Chapter 3

Current and Projected Development

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Chapter 3: *Current and Projected Development*

Introduction and Purpose

Land use and water quality are inseparable. The purpose of this chapter is to describe the relationship between land development and water resources and how it influences water quality management planning.

The Relationship between Development and Water Resources

When poorly designed and managed, development will: (1) disrupt the water cycle, (2) destabilize stream form and function, and (3) deliver more pollutants to waterways. Our water resources can become degraded aquatic systems with impaired drainage and storage capacity, less functional habitat, and limited effectiveness for the natural processing of pollutants. This undesirable outcome can be blamed on a variety of negative impacts, which are explored below.

Most of development's disruption to the water cycle occurs through changes in hydrology, or the ways that water is circulated and distributed. The Ohio Department of Natural Resources recognizes that development is a hydrological makeover, stating: "How water is intercepted, stored, used, lost or gained changes substantially after development. Less rainfall is intercepted and utilized by vegetation after development. Less rainfall is infiltrated and percolated into the soils and groundwater following development. And less rainfall is stored in or on top of the ground following storms. All these hydrologic changes result in more storm water runoff reaching creeks or rivers faster than before development." (*Rainwater and Land Development: Ohio's Standards for Stormwater Management, Land Development and Urban Stream Protection,* Ohio Department of Natural Resources, 2006)

Development displaces naturally permeable substances with rooftops, roads, parking lots and other hard surfaces. This hardening of the watershed causes streams to become flashier, meaning their flows rise more quickly with each rainfall and diminish more rapidly afterward. Resulting water quality and water quantity problems have caused planners to pay much closer attention to the percentage of watershed area placed under impervious surfaces. It would be a mistake, however, to place the entire blame for increased stormwater runoff on impervious surfaces. Development can also lead to the stripping of permeable topsoils, the compaction of remaining subsoils, the replacement of woodlands with grass turf, the draining of wetlands, the relocation of streams from natural streambeds, and other changes that make the overall landscape less permeable, even in places without impervious surfaces.

Naturalists have observed the gradual decline of permeability for more than 50 years. In his 1956 book titled *American Yesterday,* Eric Sloane wrote, "the world in which we move about today is much drier." Mr. Sloane does not attribute the added dryness to a change in climate, but to a change in our landscape: "The early American farmer invariably wore boots because he continually walked on moist ground. Even the village worker lived in a wet world because all factories were mills built over water-power. The consequence of two centuries of reclaiming wetlands and building cities on the sites of former marshes and meadows has been the creation of a far different workaday climate… The virgin forest and mossy topsoil of a century ago were a natural sponge, absorbing rains which now roll across the surface of 'tired,' dry landscapes and into abnormally swollen rivers."

American Yesterday also comments on the replacement of trees with turf grass: "A century ago, towering first-growth trees broke raindrops into tiny particles, turning a large portion of rainfall back into the atmosphere by evaporation before it reached the ground. The trees' great roots braced the soil and made a framework for moss and peat that held as much as ten to fifteen times its weight in water."

Contemporary scientists are quantifying the extent to which tree canopies increase evaporation while their root systems increase transpiration. Tree roots draw considerable amounts of water from the soil, making it less saturated and less prone to surface runoff. In effect, trees serve as evapo-transpiration water pumps for the hydrologic cycle.

Development further affects the hydrologic cycle through manmade discharges. As an area urbanizes, it generates more sewage. Sewage is first sent to wastewater treatment plants, but it ultimately is discharged to rivers and streams as treated wastewater effluent. In Southwest Ohio, effluent discharges account for well more than half the flow volume of some waterways during dry seasons. This is especially true for the Mill Creek of Butler and Hamilton counties and the Little Miami River of Warren, Clermont and Hamilton counties. In addition, many effluents have higher temperatures than the streams to which they are discharged. This can cause thermal pollution, which is addressed on page 3-5.

Effluent discharges are deliberate additions to stream flow in developed areas. Combined sewer overflows (CSOs) are not deliberate, but still have a significant impact on urbanized waterways in Cincinnati and other older communities. Combined sewers convey runoff through the same pipes that carry municipal wastes. During heavy rains, the volume of stormwater coupled with wastewater becomes too large to be processed at the treatment plant. The excess flow, which contains raw sewage, is bypassed directly into streams at overflow points. CSOs cause stream pathogen levels to rise dramatically, but only temporarily. Long-term effects will arise from court-ordered efforts by the Metropolitan Sewer District of Greater Cincinnati to methodically eliminate CSOs.

The authors of *Rainwater and Land Development* (ODNR, 2006), have noted that development is not just a surface water issue, but also a groundwater issue: "Groundwater, normally replenished by percolating rainfall, receives lower levels of recharge in urban areas, affecting both the human and natural communities dependent on groundwater. Wetlands and small streams that require groundwater recharge to sustain them are impacted hydrologically. In its extreme, reduced groundwater recharge, with the subsequent reduction in base flow, may cause former perennially flowing streams to cease flowing during dry periods." In some developed areas, the base flow is reduced not only by less groundwater recharge but also by the artificial lowering of groundwater levels by downcutting urban streams that intercept and thereby drain off the upper layer of the water table.

Oddly enough, decreasing groundwater below the earth's surface can coincide with increasing floodwaters upon the surface. "As watersheds urbanize and contribute more runoff, downstream areas experience greater flooding and longer duration flows. It's important to note that even as communities enact flood control strategies, there is still more flow in streams after development that increases flooding and stream erosion." (*Rainwater and Land Development, ODNR*, 2006)

Table 3-1 below shows how the U.S. Geological Survey has quantified the increase of peak stream flows in developed areas.

Table 3-1: Stream Discharge Increases as Land Use Changes from Agricultural Land to Residential Land

Storm Event Return Interval	Pre-Development Discharge (cfs)	Post-Development Discharge (cfs)	Percent Increase in Stream Discharges
2 years	21	27	29%
5 years	37	47	27%
10 years	43	55	28%
25 years	61	75	23%
50 years	70	85	21%
100 years	82	98	20%

cfs – cubic feet per second, a standard measure of stream flow rate

NOTE: For a typical development site in eastern Franklin County, Ohio, the U.S. Geological Survey estimated peak discharges for its pre-development condition as cropped agricultural land, then calculated discharges for the same site in post-development condition as residential land. The post-development figures are based on empirical equations found in U.S.G.S. Water Resources Investigation Report 86-4197, which is titled *Estimating Peak Discharge, Flood Volumes, and Hydrograph Shapes of Small Ungaged Urban Streams in Ohio* (Sherwood, J.M., 1986).

Larger stream flows cause more erosion, siltation and sedimentation, which are well documented as degradations to stream water quality. High flows also have other, lesser-known effects. A research report entitled *Hydrologic Disturbance Reduces Biological Integrity in Urban Streams* (published in *Environmental Monitoring and Assessment* on March 11, 2010 by James Coleman II, Michael Miller, Frank Mink, University of Cincinnati) shows that peak flow events tend to scour out streambed communities of aquatic macroinvertebrates, thus degrading the biological integrity of rivers and streams for weeks or even months; the scouring effect is most pronounced for flashy urban streams in developed areas. Given the fact that the Ohio EPA assesses stream impairments largely by biological criteria, even the temporary loss of aquatic biota to runoff-induced stream flows could put many stream miles in non-attainment of state water quality standards.

Over a longer term, aquatic habitat declines from larger stream flows. "As faster and higher stream flows occur on a regular basis, stream channels typically respond by adjusting their shape and size through erosion. Unfortunately, the typical pattern in urban areas is that a healthy stream with naturally stable form, where bank erosion is balanced by floodplain deposition, becomes degraded in form." (*Rainwater and Land Development*, ODNR, 2006) "The degraded stream cuts downward, losing access to its floodplain and the many functions provided by the floodplain and stream corridor. These deeply entrenched urban streams provide less storage and treatment of storm water runoff along their corridor than healthy channels. These streams are plagued with bank erosion, contribute more sediment to downstream areas, and rarely maintain high quality habitat features, such as clean gravel substrates, deep pools and stable riffles."

Some habitat problems are structural in nature. They consist of reservoir dams, lowhead dams, sewer line crossings, narrow bridge culverts, wide bridge abutments, stream fords, artificially shallow channels and other manmade barriers to fish movement.

Physical changes to urban streams are readily apparent. Damages to their ecological functions are harder to discern. Severe bank erosion destroys valuable riparian habitat, which can filter out pollutants headed for the stream. The loss of streamside trees and shrubs allows more sunlight to shine on the water, inducing algae blooms in nutrient-enriched streams. The algae blooms cause stressful fluctuations in dissolved oxygen levels and possible fish kills. Most importantly, in-stream habitat suffers under a blanket of sand and silt deposits. Erosion and sedimentation spoil the varied natural streambed of pebbles, rock ledges and deep pools. In addition to ruining habitat, sediments degrade chemical water quality because many pollutants tend to adhere to eroded soil particles. In addition, urban stream sediments have 3 to 10 times more heavy metals than rural stream sediments.

Chemical pollution is the quickest and most pervasive effect of development. Though urban runoff is mostly a product of nonpoint sources, it can resemble point sources in pollutant loads. The authors of ODNR's *Rainwater and Land Development* gave the following explanation on how that happens: "Increased development results in more pollutants and in more runoff, with the result that the pollutant loading from each storm event is markedly higher after development. Development also reduces the watershed's natural treatment (assimilation) as runoff speeds toward the storm water system and streams without opportunity to soak into soils. The chemical quality of urban runoff is diminished as concentrations of suspended fine sediments, nutrients, oxygen-demanding materials, bacteria, heavy metals and hydrocarbons from oil and gas, pesticides, and chlorides from road salt increase. Urban runoff has been shown to have pollutant concentrations similar to sanitary wastewater. Unfortunately storm water systems traditionally have been designed so that these constituents – once in runoff – have little opportunity to be removed before reaching a lake, creek or river."

