamilton	BoF	Bonnell silt loam, 35 to 60% slopes	516
249	Butler	CvA	Cyclone silt loam, 0 to 2% slopes	514
250	Warren	EdC2	Eden complex, 6 to 12% slopes, moderately eroded	512
251	Butler	RpB	Rossmoyne silt loam, 2 to 6% slopes	511
252	Warren	Cu	Cut and fill land	510
253	Butler	CeB	Celina silt loam, 2 to 6% slopes	509
254	Butler	CdD2	Casco and Rodman gravelly loams, 6 to 18% slopes, moderately eroded	505
255	Hamilton	RyB	Russell-Urban land complex, gently sloping	496
256	Warren	Gp	Gravel pits	495
257	Warren	FoD2	Fox-Casco complex, 12 to 18% slopes, moderately eroded	493
258	Butler	WnA	Westland silt loam, 0 to 2% slopes	493

#	County	Symbol	Soil Type (may include water area)	Acres
259	Hamilton	PrB	Princeton sandy loam, 2 to 6% slopes	490
260	Butler	Sh	Shoals silt loam	485
261	Warren	BbB	Birkbeck silt loam, 1 to 4% slopes	483
262	Warren	RsC3	Rossmoyne silty clay loam, 6 to 12% slopes, severely eroded	479
263	Clermont	SeD2	Sees silty clay loam, 12 to 18% slopes, moderately eroded	475
264	Hamilton	RoB	Rossmoyne silt loam, 2 to 6% slopes	462
265	Butler	CnC2	Cincinnati silt loam, 6 to 12% slopes, moderately eroded	457
266	Warren	AfB	Alford silt loam, till substratum, 1 to 4% slopes	454
267	Warren	RvA	Russell-Miamian silt loams, 0 to 2% slopes	442
268	Hamilton	UmC	Urban land-Martinsville complex, 8 to 15% slopes	431
269	Warren	CdD2	Casco-Rodman complex, 12 to 18% slopes, moderately eroded	421
270	Warren	Sh	Shoals silt loam	421
271	Hamilton	MoD2	Miamian-Hennepin silt loams, 15 to 25% slopes, eroded	420
272	Hamilton	PfC	Pate silty clay loam, 8 to 15% slopes	413
273	Warren	AvB2	Avonburg silt loam, 2 to 6% slopes, moderately eroded	407
274	Warren	HnD3	Hennepin-Miamian complex, 12 to 18% slopes, severely eroded	399
275	Hamilton	MoE2	Miamian-Hennepin silt loams, 25 to 35% slopes, eroded	392
276	Hamilton	CdD	Casco loam, 15 to 25% slopes	386
277	Hamilton	PbD	Parke silt loam, 15 to 25% slopes	381
278	Hamilton	PbE	Parke silt loam, 25 to 35% slopes	381
279	Hamilton	CdF	Casco loam, 35 to 70% slopes	364
280	Hamilton	FoB2	Fox loam, 2 to 6% slopes, eroded	360
281	Clermont	Mh	Medway silt loam, overwash	356
282	Hamilton	RdA	Raub silt loam, 0 to 2% slopes	353
283	Hamilton	SxB	Switzerland-Urban land complex, 3 to 8% slopes	351
284	Clermont	FnC2	Fox silt loam, 6 to 12% slopes, moderately eroded	350
285	Warren	RsB3	Rossmoyne silty clay loam, 2 to 6% slopes, severely eroded	347
286	Warren	Bln3A	Blanchester silty clay loam, 0 to 1% slopes	345
287	Butler	ThA	Thackery silt loam, 0 to 2% slopes	342
288	Butler	MlD2	Miamian silt loam, 12 to 18% slopes, moderately eroded	341
289	Clermont	SeC2	Sees silty clay loam, 4 to 12% slopes, moderately eroded	340
290	Hamilton	DaB	Dana silt loam, 0 to 4% slopes	335
291	Warren	CrB	Crider silt loam, 2 to 6% slopes	333
292	Warren	UnB	Uniontown silt loam, 1 to 6% slopes	333
293	Clermont	SaA	Sardinia silt loam, 0 to 2% slopes	324
294	Warren	HsC3	Hickory clay loam, 6 to 12% slopes, severely eroded	321
295	Butler	Rh	Riverwash	321
296	Hamilton	PcC	Parke-Urban land complex, 8 to 15% slopes	320
297	Butler	WeB	Wea silt loam, 2 to 6% slopes	312
298	Hamilton	HeF	Hennepin silt loam, 35 to 60% slopes	306
299	Warren	CcC2	Casco loam, 6 to 12% slopes, moderately eroded	305
300	Clermont	Cu	Cut and fill land	304
301	Butler	CdE	Casco and Rodman gravelly loams, 18 to 35% slopes	301
302	Hamilton	MaE2	Markland silty clay loam, 18 to 25% slopes, eroded	292
303	Hamilton	EcB2	Eden silty clay loam, 3 to 8% slopes, eroded	291
304	Warren	So	Sloan silty clay loam	286
305	Hamilton	MaC2	Markland silty clay loam, 6 to 12% slopes, eroded	281
306	Hamilton	WbA	Warsaw Variant sandy loam, 0 to 2% slopes	281
307	Warren	HiF2	Hickory silt loam, 25 to 35% slopes, eroded	279
308	Butler	UnA	Uniontown silt loam, 0 to 2% slopes	278
309	Hamilton	WeA	Wea silt loam, 0 to 2% slopes	277
310	Butler	SlA	Sleeth silt loam, 0 to 2% slopes	275

#	County	Symbol	Soil Type (may include water area)	Acres
311	Clermont	GpB	Glenford silt loam, 2 to 6% slopes	273
312	Butler	WzC3	Wynn silty clay loam, 6 to 12% slopes, severely eroded	271
313	Warren	MmB3	Miamian clay loam, 2 to 6% slopes, severely eroded	270
314	Hamilton	Uf	Udorthents, loamy	269
315	Warren	DaA	Dana silt loam, 0 to 2% slopes	260
316	Clermont	BoE	Bonnell silt loam, 25 to 40% slopes	252
317	Warren	PlB	Plattville silt loam, 1 to 6% slopes	247
318	Warren	HsD3	Hickory clay loam, 12 to 18% slopes, severely eroded	244
319	Warren	HmE	Hennepin-Miamian silt loams, 18 to 25% slopes	240
320	Warren	KeC2	Kendallville loam, 6 to 12% slopes, moderately eroded	239
321	Hamilton	CcC2	Casco gravelly loam, 8 to 15% slopes, eroded	237
322	Hamilton	Wa	Wakeland silt loam, occasionally flooded	237
323	Clermont	Mb	Mahalasville silty clay loam	227
324	Warren	PaB	Parke silt loam, 2 to 6% slopes	224
325	Hamilton	EpC2	Eldean loam, 6 to 12% slopes, eroded	223
326	Warren	PrB	Princeton fine sandy loam, 2 to 6% slopes	223
327	Warren	Kg	Kings silty clay loam, thick surface variant	222
328	Warren	HiD2	Hickory silt loam, 12 to 18% slopes, eroded	220
329	Clermont	RtC	Rossmoyne-Urban land complex, sloping	218
330	Warren	WaB	Warsaw loam, 2 to 6% slopes	217
331	Warren	WfA	Westboro-Schaffer silt loams, 0 to 2% slopes	216
332	Hamilton	HmF	Hennepin-Miamian silt loams, 25 to 50% slopes	213
333	Clermont	OdA	Ockley-Urban land complex, nearly level	205
334	Warren	Lg	Lanier sandy loam	199
335	Clermont	GpE2	Glenford silt loam, 18 to 25% slopes, moderately eroded	198
336	Warren	RbB	Rainsboro silt loam, 2 to 6% slopes	198
337	Clermont	Gr	Gravel pits	193
338	Warren	IvA	Iva silt loam, till substratum, 0 to 2% slopes	192
339	Hamilton	ArA	Ava silt loam, 0 to 3% slopes	184
340	Warren	PaD2	Parke silt loam, 6 to 18% slopes, moderately eroded	183
341	Butler	EnA	Eldean gravelly loam, 0 to 2% slopes	175
342	Butler	PrB	Princeton sandy loam, 2 to 8% slopes	172
343	Warren	WlC2	Williamsburg silt loam, 6 to 12% slopes, moderately eroded	166
344	Clermont	WvD2	Williamsburg and Martinsville silt loams, 12 to 18% slopes, moderately eroded	166
345	Warren	OcB2	Ockley silt loam, 2 to 6% slopes, moderately eroded	162
346	Clermont	Rn	Ross silt loam	162
347	Warren	RbA	Rainsboro silt loam, 0 to 2% slopes	160
348	Warren	JrB	Jonesboro-Rossmoyne silt loams, 2 to 6% slopes	159
349	Hamilton	MaD2	Markland silty clay loam, 12 to 18% slopes, eroded	157
350	Butler	MkC2	Miamian silt loam, 8 to 15% slopes, eroded	157
351	Hamilton	Ud	Udorthents, clayey	156
352	Warren	WlA	Williamsburg silt loam, 0 to 2% slopes	156
353	Warren	KeB	Kendallville loam, 2 to 6% slopes	155
354	Hamilton	CmC2	Cincinnati silt loam, 6 to 12% slopes, moderately eroded	151
355	Warren	HrB2	Hickory silt loam, 2 to 6% slopes, moderately eroded	146
356	Warren	EdB2	Eden complex, 2 to 6% slopes, moderately eroded	144
357	Butler	AvA	Avonburg silt loam, 0 to 2% slopes	138
358	Hamilton	RsB	Rossmoyne-Urban land complex, gently sloping	136
359	Warren	FaE2	Fairmount-Eden flaggy silty clay loams, 12 to 25% slopes, moderately eroded	133
360	Butler	MoB2	Miamian-Celina silt loams, 2 to 6% slopes, eroded	131
361	Warren	Re	Reesville silt loam	130
362	Hamilton	OcA	Ockley silt loam, 0 to 2% slopes	128

#	County	Symbol	Soil Type (may include water area)	Acres
363	Hamilton	WhA	Whitaker loam, 0 to 2% slopes	125
363	Hamilton	WhA	Whitaker loam, 0 to 2% slopes	125
364	Clermont	RkE2	Rodman and Casco loams, 18 to 25% slopes, moderately eroded	125
365	Clermont	RrB	Rossmoyne silt loam, 1 to 6% slopes	124
366	Warren	MsC2	Miamian silt loam, 6 to 12% slopes, eroded	121
367	Warren	RmA	Ross loam, 0 to 1% slopes, occasionally flooded	112
368	Butler	RzB	Russell-Urban land complex, 3 to 8% slopes	110
369	Clermont	FaE2	Fairmount very flaggy silty clay loam, 18 to 25% slopes, moderately eroded	109
370	Clermont	CnC2	Cincinnati silt loam, 6 to 12% slopes, eroded	108
371	Butler	RoA	Rossburg silt loam, moderately wet, sandy substratum, 0 to 1% slopes, occasionally flooded	99
372	Clermont	RkD2	Rodman and Casco loams, 12 to 18% slopes, moderately eroded	97
373	Hamilton	Sh	Shoals silt loam	96
374	Warren	CqC2	Crouse-Miamian silt loams, 6 to 12% slopes, eroded	94
375	Butler	HwE2	Hennepin-Wynn silt loams, 18 to 25% slopes, eroded	91
376	Warren	BoE	Bonnell silt loam, 25 to 35% slopes	90
377	Warren	PrC2	Princeton fine sandy loam, 6 to 12% slopes, moderately eroded	83
378	Clermont	BrD3	Bonnell silty clay loam, 15 to 25% slopes, severely eroded	82
379	Warren	MtF2	Miamian-Thrifton complex, 25 to 50% slopes, eroded	81
380	Clermont	MgA	McGary silt loam, 0 to 2% slopes	80
381	Butler	MpE2	Miamian-Hennepin silt loams, 18 to 25% slopes, eroded	80
382	Clermont	GpC2	Glenford silt loam, 6 to 12% slopes, moderately eroded	75
383	Clermont	ScA	Sciotoville silt loam, 0 to 2% slopes	74
384	Clermont	FdD2	Faywood silt loam, 15 to 25% slopes, eroded	72
385	Butler	WyD2	Wynn silt loam, 12 to 18% slopes, eroded	72
386	Warren	Mu	Muck	71
387	Warren	CcB2	Casco loam, 2 to 6% slopes, moderately eroded	70
388	Hamilton	RvB2	Russell-Miamian silt loams, bedrock substratum, 2 to 6% slopes, moderately eroded	69
389	Hamilton	WyC2	Wynn silt loam, 6 to 12% slopes, moderately eroded	68
390	Clermont	MdB	Markland silt loam, 2 to 6% slopes	68
391	Warren	AwA	Avonburg-Urban land complex, 0 to 2% slopes	67
392	Clermont	BoF	Bonnell silt loam, 40 to 60% slopes	67
393	Butler	RsB2	Russell silt loam, 3 to 8% slopes, eroded	66
394	Hamilton	EcF2	Eden silty clay loam, 25 to 50% slopes, moderately eroded	63
395	Clermont	Rh	Riverwash	63
396	Hamilton	RoC2	Rossmoyne silt loam, 6 to 12% slopes, moderately eroded	62
397	Warren	RxB2	Russell-Xenia silt loams, 2 to 6% slopes, eroded	62
398	Warren	Rh	Riverwash	58
399	Clermont	WcA	Westboro-Schaffer silt loams, 0 to 2% slopes	58
400	Warren	JrC2	Jonesboro-Rossmoyne silt loams, 6 to 12% slopes, eroded	55

The soil types listed above in Table 2-4 are map units in the soil surveys for Butler, Clermont, Hamilton and Warren counties. In *Soil Survey Geographic (SSURGO) Data Base: Data Use Information*, the Natural Resources Conservation Service states: "A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic for which it is named and some minor components that belong to taxonomic classes other than those of the major soils. . . . The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements."

In its National Water Quality Assessment of the watersheds for the Whitewater River, Great Miami River, Mill Creek and Little Miami River, the U.S. Geological Survey studied:

- all of Butler and Warren counties
- nearly all of Hamilton County, excluding only the Ninemile Creek subwatershed
- most of Clermont County, excluding 11 subwatersheds in the Ohio River corridor
  (Ninemile Creek, Tenmile Creek, Ferguson Run-Twelvemile Creek, Boat Run-Ohio River, North Fork Indian Creek-Big Indian Creek, Headwaters Big Indian Creek, Little Indian Creek-Ohio River, Bear Creek-Ohio River, Bullskin Creek, West Branch Bullskin Creek, Turtle Creek-Ohio River)

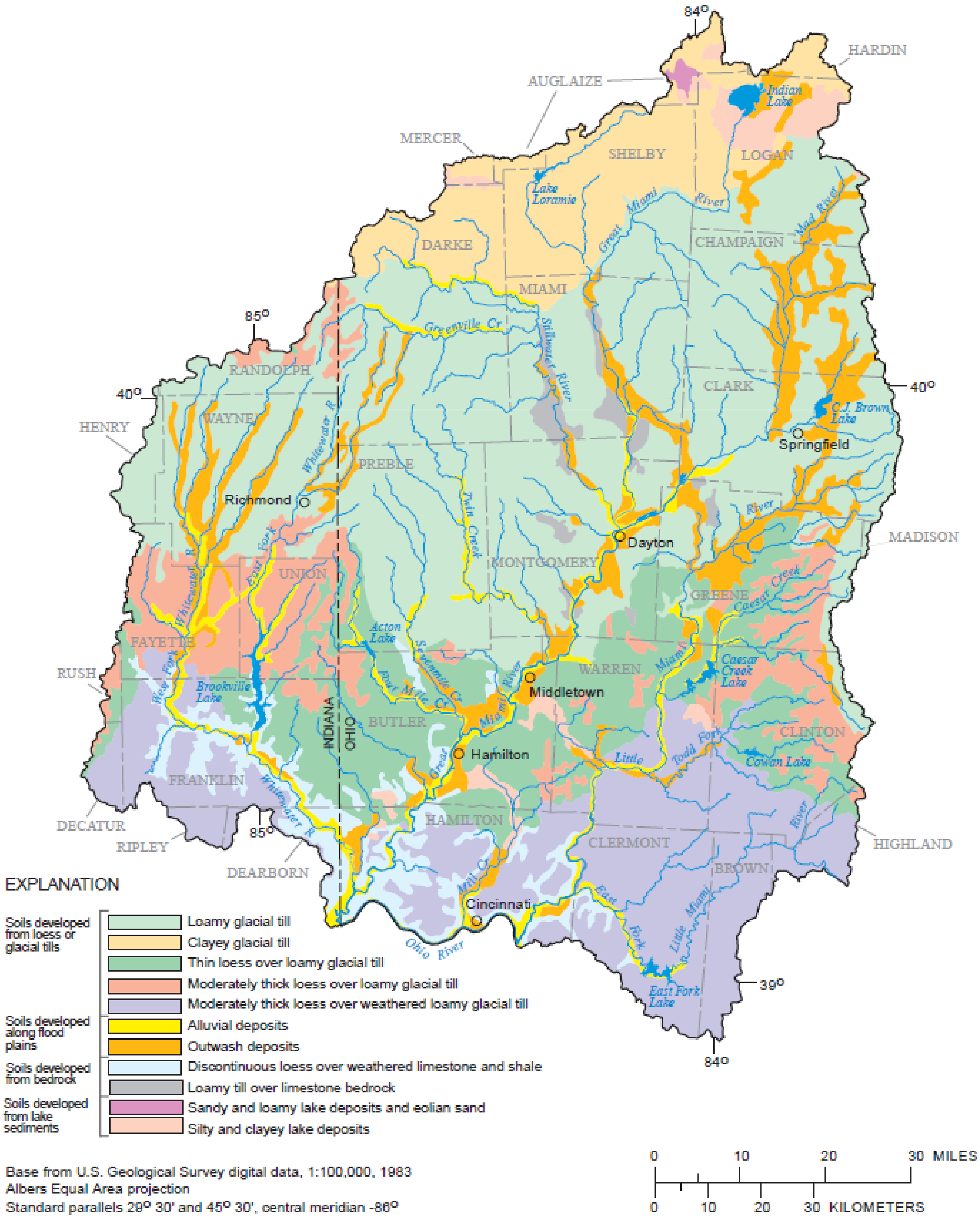
Given the fact that U.S.G.S. assessed the vast majority of this plan's study area, the National Water Quality Assessment (NAWQA) is valid for describing the soil features of Butler, Clermont, Hamilton and Warren counties. In addition, the NAWQA describes soils by geologic regions that can be determined beyond the NAWQA study area, thus making NAWQA applicable to all of the four-county study area for soils and other natural features. A particularly useful NAWQA publication is the oft-cited *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* which the U.S.G.S. compiled in 1999 and published in 2000.
U.S.G.S. describes four major types of soils in Butler, Clermont, Hamilton and Warren counties:

1. *Soils developed from loess or glacial till*. These are the most common, covering large, generally continuous areas throughout the four counties. Such soils mostly comprise Wisconsin age loamy glacial till that often are overlain by thin to moderately thick loess. These soils typically have poor to moderate drainage, high base content and high fertility. This major soil type is further divided into three soil regions: (a) loamy glacial till, (b) thin loess over loamy glacial till, and (c) moderately thick loess over loamy glacial till.
2. *Soils deposited along floodplains*. These soils include alluvial and outwash deposits along the flood plains of major streams and tributaries. They are generally well-drained and fertile. They have high base contents and support intensive row crop agriculture or livestock farming. Such floodplain soils can be found along Four Mile Creek, a bit of Seven Mile Creek and most of the Great Miami River in Butler County; most of the Little Miami River and East Fork Little Miami River in Clermont County; all of the Whitewater River, most of the Great Miami River, most of the Little Miami River and part of the Mill Creek in Hamilton County; and all of the Little Miami River, most of Caesar Creek and part of Clear Creek in Warren County. This major soil type is further divided into two soil regions: (a) alluvial deposits and (b) outwash deposits.
3. *Soils developed from bedrock*. These soils are less common in the study area. They comprise discontinuous loess over weathered limestone and shale, mainly in Hamilton County, partly in Butler and Clermont counties, but not in Warren County. These soils are generally well-drained. This major soil type can also manifest itself as loamy till over limestone bedrock, but that soil region does not occur in OKI's planning area.
4. *Soils accumulated from lake sediments*. These soils are also less common. They are composed mainly of silty and clayey lake deposits, causing them to be poorly drained. Areas with lake sediments typically are ditched or have tile drains installed to improve drainage. Lake sediment soils are in parts of Butler, Hamilton and Warren counties, but not in Clermont County. This major soil type can also manifest itself as sandy and loamy lake deposits or eolian sand, but that soil region does not occur in OKI's planning area.

A map of the soil regions delineated by the U.S.G.S. in its National Water Quality Assessment study area can be found in Figure 2-14 on the next page.

Figure 2-14: Soil Regions in the Great and Little Miami River Basins

(from *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)



The substratum soils of Butler, Clermont, Hamilton and Warren counties are fertile and have a relatively high lime content because of the limestone, dolomite and limy shale bedrock underlying the region. Many of the soils have more than 3 percent organic matter in the upper 10 inches, but the organic matter content decreases in the southern parts of the four-county study area.

Nearly all of Clermont County, most of Hamilton County and nearly half of Warren County have older, more weathered and less fertile soils derived from Illinoian and pre-Illinoian glacial deposits. These soils tend to be acidic and have a higher clay content and less organic matter than the soils of Butler County and the northwest half of Warren County. Stream valleys throughout Butler, Clermont, Hamilton and Warren counties are characterized by moderate to well-drained soils developed from fine- to coarse-grained floodplain deposits that overlie older alluvial or outwash sediments. (*Environmental Setting and Effects . . .,* U.S.G.S., 2000)

More information on soil conditions can be found in the "Ground Water Pollution Potential" reports that the Ohio Department of Natural Resources published in the 1990s for Butler, Clermont, Hamilton and Warren counties. Excerpts from those four county reports follow:

Butler County– Surficial till in most upland areas of Butler County is the Wisconsinan-aged Shelbyville Till. This till essentially comprises the Hartwell Moraine in southern Butler County and northern Hamilton County. In the northeastern corner of Butler County, the slightly younger Crawfordsville Till may overlap the Shelbyville Till in the vicinity of the Camden Moraine. Appreciable amounts of gravel exist in portions of the Camden Moraine. Extensive sand and gravel deposits, in conjunction with locally important lenses of till, silt and clay, are found in the valleys of Butler County. Silty alluvium (layered deposits of silt and gravel) represents deposition within the floodplains of modern rivers. Upland areas in Butler County are blanketed by a thin (usually less than five feet) cover of loess, which is derived from winds reworking dried silty deposits along major glacial outwash valleys. Loess has an important influence on the development of soils in the region.

