Pollutant Causes and Sources

- Land Use and Population Changes
- Urban Runoff
- Rural and Agricultural Runoff
- Habitat Modifications and Flow Alterations
- Nutrients
- Pesticides
- Sediment
- Toxic Substances
- Bacteria

Pollution, in its broadest sense, can be defined as any alteration of the natural environment producing a condition that is harmful to living organisms. While pollution can be a result of a natural process (i.e. gas emissions associated with an erupting volcano), the term typically refers to negative impacts from human activities. Pollution can be subdivided into two broad categories based on its origin:

> *Point Source Pollution* is any negative impact that originates from or can be readily traced to a specific physical source of discharge. Water pollution most often discharges through a pipe or outfall.
>
> *Nonpoint Source Pollution*, as the name implies, includes all of the less tangible sources of harmful impacts that cannot be pinned to a definite structure, but instead come from general human land uses, such as rainwater running off a parking lot.

In order to reduce and/or eliminate pollution it is necessary to understand the causes and sources of the pollution for each impairment.

> *Causes of impairment* keep waters from meeting the criteria adopted to protect designated uses including: chemical contaminates (i.e. PCBs, metals, etc), physical conditions (i.e. temperature, excess siltation, alterations of habitat, etc.), and biological contaminants (i.e. bacteria, noxious aquatic weeds).
>
> *Sources of impairment* are the activities, facilities or conditions that generate the pollutants including: municipal sewage treatment plants, factories, storm sewers, modifications of hydrology, agricultural runoff, etc.)[1]

According to the National Water Quality Inventory for 2000, a biennial summary of State surveys of water quality, approximately 40 percent of rivers and streams surveyed in the US in 2000 were impaired by pollution and did not meet water quality standards. The top causes of impairment were siltation, nutrients, bacteria, metals, and oxygen-depleting substances. The leading source of this impairment is pollution transported by urban and agricultural runoff.[2]

The majority of the point sources have been addressed through the early focus of the Clean Water Act. Now, the more difficult nonpoint sources must be dealt with in order to continue to improve our water resources. The causes and sources highlighted in this section are some of the key impairments and pollutants used to develop and organize projects for improving the Maumee AOC and the headwaters.

Land Use and Population Changes

Lake Erie was the last of the Great Lakes to be discovered by Europeans and the Maumee basin was one of the last areas around Lake Erie to be settled. “The Maumee lake plain, on which Toledo is located, was once a part of a vast swamp known as the Great Black Swamp, which was drained, canalized, and deforested during the past 140 years for agricultural development.”[3]

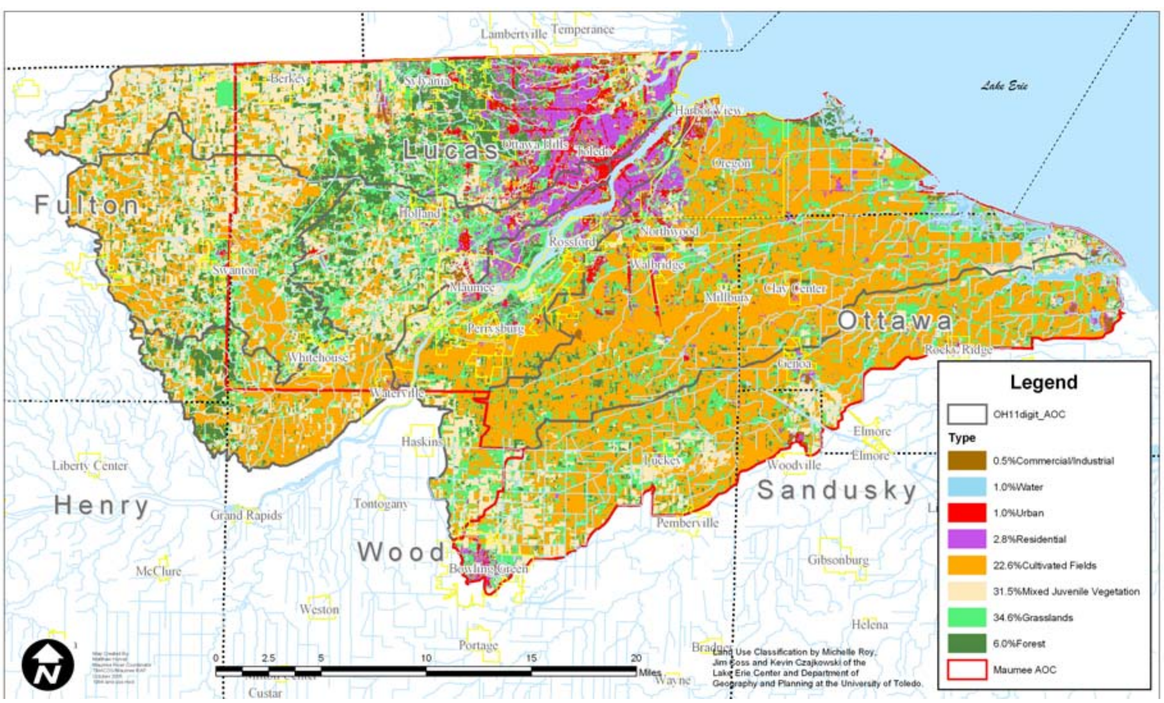
In the late 1800s to early 1900s, the Toledo area experienced a large population and industrial growth. When the Miami and Erie Canal was completed in the 1840s, trade in the area quickly expanded, and Toledo took its first step toward becoming a major shipping port.[4] In the early 1900s, Toledo was one of the top 30 most populated cities in the United States. Toledo's industrial success was in part due to its proximity to Detroit and the automotive industry. The auto industry, as well as glass manufacturing and oil refineries, found the abundant water supply of the Maumee River and Lake Erie to be a valuable resource. However, the City of Toledo reached its population peak in the 1960s before manufacturing and industries began moving to warmer climates and out of Rust Belt Mid-West; leaving behind a legacy of environmental pollution.

The next significant population shift was from the urban to the suburban areas, resulting in accelerated storm water runoff problems. Urban development increases the amount of impervious surface in a watershed, as farmland, forests, and meadowlands with natural infiltration characteristics are converted into roads, parking lots, buildings, driveways, and sidewalks with virtually no ability to absorb storm water. Since the new land cover is less permeable than the existing cover, this change results in a greater percentage of the precipitation becoming runoff. The increased runoff causes larger and more frequent floods and increases erosion of stream banks and beds. The higher flows can lead to increases in stream temperature, changes in habitat, and decreases in stream flow stability.

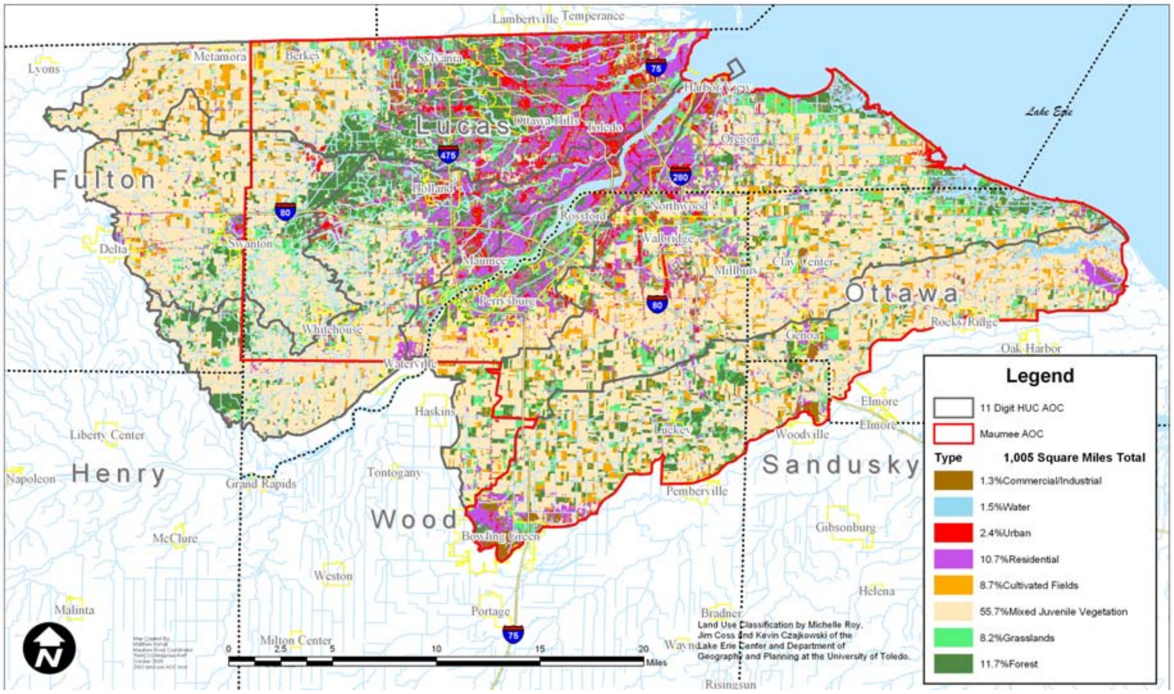
Watershed Impervious Area Changes in the Maumee AOC[5]

River Basin	1994 Impervious Area	Impervious Area Increase 1974-1994
Lower Maumee River	6.1%	10.4%
Ottawa River	30.8%	9.6%

1984 Land Use of the Maumee AOC



2003 Land Use of the Maumee AOC



Most urban land use activities deposit detrimental and sometimes hazardous materials on the impervious surfaces: sediments such as dust and sand, toxic metal particles, pesticides and fertilizers, petroleum products, harmful bacteria, salt, pet waste, and trash. As rainfall and snowmelt move rapidly across this transformed landscape, these pollutants are carried to surface and underground collection systems. These polluted, untreated flows often reach waterways that we use for drinking, swimming, fishing, and recreation, such as Lake Erie.