Thermal pollution is another problem for developed areas. "The temperature of runoff from urban land uses is much higher than normal stream flow and increases the threat to stream life. Fewer trees along urban creeks often compound the problem by allowing sunlight to warm the water surface. High temperatures stress aquatic organisms by pushing them toward or beyond their temperature tolerances in warmer seasons and by lowering the oxygen-holding capacity in the water. Often the low amount of dissolved oxygen in urban stormwater is indicated by a sewer-like smell." (*Rainwater and Land Development,* ODNR, 2006)

The impacts of development on water quality can be summarized as:

- Increased volume and velocity of runoff
- Increased frequency and severity of flooding
- Increased flashiness, or flow fluctuation, of streams
- Increased erosion, siltation and sedimentation
- Increased scouring of aquatic macroinvertebrate communities
- Increased discharges of effluents that are treated but still have pollution potential
- Increased pollutant loading
- Increased sunlight exposure, algae blooms and fish kills

- Increased stream temperatures
- Increased impervious surface area
- Increased incidence of streams and wetlands that become intermittent or dry
- Increased pathogens and other threats to human health
- More structural barriers to fish movement
- Decreased watershed permeability, even in areas without impervious surfaces
- Decreased groundwater recharge
- Decreased stream stability
- Decreased natural baseflow (groundwater contribution)
- Decreased time that water is in the natural system
- Decreased pollutant assimilation by soils
- Decreased streamside tree and shrub cover
- Loss of natural runoff storage in vegetation, wetlands and soils
- Degraded habitat in or alongside the streams
- Diminished aquatic life, both in bio-diversity and populations

The negative impacts of poorly designed or managed development underlie a variety of water quality issues. The most prominent issues are briefly explored below.

Water Quality versus Water Quantity

Regulatory schemes and government funding programs usually draw distinctions between water quality and water quantity, but land development changes both. In dealing with the impacts of development, planners find it futile to address water quality alone to the exclusion of water quantity, or vice versa. Nearly all development impacts on water quantity ultimately become impacts on water quality. Rather than treat them as polar opposites, it is best to recognize water quality and water quantity as intertwined properties. Both are essential to better development design and management practices.

Point Source Pollution versus Nonpoint Source Pollution

Water quality management planning has been careful to increase the efficiencies of point source pollution management by continually recognizing the impacts of nonpoint source pollution. This two-sided view of water quality issues reduces the likelihood of misplaced blame for wastewater management problems, but can lead to confusion. Most of the confusion arises over categorization. For example, some categorize failing septic tanks as a point source problem because they usually have discharge pipes that can be counted as point sources. Others categorize failing septic tanks as a nonpoint source problem because they tend to be numerous, widespread and diffuse in well-developed areas without centralized sewage treatment service. Sewer overflows have also been categorized on both sides of the point source/nonpoint source fence. In its original *Regional Water Quality Management Plan* (1977), OKI devised a three-way categorization scheme: (1) point source pollution, (2) nonpoint source pollution, and (3) intermittent source pollution, which includes combined sewer overflows and sanitary sewer overflows.

Chemical Standards versus Biological Standards

Ohio is at the leading edge of water quality assessment by relying more heavily on biological standards than chemical standards. The chemical water quality of a stream sample is just a snapshot, a short-term measure of certain chemical properties during the passing moment. Given the fact that stream water chemistry is not homogenous but subject to variation as different water pockets flow through, even the snapshot is not a totally reliable measure. Biological standards operate on a longer time schedule because the communities of macroinvertebrates and fish species reflect stream conditions over the course of days, weeks, months and even years. The biggest possible drawback to biological standards is that they more complicated, making them more vulnerable to misinterpretation or misrepresentation.

Designated Uses versus Habitat Conditions

Ohio's water quality standards are well designed to seek fulfillment of a stream's hydrological, ecological and economic functions rather than absolute water purity. This is the basis for designated uses. As ideal performance measures they can sometimes be costly or technically challenging, but designated uses are by definition achievable. Misunderstandings most often arise over the influence of habitat on designated uses. As development continues to urbanize a watershed, the resulting degradation of stream habitat severely limits a stream's potential to fulfill its designated uses. Streams recover more easily from water pollution than destroyed habitat. Ohio EPA recognizes the long-lasting impact of hydromodification, channelization and other habitat degradations by downgrading designated uses to modified warmwater habitat, limited resource waters or secondary contact recreation. Such downgrades stir debates over how high we should aim for water quality management and regulation.

Riparian Habitat versus Aquatic Habitat

While the quality of aquatic habitat has greater influence on determining whether Ohio waterways are impaired, the quality of riparian habitat is not ignored. The Ohio EPA quantifies the value of both types of habitat through its Qualitative Habitat Evaluation Index, but devotes most of the scoring factors to aquatic in-stream habitat. As watershed management plans play a greater part in Ohio's water quality, the role of riparian habitat becomes increasingly important. A better understanding of riparian habitat benefits is needed.

The U.S. EPA defines riparian habitat as "areas adjacent to rivers and streams with a differing density, diversity and productivity of plant and animal species relative to nearby uplands." (*Terms of Environment: Glossary, Abbreviations and Acronyms*, U.S. EPA website, 2006) Energy, materials and water all pass through riparian areas on their way to rivers and streams. Scientists have assigned six ecological functions to riparian areas (*A Framework for Ecological Analysis of Riparian Corridors,* 2003 master's thesis by Indraneel Kumar, University of Cincinnati):

1) Conduit – Riparian areas can act as distribution corridors for seeds, recreational corridors for people, and movement corridors for animals that need more than one type of habitat to live. The conduit function supports biodiversity. As conduits for water, riparian zones are essential to the hydrological cycle.
2) Barrier – Riparian areas can stop the movement of upland animals and people across waterways, thus protecting the streambanks. The riparian edge acts as a barrier to many development activities that disturb aquatic ecosystems. Riparian areas also function as a barrier to sediments and chemical pollutants by restricting their movement to water.
3) Filter – Riparian plant roots and soil microbes take up sediments, fertilizers and other chemicals draining toward waterways. This biological filtration process is supplemented by physical filtration processes that slow water movement enough to separate pollutants

from runoff. Slower water means less erosion, which stabilizes the streambank for more vegetation and more filtration.

4) Source – A riparian area is a source of native plant and animal species. In a heavily developed area, it may be the only green corridor. The riparian zone's most important source function is to provide carbon to aquatic life. After leaves fall on the streambank, they decompose and reach the water as a food source for the aquatic food chain.
5) Sink – Riparian areas function as a sink when they remove pollutants, sequester the chemicals on land and prevent them from entering the aquatic ecosystem. The two most important chemicals removed are nitrogen and phosphorus.
6) Habitat – Riparian habitat supports aquatic habitat by shading the stream and lowering the water temperature during warm seasons. Cooler water improves the spawning of many aquatic life forms and holds more of the dissolved oxygen needed by fish. In winter, a riparian forest can help maintain life-supporting water temperatures by reducing heat loss. A healthy riparian habitat increases the biodiversity of the aquatic habitat.

Because it can serve as a line of defense against the negative impacts of development, riparian habitat deserves more attention as land is developed and as watershed planning is undertaken. This will lead to better aquatic habitat and more stream miles in attainment of their designated aquatic life uses.

Gray Infrastructure versus Green Infrastructure

Gray infrastructure includes an extensive network of curbs, gutters, troughs, drainage ditches, storm drains, culvert pipes, catch basins, oil and grit separators, storm sewers, combined sewers, deep tunnels and more. For most of the nation's history, we disposed of stormwater with the idea that "dilution is the solution to pollution." For a very long time, conventional wisdom seemed to be that if we got rid of our runoff quickly enough and far away enough, it would no longer be a problem. "We have designed convenient ways to ferry water out of town and into the nearest water body where it will dilute and go away. Unfortunately, we have discovered that there is no 'away' for stormwater and its pollutants." (*Greening the Infrastructure*, Robert Emmanuel, Oregon Sea Grant Extension, 2009).

Green infrastructure encompasses the interconnected network of natural areas – including surface waters – that naturally manage stormwater, reduce flooding risks and improve water quality. High replacement costs and limited futures for deteriorating gray infrastructure have encouraged investigating the expense and sustainability of green infrastructure. The U.S. EPA has extended the concept of green infrastructure to treat polluted stormwater runoff locally with natural systems, or engineered systems that mimic natural systems.

In Hamilton County, the Metropolitan Sewer District of Greater Cincinnati (MSD) is investigating the economies of both gray and green infrastructure solutions to sewer overflows. Although they are not faced with a federal consent decree like MSD, the stormwater districts and the conservation districts of Butler, Clermont, Hamilton and Warren counties are all factoring green infrastructure into their water quality management planning.

All of the foregoing water quality issues point to the growing importance of stormwater management, floodplain management, drinking water source protection, low-impact development and related efforts. They all help mitigate the impact of development on water quality, making them relevant to regional water quality management planning.

The Relationship Among Water Quality and Land Use Data and Current Development

The *Regional Water Quality Management Plan* adheres to ambient water quality standards that reflect the impact of current development, particularly in municipal and industrial areas. These ambient standards are expressed by the following points, sometimes called the "four freedoms." Water, at all times and at all places, should be:

1) Free from substances attributable to municipal, industrial, or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits
2) Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, or other discharges in amounts sufficient to be unsightly or deleterious
3) Free from materials attributable to municipal, industrial, or other discharges producing color, odor, or other conditions in such degree as to create a nuisance
4) Free from substances attributable to municipal, industrial, or other discharges in concentrations or combinations that are toxic or harmful to human, animal, plant, or aquatic life

The impacts of development on water quality in Butler, Clermont, Hamilton and Warren counties are best documented in the *Ohio Integrated Water Quality Monitoring and Assessment Report*, which Ohio EPA generates every other year in compliance with federal guidelines. Watershed assessment unit summaries are both keyed into the *Integrated Report* and accessible online. If a watershed does not attain water quality standards for its designated aquatic life uses, the watershed assessment unit summary lists the causes and sources for such impairment. These impairment indicators can help assess the impact of development in each watershed.