Clermont County– Multiple advances of Illinoian ice sheets deposited variable thicknesses of glacial till across the county. The till is an unsorted, non-bedded mixture of clay, silt, sand and gravel directly deposited by the ice sheet. There are two main types, or facies, of till. Lodgement till tends to be dense, compact and contain more angular rock fragments. Ablation, or "melt-out" till tends to be less dense and compacted, slightly sandier, and contains more rounded rock fragments and gravel. Specific tills have not been differentiated in Clermont County. The thickness of till in the uplands of Clermont County ranges from a few feet to upwards of 30 feet. An exposure of till near Batavia has been extensively studied for many years. Thicker till exists within the buried valley underlying East Fork Little Miami River. This buried valley also contains minor silts and outwash deposits mapped as Illinoian ground moraine. Clermont County lacks any identifiable end ("ridge") moraines. A portion of far southern Clermont County is mapped as dissected moraine, where the till is particularly thin over the underlying bedrock. Till across Clermont County is highly weathered, particularly where the till thinly covers the underlying bedrock. Ice from the last (Wisconsian) ice advance of about 20,000 years ago did not extend into Clermont County. Meltwater from this ice sheet, however, deposited outwash along the Little Miami river Valley. Outwash is a bedded, sorted meltwater deposit comprised of sand and gravel with minor silts. Outwash is typically deposited by braided streams that migrate across the valley floor and leave behind a complex record of deposition and erosion. Modern streams have since downcut and dissected the pre-existing outwash deposits. Remnants of the outwash are referred to as terraces and are typically found at higher elevations than the modern alluvium. Deposits flanking the Ohio River include both sand and gravel outwash covered by varying thicknesses of finer-grained recent alluvium. The coarser materials appear to extend upstream for short distances in some of the minor tributaries of the Ohio River.

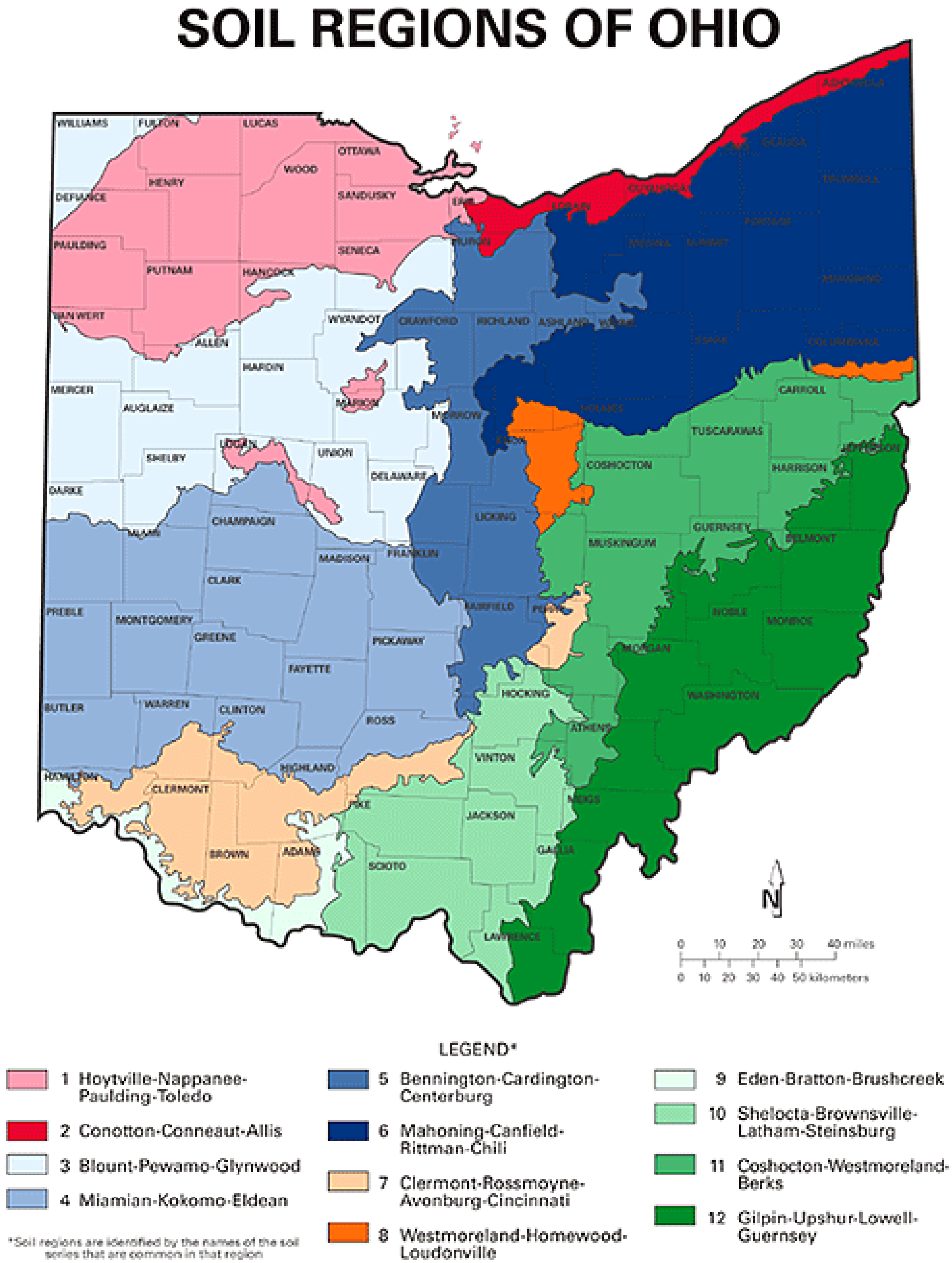
Hamilton County− When glaciers retreated northward from what is now Hamilton County, the major streams derived from the melting ice deposited large quantities of sand and gravel within the bedrock valleys eroded by the Teays tributaries and modified during Deep Stage time. Many of these deposits are now below the present-day water table and serve as aquifers for dozens of high capacity industrial and municipal wells. The upland areas of Hamilton County are covered by a mantle of glacial till, deposited during the pre-Illinoian, Illinoian and Wisconsian glacial periods, that is typically 50 feet or less in thickness. Pre-Illinoian till covers the southern and central portions of Hamilton County and represent some of the oldest known glacial deposits in the state. Till of Illinoian age overlies the central and southeastern portions of the county. This till is typically capped by a layer of windblown silt (loess) and may be discontinuous or absent in some areas. Wisconsinan tills occur in the extreme northern part of the county and include both ground moraine deposits and portions of the Hartwell end moraine.

Warren County− Evidence for the two earliest major glacial stages, the Nebraskan and the Kansan, collectively referred to as the pre-Illinoian, is lacking or obscured in Warren County. These are the oldest known glacial sediments in Ohio. Illinoian age (at least 120,000 year s ago) till is found at or near the surface in much of southeastern Warren County. Small lenses of sorted sand, gravel or silt are commonly found in Warren County's till deposits. The Illinoian till deposits are relatively flat-lying in upland areas, which have not yet undergone stream dissection. Illinoian till differs from the Wisconsinan till in that the upper portion is much more extensively weathered. Thickness of the Illinoian till plain varies but is generally less than 40 feet. No end moraines or kames are associated with Illinoian till in Warren County. The majority of the Illinoian till plain is covered by a mantle of windblown silt (loess). Thickness of the loess varies; thicker accumulations are generally found on uplands. The loess is typically highly weathered, and may be of both Illinoian and Wisconsinan origin. The surficial tills in western and northern Warren County are believed to be late Wisconsinan. The presence of early Wisconsinan tills in the region is currently considered to be doubtful. A complicating factor to interpreting these tills is that Warren County has been influenced by deposition from two major glacial lobes. The eastern margin of the Miami Lobe covered western Warren County, whereas the northeastern corner of Warren County marks the far southwestern edge of the Scioto Lobe. End moraines roughly mark both the limit of the ice margin and the lobe boundaries. As with the Illinoian till, a thin mantle of loess covers the Wisconsinan-age till in most of Warren County. Major outwash deposits are associated with the Great Miami River and Clear Creek in northwestern Warren County. Extensive outwash deposits are associated with the Little Miami River in Wayne Township. It is possible that this area initially drained northward into Greene County before subsequent ice-blockage diverted drainage to the present direction. Somewhat less extensive deposits are found the Little Miami River Valley near South Lebanon and along Muddy Creek. These outwash deposits are all presumed to be Late Wisconsinan in age; however, it is important to remember that underlying deposits within the buried valleys are probably pre-Wisconsinan. Evidence for two, large, presumably Wisconsinan-aged lakes exists in Warren County. The larger occupies the Muddy Creek basin southeast of Monroe. It was probably created by stagnating ice that blocked drainage to the south. The smaller lake is located in a low basin ringed by bedrock highs in southern Massie Township. This lake was probably created by blockage of what is now Todd Fork in Clinton County.

Barring human activity or a dynamic natural event, soils change relatively slowly. The methods for characterizing and classifying soils, however, change on a much more rapid schedule. Soil taxonomy has altered names, abbreviations and associations through the decades. A recent and general illustration of soil characteristics is shown on the Ohio Department of Natural Resources soil regions map in Figure 2-15 on the next page.

Figure 2-15: Soil Regions of Ohio

(from the Soil Regions web page of the Ohio Department of Natural Resources, Division of Soil and Water Resources)



The following conclusions can be drawn from Figure 2-15 on the preceding page:

Soil Region 4 – All of Butler County, roughly the northwestern half of Warren County, and part of northern Hamilton County are in Ohio Soil Region 4, which commonly has the soil series named Miamian-Kokomo-Eldean. This soil region is part of the Indiana and Ohio Till Plain, which formed in younger glacial deposits than neighboring soil regions to the south. The Miamian-Kokomo-Eldean soils, therefore, tend to be less weathered and more fertile. Region 4 glacial deposits have a coarser texture than the deposits in neighboring regions. Well-drained soils, such as the Miamian, are more common in Region 4. This region is in the part of Ohio where limestone, dolomite and limy shales are the most common bedrocks, and so the soils tend to have a relatively high lime content in the substratum. Soils naturally become more acid over time under Ohio's weather conditions, but soils with lime in the substratum are neutral or only slightly acid in part of the subsoil. Since most plant nutrients are chemically active under neutral or slightly acid conditions, soils with more lime in the substratum are generally more fertile for crop production. Ohio farmers commonly increase crop yields by spreading lime to neutralize the acidity of the topsoil and the upper part of the subsoil.

Soil Region 7 – Most of Clermont County not in the Ohio River corridor, much of eastern and central Hamilton County, and roughly the southeastern half of Warren County are in Ohio Soil Region 7, which commonly has the soil series named Clermont-Rossmoyne-Avonburg-Cincinnati. This soil region is part of the Southern Illinois and Indiana Thin Loess and Till Plain. Since the soils in this region formed in older glacial deposits than the soils of Soil Region 4, they are more weathered and less fertile for crop production than the soils of Region 4. Like Soil Region 4, Soil Region 7 is in the part of Ohio where a relatively high lime content in the substratum is good for crop production.

Soil Region 9 – Most of western Hamilton County and extensive parts of Hamilton and Clermont counties in the Ohio River corridor are in Ohio Soil Region 9, which commonly has the soil series named Eden-Bratton-Brushcreek. This soil region is on the edge of the Kentucky Bluegrass, which is heavily wooded and includes many scenic areas. The most common soils in Region 9 formed in materials weathered from sedimentary rocks. Because soil forms more slowly from bedrock than from unconsolidated glacial material, soils in Region 9 tend to be more shallow to bedrock than soils in Regions 4 and 7.

United States Department of Agriculture (USDA) Agriculture *Handbook 296* recognizes 26 distinct Land Resource Regions in the country based on land use, elevation and topography, climate, water, soils and potential natural vegetation. Ohio Soil Regions 4 and 7 above are part of the Central Feed Grains and Livestock Region, which includes the previously mentioned:

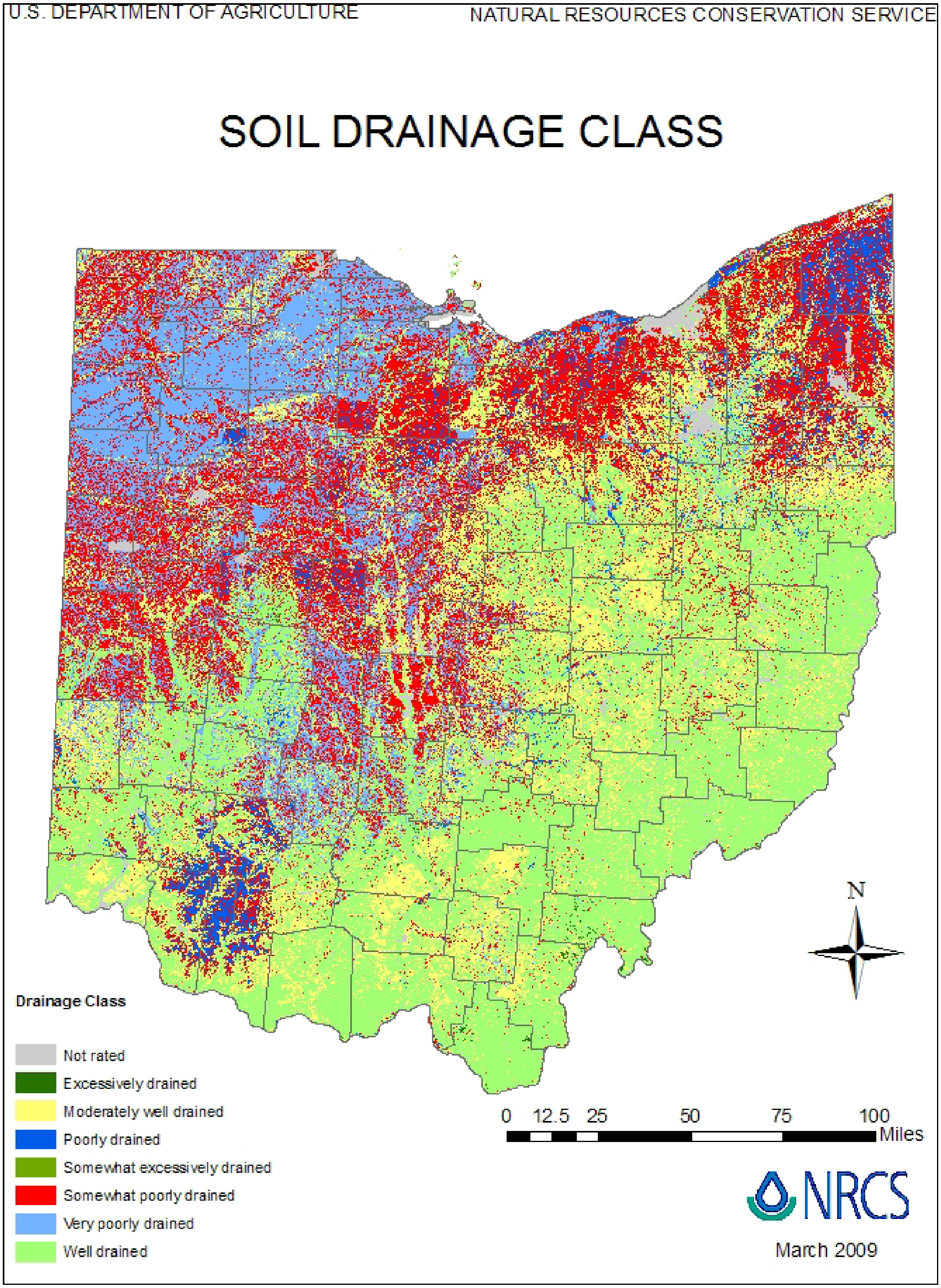
- Indiana and Ohio Till Plain (Major Land Resource Area 111 in USDA's handbook)
- Southern Illinois and Indiana Thin Loess and Till Plain (Major Land Resource Area 114)

Ohio Soil Region 9 above is part of the East and Central Farming and Forest Region, which includes the previously mentioned Kentucky Bluegrass (Major Land Resource Area 121).

The Natural Resources Conservation Service offers an alternative view of soils by drainage class. Figure 2-16 on the next page shows that:

- large areas of poorly drained soils are common in Clermont County
- pockets of somewhat poorly drained soils can be found throughout Southwest Ohio
- most of the urbanized Mill Creek Valley in Hamilton County was not rated for drainage

Figure 2-16: Soil Drainage Classes of Ohio



NOTE: This map was created by the Natural Resources Conservation Service of the U.S. Department of Agriculture.

Slope

Slope, expressed as a percent, measures the change in elevation over a distance of 100 feet. For example, an 8 percent slope has a change in elevation of 8 feet over a horizontal distance of 100 feet. Soils on slopes of more than 8 percent generally do not meet the criteria for "prime farmland" because of the hazard of erosion on cropland (webpage on soil regions, Ohio Department of Natural Resources, Division of Soil and Water Resources, 2010).

Other land uses vary in their sensitivity to slope. Residential development can take place on small scattered sites, using land that industrial development, with its more expansive land requirements, must bypass. The location and concentration of slopes in the form of hills, ridges, valleys and plains can force development into large clusters or break up the urbanization process into dispersed patterns. The wide variation in topography that characterizes Butler, Clermont, Hamilton and Warren counties has structured the form of their urbanization and located their transportation routes.

In relation to water quality management planning, slopes affect the quantity and quality of stormwater runoff that reaches streams. This relationship is determined by the slope in conjunction with soil erodibility. A slope's susceptibility to erosional disturbance is dependent upon a number of factors, including:

- degree of slope
- extent of vegetative cover
- soil type
- permeability
- bedrock characteristics

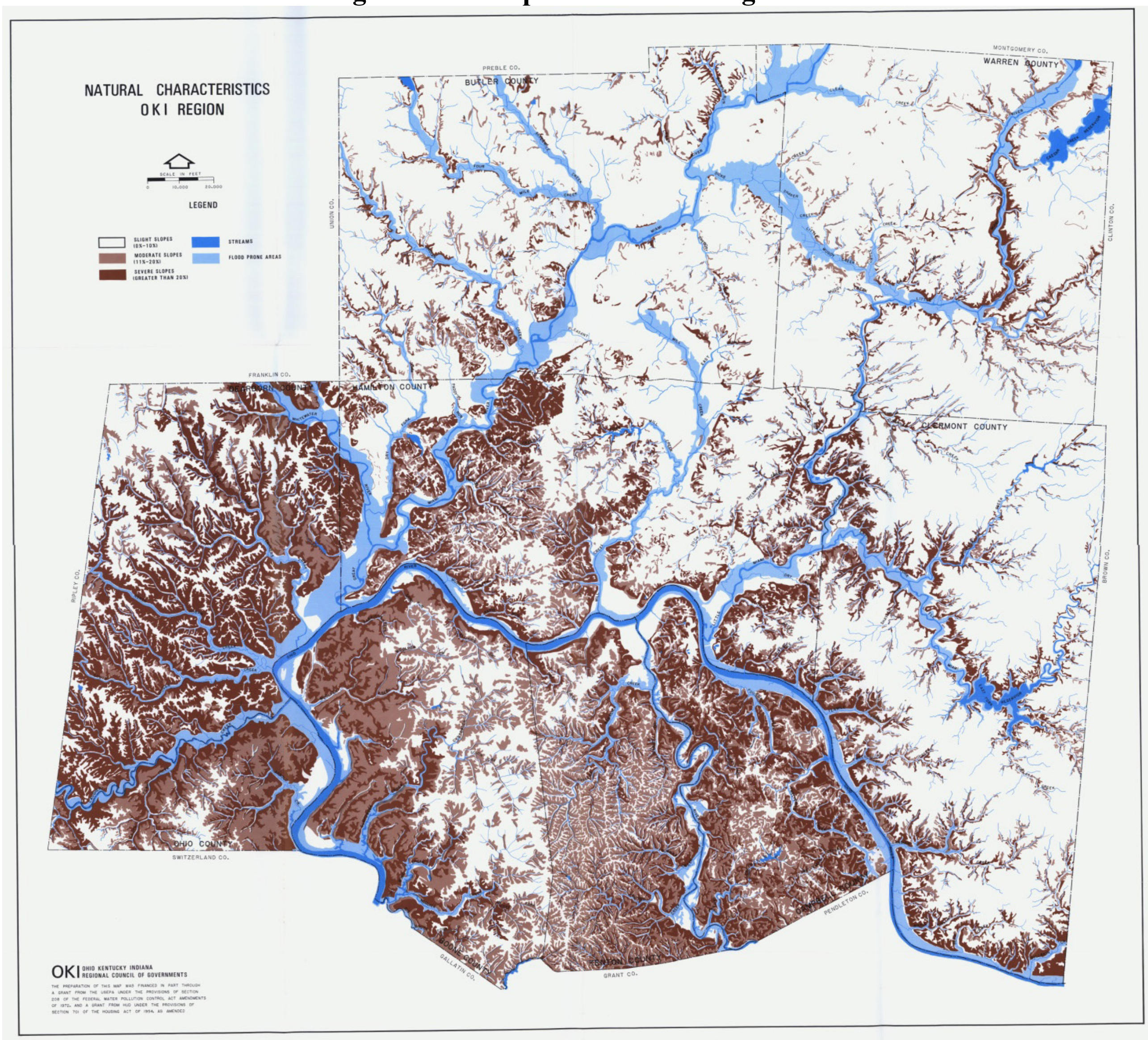
Of these, degree of slope is the most crucial factor for considering vulnerability to erosion.

Development has historically disrupted a slope's natural processes, exacerbated erosion and reduced the pervious surface area. An accelerated erosion rate on a slope may increase soil loss and stream sedimentation while worsening the speed and volume of water delivered to a surface water in a short time span. These impacts are increasingly being addressed by initiatives for stormwater management, low-impact development, conservation development, green infrastructure, sustainability and more.

Most urban development has occurred on land with a slope of 12 percent or less, with a minor amount of scattered residential development on slopes up to 15 percent. Steeper slopes have been included in some subdivisions, but typically as the undeveloped parts of deep lots.

Figure 2-17 on the next page illustrates the slopes of the OKI regiona. It has been scanned from the *Regional Water Quality Management Plan* (OKI, 1977).