Categories of Primary Storm Water Contaminants[6]

Category	Examples
Metals	Zinc, Cadmium, Copper, Chromium, Arsenic, Lead
Organic Chemicals	Pesticides, Oil, Gasoline, Grease
Pathogens	Bacteria, Viruses, Protozoa
Nutrients	Phosphorous, Nitrogen
Biochemical Oxygen Demand (BOD)	Grass clippings, Hydrocarbons, Animal waste, Fallen leaves
Sediment	Sand, Soil, Silt
Salts	Sodium Chloride, Calcium Chloride

Storm water pollution has two main impacts: the increased volume and velocity of surface runoff and the concentration of pollutants in the runoff. Both of these impacts are directly related to development in urbanizing areas.[7] As the greatest growth continues to occur on the fringes of the metropolitan areas, the impervious areas within our watersheds expand at ever increasing rates. As these land use changes occur, so have our requirements for clean water. Water can be used for many purposes; each has its own requirements as to how "clean" the water needs to be.

Water Quality Requirements for Use

Water Use	Water Quality Requirements
Commerce	Navigable waters
Industry, agriculture, power generation	Free of debris and pollutants to serve the industrial purpose, without damaging equipment or plumbing
Recreation (swimming, boating)	Microbes such as bacteria and viruses must be at low enough levels not to cause infection. Free of toxics and chemical irritants
Public supply	Must be safe to drink: free from toxics, microbes, and carcinogens, and free of unpleasant taste and odor.
Fishing	Water and sediments must be free of toxics. Nutrients (nitrates, phosphates) must be below levels that cause "toxic algae" blooms. River sediment deposits must not cover feeding or spawning areas. Water must contain dissolved oxygen to support life. Headwater streams must meet these standards to produce a food chain that ultimately feeds the fish in Lake Erie. Some fish (like carp and bluegill) are pollution tolerant, while others (like trout) are intolerant.
Natural habitat, rare or endangered species	Sediment loadings, nutrients, and toxics must be at low levels. Streams should have shaded areas to keep water cool, and riffles to provide oxygenation. The more streams that meet these qualities, including small headwater streams, the better the watershed habitat will be.

An overall population increase of 0.5 percent for the area between the 1990 and 2000 censuses does not reflect the significant shifts in population from the urban to the suburban and rural areas. For example, the City of Toledo lost over 19,000 (-5.8%) people but communities such as Monclova (+48.8%), Springfield (+20.3%) and Sylvania (+10.7%) Townships had large increases during the 1990s. Similar patterns can be seen throughout Northwest Ohio in the Jurisdictional Population Change Table below.

Jurisdiction Population Changes 1990-2000*

County	Jurisdiction	1990 Population	2000 Population	Percent 2000/1990
Lucas	Harding Township	593	724	122%
Lucas	Holland Village	1,210	1,306	108%
Lucas	Jerusalem Township	3,253	3,181	98%
Lucas	Monclova Township	4,547	6,767	149%
Lucas	Oregon City	18,334	19,355	106%
Lucas	Providence Township	3,016	3,454	115%
Lucas	Richfield Township	1,178	1,308	111%
Lucas	Spencer Township	1,665	1,708	103%
Lucas	Springfield Township	18,835	22,817	121%
Lucas	Swanton Township	3,329	3,330	100%
Lucas	Sylvania City	17,301	18,670	108%
Lucas	Sylvania Township	22,682	25,583	113%
Lucas	Washington Township	3,803	3,574	94%
Lucas	Waterville Township	1,958	1,908	97%
Lucas	Waterville Village	4,517	4,828	107%
Lucas	Whitehouse Village	2,528	2,733	108%
Ottawa	Allen Township	2,888	3,297	114%
Ottawa	Benton Township	2,046	2,232	109%
Ottawa	Carroll Township	1,735	1,931	111%
Ottawa	Clay Township	3,005	2,888	96%

County	Jurisdiction	1990 Population	2000 Population	Percent 2000/1990
Sandusky	Woodville Township	1,135	1,327	117%
Wood	Bowling Green City	28,151	29,636	105%
Wood	Center Township	1,158	1,246	108%
Wood	Freedom Township	1,241	1,330	107%
Wood	Lake Township	6,632	6,643	100%
Wood	Luckey Village	848	998	118%
Wood	Middleton Township	1,911	1,960	103%
Wood	Millbury Village	1,082	1,161	107%
Wood	Perrysburg Township**	13,176	13,613	103%
Wood	Perrysburg City	12,551	16,945	135%
Wood	Plain Township	2,021	1,706	84%
Wood	Rossford City	5,861	6,406	109%
Wood	Troy Township	3,000	3,357	112%
Wood	Washington Township	1,195	1,324	111%
Wood	Webster Township	1,111	1,277	115%

** - Township populations are unincorporated areas only. In some cases population changes may not fully reflect urbanization during the period because newly developed areas were annexed. Similarly, growth in some municipalities was due to annexation. ** - During the decade, Perrysburg City's population increased 35%, and Rossford's by 9%, while Perrysburg Township's increased 3%. The city population increases were due largely to annexation from Perrysburg Township. Perrysburg Township is therefore considered a high growth jurisdiction.*

Urban Runoff

Urban storm water runoff pollution sources are diffuse and not easily identified. With the development of open lands have come abrupt changes in the relationships between vegetation, soils, and waterways. The existing surface cover is replaced with roads, rooftops, driveways, parking lots, and other impervious surfaces. The effect of impervious surfaces on the volume of storm water runoff is dramatic. For example, a one-inch rainstorm on a 1-acre natural meadow produces approximately 218 cubic feet of runoff. The same storm over a 1-acre paved parking lot would produce almost 16 times that volume, 3,450 cubic feet of runoff. The proliferation of hard surfaces not only changes the volume of storm water flows, but also the distribution of flows over time. The storm water is forced off the land immediately, causing much sharper peaks in runoff. These "flashy" flows can lead to problematic changes in the hydraulics of the system.

Impacts from Increases in Impervious Surfaces[8]

Increased Imperviousness Leads to	Resulting Impacts				
	Flooding	Habitat Loss	Erosion	Channel Widening	Streambed Alterations
Increased volume	•	•	•	•	•
Increased peak flow	•	•	•	•	•
Increased peak flow duration	•	•	•	•	•
Increased stream temperature		•			
Decreased base flow		•			
Increased sediment loadings	•	•	•	•	•

In most communities, the majority of impervious cover is related to the transportation infrastructure-roads and parking lots. Research has show that when impervious cover reaches between 10 and 20 percent of the area of a watershed, hydrological and ecological stresses become apparent.[9] A second threshold appears to exist at around 25 to 30 percent impervious cover, where most indicators of stream quality consistently shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores).

Historically, water pollution control has focused on the more obvious point sources: municipal wastewater treatment plants and industrial discharges. The water pollution potential for storm water runoff was not fully appreciated until repeated studies revealed that urban nonpoint sources seriously threaten water quality and can exceed the impact of municipal sewage discharges.

Nonpoint problems are both water quality and quantity based. In urban areas a variety of created surfaces now cover much of the landscape. Many of these surfaces are impervious and therefore prevent rainwater and snowmelt from following their natural course into the soil. Roofs and pavement prevent infiltration completely, while even suburban lawns absorb far less than natural areas. Impervious surfaces increase the rate and volume of storm water runoff, resulting in higher flows and more frequent floods. In the Lucas County portions of the Swan Creek watershed flood flows have increased 17 to 85 percent from pre-settlement times. The elevated flows increase the erosion of waterway beds and banks.[10] Other negative impacts include increasing the receiving water's temperature, changing habitat, and decreasing stream flow stability.

Automobiles contribute a number of different types of pollutants to urban runoff. High levels of metals are found in tire wear, used motor oil and grease, diesel fuel, and vehicle rust. Engine coolants and antifreeze containing glycols are toxic and can contribute to high biochemical oxygen demand in the receiving waters. Generally, fossil fuel combustion is the largest contributor of nitrogen to the waters in urbanized areas of the United States. Salts are used to keep facilities free of ice, but in large volumes can be toxic to fish and other wildlife. These pollutants accumulate on impervious surfaces during dry weather conditions, only to form a highly concentrated first flush during storm events.