Causes are the most prominent "agents" deemed responsible for the observed aquatic life use impairment in the watershed. Nearly all of the causes of impairment for watersheds in Butler, Clermont, Hamilton and Warren counties are indicative of development impacts. They include:

(1) Ammonia
(2) Barium
(3) Copper
(4) Direct habitat alterations
(5) Flow alteration
(6) Iron
(7) Nutrient/eutrophication biological indicators
(8) Nutrients
(9) Oil and grease
(10) Organic enrichment (sewage) biological indicators
(11) Other flow regime alterations
(12) Oxygen, dissolved
(13) Phosphorus (total)
(14) Priority organics
(15) Salinity/TDS/chlorides
(16) Sedimentation/siltation
(17) Siltation
(18) Taste and odor
(19) Unionized ammonia
(20) Unknown toxicity

Sources are the most prominent origins of the "agents" (causes of impairment) deemed responsible for the aquatic life use impairment. Many of the sources of impairment for watersheds in Butler, Clermont, Hamilton and Warren counties are indicative of development impacts. They include:

(1) Channelization – development
(2) Combined sewer overflows
(3) Contaminated sediments
(4) Dam construction – development
(5) Dredging – development
(6) Flow regulation/modification – development
(7) Industrial point source (also: Minor industrial point source)
(8) Land development/suburbanization
(9) Landfills
(10) Loss of riparian habitat
(11) Major municipal point source or municipal point source (discharges)
(12) Municipal (urbanized high density area)
(13) Onsite wastewater systems (septic tanks)
(14) Other urban runoff
(15) Removal of riparian vegetation – development
(16) Sanitary sewer overflows
(17) Sewer line construction
(18) Streambank modification/destabilization – development
(19) Urban runoff/storm sewers (NPS)
(20) Upstream impoundment

Ohio EPA's watershed assessment unit summaries also provide valuable insights on development impacts through the summary section titled Land Use Statistics. For each watershed in Butler, Clermont, Hamilton and Warren counties, the Ohio EPA summarizes the percentage of land area that can be classified as "developed." This is one of five land use classifications, with the other four being: forest, grass/pasture, row crops and other.

Based on studies by the Center for Watershed Protection and many others, OKI recognizes significance in the percentage of watershed land area that is developed. In the past, researchers focused on hydrologic, physical and biological indicators to evaluate the impact of development on streams. "More recently, impervious cover (IC) has emerged as a key paradigm to explain and sometimes predict how severely these stream quality indicators change in response to different levels of watershed development." (*Impacts of Impervious Cover on Aquatic Systems*, Center for Watershed Protection, 2003) "The Center for Watershed Protection has integrated these research findings into a general watershed planning model known as the impervious cover model (ICM). The ICM predicts that most stream quality indicators decline when watershed IC exceeds 10%, with severe degradation expected beyond 25% IC."

Table 3-2 on the next page summarizes how the Center for Watershed Protection rates a subwatershed by the percentage of its land covered in impervious surfaces.

Table 3-2: Subwatershed Rating by Percentage of Impervious Cover

Percentage of subwatershed covered with impervious surfaces	Implications
less than 10%	acceptable water quality and habitat
from 10 to 25%	loss of sensitive elements; considered impacted
more than 25%	poor water quality and unable to support habitat

When considering the impervious cover model and its major influence in watershed planning, stream classification, restrictive development regulations and land use zoning, it is necessary also to consider the Center for Watershed Protection's "assumptions and caveats" for the model. *Impacts of Impervious Cover on Aquatic Systems* stated the assumptions and caveats as follows:

- Applies only to first, second and third order streams. (headwaters and small tributaries)
- Requires accurate estimates of percent impervious cover, which is defined as the total amount of impervious cover over a subwatershed area
- Predicts potential rather than actual stream quality. Some streams can be expected to depart from the model's predictions. Monitoring may reveal poor water quality in a "sensitive" stream or a surprisingly high biological diversity score in a "non-supporting" one. Impervious cover can initially diagnose stream quality, but field monitoring is recommended to confirm it.
- Does not predict the precise score of an individual stream water quality indicator but rather predicts the average behavior of a group of indicators over a range of impervious cover percentages. Extreme care should be exercised if the impervious cover model is used to predict the fate of individual species, such as fish or mussels.
- "Thresholds" defined as 10% and 25% impervious cover are not sharp "breakpoints," but instead reflect the expected transition of a composite of individual indicators in that range of impervious cover. Thus, it is virtually impossible to distinguish real differences in stream quality indicators within a few percentage points of impervious cover.
- Has not been validated for non-stream conditions, such as lakes, reservoirs, aquifers and estuaries.
- Does not currently predict the impact of watershed treatment.

Figure 3-1 on the next page shows that stream quality declines rapidly as impervious cover increases from 1 to 10 percent, continues to decline but at a slower rate when impervious cover increases from 25 to 60 percent, then stabilizes as poor quality "urban drainage" while the impervious cover increases from 60 to 100 percent.

Figure 3-1: Center for Watershed Protection's Impervious Cover Model

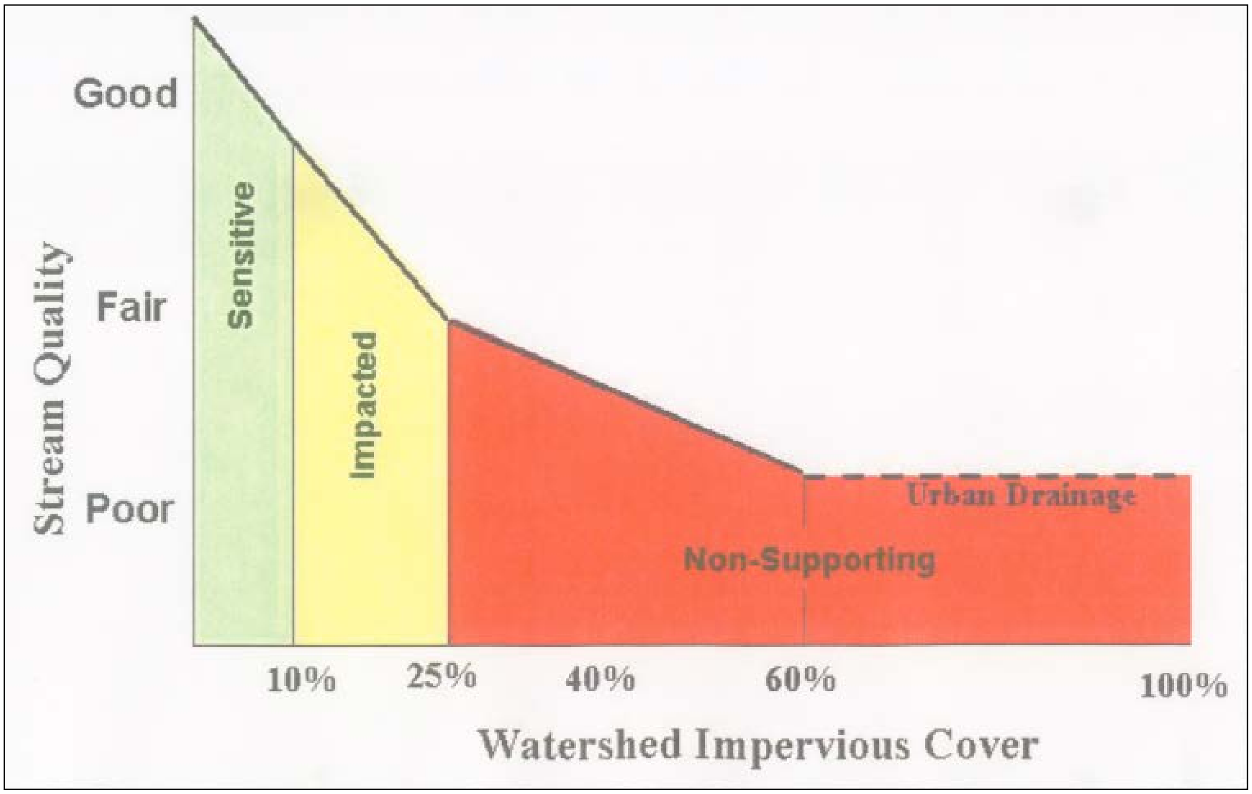


Figure from *Impacts of Impervious Cover on Aquatic Systems*, Center for Watershed Protection, 2003

Impervious Surface Analysis

OKI views the Impervious Cover Model in Figure 3-1 above as a significant analytical tool for regional water quality management planning, which led the agency to identifying impervious surfaces in Butler, Clermont, Hamilton and Warren counties.

Reliable, comprehensive data on impervious surfaces indicates the impacts of the built environment on watersheds and waterways. When coupled with relevant information about the natural environment, impervious surface data helps identify areas prone to increased runoff, excessive erosion and sedimentation, aquatic habitat degradation and reduced aquifer recharge. Regional analysis of impervious surfaces informs local governments and planning agencies about the impacts their land use decisions have had and could have on streams and watersheds. For source water protection, impervious surface analysis shows local utilities where addressing stormwater runoff and aquifer recharge are priorities.

How OKI Analyzed Impervious Surfaces

To determine impervious surfaces in Butler, Clermont, Hamilton and Warren counties, OKI performed an extensive spatial analysis using GIS (geographic information systems) data, remote sensing data from satellite imagery, and aerial orthophotographs. After delineating impervious surface areas digitally, OKI calculated impervious surface acreages for all of the 12-digit hydrologic unit code (HUC 12) watersheds in the four-county study area.

A more detailed description of the methodology for impervious surface analysis is provided in *Chapter 5: Management of Nonpoint Sources of Pollution*. Chapter 5 shows where impervious surfaces coincide with: (1) slight, moderate or severe slopes, (2) highly erodible soils, (3) riparian corridors, and (4) underlying aquifer areas. In Appendix C, impervious surface data is mapped and summarized for each HUC 12 watershed of the study area.

Impervious Surface Ratings for Watersheds in Southwest Ohio

Because the Impervious Cover Model in Figure 3-1 above is widely accepted as a water quality planning tool, OKI applied that model to local drainage areas. Using HUC 12 watersheds as the framework for local spatial analyses, OKI determined whether each coded watershed has:

a) less than 10 percent impervious surface, which predicts the watershed is sensitive but should have acceptable water quality and habitat, or
b) 10 to 25 percent impervious surface, which predicts the loss of sensitive water resource elements and some detrimental impact on the watershed's water quality and habitat, or
c) more than 25 percent impervious surface, which predicts the watershed has poor water quality and is unable to support its designated aquatic life uses.

The three statistical ranges outlined above are called **impervious surface ratings.** Table 3-3 below shows the impervious surface rating for each HUC 12 watershed in OKI's four-county study area, which envelops all or part of 82 watershed assessment units. The table is color coded with green rows for a sensitive impervious surface rating (a), yellow for an impacted rating (b) and red for a non-supporting rating (c).