Figure 2-17: Slopes in the OKI Region



Flood Prone Areas

Flood prone areas retain a stream's seasonal high flows, provide prime groundwater recharge areas, and maintain stream channel characteristics. Floodplain soils are replenished and enriched. Flooding is part of a natural cycle that increases plant and animal diversity. Levees or dams can cut a stream off from its floodplain and reduce floodwater storage capacity. An overflow may be confined within the stream's banks, but the resulting accelerated water velocity may widen the stream channel with negative impacts. Or, the overflow water may be shifted to other stream segments not normally susceptible to floods. Development in flood prone areas may seriously impair water quality, set the stage for serious flood damage, or generate the need for major public investment to manage flooding. Figures 2-18 through 2-21 on the next four pages show the flood prone areas of Butler, Clermont, Hamilton and Warren counties.

Figure 2-18: Flood Hazard Areas in Butler County

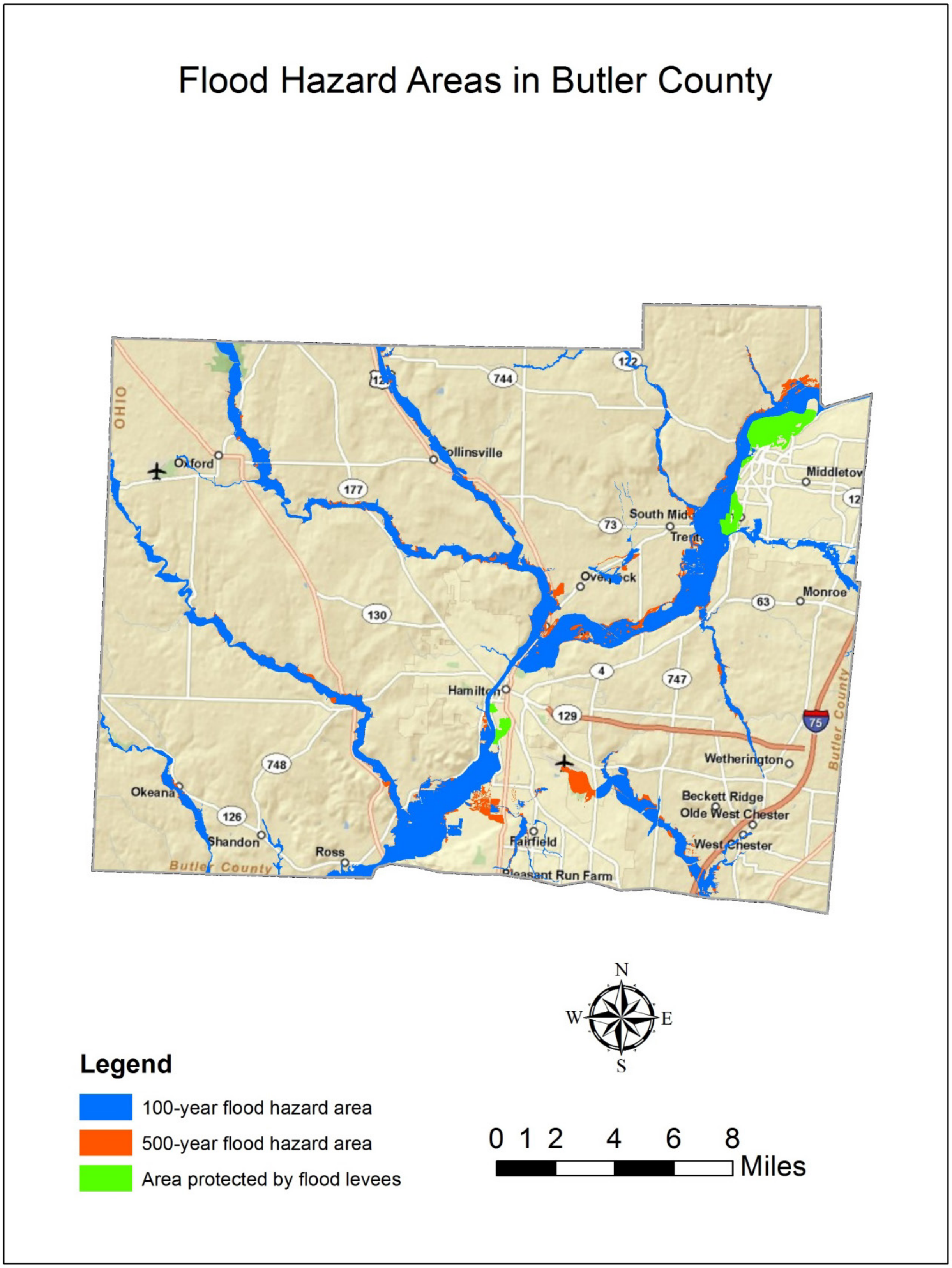


Figure 2-19: Flood Hazard Areas in Clermont County

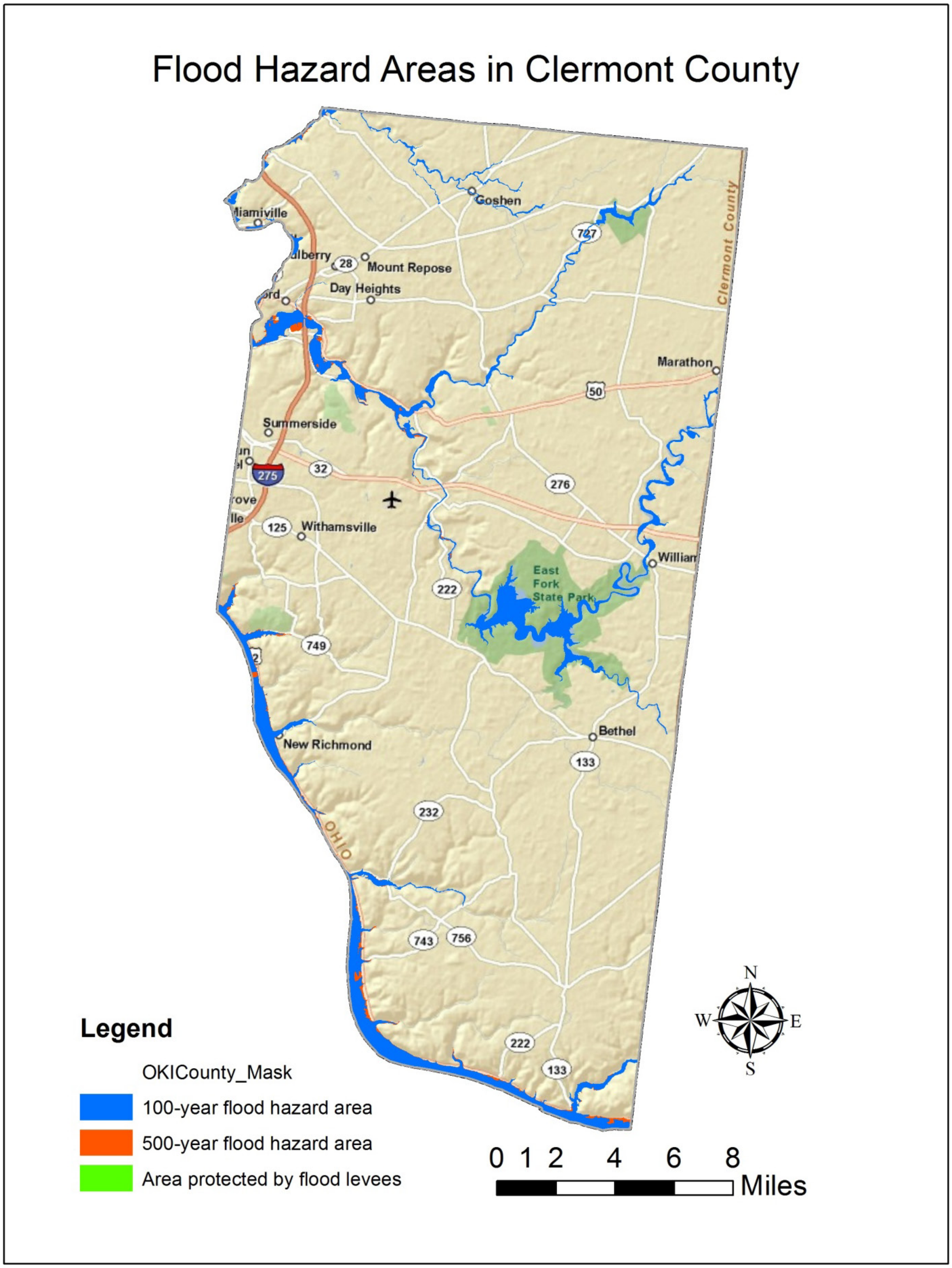


Figure 2-20: Flood Hazard Areas in Hamilton County

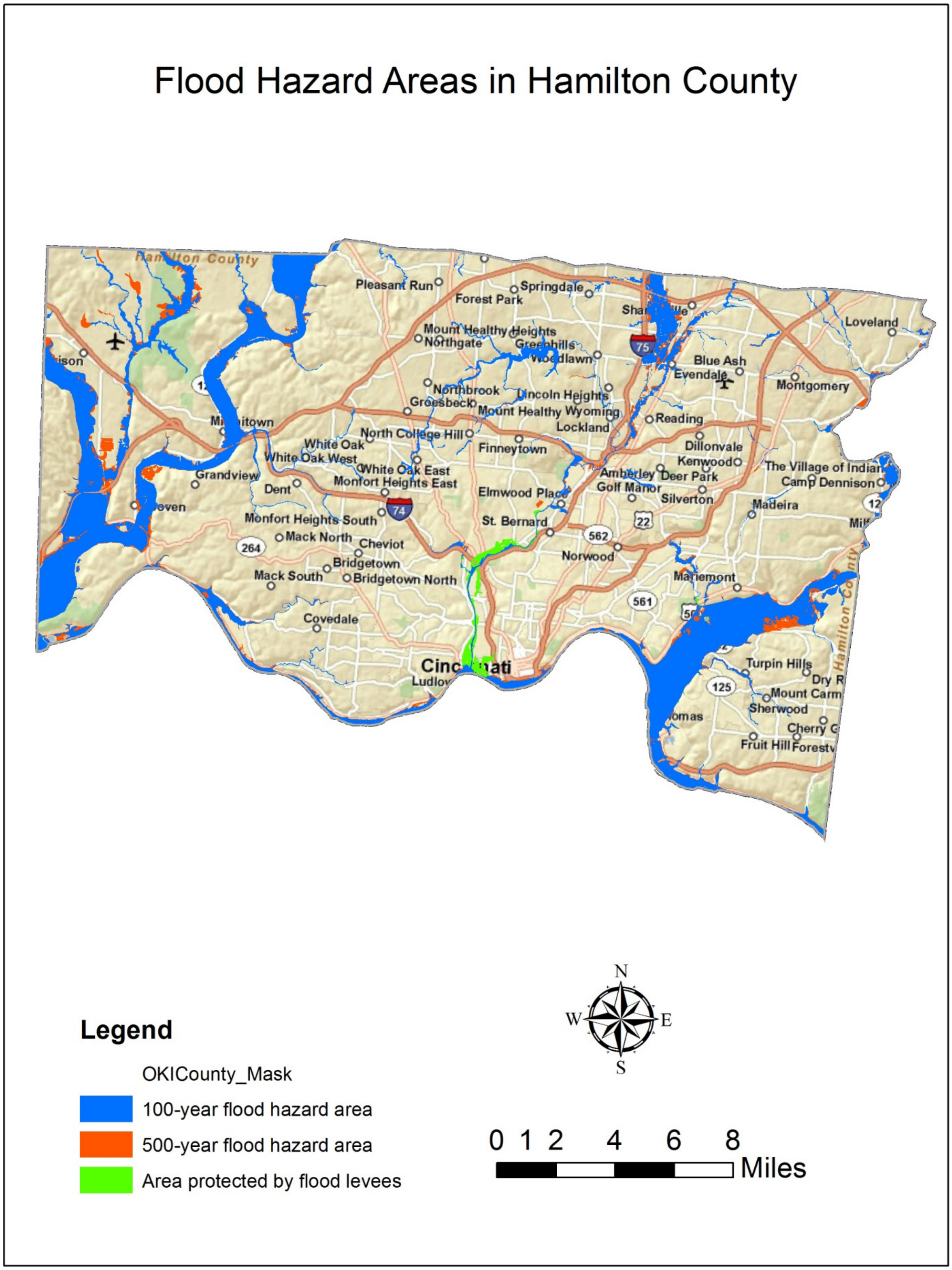
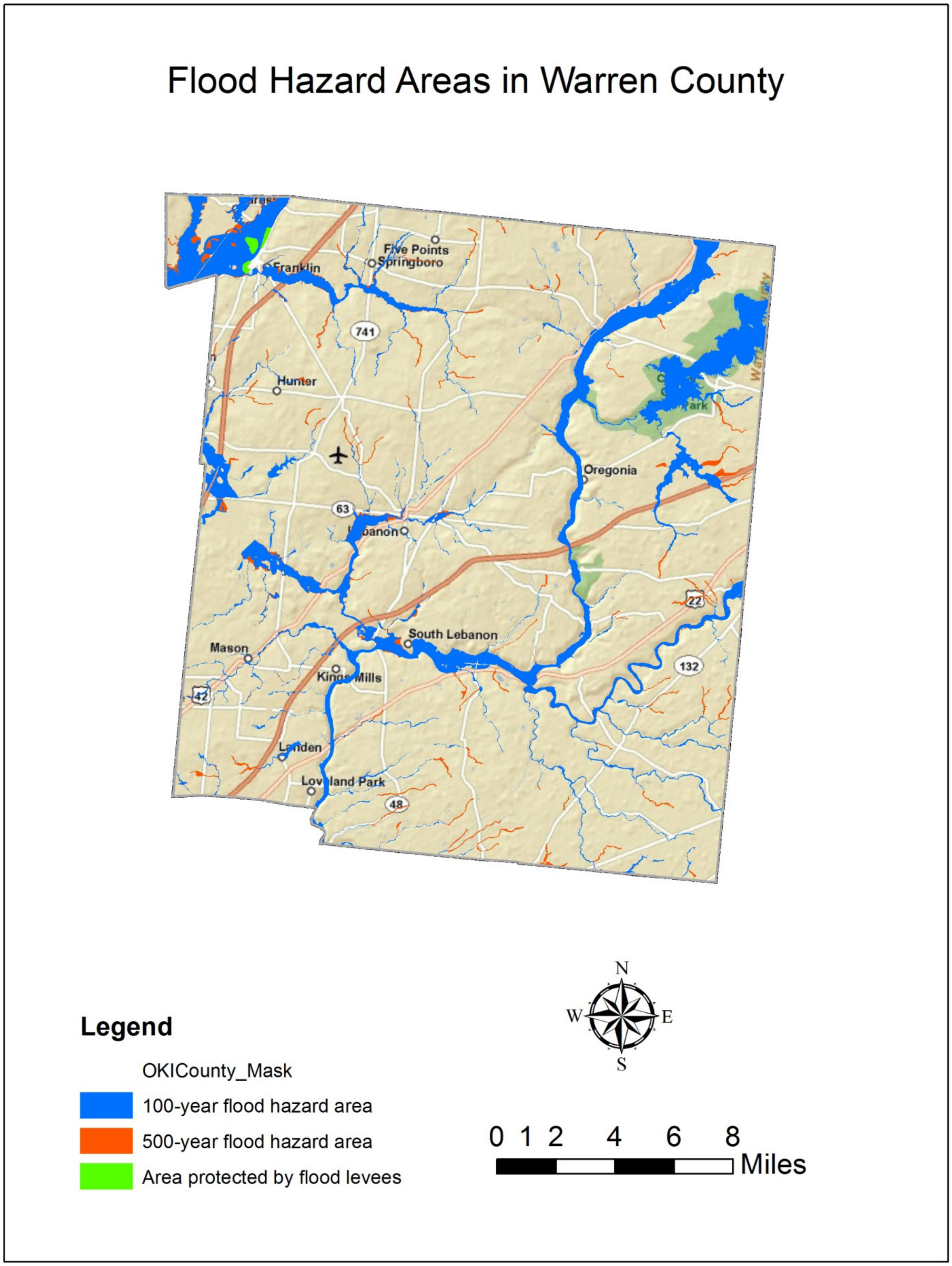


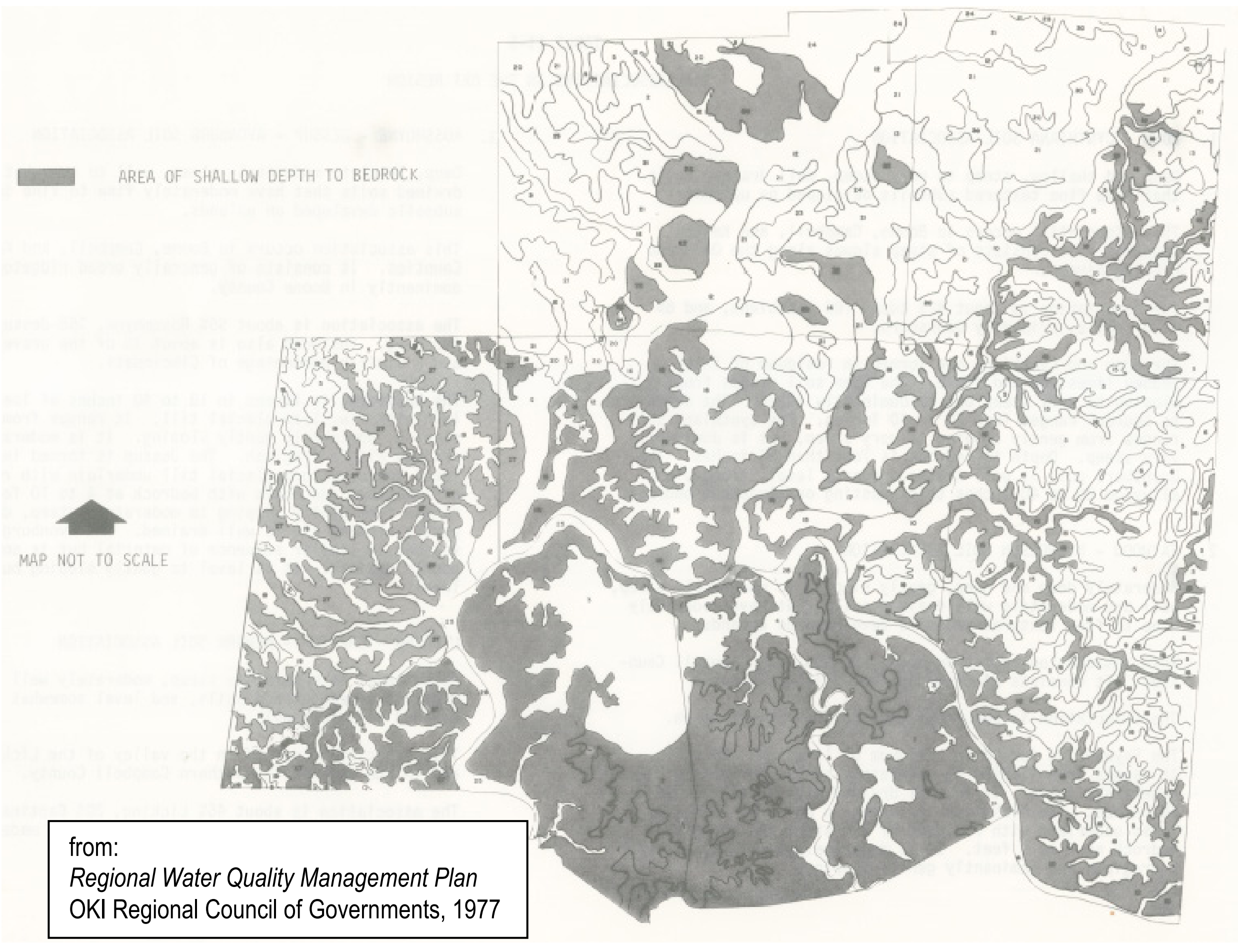
Figure 2-21: Flood Hazard Areas in Warren County



Depth to Bedrock and High Water Table

Depth to bedrock and high water table are inter-related characteristics that can have a bearing on flooding. Depth to bedrock is the distance from the surface of the soil down to the upper surface of the rock layer. A shallow depth to bedrock often coincides with a high water table, which poses limitations for certain road, building and utility projects, especially gravity-flow sewers. Shallow depth to bedrock may increase construction costs. Crop growth on soils with bedrock less than 40 inches below the surface is seasonally restricted by insufficient moisture for the root systems. Figure 2-22 below shows areas in the OKI region with a shallow depth to bedrock.