Landscaping practices and poor housekeeping practices are other potential sources of pollutants in urban runoff. Chemicals that are used in fertilizers and pesticides can lead to water quality impacts. Over and improper application at homes, golf courses, public parks, etc. is very common and the excess eventually makes its way to ditches and streams. Rain and melting snow erode piles of stored materials such as sand, loose topsoil, or road salt that is left uncovered. Similarly, precipitation can flush contaminants off "dirty" equipment that is stored outside. These common pollutants can degrade the quality of receiving waters, almost to the same degree as if they were introduced by direct discharge.

Erosion rates from construction sites are significantly greater than from almost any other land use. Field studies and erosion models have shown that erosion rates from construction sites are typically an order of magnitude larger than row crops and several orders of magnitude greater than rates from well-vegetated areas such as forest or pastures.[11] Excess sediment causes a number of problems for waterbodies. Suspended sediments increase turbidity and reduce light penetration in the water column, which directly impacts aquatic organisms. Long-term effects of sedimentation include habitat destruction and increased difficulty in filtering drinking water.

During the construction process, soil is the most vulnerable to erosion by wind and water. Studies indicate that poorly managed construction sites can release 7 to 1,000 tons of sediment per acre during a year, compared to 1 ton or less from undeveloped land.[12] Suspended sediment lowers the quality of water for municipal and industrial uses as well as for boating, fishing, swimming, and other water based recreation. Deposited sediment clogs storm sewers, culverts and drains, reduces the storage capacity of stream channels and reservoirs, fills ponds and lakes, and buries aquatic life habitat.

While sediment is the major pollutant generated on construction sites, other pollutants may be present. Potential secondary pollutants include petrochemicals (oil, gasoline, and asphalts), solid wastes (paper, wood, metals, plastics, etc.), construction related chemicals (acids, soil additives, concrete curing compounds, paints, etc.), wastewater (aggregate wash water, concrete cooling water, clean-up water, etc.), sanitary wastes, and fertilizers. Sediment can serve as a transport mechanism for a chemicals such as phosphorous and nitrogen, which in excess amounts lead to water quality impairments. Since March 2003, construction sites of one acre or more have been required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharge.

Illicit or illegal connections to the storm sewers from homes and businesses introduce pollutants and pathogens to the storm sewers that are released without appropriate treatment. Sources of illicit discharges include, but are not limited to: sanitary wastewater, effluent from septic tanks, car wash, laundry, household waste, and other miscellaneous waste products. Industrial facilities often negligently discharge wastewater that should be directed to the sanitary sewers through floor drains, dry wells, and/or cesspools, which feed into their storm water system. The result is untreated discharges that contribute high levels of pollutants into receiving waterbodies.

Some of the older urbanized areas in the region have combined sewers, where storm water and sanitary sewage flow in the same system. The storm water problems associated with urban areas can be intensified by occasional overflows from these combined systems. The City of Toledo also has sanitary sewer overflows, which discharge raw sewage straight to local waterways during periods of excessive flow and infiltration. Overflow points and treatment plant bypasses are provided, by design, to prevent damage to the wastewater treatment plant and reduce local flooding during periods of high flow. Permits for the installation of new combined and sanitary sewers overflows are no longer issued. Most communities have developed plans to reduce the number of combined and/ or sanitary sewer overflows. Upgrading existing systems requires complex engineering and can be an extremely expensive capital improvement project.

CSOs & SSOs in the Maumee AOC

Jurisdiction	Combined Sewer Overflows (CSOs)	Sanitary Sewer Overflows (SSOs)
Bowling Green	•	
Genoa	•	
Luckey	•	
Perrysburg	•	
Swanton	•	
Toledo	•	•

Rural and Agricultural Runoff

The rural population reached its peak in the Maumee AOC about the turn of the twentieth century, 50 years later than in the rest of Ohio. Soils were so productive in this newly drained land that more of the land was put into crops here than anywhere else in Ohio. What was once a vast muddy swamp on the flats of an old postglacial lake-bed has become one of Ohio's most productive rural areas.[13] In the late 1970s the Maumee River basin led the State in the number of acres devoted to farming.[14]

According to the 2002 Ohio Agricultural Statistics, Wood County was first in the State in soybean and wheat production, and fourth in corn production.[15]

Since the 1970s, the increased use of conservation tillage farming practices has been found to correspond to decreases in suspended-sediment discharge over time at two locations in the Maumee River Basin.[16] A 49.8 percent decrease in suspended-sediment discharge was detected when data from 1970–74 were compared to data from 1996–98 for the Auglaize River near Ft. Jennings, Ohio. A decrease in suspended-sediment discharge of 11.2 percent was detected from 1970–98 for the Maumee River at Waterville, Ohio.

Heidelberg College Water Quality Laboratory has provided long-term gauging and water quality sampling for several Lake Erie tributaries, since the mid 1970s. Discharges from the rivers of sediment and nutrients can vary widely from year to year, depending on the amount and severity of rainfall. Consistent monitoring over a long period of time is necessary to show whether sediment and nutrient loads are increasing or decreasing. The table below gives a trend summary for four primarily agricultural watersheds. The parameters are TSS: Total Suspended Solids, TP: Total Phosphorus, SRP: Soluble Reactive Phosphorus, NO_3: nitrate, and TKN: Total Kjeldahl Nitrogen. The Maumee River station is at Waterville, the beginning of the Maumee AOC for the Maumee River.[17] Other sampling stations have been included below for comparison.

Sediment and Nutrient Trend Summary

		Parameter				
Waterway	**Flow**	**TSS**	**TP**	**SRP**	**NO3**	**TKN**
Maumee River	9.2	-18.1	-41.6	-84.5	21.3	-28.4
		*	****	****		****
Sandusky River	6.7	-27.2	-46.3	-87.9	12.0	-21.0
		****	****	****		****
Honey Creek	-16.7	-2.5	-28.7	-78.5	45.9	-14.2
			****	****	****	**
Rock Creek	-30.5	-37.2	-41.4	-54.8	-36.9	-40.6
	*	****	****	****	**	****

Percent change from 1975 to 1995, estimated as described in the text. Negative numbers corresponding to decreasing concentrations, positive numbers to increasing concentrations. Significance levels are based on t-values adjusted for autocorrelation. *: p<.05, **: p<.01, ***: p<.001, ****: p<.0001.
* Percent change during 1983 to 1995 only, reflecting the shorter period of record for Rock Creek

Heidelberg College's data for sediment and nutrients at the four stations from 1975-1995 generally shows decreases in sediment and phosphorus loads, but increases in nitrates. The inference is that farming conservation practice changes over those 20 years reduced sediment loads (and phosphorus as well, because phosphorus tends to attach to fine soil particles). Conservation practice changes, however, have not similarly reduced nitrate loadings; nitrates are soluble, and are carried more by water flow than sediment. Use of tile drainage may increase loadings of soluble nitrates to the rivers. It should be noted, however, that the data, especially for nitrates, is highly variable and dependent on weather.

Habitat Modifications and Flow Alterations

Habitat is a critical part of the stream environment including the type and quality of substrate, amount of in-stream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient. Altering these features can damage the health of a stream. Stream modifications can also exacerbate other concerns, such as thermal stress.

Hydrologic modifications can also damage a stream by altering the flow of water. Structures or activities in the waterway that alter stream flow may be a source of stressors, such as increased sedimentation or a barrier to the upstream migration of aquatic organisms. There are several dams and/or control structures located in the Maumee AOC.

Dams and Structures in the Maumee AOC

Watershed	Name	Type	Location/River Mile
Ottawa River	Ottawa Hills Dam	Low Head Dam *(removal is being planned)*	Upstream of Secor Rd. RM 11.8
	Unnamed Dam 1	Low Head Dam	~ RM 13.5 to 14.5
	Unnamed Dam 2	Low Head Dam	~ RM 13.5 to 14.5
	Miakonda Dam	Low Head Dam *(removed 12/03)*	Boy Scout Camp Miakonda RM 17.25
Swan Creek	Highland Park Dam	Low Head Dam	Highland Park RM 4.2
	Anderson Dam	Low Head Dam *(evaluating possibility of removal)*	Downstream of Holland Rd. RM 12.5
Duck Creek	Hecklinger Pond outflow	Control Structure	Hecklinger Pond RM 3.27

The use of best management practices (BMPs) to correct the effects of stream alteration must consider all impacts. For example, restoring habitat will not restore aquatic life, unless sediment and nutrient loadings have also been addressed. It takes a combination of the following types of projects to restore the habitat in a watershed. However, the best method is to protect the waterway before an alteration can be done.

- *Stream bank restoration projects:* These projects provide habitat while reducing bank erosion that threatens property and contributes sediment to degrade stream quality.

- *Upland habitat restoration:* These projects are important for developing a thriving wildlife community, with an emphasis on plants and animals that are water dependent but not solely aquatic.

- *Aquatic habitat restoration:* These projects are needed to support stream quality that will allow for a diversity of fish and wildlife more like those that existed before the pollution occurred.

- *Free flowing stream restoration projects:* These projects involve removing dams and other obstructions that serve as barriers to fish movement (i.e. dams) or those that restrict or alter flow conditions and/or a waterway's access to the floodplain (i.e. dikes, levees).