Table 3-3: Impervious Surface Ratings for HUC 12 Watersheds

Watershed Name	County or Counties Where the Watershed Is Located	Watershed's 12-digit Hydrologic Unit Code (HUC 12)	Impervious Surface Percentage	Impervious Surface Rating
Town of Germantown-Twin Creek	Butler and Warren	050800020306	6.8%	a (sensitive)
Clear Creek	Warren	050800020403	12.4%	b (impacted)
Dry Run-Great Miami River	Butler and Warren	050800020404	13.9%	b (impacted)
Rush Run-Sevenmile Creek	Butler	050800020504	5.0%	a (sensitive)
Ninemile Creek-Sevenmile Creek	Butler	050800020505	5.4%	a (sensitive)
Little Four Mile Creek	Butler	050800020602	1.9%	a (sensitive)
Acton Lake Dam-Four Mile Creek	Butler	050800020604	8.5%	a (sensitive)
Cotton Run-Four Mile Creek	Butler	050800020605	5.2%	a (sensitive)
Elk Creek	Butler	050800020701	5.2%	a (sensitive)
Browns Run-Great Miami River	Butler and Warren	050800020702	13.8%	b (impacted)
Shaker Creek	Butler and Warren	050800020703	12.1%	b (impacted)
Dicks Creek	Butler and Warren	050800020704	23.3%	b (impacted)
Gregory Creek	Butler	050800020705	17.4%	b (impacted)
Town of New Miami-Great Miami River	Butler	050800020706	10.8%	b (impacted)
Brandywine Creek-Indian Creek	Butler	050800020802	3.9%	a (sensitive)
Beals Run-Indian Creek	Butler	050800020803	5.1%	a (sensitive)
Pleasant Run	Butler and Hamilton	050800020901	32.6%	c (non-supporting)

Watershed Name	County or Counties Where the Watershed Is Located	Watershed's 12-digit Hydrologic Unit Code (HUC 12)	Impervious Surface Percentage	Impervious Surface Rating
Banklick Creek-Great Miami River	Butler and Hamilton	050800020902	22.1%	b (impacted)
Paddys Run	Butler and Hamilton	050800020903	6.9%	a (sensitive)
Dry Run-Great Miami River	Butler and Hamilton	050800020904	9.7%	a (sensitive)
Taylor Creek	Hamilton	050800020905	16.5%	b (impacted)
Jordan Creek-Great Miami River	Hamilton	050800020906	10.2%	b (impacted)
Doublelick Run-Great Miami River	Hamilton	050800020907	4.5%	a (sensitive)
Headwaters Dry Fork Whitewater River	Butler	050800030807	4.0%	a (sensitive)
Howard Creek-Dry Fork Whitewater River	Butler and Hamilton	050800030808	4.6%	a (sensitive)
Lee Creek-Dry Fork Whitewater River	Butler and Hamilton	050800030809	8.2%	a (sensitive)
Jameson Creek-Whitewater River	Hamilton	050800030810	11.8%	b (impacted)
Turtle Creek-Ohio River	Clermont	050902011102	4.7%	a (sensitive)
West Branch Bullskin Creek	Clermont	050902011103	4.0%	a (sensitive)
Bullskin Creek	Clermont	050902011104	2.9%	a (sensitive)
Bear Creek-Ohio River	Clermont	050902011106	3.5%	a (sensitive)
Little Indian Creek-Ohio River	Clermont	050902011107	6.0%	a (sensitive)
Headwaters Big Indian Creek	Clermont	050902011201	3.6%	a (sensitive)
North Fork Indian Creek-Big Indian Creek	Clermont	050902011202	4.1%	a (sensitive)
Boat Run-Ohio River	Clermont	050902011203	6.8%	a (sensitive)
Ferguson Run-Twelvemile Creek	Clermont	050902011204	5.8%	a (sensitive)
Tenmile Creek	Clermont	050902011206	9.0%	a (sensitive)
Ninemile Creek-Ohio River	Clermont and Hamilton	050902011208	16.0%	b (impacted)
Middle Caesar Creek	Warren	050902020404	4.1%	a (sensitive)
Flat Fork	Warren	050902020405	3.6%	a (sensitive)
Lower Caesar Creek	Warren	050902020406	3.3%	a (sensitive)
Sugar Creek	Warren	050902020501	4.0%	a (sensitive)
Newman Run-Little Miami River	Warren	050902020504	5.3%	a (sensitive)
Little Creek-Todd Fork	Warren	050902020606	3.1%	a (sensitive)
East Fork Todd Fork	Warren	050902020701	1.6%	a (sensitive)
Second Creek	Warren	050902020702	4.3%	a (sensitive)
First Creek	Clermont and Warren	050902020703	5.1%	a (sensitive)
Lick Run-Todd Fork	Warren	050902020704	4.4%	a (sensitive)
Ferris Run-Little Miami River	Warren	050902020801	4.7%	a (sensitive)
Little Muddy Creek	Butler and Warren	050902020802	10.8%	b (impacted)
Turtle Creek	Warren	050902020803	11.1%	b (impacted)
Halls Creek-Little Miami River	Warren	050902020804	11.4%	b (impacted)
Muddy Creek	Butler and Warren	050902020901	24.6%	b (impacted)
O'Bannon Creek	Clermont and Warren	050902020902	7.9%	a (sensitive)
Salt Run-Little Miami River	Clermont and Hamilton	050902020903	19.9%	b (impacted)
Solomon Run-East Fork Little Miami River	Clermont	050902021101	5.0%	a (sensitive)

Watershed Name	County or Counties Where the Watershed Is Located	Watershed's 12-digit Hydrologic Unit Code (HUC 12)	Impervious Surface Percentage	Impervious Surface Rating
Fivemile Creek-East Fork Little Miami River	Clermont	050902021102	5.2%	a (sensitive)
Todd Run-East Fork Little Miami River	Clermont	050902021103	5.5%	a (sensitive)
Poplar Creek	Clermont	050902021201	6.4%	a (sensitive)
Cloverlick Creek	Clermont	050902021202	3.5%	a (sensitive)
Lucy Run-East Fork Little Miami River	Clermont	050902021203	7.4%	a (sensitive)
Backbone Creek-East Fork Little Miami River	Clermont	050902021204	9.0%	a (sensitive)
Headwaters Stonelick Creek	Clermont and Warren	050902021301	4.3%	a (sensitive)
Brushy Fork	Clermont	050902021302	4.7%	a (sensitive)
Moores Fork-Stonelick Creek	Clermont	050902021303	4.9%	a (sensitive)
Lick Fork-Stonelick Creek	Clermont	050902021304	6.5%	a (sensitive)
Salt Run-East Fork Little Miami River	Clermont and Hamilton	050902021305	17.7%	b (impacted)
Sycamore Creek	Hamilton	050902021401	26.0%	c (non-supporting)
Polk Run-Little Miami River	Butler, Clermont, Hamilton and Warren	050902021402	23.3%	b (impacted)
Horner Run-Little Miami River	Clermont and Hamilton	050902021403	13.1%	b (impacted)
Duck Creek	Hamilton	050902021404	39.7%	c (non-supporting)
Dry Run-Little Miami River	Clermont and Hamilton	050902021405	13.4%	b (impacted)
Clough Creek-Little Miami River	Hamilton	050902021406	20.2%	b (impacted)
East Fork Mill Creek-Mill Creek	Butler and Hamilton	050902030101	27.7%	c (non-supporting)
West Fork Mill Creek	Hamilton	050902030102	25.0%	b (impacted)
Sharon Creek-Mill Creek	Butler, Hamilton and Warren	050902030103	36.9%	c (non-supporting)
Congress Run-Mill Creek	Hamilton	050902030104	35.6%	c (non-supporting)
West Fork-Mill Creek	Hamilton	050902030105	33.5%	c (non-supporting)
Town of Newport-Ohio River	Hamilton	050902030201	43.0%	c (non-supporting)
Dry Creek-Ohio River	Hamilton	050902030202	34.1%	c (non-supporting)
Muddy Creek	Hamilton	050902030203	27.2%	c (non-supporting)
Garrison Creek-Ohio River	Hamilton	050902030204	20.2%	b (impacted)

Though watersheds are ideal for framing analyses of impervious surface in relation to a variety of natural characteristics, counties can also be useful frameworks because they engage in land use decisions that have impacts on water quality. Table 3-4 below provides impervious surface ratings for the four counties in OKI's water quality study area.