Figure 2-22: Shallow Depth to Bedrock in the OKI Region

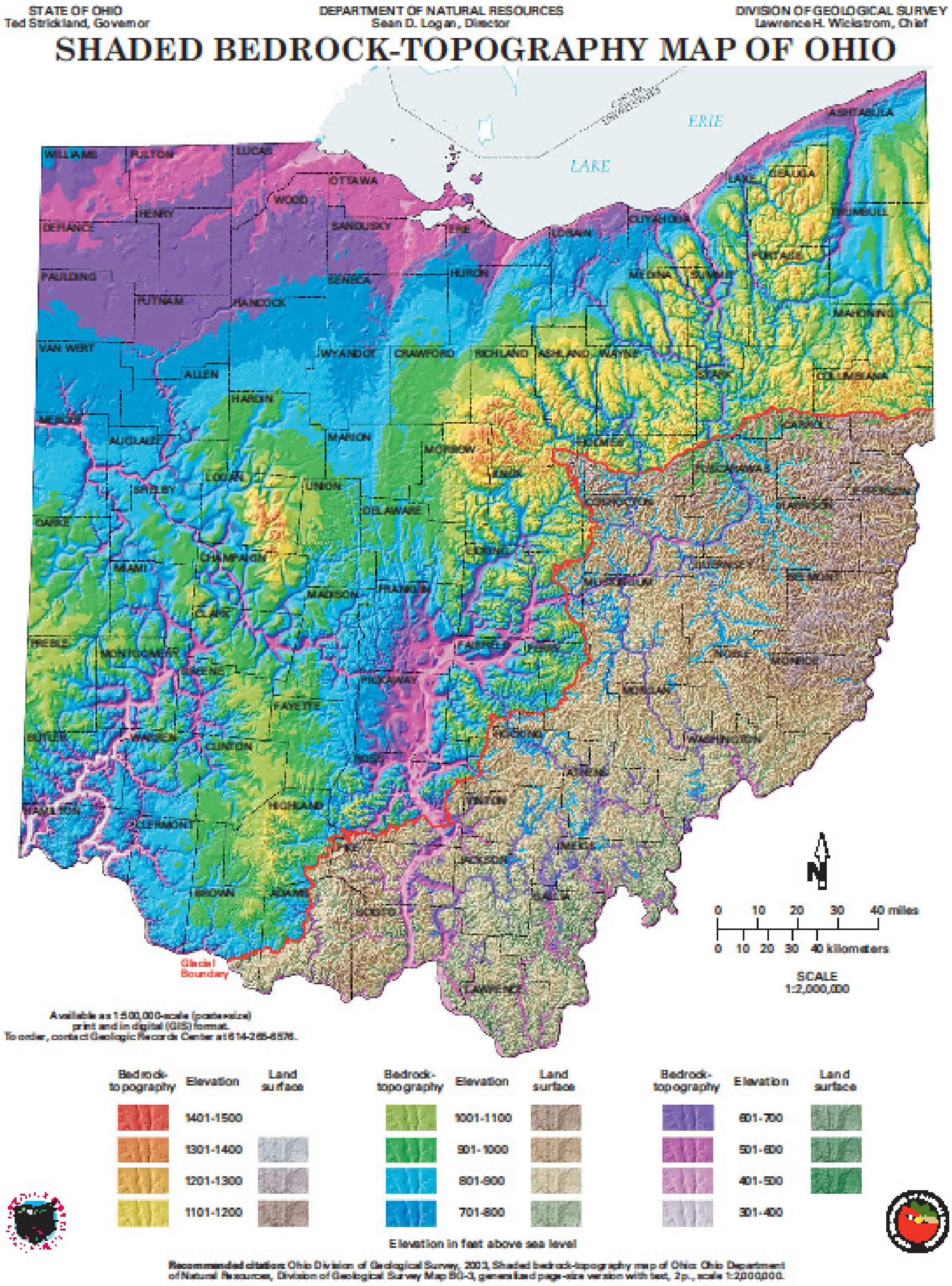


from:
Regional Water Quality Management Plan
OKI Regional Council of Governments, 1977

Bedrock elevations largely determine depth to bedrock. Figure 2-23 on the next page displays a bedrock topography map by the Ohio Department of Natural Resources. It shows that:

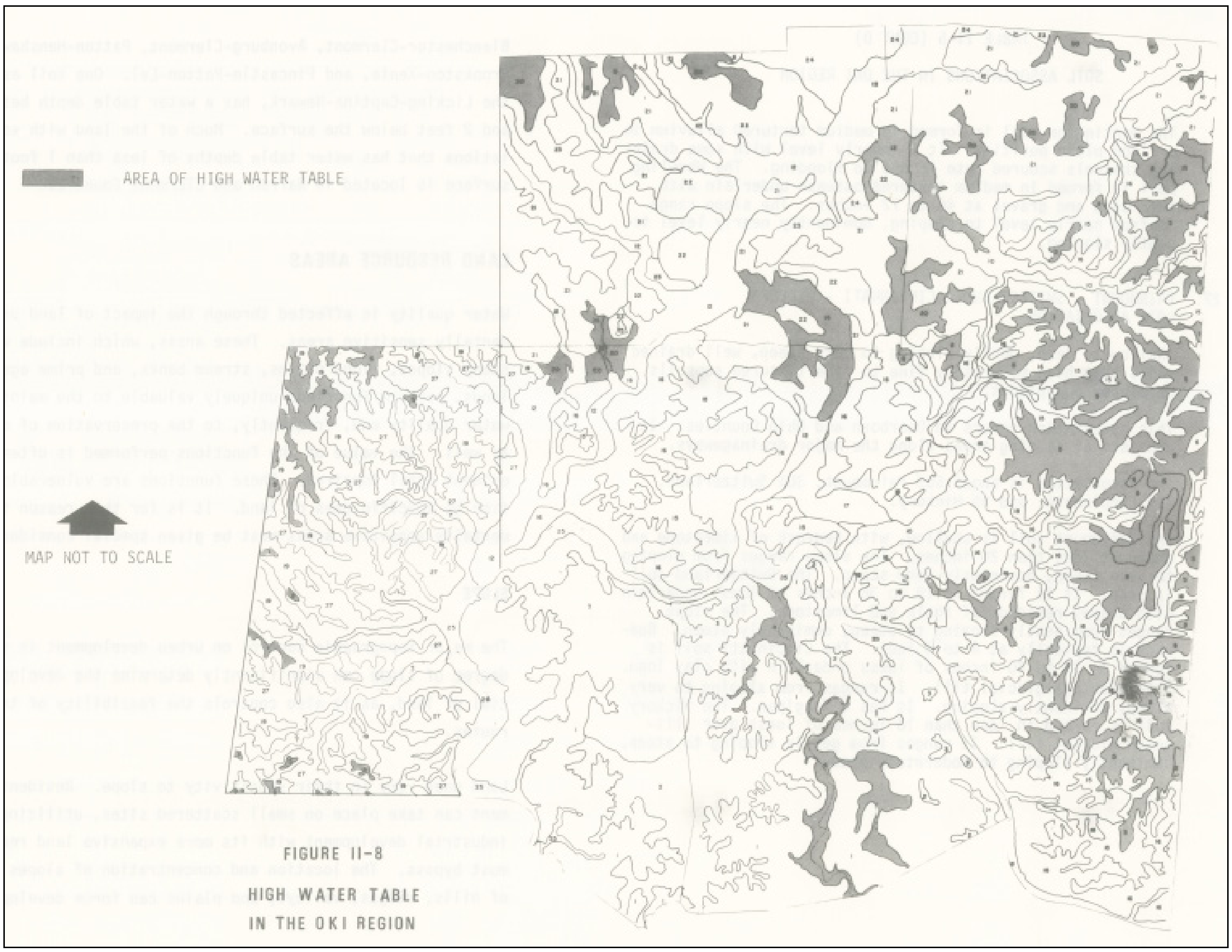
- Most of the uplands in Butler, Clermont, Hamilton and Warren counties have bedrock at elevations of 801 to 900 feet above sea level.
- Significant parts of northwestern and north central Butler County as well as northeastern and north central Warren County have higher bedrock elevations between 901 to 1,000 feet
- Small parts of Butler and Warren counties have bedrock spines above 1,000 feet
- Small areas in eastern Clermont County exceed 900 feet, but most is 801 to 900 feet.
- Ancient river valleys have much lower bedrock elevations of 301 to 700 feet, especially in Butler and Hamilton counties. (The valleys are partially filled with glacial drift.)

Figure 2-23: Shaded Bedrock-Topography Map of Ohio



One of the most noticeable impacts of a shallow depth to bedrock is a high water table. Soil associations that have a water table of three feet or less from the surface are usually considered to have high water table. Such areas play an important role in water quality management because they have a higher potential for contamination of water resources, especially groundwater. In addition to severely limiting the effectiveness of onsite wastewater treatment systems (septic tanks with leach fields), areas with high water table conditions may also pose the problems of basement flooding, sanitary sewer line infiltration and construction challenges. Figure 2-24 below shows that high water tables are most common in Clermont and Warren counties, less prevalent in Butler County, and least common in Hamilton County.

Figure 2-24: High Water Table Areas in the OKI Region



The *Regional Water Quality Management Plan* of 1977 listed these five soil associations as having water table depths of less than one foot below the ground surface:

- Blanchester-Clermont
- Avonburg-Clermont
- Patton-Henshaw
- Fincastle-Brookston-Xenia

- Fincastle-Patton-Eel

Some water tables are seasonably high. Water accumulates in soils that receive rainfall or runoff from adjacent slopes faster than the water can move through the soil. Wetlands are common in soils that are saturated in the upper 12 inches for a month or more during a typical year. Soils that are not saturated for more than a few days in the typical year are generally the easiest to manage for a wide variety of uses. (Soil Regions webpage, Ohio Department of Natural Resource, Division of Soil and Water Resources, 2010)

Prime Farmland

Prime farmland, as a designation assigned by U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It has the soil quality, growing season and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. (Soil Survey Staff (1993). "Soil Survey Manual". Soil Conservation Service. U.S. Department of Agriculture Handbook 18).

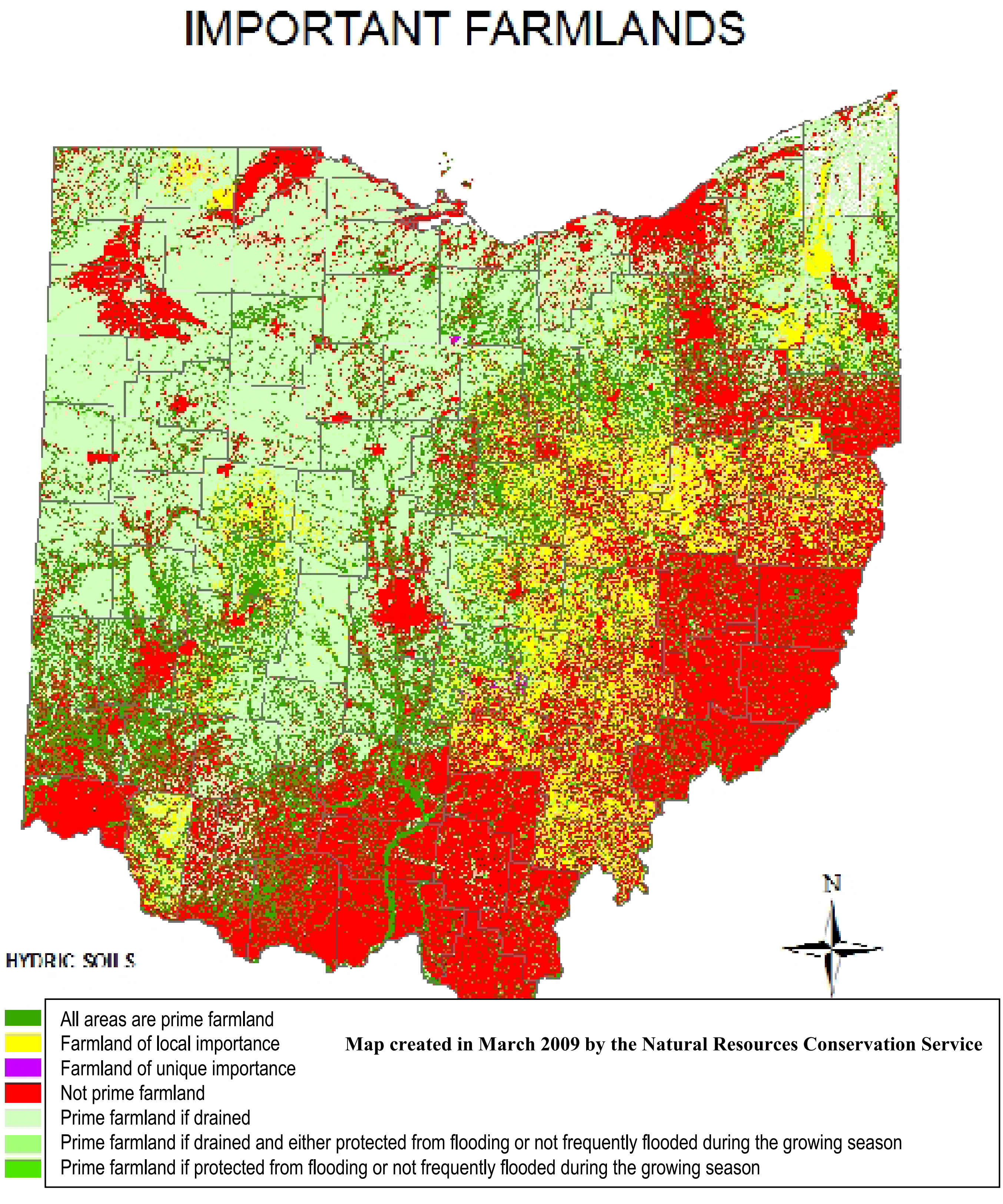
Many of the characteristics that lead to the designation of prime farmland (i.e. prime agricultural land) also make that same land desirable for housing, industrial development and most other land uses. The following five characteristics make land desirable for both cultivation and urbanization:

1. The soils contain nutrients required by plants or the soil responds well to fertilizer.
2. The soils pose little risk of erosion. If erosion is light, terraces can aid crops, or buildings.
3. The land has an adequate groundwater supply and is well drained.
4. The bedrock level is deep enough to permit cultivation, or construction excavation.
5. The land surface is relatively flat, making it ideal for row crops, or development.

While it is not realistic to assume that no development will take place on prime agricultural land, it is important to identify such land as a relatively scarce and productive commodity that should not be promoted for urban development.

Figure 2-25 on the next page shows a Natural Resources Conservation Service map of "important farmlands" (i.e., prime farmlands or prime agricultural lands) in Ohio.

Figure 2-25 Prime Farmlands in Ohio



Soil Suitability for Onsite Wastewater Treatment Systems

Determining if a tract of land can support the installation of an onsite septic tank system is a task regularly faced by planners, engineers and developers. They need to know an area's soil suitability for septic systems to forestall environmental and health problems. OKI has prepared a geographic information system (GIS) layer on soil suitability. This work is based on soil series data from the Natural Resources Conservation Service and refined by consultations with a soil scientist at the Ohio Department of Natural Resources, Division of Soil and Water Resources.

For each soil series in its region, OKI classifies soil suitability for onsite wastewater treatment systems into one of the three following categories:

1. GENERALLY SUITABLE for septic tank–leach field systems provided the systems are properly installed and maintained
2. GENERALLY REQUIRE MODIFICATIONS to septic tank–leach field systems such as a curtain drain, an operational second leach field, or an oversized leach field
3. GENEARALLY UNSUITABLE for septic tank–leach field systems but may be suited for an alternative type of onsite wastewater treatment system such as an aeration or mound system

More information on soil suitability can be found in Chapter 4: *Management of Onsite Wastewater Treatment Systems.* That chapter includes a map and table of soil suitability classes.

Vegetative Cover

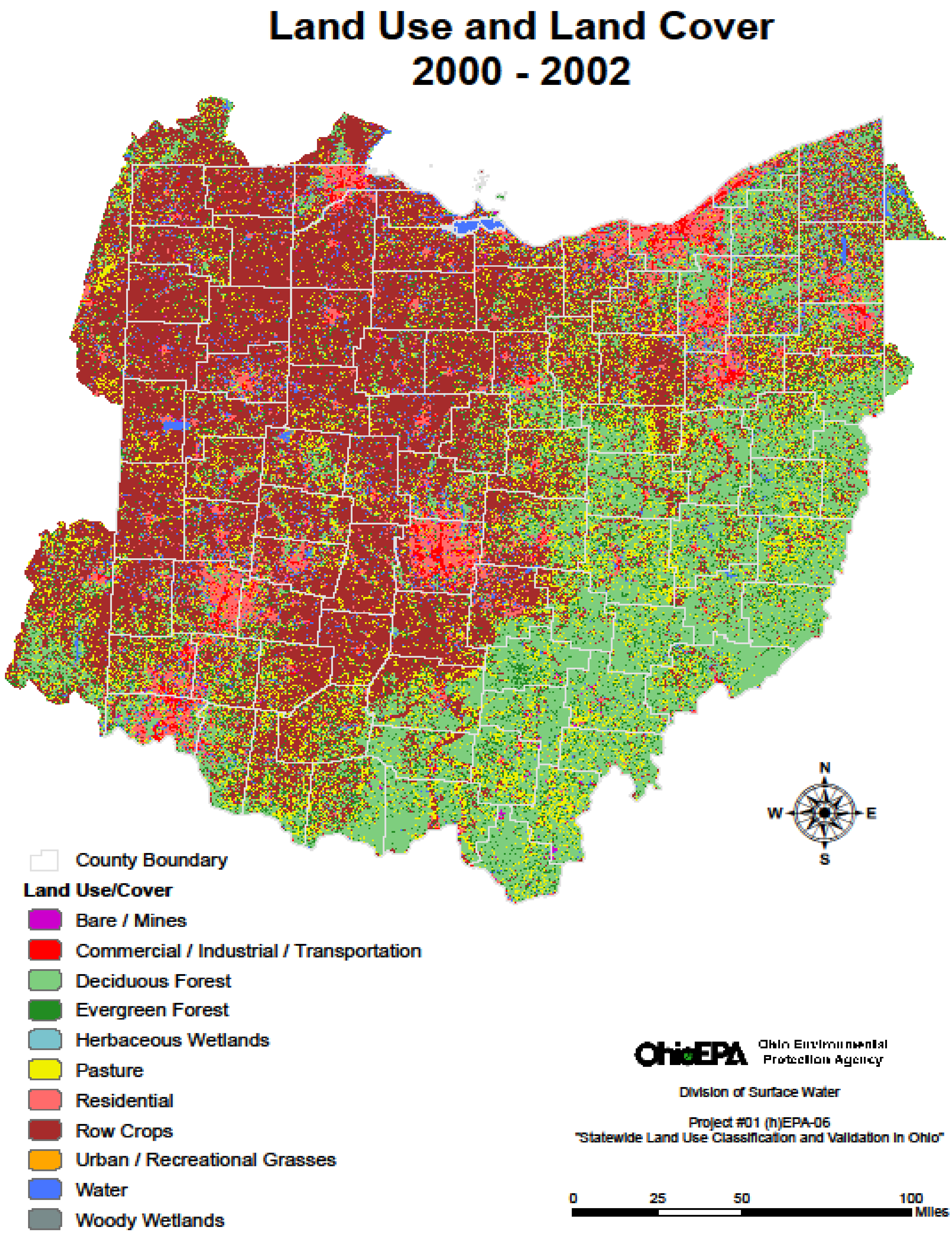
Vegetative cover is important to retain because it performs environmental functions that protect or improve water quality. Vegetation retards stormwater, thereby slowing runoff, increasing absorption, reducing erosion and limiting sedimentation in concert with topography and soil characteristics. Removal of a watershed's vegetative cover typically coincides with a loss of natural habitat, an increase of impervious surface, and the compaction of soils by heavy equipment. These changes usually reduce evapotranspiration, increase stormwater runoff, intensify pollutant loads in the runoff, increase runoff channeling, increase erosion, and degrade stream geomorphology.

The removal of riparian (streambank) vegetation is particularly harmful. In *A Guide to Developing Local Watershed Action Plans in Ohio,* the Ohio EPA states: "The riparian ecosystem is the natural vegetation that grows adjacent to flowing water. Trees and shrubs in the riparian ecosystem function as filters that trap sediments and absorb nutrients carried by water draining over the land (runoff). In addition, riparian vegetation provides shade, maintaining water temperatures at levels necessary for certain species of plants and animals. It also regulates the exchange of nutrients and woody residue between land and water. Removal of the riparian vegetation combined with the intense draining and tiling of Ohio's soil have caused our rivers and streams to run wider and shallower. Thus, flash flooding is more frequent, caused by quickly moving runoff from farmed lands and impervious surfaces. Smaller stream channels clogged by sediment also contribute to more frequent flooding and result in downstream damage."

Ohio EPA values streambank vegetation because it provides: (1) habitat for wildlife; (2) a path for migratory birds; (3) food, shelter and migration corridor for game; (4) a link in the food web; (5) streambank stability; and (6) opportunities for hunting, fishing, camping, boating and swimming.

Figure 2-26 on the next page is an Ohio EPA map that illustrates vegetative cover and land use.

Figure 2-26: Land Use and Land Cover in Ohio



Efforts to preserve or restore vegetative cover rely on native plants because they are best suited for the area's climate, soils and hydrology. Entire ecosystems are based on the type of plant community in place. Disrupted or stressed landscapes are vulnerable to non-native, invasive plant species that create imbalance in the ecosystem. More functional landscapes are conducive to original native plant communities that provide a foundation for an ecosystem at equilibrium. This generates the need for historical information on the native or natural vegetation that thrived in an area before settlement. Such a need is addressed by the Ohio Biological Survey map titled *Natural Vegetation of Ohio at the Time of the Earliest Land Surveys*. It was prepared in 1966 by Robert B. Gordon, who composed the plant community descriptions below.

Beech Forests
These forests were characterized by a large fraction of beech, sugar maple, red oak, white ash and white oak, with scattered individuals of basswood, shagbark hickory, black cherry and more rarely cucumbertree. The most familiar types were beech-sugar maple and "wet beech" on poorly drained flatlands.

Oak-Sugar Maple Forests
These included xero-mesophytic forests usually lacking beech, chestnut, red maple and tulip tree. Dominants included white oak, red oak, black walnut, black maple as well as the sugar maple, white ash, red elm, basswood, bitternut and shagbark hickories. Of indicator value today in the areas formerly occupied by these forests are Ohio buckeye, northern hackberry, honey locust and blue ash. Local components often included black cherry, Kentucky coffee-tree, chinquapin oak, redbud and eastern red cedar.