- *Wetland restoration:* These projects allow for returning areas to their original important wetland functions affecting stream quality, hydrology and wildlife habitat.

Nutrients

Eutrophic is a term that describes a waterbody enriched with nutrients (phosphates and nitrates) and organic matter. That enrichment results in increasing biological productivity. Over-nourishment leads to accelerated nuisance growths (blooms) of cyanobacteria. Cyanobacteria are photosynthetic, and were once thought to be blue-green algae.[18] Their blooms are still popularly called "toxic algae." The immediate effect is an unpleasant area because of the cyanobacteria's strong odor. Over the following winters, the mass of cyanobacteria would die and sink to the bottom. The following season the dead cyanobacteria would decay at the bottom and deplete the oxygen dissolved in the water. The eutrophication will adversely affect fish and aquatic organisms, fishing and boating, and the taste and odor of finished drinking water.[19]

Streams in the Huron-Erie Lake Plains ecoregion (where the Maumee AOC is located) have the highest background levels of phosphorus and nitrate. Small streams with low phosphorus levels have the best aquatic communities, and therefore are more likely to meet water quality standards. As phosphorus levels rise, the aquatic community quality decreases.[20]

Phosphorus has been identified as a key controlling factor in the eutrophication of Lake Erie and other area streams. These nutrients can produce nuisance growths of algae and higher aquatic plants. While some lakes are naturally eutrophic, excessive nutrient loads that accelerate eutrophication usually result from human activity.

In 1983 the United States and Canada ratified Annex III of the *Great Lakes Water Quality Agreement*. This agreement called for the reduction of annual phosphorus loadings to Lake Erie to 11,000 metric tons. This was estimated to be enough to eliminate the "algae" blooms and the resulting dead zones.[21] The needed 11,000 metric ton reduction was allocated among the watersheds, and split between point and nonpoint source loadings. Ultimately the required nonpoint source reductions were assigned to individual counties, with targets for agricultural and urban runoff reductions. The phosphorus reduction targets are listed in the table below.[22]

Annex III Phosphorus Reduction Targets

Tributary	Point Source Phosphorus Reduction Target, metric tons/year	Non-Point Source Phosphorus Reduction Target, metric tons/year	Total Phosphorus Reduction Target, metric tons/year
Ottawa	0.0	74.2	74.2
Maumee (the 74% in Ohio)	22.5	2,113.3	2,335.8
Portage / Toussaint	13.7	535.1	548.8

Public agencies took a number of steps to achieve these reductions in the amount of phosphorus entering Lake Erie:

- The discharge permit requirements for sewage treatment plants were strengthened. Phosphorus discharges were reduced to 1.0 mg/l for treatment plants discharging over 1 million gallons per day.

- The Ohio Legislature banned phosphorus from laundry detergents sold in the Lake Erie drainage area.

- Sanitary sewers have eliminated thousands of septic systems; thus reducing the direct discharge of phosphorus from residential and small commercial systems, such as cleaners (other than laundry detergent, cooking/food wastes and or residue, and drinking water treatment additives.

- Agricultural agencies and the county Soil and Water Conservation Districts promoted conservation tillage, buffer strips, and other Best Management Practices to reduce phosphorus runoff from farmland. Financial incentives have encouraged these practices through programs such as the Conservation Reserve Enhancement Program and the Ohio EPA 319 nonpoint source program.

- US EPA established the NPDES Storm water Permit program requiring urban jurisdictions to identify and control pollution from urban runoff. In Phase I of this program, large cities were required to apply for permits by 1998, and smaller jurisdictions in urban areas applied by 2003 under Phase II. The NPDES Storm water program also regulates construction sites that disturb more than an acre of land.

Progress toward achieving these agricultural phosphorus reduction goals has been substantial. NRCS tracked reductions for each Lake Erie county in Ohio through 1997. For the entire Lake Erie basin, 49 percent of the agricultural phosphorus reduction target had been met by 1997. Agricultural phosphorus reductions through 1997 for counties in the Maumee AOC are in the following table.

Agricultural Phosphorus Reduction Targets through 1997

County	Agricultural Phosphorus Reduction through 1997 (pounds)	Agricultural Phosphorus Reduction target (pounds)	Percent of Goal
Lucas	29,567	38,060	77.69%
Ottawa	27,742	46,200	60.05%
Wood	109,467	153,120	71.49%
Totals	166,776	237,380	69.74%

In 2002 the International Joint Commission discussed the issue in its biennial report on Great Lakes Water Quality:

> *Major tributaries to Lake Erie, such as the Maumee River, have achieved notable decreases in suspended sediment discharges and reductions in phosphorus loads as a result of improved agricultural practices. However, these tributaries are still very large sources of phosphorus with year-to-year loads varying with the frequency and intensity of flooding. For example, phosphorus stored in the sediment of tributaries can build up during dry or average rainfall years and can serve as a substantial load to the lake during a single flood event. Such major events could become common in the Great Lakes as a result of climate change, adding a further management challenge to achieving target loads.*[23]

In streams and rivers phosphorus is more often a limiting factor in algal growth than nitrate.[24] Nitrate concerns usually center on drinking water impacts, not algae blooms. Nitrate contamination of drinking water usually results from runoff of agricultural fertilizers, or from human or animal wastes, such as livestock feedlots or faulty septic systems.[25]

Nitrate is essentially harmless to most people, but is considered an acute toxin to infants under six months of age. In infants it can cause a condition known as methoglobinemia or “blue baby syndrome,” which can be fatal. Blue-baby syndrome is caused when bacteria in the digestive tract of infants change the nitrate into nitrite, a much more harmful substance. The nitrite then enters the bloodstream, where it can lower the blood’s ability to carry oxygen to the body, causing blueness to the skin. Infants under six months of age are at higher risk than others because their digestive tract is not fully developed. By six months of age, the hydrochloric acid in the stomach increases to a level that kills most of the bacteria which change nitrate to nitrite, significantly reducing the risk of methoglobinemia. If a nitrate advisory is issued, bottled water should be substituted for tap water until the nitrate advisory is lifted. Boiling tap water will not get rid of the nitrate; it only concentrates it. It is safe to bathe or shower in tap water.[26]

Nitrate levels only affect stream aquatic life scores in headwater streams with high nitrate levels (i.e., medians above 3-4 mg/l).[27] Additional efforts to control nitrate may be needed for small streams with high average nitrate levels. Nitrate levels over 3-4 mg/l are not uncommon.

The Heidelberg College Water Quality Lab conducts a Lake Erie Tributary monitoring program that provides nearly a thirty-year continuous record of nutrient and sediment loadings. One of its principle sites is the Maumee River at Waterville.[28] This site is very important for the comparison of water quality entering the Maumee AOC verses other sites downstream.

<u>Pesticides</u>

Pesticides are used to protect gardens and farms from nuisance insects and weeds. DDT has been banned for years, and is gradually decreasing in the environment. A variety of pesticides are used for agriculture and residential gardens, including “Triazines,” Atrazine, and Simazine. At certain exposure levels, they are potential carcinogens. Pesticides may enter surface waters either dissolved in runoff or attached to sediment or organic materials, and may enter ground water through soil infiltration. Public drinking water supplies are monitored and regulated for pesticides.[29]

U.S. EPA notes:

> *Pesticides and their effects on human health are often the focus of debate between scientists, environmental groups, public water systems, and the public. Two important issues included in the debate center on exposure, or the amount of these chemicals that people either ingest or inhale, and the duration of the exposure. Exposure is an important issue because the amount of a chemical either ingested or inhaled and the length of the exposure determine whether or not human health will be negatively affected. Consuming water that is contaminated with pesticides is one route of exposure that has made headlines over the last several years.*
>
> *The U.S. EPA has established different drinking water criteria for both short term and long term exposure periods. For children, health advisories are established for exposure durations of 1-day, 10-days and 7-years. For adults, health advisories are calculated for 7-years and lifetimes (all health advisories are non-enforceable). In addition to health advisories, the U.S. EPA has established maximum contaminant levels (MCLs), which are enforceable standards that are based on a lifetime of exposure. Compliance with the MCL is based on a public water system's running annual average of all samples taken during a 12-month period. Consumption of water with chemical concentrations less than or equal to a health advisory or MCL*

for the duration of time covered by the criteria or standard is considered by U.S. EPA to pose negligible health risks.[30]

Sediment

Sediment is a pollutant in its own right. Ecologically it is important because phosphorus attaches to and is carried with sediment. Generally speaking, actions that reduce the amount of sediment going into the lake will reduce the amount of phosphorus. When sediment settles out, it covers the bottom of streams, bays, and lakes. It may destroy fish habitat by: (1) blanketing spawning and feeding areas; (2) eliminating certain food organisms; (3) causing gill abrasion and fin rot; and (4) reducing sunlight penetration, thereby impairing photosynthesis. Suspended sediment decreases recreational values, reduces fishery habitat, adds to mechanical wear of water supply pumps and distribution systems, and adds treatment costs for water supplies. Nutrients and toxic substances attached to sediment particles may enter aquatic food chains, causing fish toxicity problems, impaired recreational uses or degrade the water as a drinking water source.[31]

Accumulating sediment can make Maumee Bay and some nearshore areas inaccessible. The Toledo shipping channel connects the Maumee River with the Western Basin of Lake Erie. It is dredged a distance of 22 miles from 18 to 28 feet below low water datum[32] (LWD), depending actual location in the Maumee River and Maumee Bay. Without annual dredging, which averages about 950,000 cubic yards per year,[33] the Port of Toledo cannot operate. Recreational access is also affected. The Ottawa and Toussaint rivers have needed recreational dredging in recent years, but have been restricted or delayed for various reasons. Access to marinas is also strongly influenced by the fluctuating lake levels.