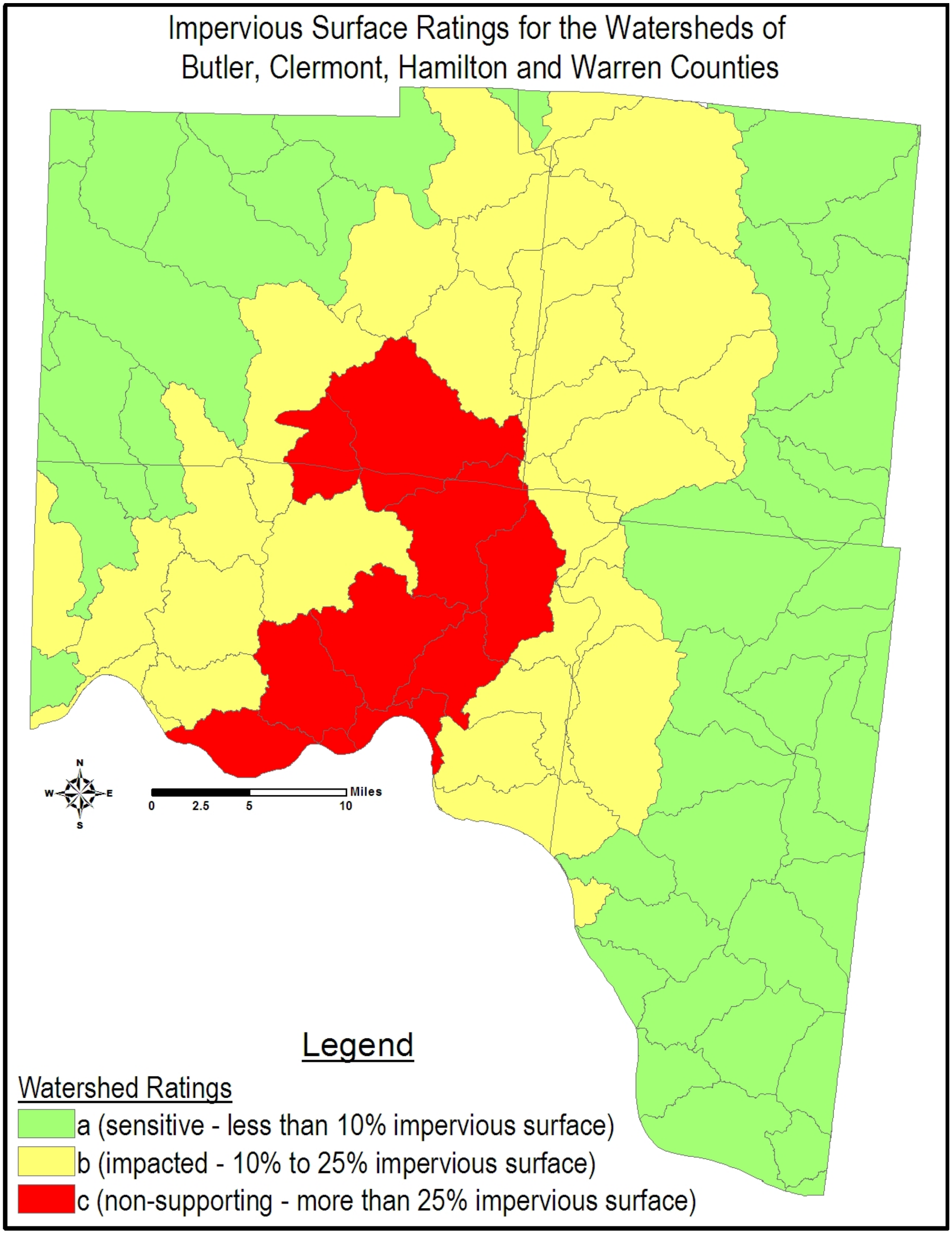
Table 3-4: Impervious Surface Ratings for Butler, Clermont, Hamilton and Warren Counties

County	Impervious Surface Percentage	Impervious Surface Rating
Butler	12.3%	b (impacted)
Clermont	7.6%	a (sensitive)
Hamilton	23.2%	b (impacted)
Warren	9.7%	a (sensitive)

NOTE: Where a watershed straddles more than one county, it is split along county lines.

Figure 3-2 below shows the spatial distribution of impervious surface ratings for watersheds in OKI's four-county study area. At this scale, regional impervious surface patterns stand out.

Figure 3-2: Impervious Surface Ratings for Watersheds in the Four-County Study Area



While multi-county maps are best suited for showing regional patterns in impervious surfaces, single-county maps are better for showing detail. Figures 3-3 through 3-6 show the areas that OKI determined to be impervious surfaces in Butler, Clermont, Hamilton and Warren counties. For each HUC 12 watershed, the county-scale maps illustrate rivers and perennial streams.

Figure 3-3: Impervious Surfaces and Ratings for the Watersheds of Butler County

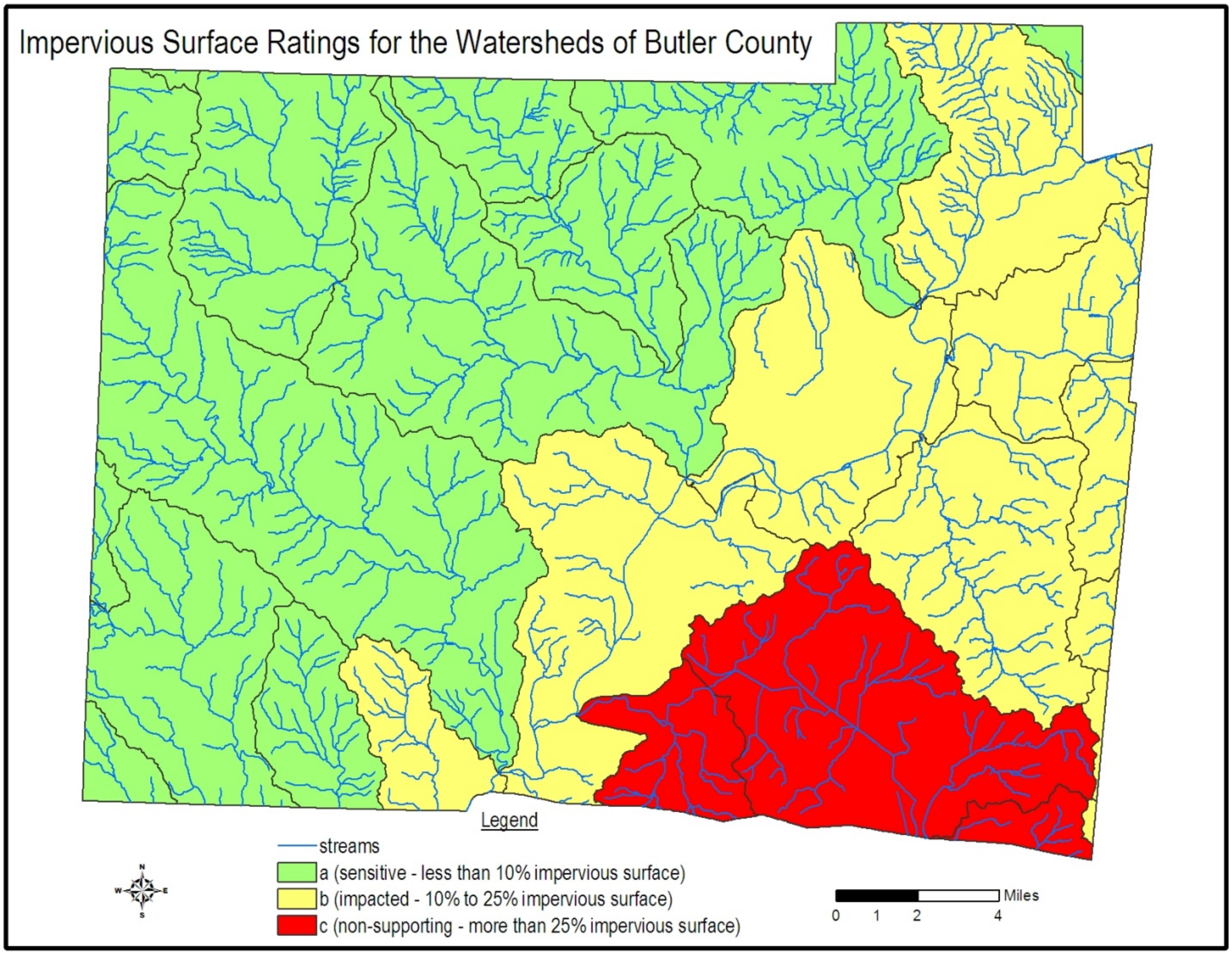


Figure 3-4: Impervious Surfaces and Ratings for the Watersheds of Clermont County

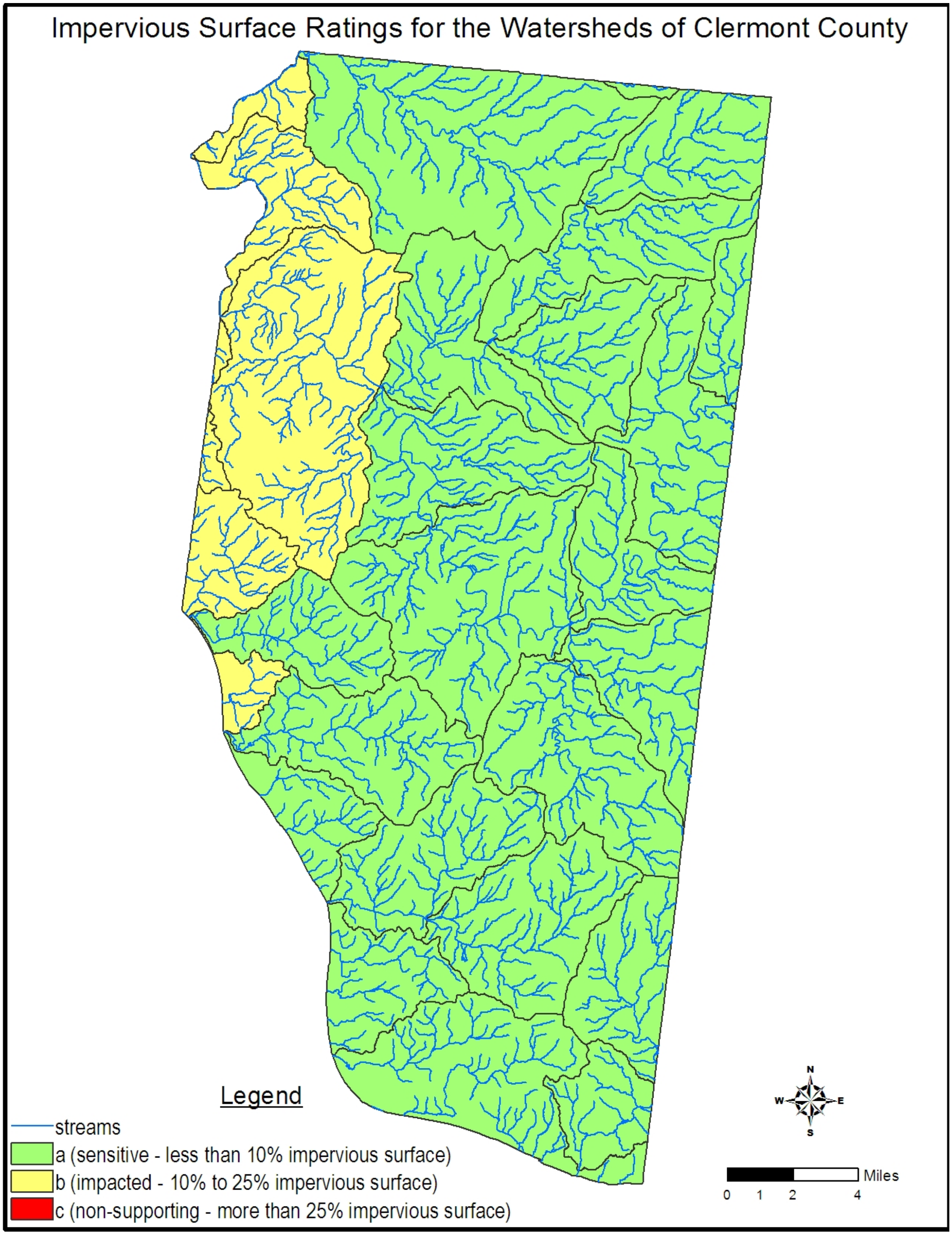


Figure 3-5: Impervious Surfaces and Ratings for the Watersheds of Hamilton County