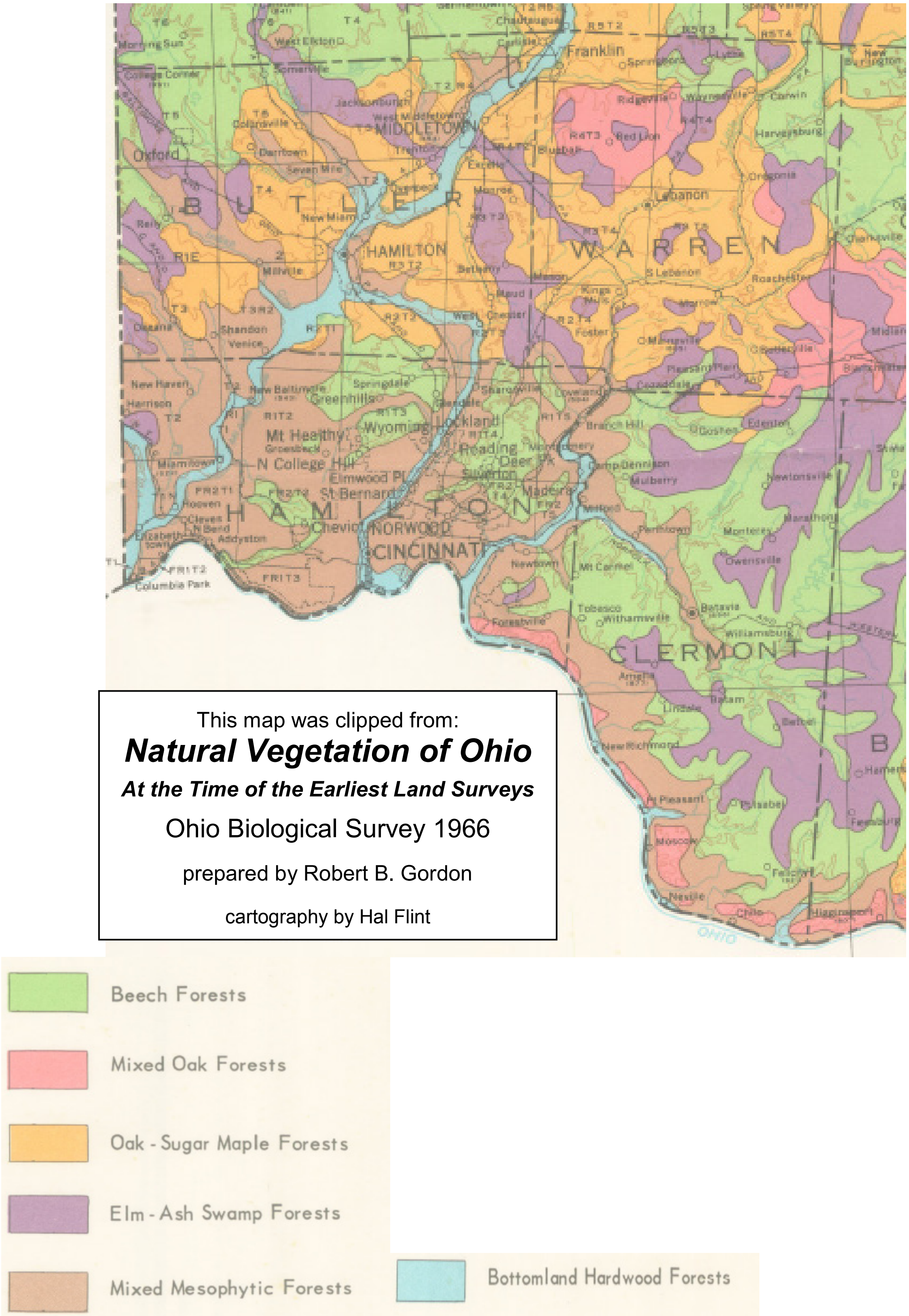
Elm-Ash Swamp Forests
These forests were consistent in having among the dominant trees of the canopy white elm, black ash and/or white ash, silver maple and/or red maple. Extremely wet phases contained cottonwood and/or sycamore. Better-drained phases or transitions recognized by Sampson (1930) are burr oak-gig shellbark hickory and red oak-basswood. These "swamp oak-hickory" communities were enriched locally with swamp white oak, pin oak, white oak, black walnut and tuliptree. Contiguous areas were covered with "wet beech" forests, wet prairies, sedge swamps and fens.

Mixed Mesophytic Forests
Mixed mesophytic forests were dominated by broad-leaved and deciduous species but not exclusively so, with no single species comprising a very large fraction of the dominants. On the map there is a mosaic of types so designated. Segregates of the mixed mesophytic climax association in Ohio include oak-chestnut-tuliptree, oak-hickory-tuliptree, white oak-beech-maple and hemlock-beech-chestnut-red oak. The mixed mesophytic forests of southwestern Ohio were generally different from those of eastern Ohio in that the former contained a large fraction of beech, white basswood and tuliptree.

Bottomland Hardwood Forests
These forests included vegetation types of variable composition and occupied older valleys and terraces of major streams as well as recent alluvium. Several types and variants are recognized; some may prove to be successional phases or "transitional" subtypes. Of those listed here, only the first three appear to be climax associations: beech-white-oak, beech-maple, beech-elm-ash-yellow buckeye, elm-sycamore-river birch-red maple and sweet gum-river birch.

Figure 2-27 on the next page is copied from *Natural Vegetation of Ohio at the Time of the Earliest Land Surveys* (Ohio Biological Survey, 1966). It is cropped and enlarged to show the natural (or native) forest communities of Butler, Clermont, Hamilton and Warren counties.

Figure 2-27: Natural Vegetation of Ohio



This map was clipped from:
Natural Vegetation of Ohio
At the Time of the Earliest Land Surveys
Ohio Biological Survey 1966
prepared by Robert B. Gordon
cartography by Hal Flint

Climate

For water quality management planning, precipitation is a key factor. The duration and intensity of rainfall largely controls the quantity and quality of runoff, which subsequently determines sediment loading and water quality impact. Rainfall, therefore, plays a substantial role in the formulation of any water quality program.

While the study of rainfall-runoff events is vital to water resources management projects, the occurrence of such events is highly unpredictable. A familiar example of how rainfall data is used in water quality management decisions can be found in a stream receiving effluent from both point and nonpoint sources. In one instance, meeting water quality standards may dictate a concern with low flow rates. In another situation, a high flow rate caused by erosive precipitation may be more critical. In a third example, a cost-effective solution to a pollution problem might require the study of effluents combined with rainfall events ranging from no rainfall to intense rainfall.

Climatological data is thus critical in the analysis of water quality in the region. In general terms, Butler, Clermont, Hamilton and Warren counties have a temperate continental climate with a wide range of temperatures in the winter and summer. Most precipitation occurs during winter and spring, while the least precipitation occurs in late summer and fall. Summers are hot and humid, and the winters are moderately cold. The most snow typically occurs in January, although heavy snows have been recorded in November and February.

More specific climatic data is available from the Midwestern Regional Climate Center (MRCC), which has a website at: http://mrcc.isws.illinois.edu/climate_midwest/maps/oh_mapselector.htm. As an affiliate of the National Oceanic and Atmospheric Administration, the MRCC posted the following tables for Kings Mills, which has the most centrally located weather station in the four-county study area.

Table 2-5: Normal Precipitation at Kings Mills

(based on 1971-2000 averages from the National Climate Data Center)

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Precipitation (inches)	3.07	2.63	3.57	4.26	4.89	4.01	4.01	4.03	3.11	3.04	3.47	3.21	43.30

Table 2-6 on the next page looks beyond total precipitation averages by analyzing the number of days with light precipitation as compared to the number of days with heavier precipitation. Such data is more useful for runoff analysis and wastewater treatment system design.

Table 2-6: Precipitation Threshold Climatology at Kings Mills*
(based on 1971-2000 averages from the National Climate Data Center)

Month	# Days Total ≥ 0.01"	# Days Total ≥ 0.10"	# Days Total ≥ 0.50"	# Days Total ≥ 1.00"
JAN	11.1	7.4	1.7	0.5
FEB	9.8	6.6	1.4	0.4
MAR	11.3	8.1	2.4	0.6
APR	12.8	9.0	3.0	0.9
MAY	12.2	8.6	3.4	1.5
JUN	10.7	7.8	2.6	0.9
JUL	9.8	7.2	2.7	1.0
AUG	8.6	6.2	3.0	1.2
SEP	8.0	5.6	2.1	0.9
OCT	8.9	6.1	2.0	0.8
NOV	10.5	7.4	2.4	0.9
DEC	10.9	7.2	2.2	0.6
Annual	124.6	87.1	29.2	10.3
Winter	31.8	21.1	5.4	1.6
Spring	36.4	25.6	8.9	3.0
Summer	29.1	21.3	8.4	3.2
Fall	27.4	19.0	6.5	2.5

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding

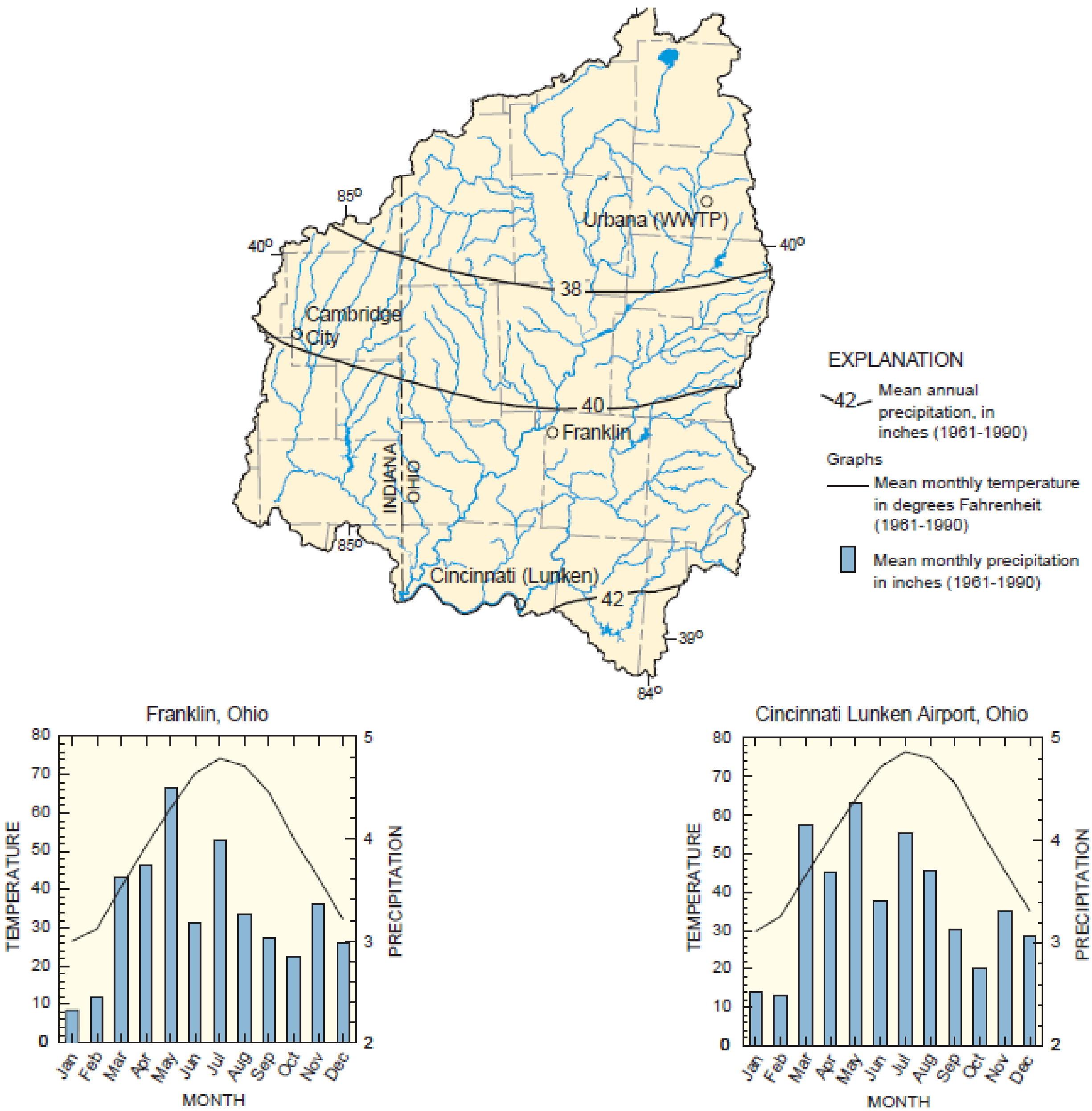
The preceding tables show May to be the month having the highest average precipitation, as well as the month having the most days with one or more inches of precipitation.

The U.S. Geological Survey explains the origins of the region's weather trends: "Seasonal temperature variations reflect the dominance of polar continental air masses in the fall and winter and tropical maritime air masses in the late spring, summer, and early fall. The main sources of moisture are tropical maritime air masses from the Gulf of Mexico and the western Atlantic Ocean. Additional moisture is derived from local and upwind sources, including water recycled through the land-vegetation-air interface. The area experiences frequent cyclonic disturbances caused by tropical air masses moving northeast from the Gulf of Mexico. These storms interact with arctic air masses moving south and can transport considerable amounts of moisture. In the spring and summer, most precipitation is associated with thunderstorms produced by daytime convection or passing cold fronts. Because the spatial distribution of rainfall is influenced by relative proximity to the humid tropical maritime air masses, mean annual precipitation increases from north to south." (*Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)

Figure 2-28 on the next page illustrates the increase of mean annual precipitation from north to south. It also indicates that most of the four-county study had a mean annual precipitation of 40 to 42 inches from 1961 to 1990, rather than the higher average annual precipitation of 43.3 inches at the Kings Mills weather station from 1971 to 2000.

Figure 2-28: Mean Monthly Temperature and Precipitation at Selected Weather Service Stations in the Great and Little Miami River Basins

(from *Environmental Setting and Effects on Water Quality in the Great and Little Miami River Basins, Ohio and Indiana,* U.S. G.S., 2000)



An important consideration for analyzing the impact of precipitation on water quality is the relationship between stormwater runoff and the rate of rainfall accumulation over a short time period (inches of rainfall per hour). This is termed rainfall intensity. When the rainfall intensity exceeds a watershed's capacity to normally drain the storm's water volume, rivers and streams are subjected to higher levels of polluted runoff, erosion, scouring and sedimentation.

The absence of precipitation during dry spells or droughts can also have an impact on water quality by inducing a variety of problems associated with low flow stream conditions. Low flows are an important factor for streams that receive treated effluents from wastewater treatment plants. In such cases, there is utility to the old saying that dilution is the solution to pollution. Table 2-7 below displays the lowest and highest monthly precipitation totals at the Kings Mills weather station during an 89-year period. It also shows the volume and date of the maximum one-day precipitation event for each month at Kings Mills. Despite a data collection period of nearly 90 years, half of the one-day maximum rainfall events by month occurred in the relatively short time span from 1996 through 2001. This pattern also appears for maximum one-day rainfall event by season because two of four occurred during the final two monitoring years.

Table 2-7: Precipitation Extremes at Kings Mills*
(based on 1912-2001 averages from the National Climate Data Center)

Month	High (in)	Year	Low (in)	Year	1-Day Max (in)	Date
JAN	13.22	1937	0.56	1967	3.48	01-04-2000
FEB	6.17	1926	0.47	1968	2.23	02-14-2000
MAR	10.92	1964	0.65	1969	4.06	03-26-1913
APR	9.99	1998	0.82	1962	3.63	04-16-1998
MAY	11.64	1996	0.54	1934	3.35	05-11-1996
JUN	8.59	1928	0.46	1933	4.36	06-23-1974
JUL	11.64	1929	0.33	1940	5.21	07-18-2001
AUG	10.99	1926	0.89	1951	3.63	08-29-1914
SEP	9.23	1971	0.52	1953	4.90	09-14-1979
OCT	8.90	1925	0.01	1924	2.51	10-02-1973
NOV	9.13	1985	0.41	1917	2.52	11-06-1948
DEC	7.80	1990	0.47	1955	2.67	12-22-1998
Annual	64.33	1926	21.64	1934	5.21	07-18-2001
Winter	18.67	1950	3.68	1970	3.48	01-04-2000
Spring	24.64	1996	4.48	1934	4.06	03-26-1913
Summer	24.23	1926	4.95	1951	5.21	07-18-2001
Fall	20.48	1925	1.87	1963	4.90	09-14-1979

*Annual/seasonal totals may differ from the sum of the monthly totals due to rounding

Streamflow

Streamflow characteristics are vital data for water quality management planning. Such data is needed to reliably calculate waste load allocations, total maximum daily loads, assimilative capacities and other numerical indices that support wastewater management. Based on the water budget that the U.S. Geological Survey calculated for the Great Miami, Mill Creek and Little Miami drainage basins, it is reasonable to say that about two-thirds of the 40 to 42 inches of precipitation that falls annually on Butler, Clermont, Hamilton and Warren counties is returned to the atmosphere by evapotranspiration. The remaining third ultimately makes its way to the Ohio River as streamflow.

Table 2-8 on the next page summarizes the daily mean streamflow characteristics at four U.S. Geological Survey streamflow gauging stations in the study area, from 1968 to 1997.

Table 2-8: Summary of Daily Mean Streamflow

Streamflow Gauging Location and Number	Drainage Area	Percentage of time that daily mean streamflow was greater or equal to the value shown, in cubic feet per second							
		95%	90%	75%	50%	25%	10%	5%	1%
Little Miami River at Milford 03245500	1,203 sq. mi.	145	182	301	632	1,480	3,520	5,240	11,400
East Fork Little Miami River at Williamsburg 03246500	237 sq. mi.	1.50	3.67	20.9	64.2	220	707	1,580	3,850
Mill Creek at Carthage 03259000	115 sq. mi.	10.8	13.4	22.1	46.9	117	325	576	1,250
Great Miami River at Hamilton 03274000	3,630 sq. mi.	517	645	1,020	2,030	4,080	8,620	13,600	24,500

The U.S. Geological Survey has calculated an increase in mean daily discharges by five-year intervals for the Great Miami River at Hamilton, since 1966, but little change for the Little Miami River at Milford. A trend analysis, however, indicated a significant increase in the annual 7-day low flow for the Little Miami River from 1927 to 1997. This increase was attributed to increases in the discharge of treated wastewater that accompanied rapid development in Greene and Warren counties. Figures 2-29 and 2-30 below illustrate the U.S. Geological Survey's streamflow findings.

Figure 2-29: Mean Daily Discharge by 5-Year Intervals

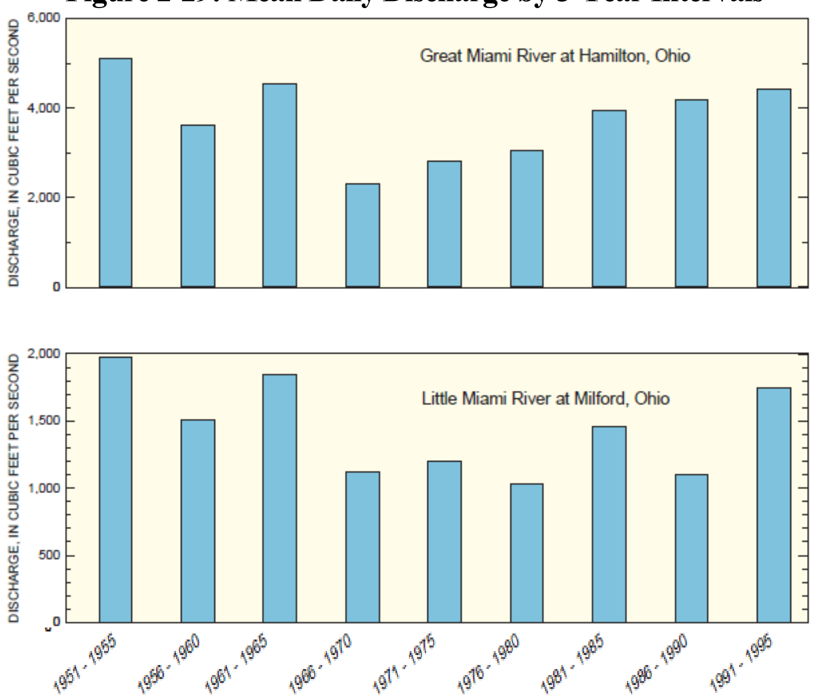
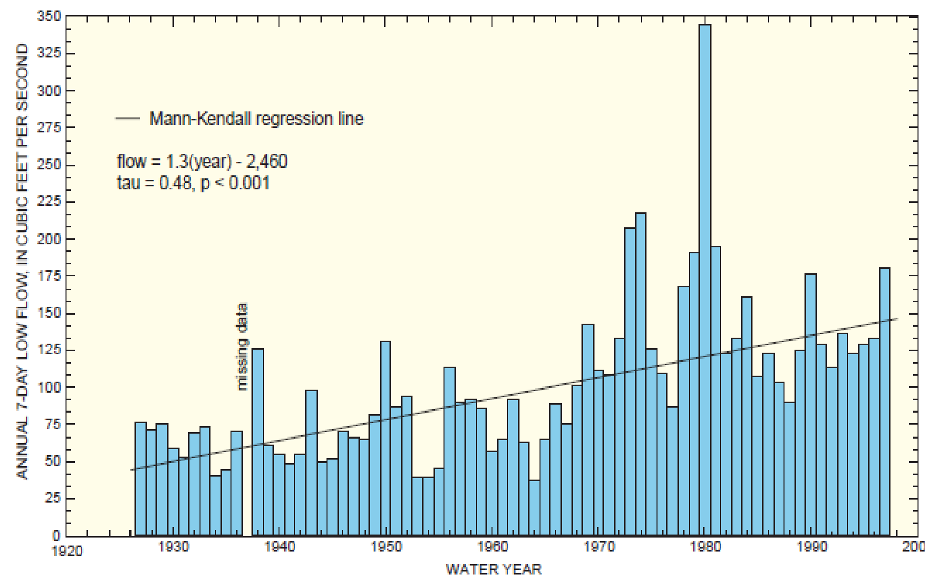


Figure 2-30: Annual 7-Day Low Flow for Little Miami River at Milford



Water Uses

Water is essential for all life. A good explanation of water's many and varied uses can be found in *Understanding Ohio's Surface Water Quality Standards* (Ohio EPA, 1995). This publication is a source for much of the text that follows.

State law and administrative code designate five types of uses for surface waters in Ohio:

1. aquatic life habitat
2. recreation
3. human health (fish contaminants)
4. State Resource Waters, which lie in environmentally significant areas
5. water supply, which is subdivided into public drinking water supply, agricultural water supply and industrial water supply

These designated uses will be further explained in the next chapter section, entitled Assessments for Southwest Ohio's Water Resources. Designated uses are introduced here because they are part of two federal laws that enable most water quality management efforts. These two laws are the Federal Water Pollution Control Act, commonly known as the Clean Water Act (of which Section 208 requires areawide water quality management plans such as this document), and the Safe Drinking Water Act. Basically, the Clean Water Act concentrates on reducing the pollution of water resources, while the Safe Drinking Water Act ensures that the public is provided with water that is safe for drinking and cooking. The Clean Water Act applies primarily to surface waters while the Safe Drinking Water Act applies primarily to public water systems, which may rely on either surface water or groundwater or a combination of both.

The Clean Water Act emphasizes that water quality standards should:

- restore and maintain the chemical, physical and biological integrity of surface waters
- provide water quality for the protection of fish, mollusks, wildlife and recreational waters
- consider the use and value of surface waters for public water supplies, propagation of fish and wildlife, recreation, agriculture and industrial purposes, and navigation

The Safe Drinking Water Act emphasizes two types of water quality standards known as primary standards and secondary standards. Primary standards may be either Maximum Contaminant Levels (MCL) or Treatment Technique Requirements. The MCL is the level at which the contaminant has been reduced so it poses no health risk to the consumer. Treatment Technique Requirements are set for contaminants that are too difficult or costly to measure for MCLs. Secondary standards are federal guidelines, rather than enforceable numbers, associated with the aesthetic quality of water, such as taste, odor or color.