One of the biggest environmental issues regarding sediment in the Maumee AOC is what to do with the material dredged from the Toledo shipping channel. Since the mid-1980s disposal of the dredged material has been split between a Confined Disposal Facility (CDF) and open-lake disposal. Sediments contaminated by chemicals or metals are placed in the CDF. Uncontaminated sediments (which are still a pollutant) have been confined or dumped out in Lake Erie, depending on CDF capacity. Here are some of the issues:

- CDFs are expensive to build. When a CDF is full, it is necessary to expand it or build another one. CDFs cover lake bottom, which is habitat for fish and other aquatic organisms. A new or expanded CDF can interfere with access and enjoyment of the Lake Erie by lakefront property owners.

- Dredging removes sediment and any chemicals they contain from the ecosystem. Confining uncontaminated sediments benefits water quality by taking sediment and phosphorus out of the system.

- Open lake disposal of dredged materials may promote eutrophication by bringing sediment and phosphorus back into contact with the lake water.

- Dredged materials dumped out in Lake Erie may be washed back into Maumee Bay by storms. By not removing sediments from the River, Bay, and Lake, we could be dredging the same sediments year after year. Sediment currents in Maumee Bay are not well understood, and are influenced by Lake Erie seiche, the shallowness of the Bay, and strong flows from the Maumee and Detroit rivers. A recent study commissioned by the Toledo-Lucas County Port Authority has greatly contributed to our understanding of sediments in Maumee Bay.[34]

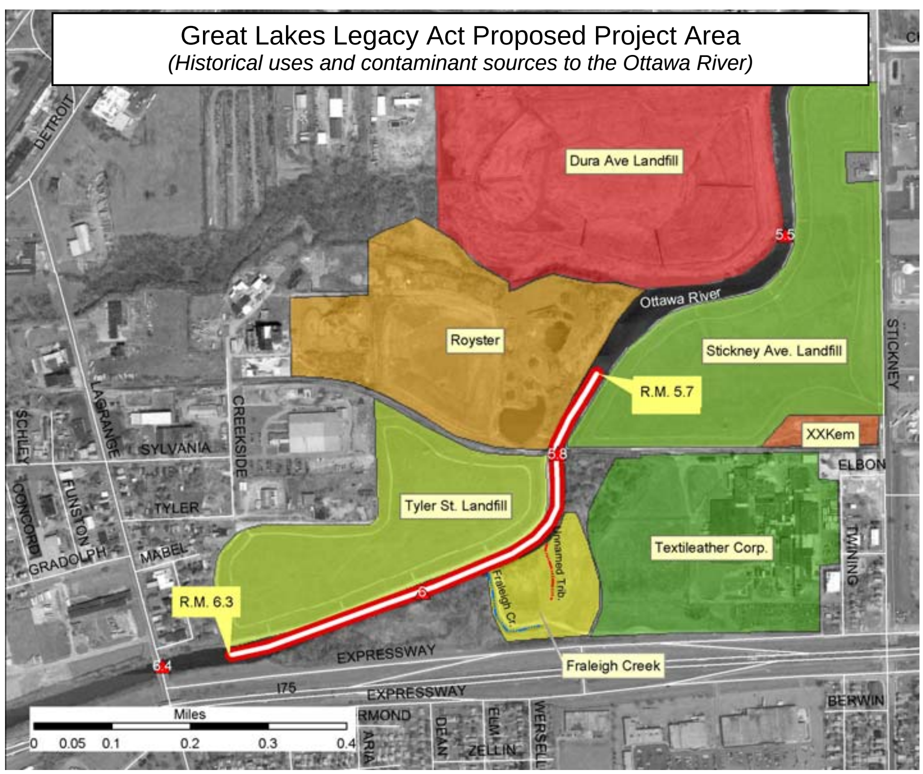
- Dredging is necessary for the Port of Toledo to operate. It is one of the largest ports on the Great Lakes, and it is economically very important to the region.

Sediment issues in the Maumee River watershed are more complex than any other area in Ohio due to the volume of materials. The complexity of nutrient loadings combined with dredging and disposal concerns makes the need for load reductions critical to the restoration of the Maumee AOC.

<u>Toxic Substances</u>

Since the 1800s, the industrial heritage and population growth in Maumee AOC has left a legacy of environmental pollution. The oldest continually operating automotive assembly plant in the world, the North Cove Assembly Plant (presently owned by the Chrysler Corp.), was built along the Ottawa River at RM 7.6. Although most of this plant was closed and demolished in 2003, a new plant replaced it downstream on the Ottawa River at river mile 4.75. With this major industrial investment early in Toledo's economic history, many other industries developed to meet the production demands of creating the world famous Jeep. Industries, as well as landfills, grew through the Maumee AOC.

Another key investment of early industry was in the Otter Creek watershed. The first documented industrial development in this area began in 1895 as the Crystal Oil Co. In 1919 the Standard Oil Company constructed its first plant in the watershed. These and other environmental pressures had a profound effect on the health of the Creek. Between 1895 and the 1920s, the Otter Creek fish community declined, until it was eliminated in the mid-1920s.[35]



Great Lakes Legacy Act Proposed Project Area
(Historical uses and contaminant sources to the Ottawa River)

The lack of environmental regulations during early industrial development encouraged the disposal of industrial wastes into the naturally occurring floodplains and wetlands. This common practice resulted in the degradation of all environmental and economic aspects of the industrially developing area. This industrial heritage has led to historical contamination in our waterways. Toxic substances enter the surface waters either dissolved in runoff or attached to sediment or organic materials. The sources can include leaching industrial and municipal landfills, and abandoned industrial sites. The results can be contaminated sediments, poor water quality, and fish or wildlife deformities. The Ottawa River between river mile 5.0 and 7.0 are a very good example of a waterway that was historical abused.

The table below is a listing of the dumps, landfills, and brownfields as identified by the Maumee RAP in 2001.[36] The *Activities and Accomplishments in the Maumee Area of Concern* provides specific information about each site listed below including information such as the site location, former facility names, sampling results, and remedial actions implemented.

Dumps, Landfills and Brownfields in the Maumee AOC[37]

Watershed	Facility/Site Name	Facility/Site Location
Duck Creek	Buckeye Pipeline Company	3321 York Street, Oregon
	Consaul Street Dump	2510 Consaul St., Toledo
	Gulf Oil Refinery and Terminal (a.k.a. Chevron)	2935 Front St., Toledo
	Millard Ave. Overpass	Millard Ave. between Front St. and Otter Creek Rd., Toledo and Oregon
	Norfolk & Southern Railway (a.k.a. Norfolk & Western, Ironville Yard)	2750 Front Street, Toledo
	Paine Street Landfill	Northwest corner of Paine Street and Consaul Street, Toledo
	Phillips Petroleum (a.k.a. Toledo Philblack Plant, River East Industrial Park)	275 Millard Ave., Toledo
Maumee River	Bassett Street Warehouse (a.k.a. Oldberg Manufacturing Co., Schachner Property, Maumee Refining, Greise Brothers)	600 Bassett Street, Toledo
	Florence Avenue Dump	Florence Ave., Toledo
	Gulf Oil Refinery and Terminal (a.k.a. Chevron)	2935 Front St., Toledo
	Koppers (a.k.a. Toledo Coke)	2563 Front St., Toledo
	Libbey Plant 27 (a.k.a. Owens-Illinois, Inland Chemical)	940 Ash Street, Toledo
	Old Peanut Hill Dump	Oak Street, near Akron St., Oaklawn Dr., and Richford St., Toledo
	Phillips Petroleum (a.k.a. Toledo Philblack Plant, River East Industrial Park)	275 Millard Ave., Toledo
	Plaskon	2829 Glendale Ave., Toledo
	South Avenue Dump (a.k.a. South and Western Dump, Toledo Municipal Sanitary Landfill, S/W Dump)	103 South St., Toledo
	Sun Oil Company	1819 Woodville Rd., Oregon
	TAG Chemicals, Inc.	100 Edwin Dr., Toledo
	Unitcast	1440 East Broadway, Toledo
Ottawa River	Cleveland Metals (a.k.a. New York Central Railroad, Fanner Manufacturing, HLR Enterprises)	2351 Hill Ave., Toledo
	Dura Avenue Landfill	Dura Ave., Toledo
	Harrison Junk Yard (a.k.a. Reneger)	10259 ½ Dorr Street, Spencer Township
	Herbert E. Orr Company (a.k.a. Devilbiss Manufacturing)	3863 Lagrange Street, Toledo
	Jeep/DaimlerChrysler (a.k.a. Overland, American Motors Company, Chrysler Corporation)	1000 Jeep Parkway, 4000 Stickney Ave., and 4400 Chrysler Drive
	Joe E. Brown Park Landfill	Manhattan Blvd., west of Lagrange, Toledo
	King Road Landfill	3535 King Rd., Sylvania Township
	North American Car Corporation	3648 Hoffman Road, Toledo
	North Cove Landfill	Foot of Drexel Dr., I-75 and North Cove Blvd.
	Northern Ohio Asphalt Paving Company	7950 Sylvania Avenue, Sylvania
	Owens Illinois-Hilfinger	1800 N. Westwood Avenue, Toledo