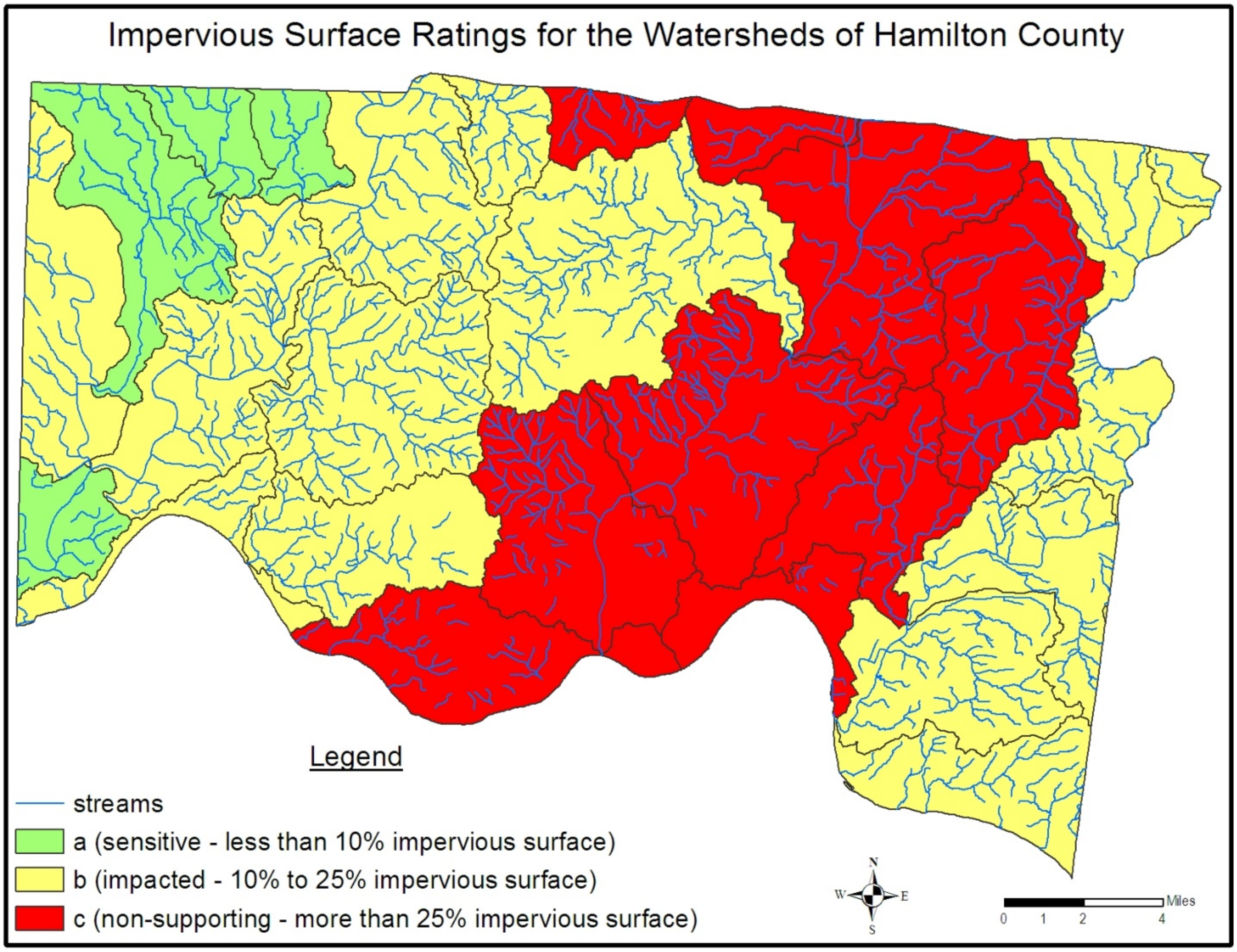
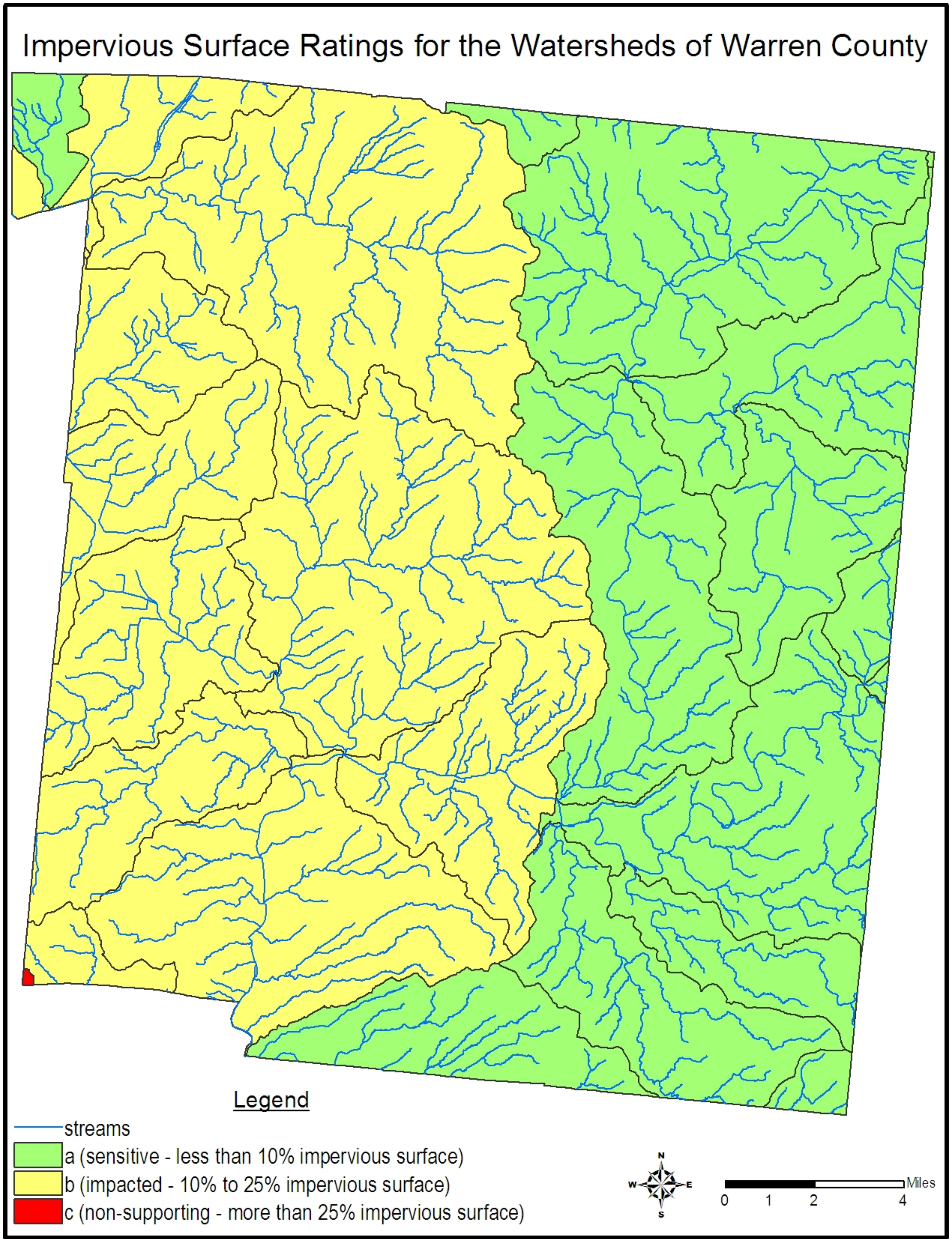


Figure 3-6: Impervious Surfaces and Ratings for the Watersheds of Warren County



<u>Conclusions on the Impervious Surface Ratings</u>

Of the 82 watersheds (HUC 12) that drain Butler, Clermont, Hamilton and Warren counties, OKI's impervious surface analysis found that:

- 48 watersheds have less than 10 percent impervious surface, indicating that sensitive elements should still remain and they should have acceptable water quality and habitat (provided other factors, such as concentrated animal feeding operations or natural low flows, do not compromise stream health)
- 24 watersheds have 10 to 25 percent impervious surface, indicating the loss of sensitive elements and some detrimental impact on the watershed's water quality and habitat
- 10 watersheds have more than 25 percent impervious surface, indicating the watersheds have poor water quality and are unable to support their designated aquatic life uses.

The figures show that clearly more than half (58.5 percent) of the study area's watersheds should still be able to assimilate development impacts and satisfy their habitat and water quality standards. Less than an eighth (12.2 percent) of the study area's watersheds are challenged by excessive impervious surface, leaving them impaired. That leaves a bit less than a third (29.3 percent) of the watersheds to fit into that middle category where stream health is degraded, but not necessarily to the point of full impairment.

Clermont and Warren counties have none of the 10 watersheds with more than 25 percent impervious surface in which aquatic life uses are probably not being supported. Hamilton County, on the other hand, has all or part of the 10 non-supporting watersheds. Butler County shares three non-supporting watersheds with Hamilton County, but the Pleasant Run watershed (050800020901) is the only non-supporting watershed with its mouth in Butler County.

All 10 non-supporting watersheds are contiguous, with the HUC 10 Mill Creek watershed being the core of this impervious cluster. Of the five HUC 12 watersheds draining to the Mill Creek, four are in the non-supporting category. The one HUC 12 watershed that escapes that distinction is the West Fork Mill Creek watershed (050902030102), which is on the brink of non-supporting status with 25 percent impervious surface.