In Southwest Ohio, drinking water is withdrawn from both surface water and groundwater sources. Regional groundwater protection efforts gained momentum in 1988 with federal designation of the Great Miami Buried Valley Aquifer System as a Sole Source Aquifer, indicating that this system is an irreplaceable resource that is the sole or primary source of drinking water for water systems that rely on it. The purpose of such a designation is to prevent federal funds from being used for projects that could contaminate an aquifer and create a significant hazard to public health. This federal protection does not apply to projects that are locally or privately funded. The remainder of the responsibility for protecting groundwater lies with the state and local governments. Because the Great Miami Buried Valley Aquifer System underlies most or parts of 13 counties in Southwest Ohio, the system required complementary Sole Source Aquifer designation petitions by both the Miami Valley Regional Planning Commission and the OKI Regional Council of Governments. Both petitions succeeded.

Boundaries of the Great Miami Buried Valley Aquifer System are based on productivity data primarily as shown on the Ohio Department of Natural Resources (ODNR) Groundwater Resources Maps. Since designation of the Sole Source Aquifer in 1988, more detailed hydrogeologic data have become available, principally from ODNR's groundwater pollution potential mapping. Figure 2-31 below illustrates aquifer boundaries that conform to ODNR's more recent work. Figure 2-32 below shows the Sole Source Aquifer boundaries in Butler, Clermont, Hamilton and Warren counties, as designated by the U.S. EPA in 1988.

It is worth noting that the Mill Creek watershed portion of the overall aquifer system was excluded from designation by a Federal Register Notice on July 8, 1988. The notice stated: "The designated area does not include the Mill Creek Basin in Butler and Hamilton Counties. This basin contains a Class I aquifer, but the population in the drainage basin depends primarily on surface water for their drinking water supply…When considered as a separate hydrologic system, the Mill Creek Basin does not meet the criteria established by EPA for sole source eligibility."

Figure 2-31: Great Miami Buried Valley Aquifer System in Butler, Clermont, Hamilton and Warren Counties

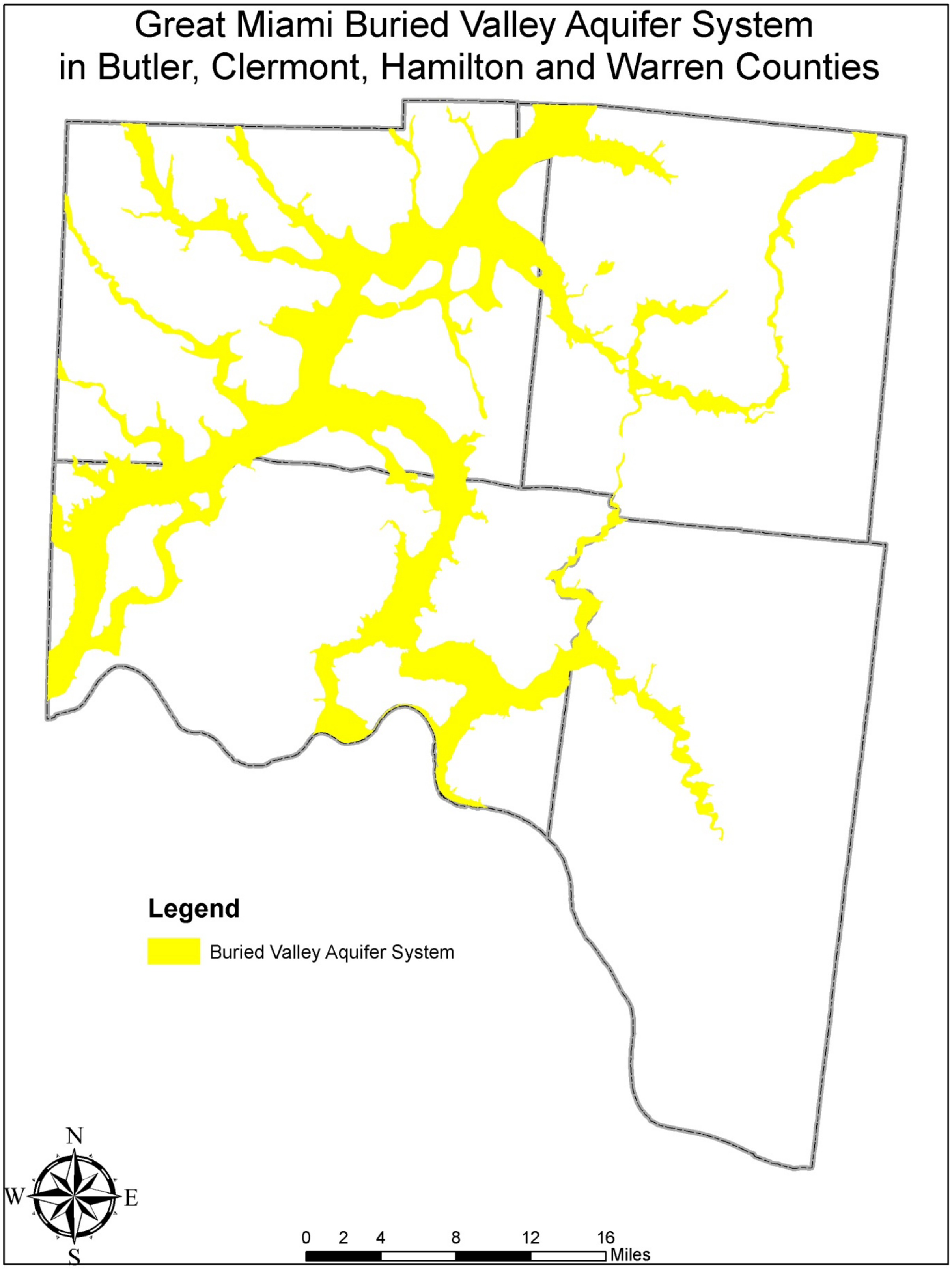
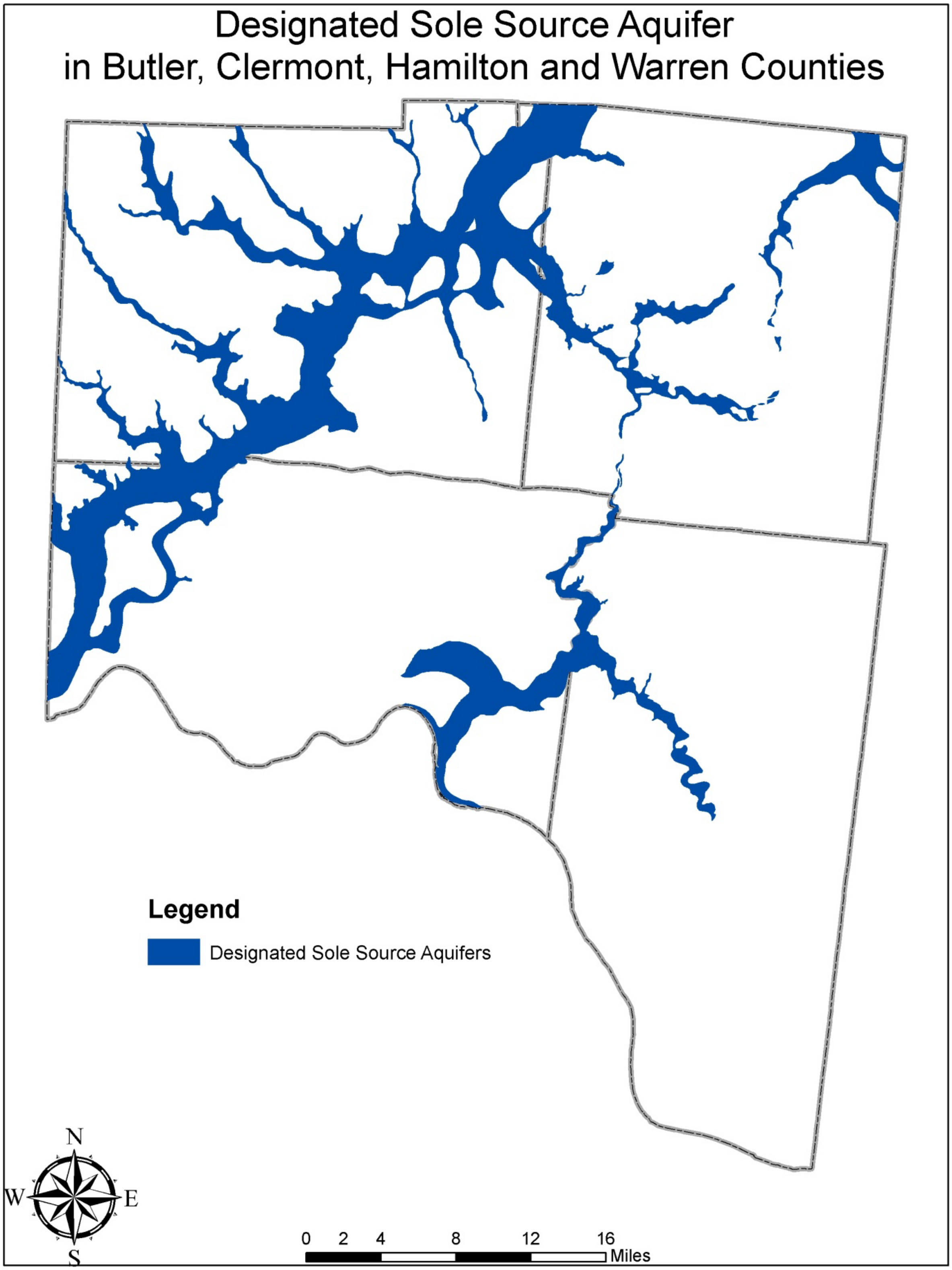


Figure 2-32: Designated Sole Source Aquifer in Butler, Clermont, Hamilton and Warren Counties



The safety of drinking water supplies in southwest Ohio is also addressed by Ohio's Source Water Protection Program. Operated by Ohio EPA's Division of Drinking and Ground Waters, the Source Water Protection Program helps public water suppliers with protecting sources of drinking water (streams and aquifers) from contamination. The program does not address private residential water systems, nor does it replace water quality requirements set by the federal government for public water systems. Instead, Ohio EPA encourages public water systems to develop and implement a local drinking water source protection plan, which is the second phase of source water protection. The first phase is assessment, which consists of three steps: (1) delineating the protection area, (2) identifying the potential contaminant sources in that area, and (3) determining the susceptibility of the source water to contamination.

Tables 2-9 through 2-12 on the next four pages indicate the source water protection status of active community water systems in Butler, Clermont, Hamilton and Warren counties. County by county, the tables shows whether community water systems have a delineated a protection area, potential contaminant source inventory and a local drinking water protection plan. Ohio EPA's susceptibility rating for a water system is also tabulated, if available. Ohio EPA has digitally compiled all of this data and posted it at a secured website that is accessible online through registration at: http://epa.ohio.gov/ddagw/swap_assessments.aspx

For each table, the following applies:

- Unshaded rows show community water systems, which serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents.
- Shaded rows show non-transient, non-community water systems, which serve at least 25 of the same nonresident persons per day for more than six months a year. Clermont County has no such water systems that are active.
- If the public water system relies on purchased groundwater or purchased surface water, it has no need for a delineated protection area, potential contaminant source inventory or local drinking water source protection plan.
- The last column, titled susceptibility, reports Ohio EPA's rating of the likelihood that the water system's drinking water source will become contaminated at concentrations that pose a concern. The susceptibility rating is not a judgment of the community water system's competence, but more of an assessment of hydrogeological conditions and land uses in the vicinity of the water system's drinking water source.
- The full name of the "Consortium" cited in the table is the Hamilton to New Baltimore Ground Water Consortium, which was created in 1964.
- Most information is from Ohio EPA online sources as of Sept. 23, 2009.

Table 2-9: Source Water Protection Status of Active Community Water Systems and Non-Transient, Non-Community Water Systems in Butler County

Community Water System & Ohio EPA identification #	Drinking Water Source	Protection area delineated?	Potential contaminant sources inventoried?	Local protection plan status?	Susceptibility
Butler County Water Dist. #2 OH0900303	purchased surface water	not needed	not needed	not needed	not applicable
Catalina Mobile Home Park OH0900512	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Crouse Mobile Home Park OH0900912	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Edgewood Mobile Home Park OH0900612	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Fairfield, City of OH0900715	groundwater	yes by CH2M Hill	yes, by Brandstetter Carroll, Inc. and Eagon & Associates	state endorsed, as a part of Consortium plan	high
Hamilton Public Water System OH0904012	groundwater	yes by CH2M Hill	yes, by Brandstetter Carroll, Inc. and Eagon & Associates	state endorsed, as a part of Consortium plan	high
Linda Mobile Home Park OH0901412	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Middletown, City of OH0901712	groundwater	yes by CH2M Hill	yes by CH2M Hill	state endorsed	high
Monroe, City of OH0902012	purchased surface water	not needed	not needed	not needed	not applicable
New London #1 OH0903503	purchased groundwater	not needed	not needed	not needed	not applicable
New Miami, Village of OH0902112	groundwater	yes by Ohio EPA	yes by village & OKI	state endorsed	high
Oxford, City of OH0902312	groundwater	yes, by Miami Univ. & Smith-Comesky, LLC	yes by city	state endorsed	high
Ross Meadows OH0902512	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Seven Mile, Village of OH0902612	purchased groundwater	not needed	not needed	not needed	not applicable
Southwest Regional Water District, North Plant OH0903912	groundwater	yes by CH2M Hill	yes, by Brandstetter Carroll, Inc. and Eagon & Associates	state endorsed, as a part of Consortium plan	high
Trenton, City of OH0903012	groundwater	yes by AECOM	voluntary drinking water source assessment	voluntary source assessment	high
333					
Advanced Drainage Systems	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Miller Breweries East, Inc.	groundwater	yes, by Burgess & Niple	yes, by Burgess & Niple	vol. drinking water source assessment	high
Trenton Church of God	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high

Table 2-10: Source Water Protection Status
of Active Community Water Systems in Clermont County

Community Water System & Ohio EPA identification #	Drinking Water Source	Protection area delineated?	Potential contaminant sources inventoried?	Local protection plan status?	Susceptibility
Batavia, Village of OH1300011	purchased surface water	not needed	not needed	not needed	not applicable
Bethel, Village of OH1300116	purchased groundwater	not needed	not needed	not needed	not applicable
Clermont County Public Water System OH1302212	surface water	yes by water system	yes by water system	yes by water system	high
Felicity, Village of OH1300612	groundwater	yes, by John C. Van Harlingen	yes, by John C. Van Harlingen	vol. drinking water source assessment	high
Loveland, City of OH1300812	groundwater	yes, by Jones & Henry Engineers	yes by LJB, Inc.	vol. drinking water source assessment	high
Milford, City of OH1301012	groundwater	yes, by Beljin & Associates	yes, by U.C. Dept. of Civil Engineering	vol. drinking water source assessment	high
New Richmond Robin-Grays OH1330912	purchased surface water	not needed	not needed	not needed	not applicable
New Richmond, Village of OH1301212	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Tate-Monroe Water Association OH1301312	groundwater	yes, Panterra Corp.	yes, by Panterra Corp.	recommendations by Panterra	high
Williamsburg, Village of OH1301411	purchased surface water	not needed	not needed	not needed	not applicable

Table 2-11: Source Water Protection Status of Active Community Water Systems and Non-Transient, Non-Community Water Systems in Hamilton County

Community Water System & Ohio EPA identification #	Drinking Water Source	Protection area delineated?	Potential contaminant sources inventoried?	Local protection plan status?	Susceptibility
Addyston, Village of OH3100012	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Cincinnati Public Water System OH3102612	groundwater	yes, by CH2M Hill for Bolton Treatment Plant	yes, by Brandstetter Carroll, Inc. and Eagon & Associates	state endorsed, as a part of Consortium plan	high
Cincinnati Public Water System OH3102612	surface water	yes, by Ohio EPA for Miller Treatment Plant	yes, by Ohio EPA for Miller Treatment Plant	strategies suggested by Ohio EPA	high
Cleves, Village of OH3100512	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Dry Fork Mobile Home Park OH3100612	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Glendale, Village of OH3100712	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Harrison, City of OH3100812	groundwater	yes, by Burgess & Niple	yes, by Burgess & Niple	vol. drinking water source assessment	high
Indian Hill, City of OH3101112	groundwater	yes by Ohio EPA	yes by Panterra Corp.	yes by Panterra Corp	high
Lockland, Village of OH3101212	groundwater	yes, by Eagon & Associates	yes, by Village of Lockland	vol. drinking water source assessment	high
Norwood, City of OH3101703	purchased surface water	not needed	not needed	not needed	not applicable
Reading City of OH3101812	purchased surface water	not needed	not needed	not needed	not applicable
Red Wood Mobile Home Park OH3100112	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Twin Rivers Water Corporation OH3102303	purchased groundwater	not needed	not needed	not needed	not applicable
Wyoming, City of OH3102212	groundwater	yes, by Eagon & Associates	yes, by City of Wyoming	vol. drinking water source assessment	high
Non-Transient Non-Community Water Systems					
Cincinnati Incorporated OH3130612	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Cincinnati Technical Center OH3137412	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Cincinnati Test Systems #1 OH3138312	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Cincinnati Test Systems #1 OH3138412	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Whitewater Processing Company OH3136212	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high

Table 2-12: Source Water Protection Status of Active Community Water Systems and Non-Transient, Non-Community Water Systems in Warren County

Community Water System & Ohio EPA identification #	Drinking Water Source	Protection area delineated?	Potential contaminant sources inventoried?	Local protection plan status?	Susceptibility
Caesars Lake Mobile Home Park OH8300012	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Carlisle, City of OH8303803	purchased groundwater	not needed	not needed	not needed	not applicable
Franklin Public Water System OH8300412	groundwater	yes, by Panterra Corp.	yes, by Panterra Corp	vol. drinking water source assessment	high
Lebanon Correctional Institution OH8301012	groundwater	yes, by Univ. of Cincinnati	yes by Reynolds, Inc.	vol. drinking water source assessment	moderate
Lebanon Public Water System OH8304112	groundwater	yes, by Woolpert Consultants	yes, by Woolpert Consultants	yes, by Woolpert Consultants	high
Morrow Village Public Water System OH8300912	groundwater	yes, by Burgess & Niple	yes, by Panterra Corp	vol. drinking water source assessment	high
Otterbein-Lebanon Retirement Ctr. OH8301112	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
South Lebanon, Village of OH8301312	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Springboro, Village of OH8301412	groundwater	yes, by Panterra Corp.	yes, by MACTEC Eng. & Consulting	vol. drinking water source assessment	high
The Meadows OH8300312	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Warren County Beal Road PWS OH8304303	purchased groundwater	not needed	not needed	not needed	not applicable
Warren County Franklin Area PWS OH8301603	groundwater	yes, by Camp Dresser & McKee	yes, by Camp Dresser & McKee	yes, by Camp Dresser & McKee	high
Warren County Massie/Wayne PWS OH8345912	purchased groundwater	not needed	not needed	not needed	not applicable
Warren Co. Pennyroyal Area PWS OH8301803	purchased groundwater	not needed	not needed	not needed	not applicable
Warren County Richard Renneker OH8301512	groundwater	yes, by Camp Dresser & McKee	yes, by Camp Dresser & McKee	yes, by Camp Dresser & McKee	high
Warren County Sharts Road PWS OH8346912	purchased groundwater	not needed	not needed	not needed	not applicable
Warren County Socialville PWS OH8304203	purchased surface water	not needed	not needed	not needed	not applicable
Wayne Mobile (formerly Dakin) OH8300212	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Waynesville, Village of OH8300212	groundwater	yes, by Panterra Corp.	yes, by Panterra Corp	vol. drinking water source assessment	high
Western Water Co. OH8300512	groundwater	yes, by Burgess & Niple	yes, by Burgess & Niple	vol. drinking water source assessment	high
Non-Transient Non-Community Water Systems					
Carlisle High School OH8344612	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Carlisle Primary & Jr. High School OH8344512	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high
Kings Island Public Water System OH8345615	groundwater	yes, by Burgess & Niple	yes, by Burgess & Niple	vol. drinking water source assessment	high
MMMIL Grove Road, LLC OH8331612 (formerly Siemens)	groundwater	yes by Ohio EPA	yes by Ohio EPA	strategies checklist by Ohio EPA	high

Beyond the household uses of drinking, cooking, bathing and cleaning, water resources serve many functions. By sheer volume, electrical power generation is easily the most common use for water in Ohio. Manufacturing is a distant second and public water supply is third. (*Water Quality Standards Handbook*, U.S. EPA, 1983) While most manufacturers rely on water for cooling processes, it is worth noting the four-county study area includes the MillerCoors brewery, which depends on massive quantities of clean groundwater on a daily basis.

Agriculture, still a major source of income in Butler, Clermont and Warren counties, depends on water to irrigate crops, raise livestock and provide commercial fish ponds. Transportation is another major use of water. The tonnage of shipping on the Ohio River navigation system is almost double that of the Panama Canal and triple that of the St. Lawrence Seaway (*Ohio's Water, Ohio's Future;* Governor's Blue Ribbon Task Force on Water Resources Planning and Development, 1994).

Other significant water uses include firefighting, outdoor sports and recreation, geothermal heating and cooling, and economic development at marinas, docks, liveries, riverfronts, lakefronts and other water features. While dollar values can be estimated for these uses, much of the value of water resources is intangible. Water resources also create countless opportunities for education.

Pragmatically, one of water's most essential uses is waste disposal. Water is the vital component for waste filtration, dilution, storage, treatment and transport. This water use is discussed in Chapter 7: *Wastewater Facilities Planning*.

Designations and Assessments of Southwest Ohio's Water Resources

Water Supply

As previously stated, water supply is one of the five types of water use designations addressed by Ohio law and administrative code. Ohio EPA has assigned the designations of industrial water supply and agricultural water supply to all of the watersheds in Butler, Clermont, Hamilton and Warren counties because virtually all rivers and streams have potential uses for the manufacturing and farming sectors.