Ottawa River *(continued)*	Owens Illinois-Tech Center	1700 N. Westwood, Toledo
	Perstorp Polyols (a.k.a. Pan American, Dupont E.I. DeNemours & Co., Inc.)	622 Matzinger Road, Toledo
	Royster Property (a.k.a. Stickney West Industrial Park)	4401 Creekside Ave., Toledo
	Scott Park	Hill Ave., Toledo
	Sheller-Globe/Armored Plastics (a.k.a. City Auto Stamping, United Technologies Automotive Systems, Inc., Globe-Warnicke Industries, Inc)	4510 Lint Ave. and 303 Dura Ave., Toledo
	South Cove Landfill	South Cove Blvd. near Beatty Park, Toledo
	Stickney Avenue Landfill	3900 Stickney Ave, Toledo
	Textileather Corporation (a.k.a. Gencorp Maunfacturing)	3729 Twining, Toledo
	Toledo Tie Treatment Facility	Arco Industrial Park, S. Frenchmens Rd., Toledo
	Treasure Island Landfill (a.k.a. Miracle Park, Manhattan Park, Manhattan Dump)	between New York and Counter Streets, south of Manhattan St.
	Tuber Dump (a.k.a. Miracle Park, Manhattan Park, Manhattan Dump)	north of the intersection of Columbus and Ontario Streets
	Tyler Street Landfill	east end of Tyler St. near Creekside Ave., Toledo
	Willy's Park Landfill (a.k.a. Willy-Jeep Test Track)	Drexel Dr., Toledo
	XXKem Company (a.k.a. Incorporated Crafts, Robert Oberly)	3903-3905 Stickney Ave., Toledo
Otter Creek	Bill's Road Oil Services	3500 York St., Oregon
	BP Oil Company- ToledoRefinery (a.k.a. Standard Oil)	4001 Cedar Point Road, Oregon
	Buckeye Pipeline Company	3321 York Street, Oregon
	Gulf Oil Refinery and Terminal (a.k.a. Chevron)	2935 Front St., Toledo
	Commercial Oil	3600 Cedar Point Road, Oregon
	Envirosafe Services of Ohio, Inc. (a.k.a. Fondessy Enterprises, Inc.)	876 Otter Creek Road, Oregon
	Fondessy Landfill #1 (a.k.a. Millard Ave. Landfill)	southwest corner of Otter Creek Road and Millard Ave. Overpass, Oregon
	Gradel Landfill (a.k.a. Old Westover Landfill)	1150 Otter Creek Road, Oregon
	Libbey-Owens-Ford, Inc. (a.k.a. Pilkington)	1769 East Broadway, Toledo
	Matlack Trucking	1728 Drouillard Road, Toledo
	Millard Ave. Overpass	Millard Ave. between Front St. and Otter Creek Rd.
	Sun Oil Company	1819 Woodville Rd., Oregon
	Toledo Powdered Metals (a.k.a. Republic Steel Corp., Metal Deck, Inc., Epic Metals Corp., Co-Bar Corp.)	1700 Landis Ave., Oregon
	Union Oil Company (a.k.a. UNO-VEN Corp., UNOCA, Pure Oil Co.)	1840 Otter Creek Rd., Oregon
	Westover Corporation Sanitary Landfill	815 Otter Creek Road, Oregon
Swan Creek	Allied Automotive Toledo Stamping (a.k.a. Toledo Stamping and Manufacturing, Co.)	43 S. Fearing Blvd., Toledo
	American National Can Company	10444 Waterville-Swanton Road, Whitehouse
	Angola Road Landfill	7717 Angola Road, Holland
	Arlington Ave. Dump	Arlington Ave., southwest of Detroit and South Ave., Toledo
	Bethel Lutheran Church	1853 South Ave., Toledo
	Champion Spark Plug (a.k.a. Cooper Automotive Company)	900 Upton Ave., Toledo
	Champion Street Dump (a.k.a. Swan Creek at Champion Street Dump)	Swan Creek at Champion St, Toledo

Swan Creek *(continued)*	Chester Street Dump	Swan Creek at Chester St, Toledo
	Columbia Gas (a.k.a. Toledo Coal Gas Plant, Toledo Gas, Light, and Coke Company, Ohio Fuel Gas Co.)	328 South Erie St, Toledo
	Detroit Lead Battery Recycler	5715 Angola Road, Toledo
	Frankfort Auto Parts (a.k.a. Hudson Site)	229 South Schwamberger Road, Holland
	Griswold Landfill	10745 Old State Line Road, Swanton
	Holland Village Dump	Northwest Corner of Front St and Conrail Tracks
	International Mineral and Chemical	10401 Old State Line Road, Spencer Township
	Irwin Road Dump	809 South Irwin Road, Spencer Township
	Jennison-Wright Corporation	2332 Broadway Ave, Toledo(east of Toledo Zoo)
	Louie Street Dump	Louie Street at Swan Creek, Toledo
	NL Industries Bearings Division (a.k.a. Bunting, Brass, and Bronze, Inc., Eagle-Picher Bearings Co.)	715 Spencer Street, Toledo
	Ohio Air National Guard	at the Toledo Express Airport, Swanton
	Providence Township Dump	7349 and 7421 Manore Road, Providence Township
	Providence Township Dump	Between Schadel Road and Hertzfeld Road, Providence Township
	Spencer Township Dump (a.k.a. Eber Road Dump)	340 Eber Rd. - between Frankfort Rd. and the Tributary, Spencer Township
	Springfield-Monclova Township Dump (a.k.a. Reed Road Landfill)	Reed Rd, Swanton
	Swan Creek Landfill	north side of Glendale Road near Reynolds Road, Toledo
	Swanton Township Dump	on Manore Rd, North of Neapolis-Waterville Rd., Swanton Township
	Swanton Township Dump	North of Monclova Rd., East of Southern Rd., South of Route 295, and West of Spencer St., Swanton Township
	Webstrand Corporation	525 Hamilton St., Toledo
	Western Ave. Dump a.k.a. Swan Creek at Western Ave. Dump	1401-1463 Western Ave., Toledo
Shantee Creek	Dial Corporation	6120 N. Detroit Ave., Toledo
	General Motors Corp.	1455 W. Alexis Rd., Toledo
	NL Industries (a.k.a. Doehler-Jarvis Farley/Farley Metals, Inc.)	5400 N. Detroit Avenue, Toledo
Silver Creek	General Motors Corp.	1455 W. Alexis Rd., Toledo
	NL Industries (a.k.a. Doehler-Jarvis Farley/Farley Metals, Inc.)	5400 N. Detroit Avenue, Toledo
Driftmeyer Ditch	Heist Corporation (a.k.a. Colander, C.H. Heist Cleaning Services)	3804 Cedar Point Road, Oregon
Ward Canal	Jerusalem Township Dump	11670 State Route 2, Jerusalem Township

These substances may also enter ground water through soil infiltration. The principal infiltration concerns for watersheds are the entry of these contaminants into the food chain; bioaccumulation; toxic effects on aquatic organisms, other wildlife and microorganisms; habitat degradation; and degradation of water supplies. The concerns regarding ground water contamination are primarily from the impacts related to the degradation of drinking water supply sources.

Today's environmental regulations require any discharge to a waterway to be permitted. The tables below list general, industrial, and public National Pollutant Discharge Elimination System (NPDES) permitted point sources in the Maumee AOC.