It can be said that six of the 10 non-supporting watersheds have a Mill Creek connection because two non-supporting watersheds in the Ohio River corridor (050902030201 and 050902030202) are in the Mill Creek sewershed, meaning much of their sanitary sewage and combined sewer stormwater is pumped to the Mill Creek Regional Wastewater Treatment Plant. The three non-supporting watersheds without Mill Creek connections are Pleasant Run (050800020901) in Butler and Hamilton counties, Sycamore Creek (050902021401) in Hamilton County, and Muddy Run (050902030203) in Hamilton County.

Hamilton County has significantly more impervious surface than its three neighboring Ohio counties because it contains Cincinnati, the urban core of the Tri-State region, and a patchwork of suburban communities. With 23.2 percent of its land area covered by impervious surfaces, Hamilton County has almost twice as much impervious cover as its nearest counterpart, which is Butler County at 12.3 percent impervious cover. Despite their numerical gap, Hamilton and Butler counties both fit into the Center for Watershed Protection's statistical mid-range, which predicts the loss of sensitive elements and impact on water quality and habitat. At 9.7 percent impervious cover, Warren County could also become an *impacted* county if only 788 more acres of impervious surface is developed there. Most of the watersheds in Clermont County—about 7,060-acres—retain their sensitive elements, though several are impaired for aquatic life use.

Of the 48 watersheds with less than 10 percent impervious surface, only five have any land area in Hamilton County. None of the five are solely within Hamilton County. At the other extreme, Clermont County has all or part of 33 watersheds with less than 10 percent impervious surface.

The eastern edge and, to a lesser degree, western edge of the four-county study area have watersheds with less than 5 percent impervious surface, indicating they are subject to relatively light development impacts. Overall, 23 of the study area's 82 watersheds are less than 5 percent impervious. Of the 23 least developed watersheds, 10 are in Clermont County, nine are in Warren County, three are in Butler County and two are in Hamilton County. (Though much of Howard Creek-Dry Fork Whitewater River watershed drains southwestern Butler County, it is counted here as a Hamilton County watershed because that is where its mouth is located.)

Though none of the HUC 12 watersheds have enough impervious surface to be classified by the Center for Watershed Protection as "urban drainage" areas, they certainly have subwatersheds or catchment areas where more than 60 percent of the land is covered by impervious surface. Seven of the 10 watersheds that fall into the non-supporting category (more than 25 percent impervious surface) do so by significant margins because they have 32.6 to 43 percent of impervious surface.

In Butler, Clermont, Hamilton and Warren counties there are four major drainage basins:

1. Great Miami River basin in Warren, Butler and Hamilton counties
2. Little Miami River basin in Warren, Clermont and Hamilton counties with a small part in Butler County
3. Ohio River corridor in Clermont and Hamilton counties
4. Mill Creek basin in Butler and Hamilton counties, with a tiny part in Warren County

The Great Miami River Basin has 27 watersheds in the four-county study area, including the Whitewater River and three tributaries. Of the Great Miami's 27 study area watersheds:

- 15 watersheds (55.6 percent) have less than 10 percent impervious surface
- 11 watersheds (40.7 percent) have 10 to 25 percent impervious surface
- 1 watershed (3.7 percent, Pleasant Run) has more than 25 percent impervious surface

The Little Miami River Basin has 35 watersheds, of which:

- 23 watersheds (65.7 percent) have less than 10 percent impervious surface
- 10 watersheds (28.6 percent) have 10 to 25 percent impervious surface
- 2 watersheds (5.7 percent, Sycamore Creek and Duck Creek) exceed 25 percent impervious surface

The Ohio River Corridor Basin has 15 watersheds, of which:

- 10 watersheds (66.7 percent) have less than 10 percent impervious surface
- 2 watersheds (13.3 percent)have 10 to 25 percent impervious surface
- 3 watersheds (20 percent) have more than 25 percent impervious surface

The Relationship Between Demographic Data and Water Quality Management Planning

As development occurs, and as population and households grow, so does the generation of wastewater and the need for it to be contained and treated—either onsite, in areas of low-density development and suitable soils, or through sewer lines to a centralized treatment facility in areas where population densities warrant and soils are unsuitable for onsite treatment. To forecast the growth of wastewater treatment demand, it is necessary to make projections of population and household growth based on existing demographic data and trends. Existing demographic data and trends are already used by OKI for several planning functions.

As a metropolitan planning organization, OKI has final authority over federal funds spent on transportation in the region. This leads the agency to develop population and housing projections in a format that is vital to transportation planning but also serves other agency functions, including OKI's role as the federally designated regional water quality management planning agency. Traffic analysis zones are the geographical building blocks of population projections for transportation. To maintain consistency, OKI used the traffic analysis zones as the starting point to project population and housing for each of the wastewater facility planning areas in Butler, Clermont, Hamilton and Warren counties.

Developing Population Projections for Facility Planning Areas

As conducted with transportation planning, OKI used 2010 as the base year and 2040 as the horizon year for demographic projections in each wastewater facility planning area (FPA). FPAs were initially delineated when the Regional Water Quality Management Plan was first developed in the 1970s, as areas in which alternatives for wastewater treatment could be identified. In many cases the FPAs followed natural drainage divides, with some modifications for municipal, county and state boundaries. FPA boundaries were then adopted as part of the 1977 plan, and subsequently have been amended several times through interlocal consultation as circumstances warranted. The FPA boundaries as they existed in 2013 were the departure point for the most recent update of demographic analysis and population projections as they relate to potential demand for centralized wastewater treatment.

OKI is required to develop its population projections in the context of county level population control totals developed and issued by the Ohio Development Services Agency (ODSA). OKI has the prerogative to decide where in each county population gain or loss will occur over the projection period, but the total county population must equal the projection developed by ODSA for each analysis year. Each county's total population can be divided into household population and non-household (group quarter) population. OKI estimates the household population by removing estimated non-household population. The household population for a county becomes the control total for the county's household population projections. Relevant total and household population control totals for Butler, Clermont, Hamilton and Warren Counties are shown in Table 3-5.

Table 3-5: County Populations for 2010 and 2040

County	2010 Total Population Control Total	2040 Total Population Control Total	2010 Household Population Control Total*	2040 Household Population Control Total
Butler	368,130	430,360	357,177	419,407
Clermont	197,363	216,190	195,646	214,470
Hamilton	802,374	786,090	782,863	766,309
Warren	212,693	239,060	206,708	233,025

*U.S. Census, 2010, Summary File 1, DP-1

The 2010 Census served as the statistical foundation of household and population data in base year 2010. OKI used census blocks, which are the smallest geographical units for a federal census, to allocate figures on the 2010 Census households, household population and group quarter population to the previously mentioned traffic analysis zones. This was done in proportion to land areas through use of ArcMap, a geographic information system software. Household size for each traffic analysis zone was calculated by dividing the zone's population by its number of households.

Year 2010 household population for each traffic analysis zone was estimated by first multiplying the 2010 number of households by the 2010 Census household size. The household size was then factored so that the sum of household population across all TAZs in a county equaled the 2010 county household population control total. The total population in each TAZ was calculated by adding the non-household (group quarter) population to the household population. Once the number of households and total population were established for base year 2010 for each TAZ, the data was aggregated to the facility planning areas on an area proportion basis through use of ArcMap.

The year 2040 is the horizon year (i.e., future year) for OKI's planning work. The horizon year population and households for each traffic analysis zone were developed based on multiple factors. Staff consulted all available comprehensive plans and related studies for jurisdictions within the study area for population projections and anticipated development trends, as well as current and future land use maps. Build-out housing unit estimates within each TAZ were calculated by measuring the acres of developable vacant land assigned to residential use in the future and multiplying that number by the future residential land use's associated density. These build-out calculations provided a ceiling for the allocation of future households.

Based on these considerations, a portion of the county's household change was allocated to the TAZ. Review also resulted in removing some of the existing households in areas of population decline, deteriorating housing, or clearance. Once the determination of households for 2040 for TAZs was made, the year 2010 household size was multiplied by the household total in each TAZ to determine the population associated with the 2040 households. Adjustments were made to the household size so that the sum of household population across all TAZs in a county equaled the county household control total, as shown by Table 3-5. The TAZ household population was combined with the non-household (group quarter) population and then aggregated to the facility planning areas (FPAs) using area proportion in ArcMap. These preliminary FPA projections were then subjected to the scrutiny of expert review.

OKI began review of the preliminary 2040 facility planning area projections by meeting with local planners, engineers, wastewater personnel, and other individuals knowledgeable about residential development trends in each county in the study area. These individuals helped OKI staff by:

1. identifying areas of anticipated growth on maps (see Figure 3-7)
2. reacting to preliminary 2040 population projections for each facility planning area
3. identifying areas targeted for new water service, sewer service or both
4. indicating where substantive transportation improvements were under way or planned
5. providing electronic or hard copy itemization of approved subdivisions, which identified the subdivision locations and numbers of lots (built and unbuilt)

After the meetings with local planners, engineers, and wastewater personnel, OKI staff revisited the preliminary population projections for each facility planning area to ensure that they conformed to anticipated land uses and densities and reflected guidance provided by the local planning authorities**.**

Facility Planning Area (FPA) Boundary Updates

As a result of interlocal consultations with neighboring wastewater management agencies in Butler, Clermont, Hamilton and Warren counties during the plan update process, OKI has updated wastewater FPA boundaries both to reflect evolving conditions and the availability of electronic mapping capabilities which did not exist when the original plan was prepared. The methodology previously described was then applied to the updated FPA boundaries as reflected in Figure 3-8, which shows base year and horizon year populations for each facility planning area for ease of reference.

Overlay Facility Planning Areas

A slightly different approach was used to develop population projections for the overlay facility planning areas, which include Batavia, Moscow and New Richmond Village in Clermont County, Glendale and Whitewater Township in Hamilton County and Mason and Waynesville in Warren County. These overlay facility planning areas reflect their designation for providing wastewater service within their jurisdictional boundaries in the original plan, in plan amendments or, in the case of the Whitewater Township Regional Sewer District, co-designation with the Metropolitan Sewer District of Greater Cincinnati for the area within Whitewater Township boundaries pursuant to their interlocal agreement.

Population data from the 2010 Census was available specifically for these jurisdictions. For 2040, the area proportion technique used for apportioning traffic analysis zone data to facility planning areas was inappropriate for the smaller jurisdictions comprising several of the overlay facility planning areas. Instead, 2040 population projections for the overlay facility planning areas were developed based on several factors, including the number of household units already approved for development by local planning authorities, local comprehensive plans, residential sewer connections projected by local providers for 2040, and 2010 census household size.