The designation of public water supply is scarce, however, because Ohio EPA has limited that status to the watersheds with public water systems that rely on surface water intakes, rather than wells, for their raw water. At the 12-digit Hydrologic Unit Code (HUC) level of classification, five watersheds in the four-county study area have public water supply as a designated use:

1. Lower Caesar Creek in northeast Warren County (HUC 12 code: 050902020406)
2. Second Creek in southeast Warren County (HUC 12 code: 050902020702)
3. Cloverlick Creek in southern Clermont County (HUC 12 code: 050902021202)
4. Lucy Run-East Fork Little Miami River in central Clermont (HUC 12 code: 050902021203)
5. Headwaters of Stonelick Creek in northeast Clermont County and southeast Warren County (HUC 12 code: 050902021301)

Aquatic Life Habitat

Aquatic life habitat is a well known designated use for Ohio's water resources, especially among people who work to improve the overall health of the state's surface waters. Aquatic life designations also generate the most effort, as acknowledged in the *Ohio 2010 Integrated Water Quality Monitoring and Assessment Report*: "Ohio EPA has been evaluating streams using standardized biological field collection methods for over thirty-five years. Stream assessments are based on the experience gained through the collection of over 22,000 fish population samples, over 11,000 macroinvertebrate community samples and more than 72,500 water chemistry samples."

When designating the aquatic life use of a particular stream or river, Ohio EPA can choose among seven subcategories, which are described below with excerpts from the Ohio Administrative Code 3745-1-07:

1. Warmwater– "these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within the ecoregion for that river or stream."

   The warmwater habitat designation predominates among the Watershed Assessment Units of Butler, Clermont, Hamilton and Warren counties.

   It applies along the length of two Large River Assessment Units through the study area:
   - *Great Miami River-Mad River to Four Mile Creek (050800029001) in Warren County*
   - *Great Miami River-Four Mile Creek to Ohio River (050800029002) in Butler and Hamilton counties*

Warmwater habitat is the designation for segments of two additional Large River Assessment Units in the study area:

- *Little Miami River-Caesar Creek to O'Bannon Creek (050902029001) in Clermont and Hamilton counties*
- *Little Miami River-O'Bannon Creek to Ohio River (050902029002) in Hamilton County*

2. Limited warmwater–"these are waters that were temporarily designated in the 1978 water quality standards as not meeting specific warmwater habitat criteria. Criteria for the support of this use designation are the same as the criteria for the support of the use designation warmwater habitat. However, individual criteria are varied on a case-by-case basis and supersede the criteria for warmwater habitat where applicable."

   None of the Watershed Assessment Units in the study area now have this temporary designation.

3. Exceptional warmwater – "these are waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the seventy-fifth percentile of the identified reference sites on a statewide basis."

   All or part of twenty-two Watershed Assessment Units in the study area have been designated as exceptional warmwater habitat:

   - *Town of Germantown-Twin Creek (050800020306) in Butler and Warren counties*
   - *Rush Run-Sevenmile Creek (050800020504) in Butler County*
   - *Ninemile Creek-Sevenmile Creek (050800020505) in Butler County*
   - *Little Four Mile Creek (050800020602) in Butler County*
   - *Cotton Run-Four Mile Creek (050800020605) in Butler County*
   - *Elk Creek (050800020701) in Butler County*
   - *Jordan Creek (050800020906) in Hamilton County*
   - *Headwaters Dry Fork Whitewater River (050800030807) in Butler County*
   - *Howard Creek-Dry Fork Whitewater River (050800030808) in Butler and Hamilton counties*
   - *Lee Creek-Dry Fork Whitewater River (050800030809) in Butler and Hamilton counties*
   - *Jameson Creek-Whitewater River (050800030810) in Hamilton County*
   - *Middle Caesar Creek (050902020404) in Warren County*
   - *Lower Caesar Creek (050902020406) in Warren County*
   - *Newman Run-Little Miami River (050902020504) in Warren County*
   - *Ferris Run-Little Miami River (050902020801) in Warren County*
   - *Halls Creek-Little Miami river (050902020804) in Warren County*
   - *Solomon Run-East Fork Little Miami River (050902021101) in Clermont County*
   - *Fivemile Creek-East Fork Little Miami River (050902021102) in Clermont County*
   - *Todd Run-East Fork Little Miami River (050902021103) in Clermont County*
   - *Lucy Run-East Fork Little Miami River (050902021203) in Clermont County*
   - *Backbone Creek-East Fork Little Miami River (050902021204) in Clermont County*
   - *Salt Run-East Fork Little Miami River (050902021305) in Clermont County*

Parts of two Large River Assessment Units are designated as exceptional warmwater habitat in the four-county study area:

- *Little Miami River-Caesar Creek to O'Bannon Creek (050902029001) in Clermont and Hamilton counties*
- *Little Miami River-O'Bannon Creek to Ohio River (050902029002) in Hamilton County*

The entire length of one Large River Assessment Unit in the study area has the designation of exceptional warmwater habitat:

- *Whitewater River-Entire Length (050800039001) in Hamilton County*

4. Modified warmwater – "these are waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., twenty years or longer) and may include the following examples: extensive stream channel modification activities permitted under sections 401 and 404 of the act or Chapter 6131. of the Revised Code, extensive sedimentation resulting from abandoned mine land runoff, and extensive permanent impoundment of free-flowing water bodies."

   Parts of two Watershed Assessment Units in Butler and Hamilton counties are modified warmwater habitat:

   - *Dicks Creek (050800020704) in Butler County*
   - *West Fork-Mill Creek (050902030105) in Hamilton County*

5. Seasonal salmonid – "these are rivers, streams and embayments capable of supporting the passage of salmonids from October to May and are water bodies large enough to support recreational fishing."

   None of the Watershed Assessment Units in Butler, Clermont, Hamilton or Warren counties have the seasonal salmonid assessment.

6. Coldwater habitat – this designation applies to two types of streams:
   – "inland trout streams: these are waters which support trout stocking and management under the auspices of the Ohio department of natural resources, division of wildlife, excluding waters in lake run stocking programs, lake or reservoir stocking programs, experimental or trial stocking programs, and put and take programs on waters without, or without the potential restoration of, natural coldwater attributes of temperature and flow."
   – "native fauna: these are waters capable of supporting populations of native coldwater fish and associated vertebrate and invertebrate organisms and plants on an annual basis."

   Only part of the Turtle Creek watershed (050902020803) in Warren County has the coldwater habitat assessment, which is infrequent in Southwest Ohio.

7. Limited resource water – "these are waters that have been the subject of a use attainability analysis and have been found to lack the potential for any resemblance of any other aquatic life habitat . . . The use attainability analysis must demonstrate that the extant fauna is substantially degraded and that the potential for recovery of the fauna to

the level characteristic of any other aquatic life habitat is realistically precluded due to natural background conditions or irretrievable human-induced conditions."

All or part of six Watershed Assessment Units in the study area have been designated as limited resource waters. All six watersheds are solely in Hamilton County:

- *Congress Run-Mill Creek (050902030104)*
- *West Fork-Mill Creek (050902030105)*
- *Town of Newport-Ohio River (050902030201)*
- *Dry Creek-Ohio River (050902030202)*
- *Garrison Creek-Ohio River (050902030204)*
- *Duck Creek (050902021404)*

Recreation

Another well-known designated use is recreation because it is important to the many people who come in contact with waters of the state for sport, fun and relaxation. As stated in the Ohio Administrative Code (OAC), the recreation use designations are in effect only during the recreation season, which starts May 1 and ends October 31 each year. The director of Ohio EPA may require effluent disinfection during the months outside the recreation season if necessary to protect an unusually high level of water based recreation activity such as, but not limited to, canoeing, kayaking, scuba diving, or sport fishing during spawning runs.

The OAC divides recreation use designations into three major categories and three subcategories:

1. Bathing waters – "these are waters that, during the recreation season, are heavily used for swimming. The bathing water use applies to all waters in areas where a lifeguard or bathhouse facilities are present, and to any additional water bodies designated (as) bathing waters . . ."

   None of the Watershed Assessment Units or Large River Assessment Units in Butler, Clermont, Hamilton and Warren counties has the bathing waters designation. The study area, however, has five inland lake public beaches subject to swimming advisory postings:

   - *Caesar Creek State Park's north beach in Warren County*
   - *Caesar Creek State Park's south beach in Warren County*
   - *East Fork State Park's main beach in Clermont County*
   - *East Fork State Park's camp beach in Clermont County*
   - *Stonelick Lake State Park beach in Clermont County*

   Hueston Woods State Park includes acreage in Butler County's northwest corner, but the park's public beach on Acton Lake is located in Preble County. In addition to the five public beaches listed above, the study has other lakes or reservoirs open to public recreation, such as Winton Lake and Sharon Lake in the Mill Creek watershed of Hamilton County.

2. Primary contact – "these are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving. Three classes of primary contact recreation use are defined to reflect differences in the observed and potential frequency and intensity of usage."

Of the 80 Watershed Assessment Units in Butler, Clermont, Hamilton and Warren counties, 74 are designated solely for primary contact recreation. Five more Watershed Assessment Units are designated for both primary contact recreation and secondary contact recreation, which is defined below.

All five Large River Assessment Units (LRAUs) in the study area have the designation for primary contact recreation. Of the five, three LRAUs have been specified for class A primary contact recreation, which is explained below. Those three class A units are:

- *Little Miami River-Caesar Creek to O'Bannon Creek (050902029001)*
- *Little Miami River-O'Bannon Creek to Ohio (050902029002)*
- *Whitewater River-Entire length (050800039001)*

The other two LRAUs are presumably to be sub-categorized as class B primary contract recreation rivers. Those two class B units are:

- *Great Miami River-Mad River to Four Mile Creek (050800029001)*
- *Great Miami River-Four Mile Creek to Ohio River (050800029002)*

Effective March 15, 2010, the Ohio Administrative Code designated these six popular paddling stream segments in the four-county study area as class A primary contact recreation streams from the most upstream identified public access point to the mouth:

- *Caesar Creek in the Little Miami River drainage basin, from Caesar Creek Lake dam (river mile 3.0) to the mouth at the Little Miami River*
- *Fourmile Creek in the Great Miami River drainage basin, from Hueston Woods State Park (river mile 25.0) to the mouth at the Great Miami River*
- *Little Miami River, East Fork, in the Little Miami River drainage basin ,from State Route 131 west of Chasetown (river mile 54.4) to the mouth on the Little Miami River*
- *Little Miami River, from Clifton Gorge (river mile 88.0) to the mouth at the Ohio River*
- *Twin Creek in the Great Miami River drainage basin, from State Route 35 east of West Alexandria (river mile 29.96) to the mouth on the Great Miami River*
- *Whitewater River in the Great Miami River drainage basin, from the Indiana border at Harrison (river mile 8.28) to the mouth on the Great Miami River*

3. Secondary contact – "these are waters that result in minimal exposure potential to water borne pathogens because the waters are: rarely used for water based recreation such as, but not limited to, wading; situated in remote, sparsely populated areas; have restricted access points; and have insufficient depth to provide full body immersion, thereby greatly limiting the potential for water based recreation activities."

   The five Watershed Assessment Units that are designated for secondary contact recreation in combination with primary contact recreation are:

   - *Howard Creek-Dry Fork Whitewater River (050800030808) in Butler and Hamilton counties, along Kiata Creek*
   - *Duck Creek (050902021404) in Hamilton County, for 8.2 miles on its way to the Little Miami River*
   - *East Fork Mill Creek-Mill Creek (050902030101) in Butler and Hamilton counties, for 7.1 miles along East Fork Mill Creek on its way to the Mill Creek*
   - *Congress Run-Mill Creek (050902030104) in Hamilton County, for 4.1 miles along Ross Run on its way to the Mill Creek*

- *West Fork-Mill Creek (050902030105) in Hamilton County, for 15.2 miles along two segments of West Fork Mill Creek from its headwaters to its mouth at Mill Creek*

Two Watershed Assessment Units in the four-county study area have been solely designated for secondary contact recreation:

- *Town of Newport-Ohio River (050902030201) in Hamilton County*
- *Dry Creek-Ohio River (050902030204) in Hamilton County, along Wulff Run, a tributary to Rapid Run*

The designation of primary contact recreation is divided into three subcategories:

1. Class A primary contact recreation – "These are waters that support, or potentially support, frequent primary contact recreation activities. The following water bodies are designated as class A primary contact recreation waters:
   (a) All lakes having publicly or privately improved access points; and
   (b) All water bodies listed in table 7-16 of this rule. The streams and rivers listed in table 7-16 of this rule are popular paddling streams with public access points developed, maintained, and publicized by governmental entities."

2. Class B primary contact recreation – "These are waters that support, or potentially support, occasional primary contact recreation activities. All surface waters of the state are designated as class B primary contact recreation unless otherwise designated as bathing waters, class A primary contact recreation, class C primary contact recreation or secondary contact recreation."

   Given the fact that class B primary contact recreation is the default recreation classification for waterways, it is safe to say that most of the 80 Watershed Assessment Units in Butler, Clermont, Hamilton and Warren counties have this particular sub-category of designation. The exceptions would be
   - *five Watershed Assessment Units listed on the previous page for secondary contact recreation designations*
   - *all of Watershed Assessment Units associated with the six lengthy stream segments listed above on this and the previous page for class A primary contact recreation designations*
   - *any Watershed Assessment Units that will be designated as class C primary contact designation in the course of Ohio EPA's periodic monitoring visits and assessments of waterways in Southwest Ohio*

3. Class C primary contact recreation – "These are water bodies that support, or potentially support, infrequent primary contact recreation activities such as, but not limited to, wading. The following water bodies are designated class C primary contact recreation:

   (a) All water body segments with drainage areas less than 3.1 square miles and meeting the definition in 6111.01 of the Revised Code of historically channelized watercourse, unless they are specifically 3745-1-07 9 designated a different recreational use in rules 3745-1-08 to 3745-1-30 of the Administrative Code; and
   (b) All water bodies specifically designated class C primary contact recreation in rules 3745-1-08 to 3745-1-30 of the Administrative Code."

Human Health (Fish Contaminants)

Ohio's water quality standards do not describe human consumption of sport fish as an explicit element of aquatic life protection. However, the standards do include human health criteria that are applicable to all surface waters of the state. Certain of these criteria are derived using assumptions about the bioaccumulation of chemicals in the food chain, and the criteria are intended to protect people from adverse health impacts that could arise from consuming fish caught in Ohio's waters. (*Ohio 2010 Integrated Water Quality Monitoring and Assessment Report,* Ohio EPA, 2010).

Six Watershed Assessment Units in Butler, Hamilton or Warren counties are listed in the 2010 Integrated Report as having excessive levels of polychlorinated biphenyls (PCBs) in fish tissue:

- *Dicks Creek (050800020704) in Butler and Warren counties*
- *Beals Run-Indian Creek (050800020803) in Butler County*
- *Jameson Creek-Whitewater River (050800030810) in Hamilton County*
- *Town of New Miami-Great Miami River (050800020706) in Butler County*
- *Salt Run-Little Miami River (050902020903) in Warren County*
- *Newman Run-Little Miami River (050902020504) in Warren*

Two Large River Assessment Units in Hamilton and Warren counties also exceed state water quality standards by having excessive levels of PCBs in fish tissue:

- *Whitewater River (050800039001) in Hamilton County*
- *Little Miami River-Caesar Creek to O'Bannon Creek (050902029001) in Warren County*

Seventeen Watershed Assessment Units are listed in Section L-1 of the 2010 Integrated Report for having historical data indicating impairment for human health because of fish contaminants:

- *Elk Creek (050800020701) in Butler County*
- *Browns Run-Great Miami River (050800020702) in Butler and Warren counties*
- *Shaker Creek (050800020703) in Butler and Warren counties*
- *Gregory Creek (050800020705) in Butler County*
- *Pleasant Run (050800020901) in Butler and Hamilton counties*
- *Banklick Creek (050800020902) in Butler and Hamilton counties*
- *Paddys Run (050800020903) in Butler and Hamilton counties*
- *Dry Run-Great Miami River (050800020904) in Butler and Hamilton counties*
- *Taylor Creek (050800020905) in Hamilton County*
- *Jordan Creek (050800020906) in Hamilton County*
- *Doublelick Run-Great Miami River (050800020907) in Hamilton County*
- *Sugar Creek (050902020501) in Warren County*
- *East Fork Mill Creek-Mill Creek (050902030101) in Butler and Hamilton counties*
- *West Fork Mill Creek (050902030102) in Hamilton County*
- *Sharon Creek-Mill Creek (050902030103)in Butler and Hamilton counties*
- *Congress Run-Mill Creek (050902030104) in Hamilton County*
- *West Fork-Mill Creek (050902030105) in Hamilton County*

Ohio has operated a formal sport fish consumption advisory program since 1993. In 2002, responsibility for the program's technical decisions was transferred to the Ohio EPA. The agency's website at http://www.epa.state.oh.us/dsw/fishadvisory/questions.aspx says most Ohio sport fish are of high quality, but low levels of chemicals like polychlorinated biphenyls (PCBs), mercury and lead have been found in some fish from certain waters. To ensure good health, the Ohio Department of Health offers an advisory for how often these fish can be safely be eaten. An advisory is advice, and should not be viewed as law or regulation. It is intended to help people make educated choices about where to fish, what types of fish to eat, and how to limit the amount and frequency of fish consumed.

The fish advisory website indicates that fish tissue from 19 rivers or streams and 5 lakes in Butler, Clermont, Hamilton and Warren counties had been sampled by Ohio EPA or the Ohio Department of Natural Resources by December 2009. Of the 24 water bodies sampled, the state issued specific fish consumption advisories for 12 waterbodies. Of the 12 waterbodies with specific advisories, 11 are streams and 1 is a lake. Of those 11 streams with specific advisories, 6 of them flow in HUC-12 watersheds that have been designated by Ohio EPA as exceptional warmwater habitats:

- Caesar Creek in Warren County
- East Fork Little Miami River in Clermont County
- Fourmile Creek in Butler County
- Little Miami River (segment) in Warren County
- Sevenmile Creek in Butler County
- Whitewater River in Hamilton County

The presence of contaminated fish in the highly rated exceptional warmwater habitats may be more a sign of fish mobility than a strike against the water quality of the watersheds in which they happened to be caught and sampled.

Most of the specific fish consumption advisories for Butler, Clermont, Hamilton and Warren Counties advise people to eat no more than one of certain fish species per month. Two water bodies, however, are subject to a stricter “do not eat” advisory:

- Dicks Creek in Butler County, from Cincinnati-Dayton Road in Middletown to the stream’s mouth at the Great Miami, for all species of fish, due to high levels of PCBs in the fish tissue
- Great Miami River, in Warren, Butler and Hamilton counties, from where the river enters the study area all the way to the Great Miami’s mouth on the Ohio River, for all sucker fish species, due to high levels of PCBs in the fish tissues

Dicks Creek is the only stream in the study area that warrants the Ohio EPA’s recommendation against wading or swimming because its water or sediments are highly contaminated.

PCBs, mercury or both account for all of the specific fish consumption advisories in the study area. In addition, high levels of lead were found in the flathead catfish and striped bass hybrids of the Great Miami River, along its entire length through Warren, Butler and Hamilton counties.

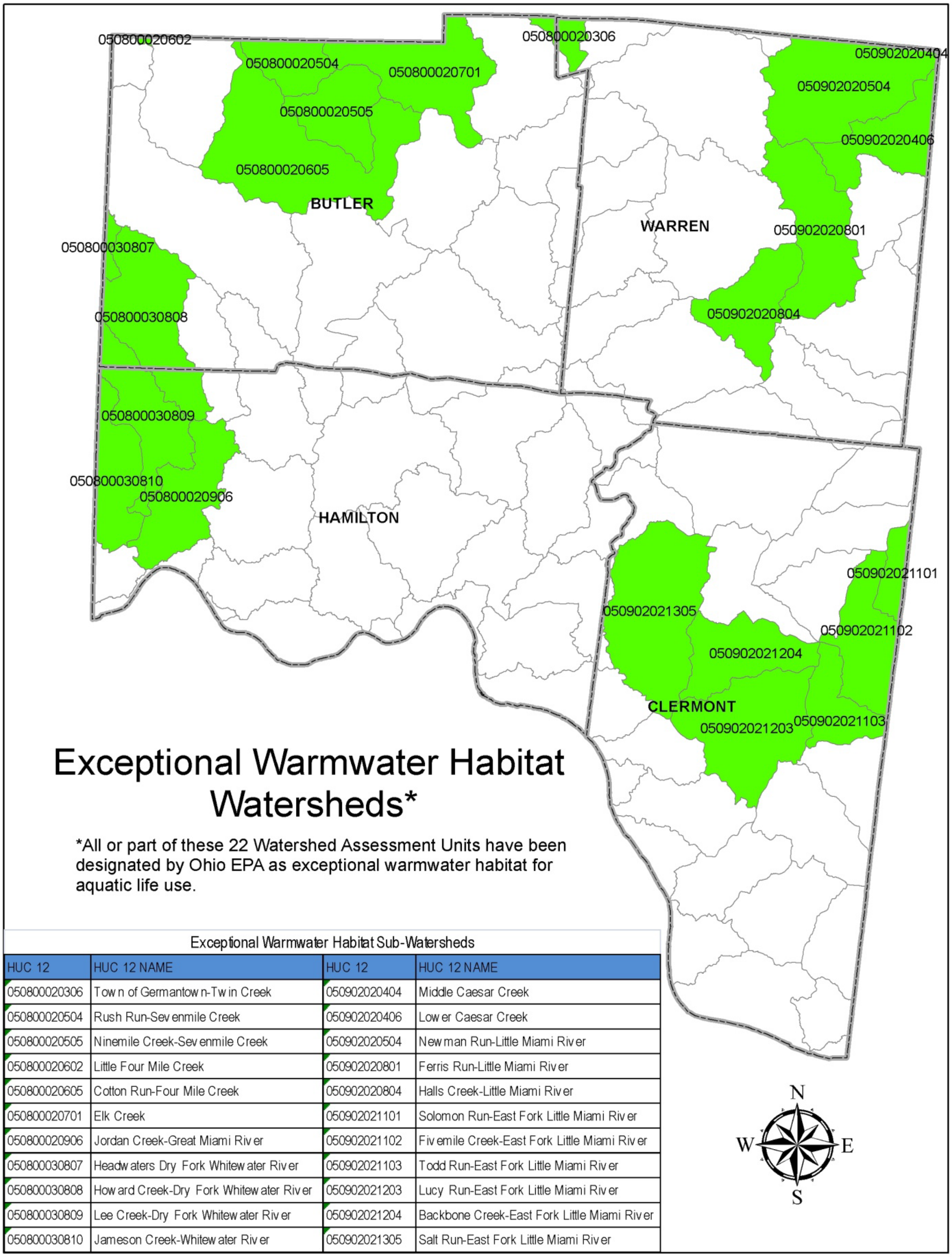
Table 2-13 on the next page summarizes fish consumption advisory data on the 24 water bodies sampled for fish tissue in Butler, Clermont, Hamilton and Warren counties.

