Biological and Water Quality Study of the Middle Great Miami River and Principal Tributaries, 2009

Miami, Shelby, Montgomery, and Clark Counties

OHIO EPA Technical Report EAS/2012-1-2

Division of Surface Water
Ecological Assessment Section

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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (Ohio Administrative Code [OAC] 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data (OAC 3745-1-07, Table 7-15). Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents, the following new publications by the Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Ohio Environmental Protection Agency.2008a. Updates to Biological criteria for the protection of aquatic life: Volume II and Volume II Addendum. Users manual for biological field assessment of Ohio surface waters. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2008b. Updates to Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2006a. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Revised by the Midwest Biodiversity Institute for Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

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Copies of this report are located on the Ohio EPA internet web page (http://www.epa.ohio.gov/dsw/document_index/psdindx.aspx) or may be available on CD from:

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FOREWORD

What is a Biological and Water Quality Survey?
A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 4-5 watersheds study areas with an aggregate total of 350-400 sampling sites.

The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]) and Total Maximum Daily Load (TMDL) reports developed to address identified pollutants impairing Ohio waterbodies.

Hierarchy of Indicators
A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Figure A). The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination,

Administrative → True Environmental

LEVEL 1	Actions by EPA and States	NPDES Permit Issuance Compliance/Enforcement Pretreatment Program Actual Funding CSO Requirements Storm Water Permits 319 NPS Projects 404/401 Certification Stream/Riparian Protection
LEVEL 2	Responses by the Regulated Communitiy	POTW Construction Local Limits Storm Water Controls BMPs for NPS Control Pollution Prevention Measures
LEVEL 3	Changes in Discharge Quantities	Point Source Loadings - Effluent & Influent Whole Effluent Toxicity (WET) NPDES Violations Toxic Release Inventory Spills & Other Releases Fish Kills
LEVEL 4	Changes in Ambient Conditions	Water Column Chemistry Sediment Chemistry Habitat Quality Flow Regime
LEVEL 5	Changes in Uptake and/or Assimilation	Assimilative Capacity - TMDL/WLA Biomarkers Tissue Contamination
LEVEL 6	Changes in Health and Ecology, or Other Effects	Biota (Biocriteria) Bacterial Contamination Target Assemblages (RT&E, Declining Species)

Figure A. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition. Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Use

The Ohio Water Quality Standards (OAC 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Cold-water Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 $miles^2$ drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to meet either criterion the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g., E. coli)* and the criteria for each are specified in the Ohio WQS.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health and detailed in other documents.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria (Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The AWS and IWS use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.

MECHANISMS FOR WATER QUALITY IMPAIRMENT

The following paragraphs describe the various causes of impairment that were encountered during the middle Great Miami River study. While these perturbations are presented under separate headings, it is important to remember that they are often interrelated and cumulative in terms of the detrimental impact that can result.

Habitat and Flow Alterations

Habitat alteration, such as channelization, negatively impacts biological communities by limiting the complexity of living spaces available to aquatic organisms. Consequently, fish and macroinvertebrate communities are not as diverse. Indirect impacts include agricultural activities such as the removal of trees and shrubs adjacent to streams (described throughout this report as riparian vegetation) and field tiling to facilitate drainage. Urbanization impacts include removal of riparian trees, influx of stormwater run off, straightening and piping of stream channels, and riparian vegetation removal. Following a rain event, most of the water is quickly removed from tiled fields or urban settings rather than filtering through the soil, recharging groundwater, and reaching the stream at a lower volume and more sustained rate. As a result, small streams more frequently go dry or become intermittent.

Tree shade is important because it limits the energy input from the sun, moderates water temperature, and limits evaporation. Removal of the tree canopy further degrades conditions because it eliminates an important source of coarse organic matter essential for a balanced ecosystem. Riparian vegetation aids in nutrient uptake, may decrease run-off rate into streams, and helps keep soil in place. Erosion impacts channelized streams more severely due to the lack of a riparian buffer to slow runoff, trap sediment and stabilize banks. Deep trapezoidal channels lack a functioning flood plain and therefore cannot expel sediment as would occur during flood events along natural watercourses. Additionally, the confinement of flow within an artificially deep channel accelerates the movement of water downstream, exacerbating flooding of neighboring properties.