Petroleum Corrective Action General Permits in the Maumee AOC[38]

Watershed	Facility
Amolsch Ditch	BP Gas Station #06824
Blue Creek	Former EMRO Propane
Crane Creek	Flying J Travel Center
Ottawa River	BP Gas Station #06793
	BP Gas Station #06850
	BP Gas Station #06725
	Speedway SuperAmerica # 3556
	Sterling Food Store #12
Packer Creek	BP Gas Station #16400
Shantee Creek	7-Eleven Inc Store # 19775
Swan Creek	Former Buckeye Pipeline – Right of Way

Non-Contact Cooling Water General Permits in the Maumee AOC[39]

Watershed	Facility
Cedar Creek	First Solar Inc
	DaimlerChrysler Toledo Machining Plant
Maumee River	Arbor Biodiesel Co LLC
Ottawa River	Fenner Nationwide Conveyor Belting
Shantee Creek	New Mather Metals Inc

Industrial and Public Permits in the Maumee AOC[40]

Watershed	Facility
Berger Ditch	Oregon WTP
Cedar Creek	Stoneco Inc Lime City Plant
Crane Creek	Wildflower Place Subdiv WWTP
	BP Amoco Oil Corp Bulk Plant Millbury
	Fuel Mart #641
	National Auto - Truckstop Inc
	Perrysburg Estate MHP
	Petro Stopping Center Inc No 17
	Pilot Travel Center LLC No 012
	Village Green
	Luther Home of Mercy
Driftmeyer Ditch	CITGO Petroleum Corp Toledo Terminal
	Marathon Ashland Petroleum LLC Oregon Terminal
Duck Creek	Toledo WTP
Grassy Creek	Southview Estates MHP
Heckman Ditch	Asphalt Materials Inc
Maumee Bay	BP Oil Co Toledo Refinery
	Oregon WWTP
	Toledo Edison Bay Shore Plant
Maumee River	Bowling Green WTP
	Country Manor Estates
	Maurer's MHP
	Perrysburg WWTP
	Pilkington North America Rossford Plt 6
	Consolidated Rail Corp Conrail Toledo Maint
	Libbey Glass Inc
	Paxton Recycling Operations
	Shell Oil Products US - Toledo Terminal
	Sun Co Inc R & M Marine Terminal
	Toledo Bay View Park WWTP
	Hanson Aggregates Midwest Inc-Waterville Quarry
	Maumee River WWTP
Ottawa River	DaimlerChrysler Corp Jeep Parkway Assembly Plant
	Fenner Dunlop Toledo LLC
	Hoffman Road Sanitary Landfill
	Perstorp Polyols Inc
	Textileather Corp
	EI Dupont de Nemours and Co Toledo Plant
Otter Creek	Evergreen Recycling & Disposal
	BP Oil Co Toledo Refinery
	Buckeye Pipe Line Co LP Toledo Station
	CSX Transportation Inc
	Envirosafe Services of Ohio
	TWO LLC Sunoco WWTP
	Pilkington North America E Broadway
	Toledo WTP
Packer Creek	Troy Energy LLC
Silver Creek	Browning-Ferris Industries of Ohio and Michigan
	GM Powertrain Group
	Remediation & Liability Mgmt Co
Swan Creek	StoneCo Inc Maumee Quarry
	US Dept of the Air Force 180 Fighter Group
Ten Mile Creek	Hanson Aggregates Sylvania Quarry
	Old Castle Materials - Sylvania Quarry
Toussaint Creek	Genoa WWTP
	Graymont Dolime OH Inc
	Luckey STP
	Uretech International Inc
	Eastwood Middle School
	Rocky Ridge Elem School
Turtle Creek	White Rock Quarry LP
	Stoneco Inc Rocky Ridge Quarry

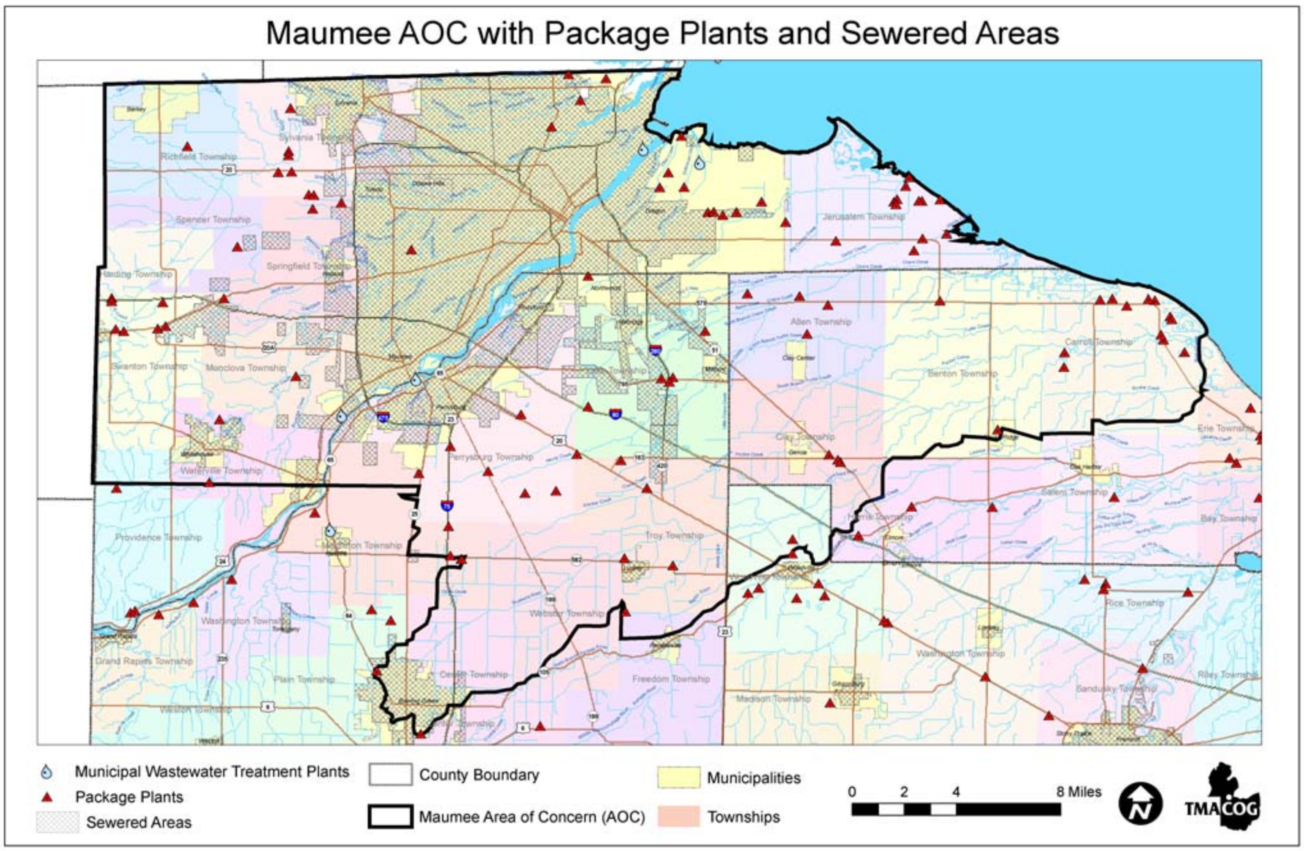
Bacteria

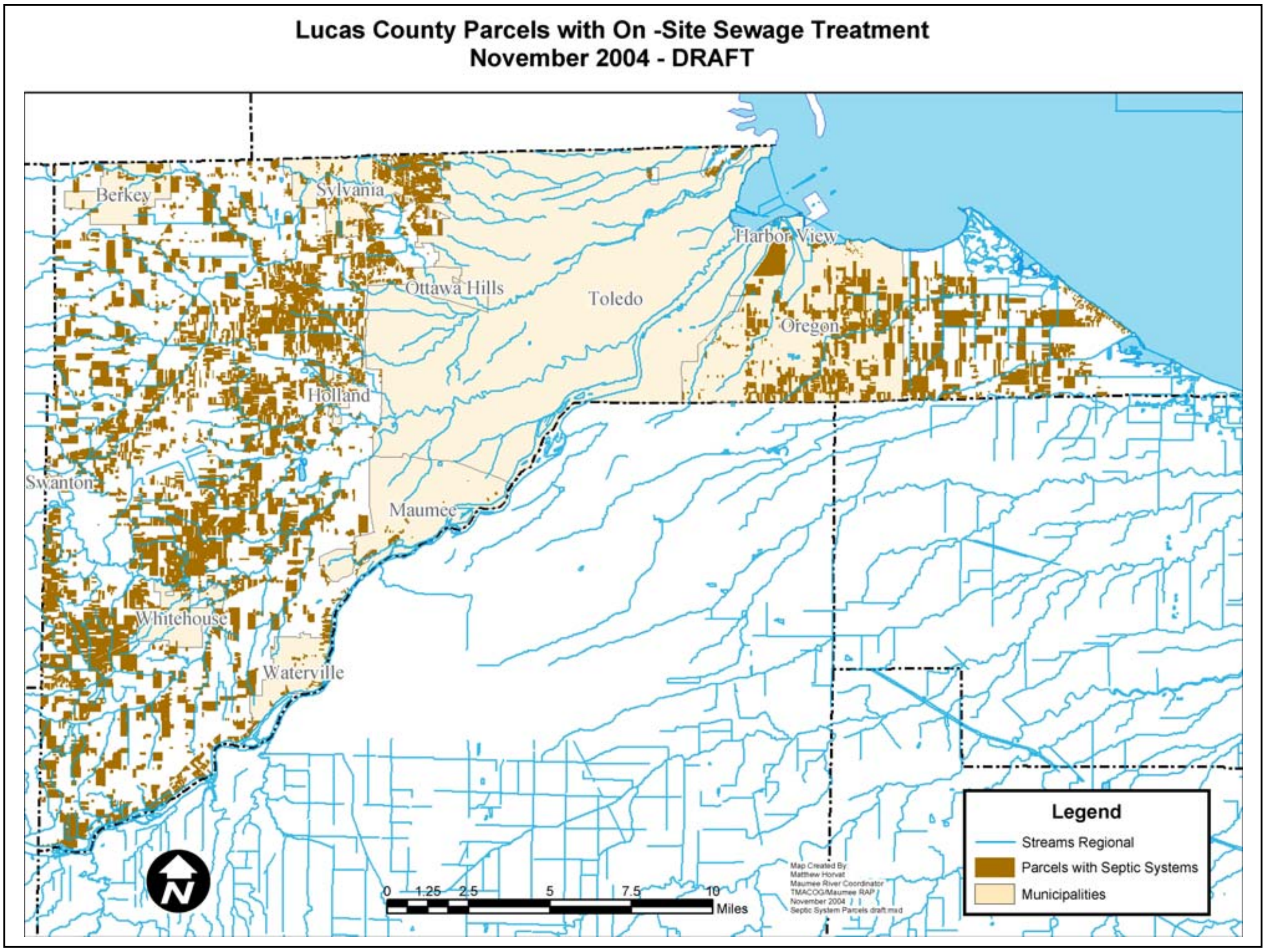
Fecal bacteria can carry a variety of disease organisms, including typhoid fever, cholera, dysentery, infectious hepatitis, and numerous others.[41] There were outbreaks of cholera in northwest Ohio before public sewerage systems came into use.[42] In terms of public health, fecal bacteria is the most critical pollutant. Waterborne disease can lead to sickness and death within days. Major outbreaks of these diseases are a thing of the past — a tribute to our public health and wastewater treatment systems.