The base year and horizon year populations for each facility planning area (FPA) were mapped for easy reference and comparison. Figure 3-8 shows these FPA populations, which are to be considered as OKI final projections for 2040.

Figure 3-7
Anticipated Growth Areas and Recommended Facility Planning Areas in Butler, Clermont, Hamilton, and Warren Counties

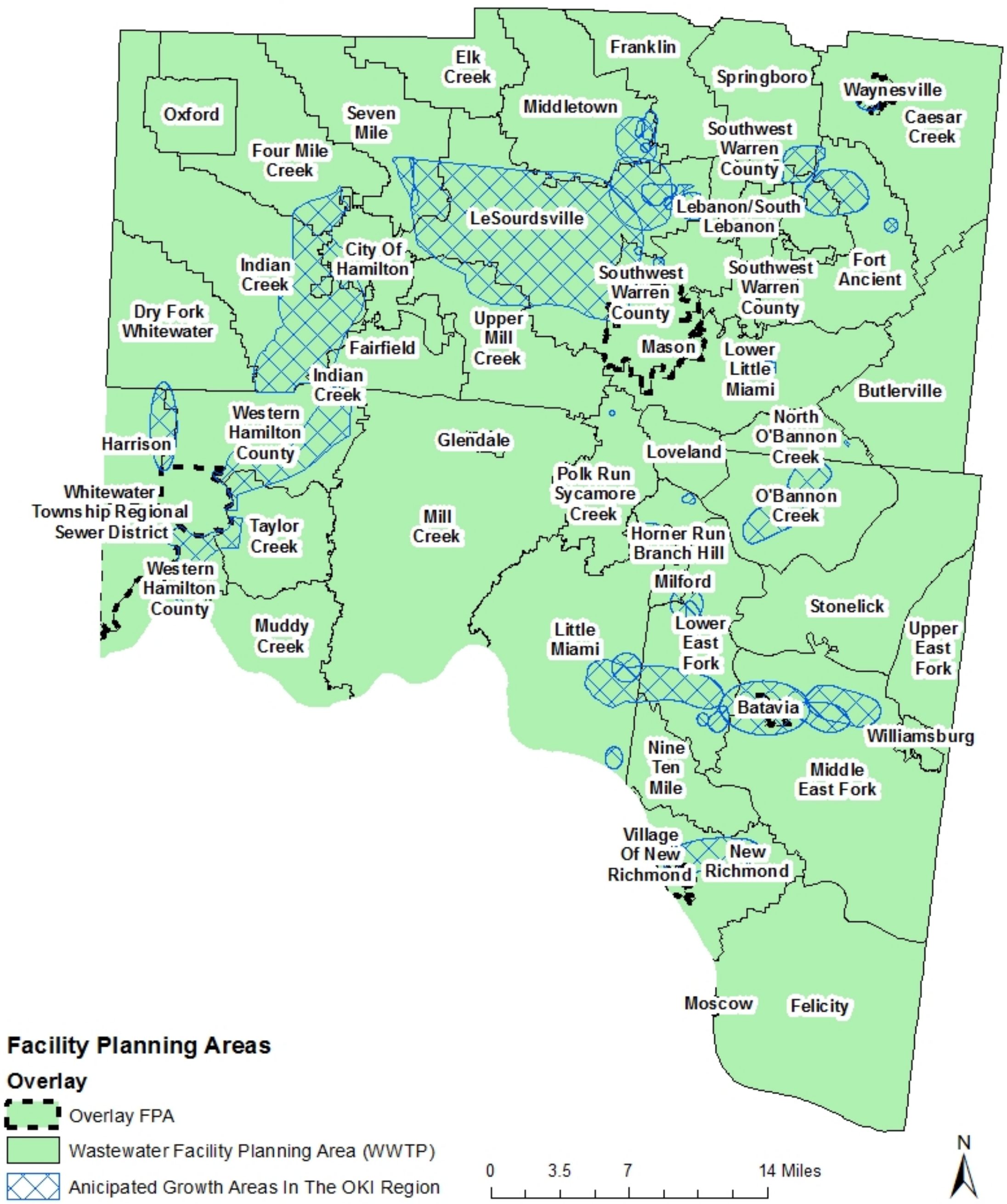
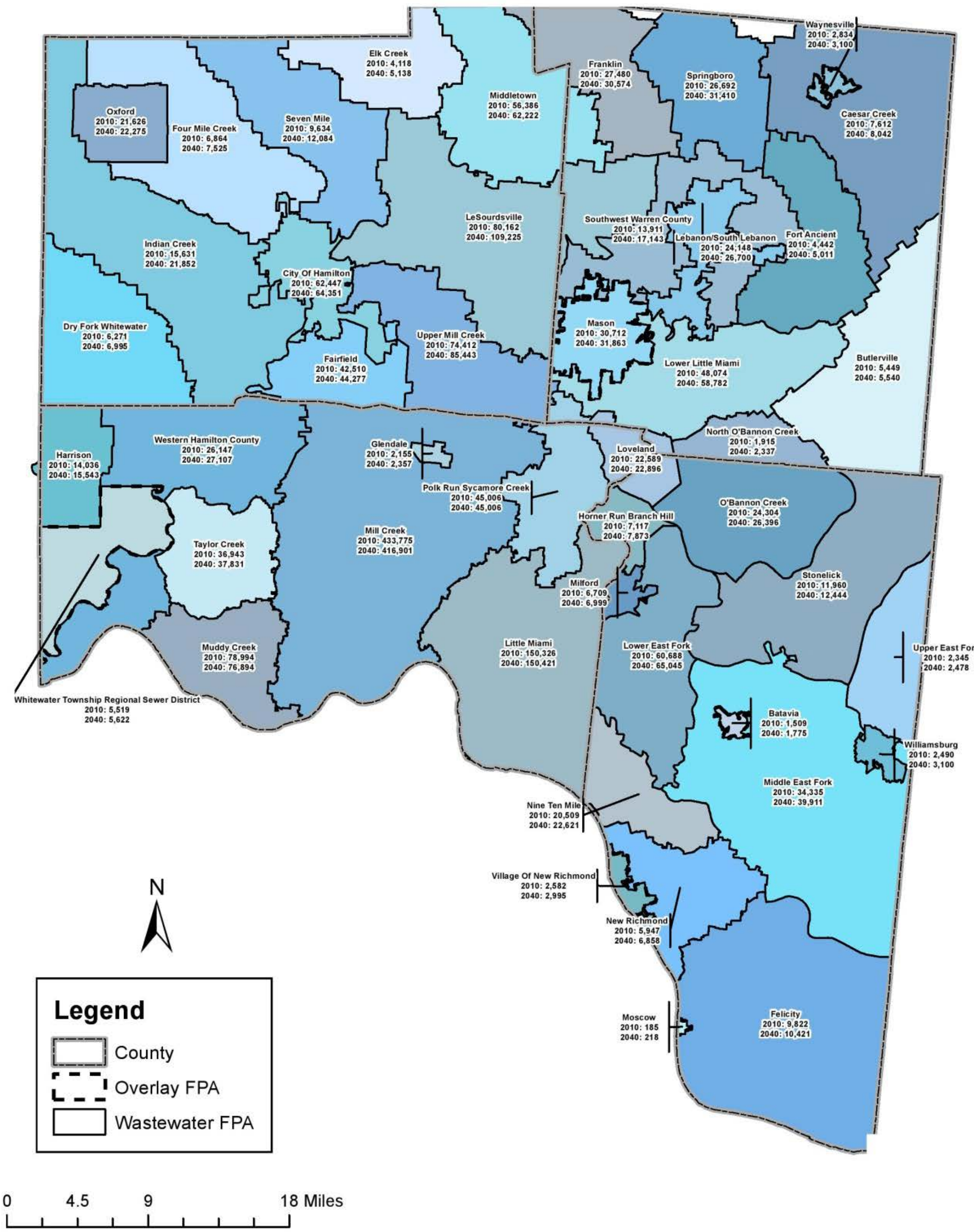


Figure 3-8: 2010 Population and 2040 Population Projections for Facility Planning Areas in Butler, Clermont, Hamilton and Warren Counties



In considering development trends, population projections and associated potential needs for centralized wastewater treatment, OKI continues to be mindful of the relationship between the timing and location of infrastructure improvements and the timing and location of development. The *Strategic Regional Policy Plan* adopted by OKI in 2005 stresses "the need to time and locate (wastewater) infrastructure improvements concurrently with development. . . . The haphazard provision of public facilities is almost always more costly to taxpayers than if a planned capital improvements schedule were employed."

When centralized sewage service lags behind development, inefficiencies arise. In their 2001 report titled *Cincinnati Metropatterns: A Regional Agenda for Community Stability*, Myron Orefield and Thomas Luce state: "It costs more to retrofit or expand infrastructure such as sewers and roads to low density, sprawling communities after the houses are built than it does to provide such infrastructure to well planned neighborhoods as they develop. "

OKI's *Strategic Regional Policy Plan* names centralized sewage service as one of the key factors for guiding development. It states: "The placement of public facilities, specifically water, sewers, and roads and their capacities affects the location and intensity of new development. Publicly funded capital improvements can be used as inducements for new development; they can direct and manage land development and redevelopment. Public facilities can draw development to various specific locations. The provision of public facilities and services without proper planning and analyses may mean communities trend towards scattered, untimely, poorly planned development in urban fringe and rural areas. These patterns are typically manifested in one or more of the following ways: leapfrog development; ribbon or strip development; and large expanses of low-density, single-dimensional development." Further, the plan notes that a continuation of such patterns "will result in costly long-term impacts, including scattered, untimely, poorly planned extension of water, sewer, and road facilities and services."

The *Strategic Regional Policy Plan* also favors a watershed protection approach, saying it "has the potential to refocus existing water pollution control programs on more comprehensive goals, while bringing more players into the picture." At the same time, the Strategic Regional Policy Plan acknowledges: "Protection and sustainability of water resources are most effectively addressed on a watershed basis, while local governments make planning and budgeting decision on a jurisdictional basis." The *Strategic Regional Policy Plan* directs OKI to share information about watersheds while assisting local governments and watershed groups in watershed management efforts.