Table 2-13: Fish Tissue Samplings and Sport Fish Consumption Advisories in Butler, Clermont, Hamilton and Warren Counties

River or Stream	Years Sampled	River Miles	Local County(ies)	Specific Advisory?	Contaminant(s)
Caesar Creek	1998	16.5 to 2.7	Warren	no	
Dicks Creek	1998, 2000, 2002	5.5 to 0.9	Butler	YES	PCBs
East Fork Little Miami River	1996, 1998	75.3 to 4.8	Clermont	YES	mercury
Fourmile Creek	1995, 2004, 2007	24.7 to 5.4	Butler	YES	mercury
Great Miami River	1993, 1994, 1998, 2002, 2008, 2009	148.4 to 1.8	Butler, Hamilton	YES	PCBs, mercury, lead
Hamilton Hydraulic Canal	1998	3.3 to 0.1	Butler	YES	PCBs
Indian Creek	2005	15.1 to 1.6	Butler	no	
Little Miami River	1993, 1998, 2006, 2007	83.1 to 3.5	Warren, Clermont, Hamilton	YES	mercury
Little Three Mile Creek	1998	0.9	Clermont	no	
Mill Creek	1992	16.5 to 0.3	Hamilton	YES	PCBs
O'Bannon Creek	2000	0.3	Clermont	no	
Ohio River	1994, 1995, 1998, 1999, 2001, 2003	491 to 42	Clermont, Hamilton	YES	PCBs
Pleasant Run	1998	1.3	Clermont	no	
Sevenmile Creek	2004	14.5 to 1.3	Butler	YES	mercury
Stonelick Creek	1996	2.6	Clermont	no	
Todd Fork	1996	25.2 to 5.5	Warren	no	
Twin Creek	1995, 2004	35.5 to 0.1	Warren	YES	mercury
West Fork Mill Creek	2002	4.5 to 2.0	Hamilton	no	
Whitewater River	2000, 2002	8.3 to 5.1	Hamilton	YES	mercury, PCBs
Lake or Reservoir	**Park**	**Yrs. Sampled**	**Local County(ies)**	**Specific Advisory?**	**Contaminant(s)**
Acton Lake	Hueston Woods State Park	1994, 2005	Butler	no	
Caesar Creek Reservoir	Caesar Creek State Park	1993, 2004	Warren	no	
East Fork Lake (Harsha Lake)	East Fork State Park	1993, 1994, 2006	Clermont	YES	mercury
Stonelick Reservoir	Stonelick State Park	1994	Clermont	no	
West Fork Mill Creek Lake (Winton Lake)	Winton Woods (Hamilton County Park Dist.)	1995	Hamilton	no	

Watersheds or streams with high level designations have stricter water quality standards. Figure 2-33 below maps the twenty-two watersheds with aquatic life designations for exceptional warmwater habitat. Figure 2-34 on the next page maps the six streams with the recreation designation of class A primary contact.

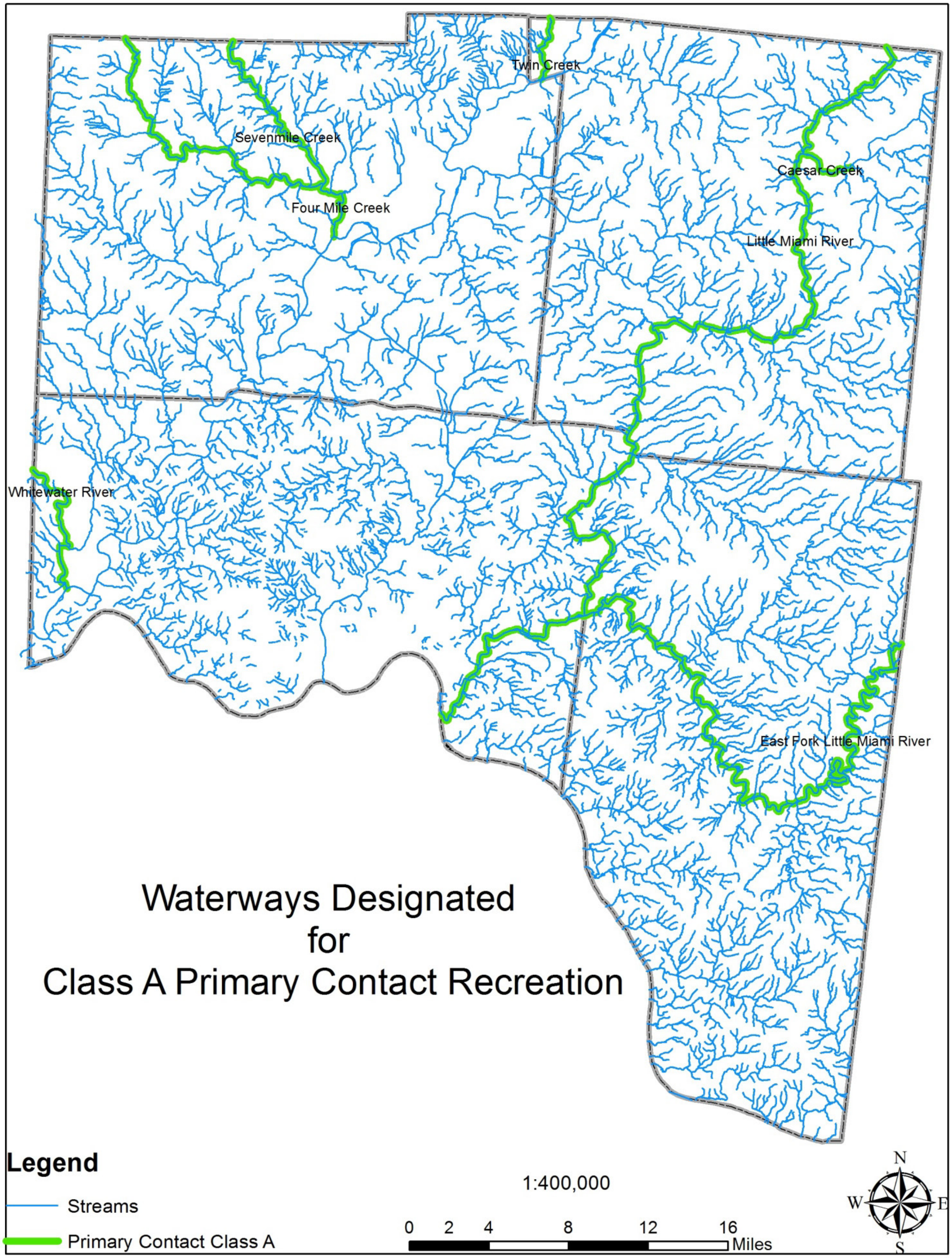
Figure 2-33: Exceptional Warmwater Habitat Watersheds in Butler, Clermont, Hamilton and Warren Counties



Exceptional Warmwater Habitat Sub-Watersheds

HUC 12	HUC 12 NAME	HUC 12	HUC 12 NAME
050800020306	Town of Germantown-Twin Creek	050902020404	Middle Caesar Creek
050800020504	Rush Run-Sevenmile Creek	050902020406	Lower Caesar Creek
050800020505	Ninemile Creek-Sevenmile Creek	050902020504	Newman Run-Little Miami River
050800020602	Little Four Mile Creek	050902020801	Ferris Run-Little Miami River
050800020605	Cotton Run-Four Mile Creek	050902020804	Halls Creek-Little Miami River
050800020701	Elk Creek	050902021101	Solomon Run-East Fork Little Miami River
050800020906	Jordan Creek-Great Miami River	050902021102	Fivemile Creek-East Fork Little Miami River
050800030807	Headwaters Dry Fork Whitewater River	050902021103	Todd Run-East Fork Little Miami River
050800030808	Howard Creek-Dry Fork Whitewater River	050902021203	Lucy Run-East Fork Little Miami River
050800030809	Lee Creek-Dry Fork Whitewater River	050902021204	Backbone Creek-East Fork Little Miami River
050800030810	Jameson Creek-Whitewater River	050902021305	Salt Run-East Fork Little Miami River

Figure 2-34: Class A Primary Contact Streams in Butler, Clermont, Hamilton and Warren Counties



The maps on the previous two pages show that watersheds that are partly or wholly designated as exceptional warmwater habitat for aquatic life are much more likely to be drained by a stream that is designated class A primary contact for recreation.

Antidegradation Policy

A key component of Ohio's water quality standards is the antidegradation policy, which consists of three tiers of protection. The first tier states that existing uses must be maintained and protected. No further water quality degradation that would interfere with existing designated uses is allowed. The second tier requires that water quality better than that needed to protect uses must be maintained unless it is shown that lower water quality is necessary for important economic or social development. The third tier says that ambient water quality for State Resource Waters will not be degraded by any substances determined to be toxic or to interfere with any designated use. Increased pollutant loads are allowed to be discharged into State Resource Waters only if they do not result in lowering the existing water quality. State Resource Waters are water bodies that lie within park systems, wetlands, wildlife areas, wild, scenic and recreational rivers, publicly owned lakes, and waters of exceptional recreational or ecological significance. (*Understanding Ohio's Water Quality Standards*, Ohio EPA, 1995).

Ohio's antidegradation policy has generated a list of Special High Quality Waters that are recognized in the Ohio Administrative Code (OAC). Table 2-14 below shows the six water bodies of Butler, Clermont, Hamilton and Warren counties that received this high level designation. It should be noted that the OAC relies on the 11-digit hydrologic unit code classification system rather than the more recent 10-digit code.

Table 2-14: Special High Quality Waters in Butler, Clermont, Hamilton and Warren Counties

Water Body -- Water Body Segment	Hydrologic Unit Code (HUC-11)	Flows Into	Drainage Basin	Antidegradation Category
Caesar Creek -- from Caesar Creek Lake to the mouth	05090202 050	Little Miami River	Little Miami	Superior High Quality Water
East Fork Little Miami River -- from East Fork Lake to the mouth	05090202 120 05090202 130	Little Miami River	Little Miami	Superior High Quality Water
Little Miami River -- entire length	05090202 001 05090202 010 05090202 020 05090202 030	Ohio River	Little Miami	Outstanding State Water, based on ecological values
Sevenmile Creek-- entire length	05080002 060	Fourmile Creek	Great Miami	Superior High Quality Water
Twin Creek – entire length	05080002 030 05080002 040	Great Miami River	Great Miami	Outstanding State Water, based on ecological values
Whitewater River -- Indiana state line to the mouth	05080003 001	Great Miami River	Great Miami	Superior High Quality Water

A comparison of Table 2-14 with Figures 2-33 and 2-34 shows agreement among the designation systems for aquatic life habitat, recreational use and antidegradation category. If a river or stream is exceptional warmwater habitat or suitable for class A primary contact recreation, it is likely to also be listed as a Superior High Quality Water or Outstanding State Water, which are the highest antidegradation categories. Such designations and categories help prioritize water resources. The Ohio EPA is methodical about prioritizing impaired waters, or water bodies that do not attain their designated uses and violate their water quality standards.

Total Maximum Daily Loads (TMDLs)

As stated on the Ohio EPA's website (http://www.epa.state.oh.us/dsw/tmdl/index.aspx), the Total Maximum Daily Load (TMDL) program focuses on identifying and restoring polluted rivers, streams, lakes and other surface waterbodies. A TMDL is a written, quantitative assessment of water quality problems in a waterbody and contributing sources of pollution. It specifies the amount a pollutant needs to be reduced to meet water quality standards, allocates pollutant load reductions, and provides the basis for taking actions needed to restore a waterbody. The TMDL process has four broad, overlapping phases:

- *Assess* waterbody health: biological, chemical, habitat
- *Develop* a restoration target and a viable scenario
- *Implement* the solution: inside/outside Ohio EPA
- *Validate* to monitor progress: delist or relist

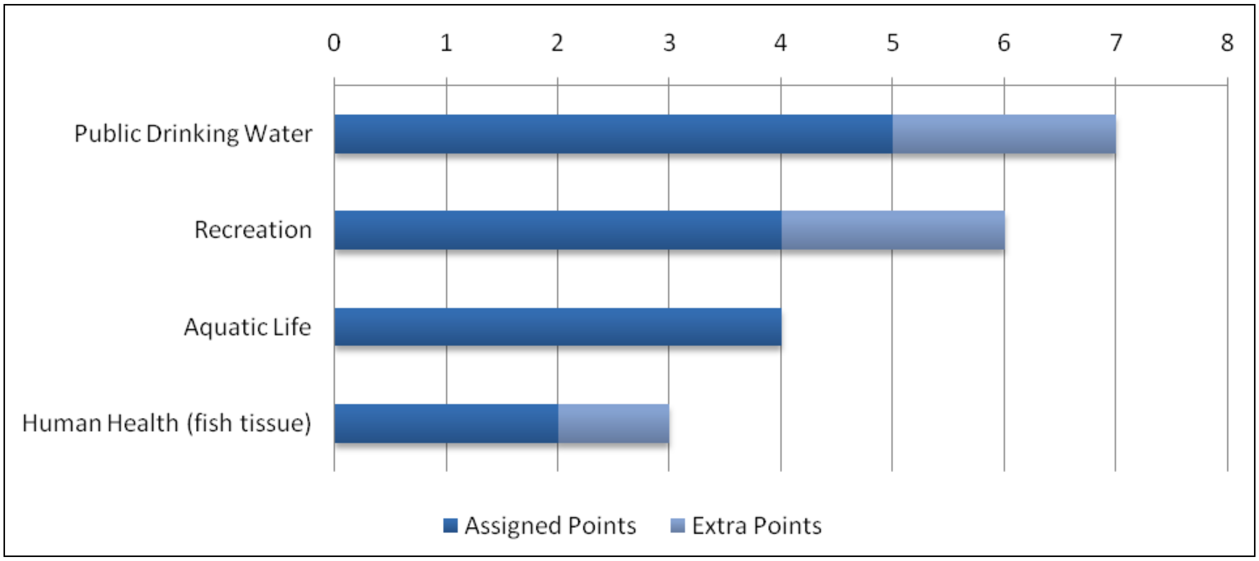
The overall goal of the TMDL program is to bring waters into attainment of their designated beneficial uses. Like other states, Ohio is required to submit a prioritized list of impaired waters to U.S. EPA for approval. The list indicates which waters are impaired and may require TMDL development in order to meet water quality standards. Summaries that follow say what year a TMDL is scheduled for each Watershed Assessment Unit or Large River Assessment Unit. Water quality monitoring is part of the TMDL process. The summaries also say what year that monitoring is scheduled by the Ohio EPA.

Submitting a prioritized list of impaired waters to U.S. EPA for approval is required by Section 303(d) of the federal Clean Water Act, so the prioritized list is known as the 303(d) list. It indicates which impaired waters may require TMDL development to meet water quality standards. A key element of the prioritization process is the assignment of priority points, which are described next.

Priority Points

For each Watershed Assessment Unit or Large River Assessment Unit, the Ohio EPA assigns up to 20 priority points. The assessment units are ranked according to level of impairment to help indicate which have the greatest need for TMDL development. Figure 2-35 on the next page was copied from the *Ohio 2010 Integrated Water Quality Monitoring and Assessment Report* to show how the Ohio EPA assigns priority points, based on impairment or other factors (extra points).

Figure 2-35: Ohio EPA's System for Assigning Up to 20 Priority Points to Impaired Waters



An assessment unit with more priority points has a higher priority for Ohio-EPA-initiated action to generate a TMDL report. The Ohio River next to Hamilton and Clermont counties, however, has a low priority for Ohio EPA action because the Ohio Valley River Water Sanitation Commission (ORSANCO) has lead responsibility for that multi-state waterway.

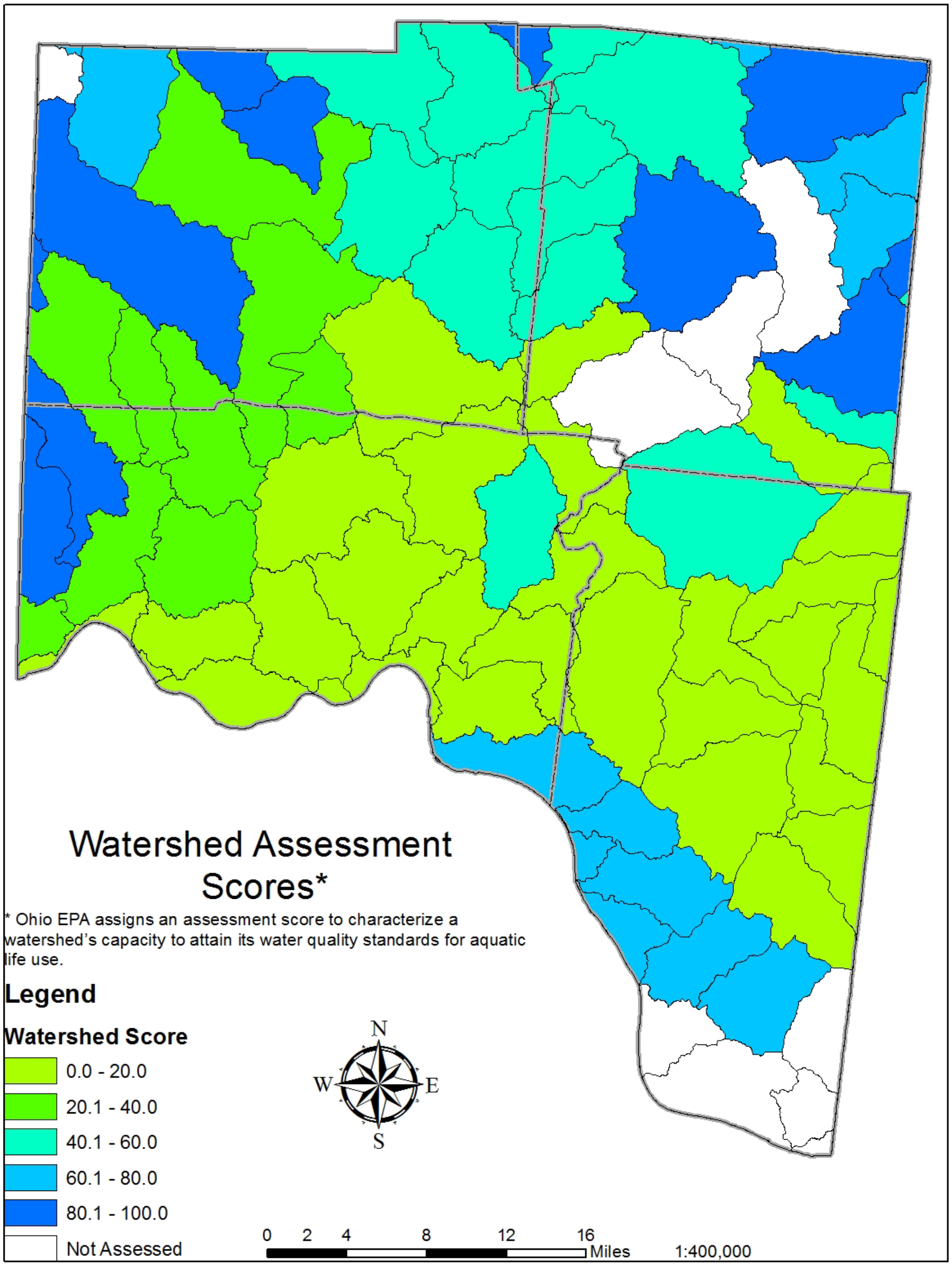
Ohio EPA explains its priority point methodology in the *Ohio 2010 Integrated Report* as follows:
"The points assigned to the public drinking water and human health uses are straightforward. For the recreation and aquatic life uses, points are assigned based on a computed index score. The lowest quartile (scores between 0 and 25) get the fewest points because a TMDL may not be the most effective way to address the impairments. Scores in this range indicate severe basin-wide problems, comprehensive degradation that may require significant time and resources and broad-scale fixes, including, possibly, fundamental changes in land use practices. Educating about how water quality is affected by various practices and encouraging stewardship may be more effective in these areas than a traditional TMDL approach."

"Scores in the highest quartile (between 75.1 and 100) generally indicate a localized water quality issue. Addressing the impairment may not require a complete watershed effort; rather, a targeted fix for a particular problem may be most effective. Thus, these receive the next lowest number of priority points. The most points are awarded for scores in the middle quartiles (between 25.1 and 50 and between 50.1 and 75), indicating problems of such scale that purposeful action should produce a measurable response within a 10-year period. These waters are the best candidates for a traditional TMDL."

"Two additional points may be awarded to assessment units that are impaired for the Recreation use and contain Class A waters. Class A waters are those most suitable for recreation, such as popular paddling streams and lakes with public access points developed, maintained, and publicized by governmental entities."

In the study area, 10 was the highest number of priority points assigned to a watershed. While priority points are assigned to impaired watersheds only, assessment scores are assigned to all water bodies that have been assessed for attainment of the water quality standards for aquatic life use. The aquatic life assessment score is derived from weighted averages of bio-criteria scores calculated for headwater assessment, wading stream assessment and principal stream assessment. Ohio EPA uses the assessment scores to track trends of attainment levels across Ohio's principal streams and large rivers in an effort to quantify progress made in point and nonpoint source pollution controls and in meeting Ohio's goal of 80% full aquatic life use attainment by 2010. Aquatic life assessment scores indicate the relative natural health of rivers and streams. Figure 2-36 on the next page shows the ranges of aquatic life assessment scores for the HUC-12 watersheds of Butler, Clermont, Hamilton and Warren counties.

Figure 2-36: Watershed Assessment Scores for Aquatic Life Use in Butler, Clermont, Hamilton and Warren Counties



Total Maximum Daily Load schedule, monitoring schedule, priority points and aquatic life assessment scores are among the many informational items addressed in the 85 summaries that are provided in Appendix A. The section includes 80 Watershed Assessment Unit (WAU) summaries for the all of the HUC-12 subwatersheds that are wholly or partly located in Butler, Clermont, Hamilton and Warren counties. The section also has five Large River Assessment Unit (LRAU) summaries for the LRAUs located in the study area along two segments of the Little Miami River, two segments of the Great Miami River and one segment of the Whitewater River.

Much of the information summarized in this chapter can be accessed in more detail in the Stream Database which is provided in Appendix B along with several other types of information. The Stream Database includes tabular information about each HUC-12 watershed, each large river assessment unit, and each stream, including information about beneficial uses, stream impairments, wastewater treatment plant locations, geographical information, and watershed management efforts.