The sources of fecal bacteria are birds, mammals, and humans. Sewage in water is detected by testing for “indicator” bacteria. One indicator group is called fecal coliform. These bacteria are present in sewage and contaminated water in far greater numbers than pathogens. As such, they are easier to detect, and demonstrate the presence of fecal matter. In recent years many regulatory agencies have begun using a test for a specific bacterium, *Escherichia coli* (*E. coli*).

In streams the presence of fecal coliform has documented the need for sewerage facilities to eliminate septic systems, package plants, sewer overflows, and to mandate improved sewage treatment. Despite these improvements, fecal bacteria counts often exceed standards at public beaches. This problem is not unique to the Maumee AOC; in fact, it is very common on beaches nationwide.

TMACOG created the map below to illustrate the location of package plants and wastewater treatment plants throughout the Maumee AOC. A similar map for septic systems is also being created under another TMACOG grant. The preliminary version is also below.





There are many possible sources of fecal bacteria, as noted above. Understanding what bacteria sources contaminate a given beach is complicated by the question of survival. Normally fecal bacteria do not survive long in a waterway. Studies of Maumee Bay and Wolf Creek in eastern Lucas County indicate *E. coli* accumulate in stream sediment, where they may survive for extended periods and be stirred up again by a later storm.[43] Further research is needed for a better understanding of the sources of fecal contamination, survival, and travel in Maumee Bay and the Lake Erie nearshore.

Bibliography

"208" *Areawide Water Quality Management Plan,* TMACOG, 2003-2004.

References

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[1] *2002 National Assessment Database: Assessing Water Quality Q&A*, US EPA web site at: http://www.epa.gov/waters/305b/assessing_quality.html.
[2] *National Water Quality Inventory for 2000 – Executive Summary,* US EPA. Available at: http://www.epa.gov/305b/2000report.
[3] *Environmental Baseline for Maumee Bay,* Pinsak, A.P. and T.L. Meyer, Great Lakes Basin Commission, Level B Study, p 11, 1976.
[4] *Soil Survey of Lucas County, Ohio*, US Dept of Agriculture Soil Conservation Service, June 1980.
[5] *Ohio Coastal Nonpoint Pollution Control Program Plan*, September 2000.
[6] *Sources of Pollution in Wisconsin Stormwater,* Bannerman, R.T., D.W. Owens, R.B. Dodds, and N.J. Hornewer, Water, Science and Technology vol. 28, no. 3-5, 1993.
[7] *Stormwater Strategies: Community Responses to Runoff Pollution*. Lehner, P.H., G.P.A. Clarke, D.M. Cameron, A.G. Frank. Natural Resources Defense Council. 269 pp 1999.
[8] *Urbanization of Streams: Studies of Hydrologic Impacts,* EPA 841-R-97-009, 1997.
[9] *The Importance of Imperviousness*. Watershed Protection Techniques, vol. 1, no. 3, Schueler, T.R., Fall 1994, pp100-111.
[10] *Flooding and Erosion Related to Urbanization: Swan Creek Watershed, Lucas County, Ohio,* Earthview Inc., April 1973.
[11] 64 Federal Register 235, December 1999.
[12] *Guidance specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, EPA 840/B-92/002, US Environmental Protection Agency, 1993.
[13] Dr. Jane Forsyth, Bowling Green State University, Professor Emeritus, Geology.
[14] *Initial Water Quality Management Plan: Maumee/Wabash River,* Ohio EPA, 1979.
[15] *The 2002 Ohio Agricultural Statistics and Ohio Department of Agriculture Annual Report*, Ohio Department of Agriculture, 2003. Available at: http://www.nass.usda.gov/oh/currbull.htm.
[16] *Status and Trends in Suspended-Sediment Discharges, Soil Erosion, and Conservation Tillage in the Maumee River Basin - Ohio, Michigan, and Indiana*; U.S. Department of the Interior U.S. Geological Survey Water-Resources Investigations Report 00-4091, 2000.
[17] *Trends in Water Quality in LEASEQ Rivers and Streams (Northwestern Ohio), 1975-1995,* Heidelberg College Water Quality Laboratory, R. Peter Richards and David B. Baker.
[18] Personal communication: Dr. Thomas B Bridgeman, Ph.D., University of Toledo Lake Erie Center, February 2004.
[19] *A Guide to Developing Local Watershed Action Plan in Ohio*, Ohio EPA, June 1997, pp 31-33.
[20] *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams,* Ohio EPA Technical Bulletin MAS/1999-1-1, 1999, pp 1-2.
[21] *Ohio Phosphorus Reduction Strategy for Lake Erie | Ohio Water Quality Management Plan,* Ohio EPA Office of The Planning Coordinator, June 1985, p 1.
[22] *Ohio Phosphorus Reduction Strategy for Lake Erie | Ohio Water Quality Management Plan,* Ohio EPA Office of The Planning Coordinator, June 1985, p 5.
[23] *Eleventh Biennial Report on Great Lakes Water Quality* International Joint Commission September 2002, pp 50-51.
[24] *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams,* Ohio EPA Technical Bulletin MAS/1999-1-1, 1999, pp 24.
[25] *Nitrate in Public Drinking Water* Fact Sheet, Ohio EPA, May 2002.
[26] *Nitrate in Public Drinking Water* Fact Sheet, Ohio EPA, May 2002.

[27] *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams*, Ohio EPA Technical Bulletin MAS/1999-1-1, 1999, pp 2, 29.

[28] "Trends in water quality in LEASEQ Rivers and Streams (Northwest Ohio), 1975-1995". *Journal of Environmental Quality* 31(1): 90-96 Richards and Baker. 2003. See also http://www.heidelberg.edu/WQL/publish.html.

[29] US EPA's website on pesticides provides many references and links: http://www.epa.gov/ebtpages/pesticides.html.

[30] *Ohio EPA Pesticide Special Study: May 1995 Through August 1998 Summary*, Ohio EPA 1998; posted of Ohio EPA website: http://www.epa.state.oh.us/ddagw/pestspst.html.

[31] *A Guide to Developing Local Watershed Action Plan in Ohio*, Ohio EPA, June 1997, pp 31-33.

[32] *Recreational Chart 14846 West End of Lake Erie*, US Dept of Commerce NOAA, 8th Edition, June 1991.

[33] Public Notice: Operation and Maintenance Dredging and Dredge Material Discharge, Toledo Harbor, US Army Corps of Engineers, September 2003.

[34] *The Results of a Sediment Trend Analysis in Maumee Bay, Lake Erie*, GeoSea Consulting, 2003.

[35] *Duck and Otter Creeks: The Watersheds, The Problems, and The Cleanup*, Maumee RAP Newsletter, January 1999.

[36] *Activities and Accomplishments in the Maumee Area of Concern (1991-2001)*, Maumee RAP, April 2002.

[37] *Activities and Accomplishments in the Maumee Area of Concern (1991-2001)*, Maumee RAP, April 2002.

[38] Ohio EPA GENTRAK data, extracted November 5, 2004.

[39] Ohio EPA GENTRAK data, extracted November 5, 2004.

[40] Ohio EPA SWIMS data, extracted October 29, 2004.

[41] *Water and Wastewater Engineering, Volume 2*, Fair, Geyer, and Okun, John Wiley & Sons, 1958; pp 19-4 through 19-9.

[42] One such outbreak is discussed in *An Historical Gazetteer of Wood County Ohio*, Lyle Rexford Fletcher, Emeritus Professor of Geography, Bowling Green State University, 1988, p 116.

[43] *Wolf Creek Bacterial Impact on Maumee Bay State Park Beach*, University of Toledo and TMACOG, June 2003.