The lack of water movement under low flow conditions can exacerbate degradation from organic loading and nutrient enrichment by limiting reaeration of the stream. The amount of oxygen soluble in water decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion, but channelization eliminates turbulence produced by riffles, meanders, and debris snags. Plant photosynthesis produces oxygen, but at night, respiration reverses the process and consumes oxygen. Conversely, oxygen concentrations can become supersaturated during the day, due to abnormally high amounts of photosynthesis, causing gas bubble stress to both fish and invertebrate communities. Oxygen is also used by bacteria that consume dead organic matter. Nutrient enrichment promotes the growth of nuisance algae that subsequently dies and serves as food for bacteria. Under these conditions, oxygen can be depleted unless it is replenished from the air.

Siltation and Sedimentation

Whenever the natural flow regime is altered to facilitate drainage, increased amounts of sediment are likely to enter streams either by overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosional process. Channelization keeps all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and facilitated the removal of sediment from the primary stream channel no longer serve this function. As water levels fall following a rain event, interstitial spaces between larger rocks fill with sand and silt and the diversity of available habitat to support fish and macroinvertebrates is reduced. Silt also can clog the gills of both fish and macroinvertebrates, reduce visibility thereby excluding obligate site feeding fish species, and smother the nests of lithophilic fishes. Lithophilic spawning fish require clean substrates with interstitial voids in which to deposit eggs. Conversely, pioneering species benefit. They are generalists and best suited for exploiting disturbed and less heterogeneous habitats. The net result is a lower diversity of aquatic species compared with a typical warmwater stream with natural habitats.

Sediment also impacts water quality, recreation, and drinking water. Nutrients adsorbed to soil particles remain trapped in the watercourse. Likewise, bacteria, pathogens, and pesticides which also attach to suspended or bedload sediments become concentrated in waterways where the channel is functionally isolated from the landscape.

Nutrient Enrichment

The element of greatest concern is phosphorus because it is critical for plant growth and is often the limiting nutrient. The form that can be readily used by plants and therefore can stimulate nuisance algae blooms is orthophosphate (PO_4^{3-}). The amount of phosphorus tied up in the nucleic acids of food and waste is actually quite low. This organic material is eventually converted to orthophosphate by bacteria. The amount of orthophosphate contained in synthetic detergents is a great concern however. It was for this reason that the General Assembly of the State of Ohio enacted a law in 1990 to limit phosphorus content in household laundry detergents sold in the Lake Erie drainage basin to 0.5 % by weight. Inputs of phosphorus originate from both point and nonpoint sources. Most of the phosphorus discharged by point sources is soluble. Another characteristic of point sources is they have a continuous impact and are human in origin, for instance, effluents from municipal sewage treatment plants. The contribution from failed on-site wastewater treatment systems can also be significant, especially if they are concentrated in a small area. The phosphorus concentration in raw waste water is generally 8-10 mg/l and after secondary treatment is generally 4-6 mg/l. Further removal requires the added cost of chemical addition. The most common methods use the addition of lime or alum to form a precipitate, so most phosphorus (80%) ends up in the sludge.

A characteristic of phosphorus discharged by nonpoint sources is that the impact is intermittent and is most often associated with stormwater runoff. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion, although some comes from tile drainage. Phosphorus input from urban stormwater is more of a concern if combined sewer overflows are involved. Phosphorus loading from rural stormwater varies depending on land use and management practices and includes contributions from livestock feedlots and pastures and row crop agriculture. Crop fertilizer includes granular inorganic types and organic types such as manure or sewage sludge. Pasture land is especially a concern if the livestock have access to the stream. Large feedlots with manure storage lagoons create the potential for overflows and accidental spills. Land management is an issue because erosion is worse on streams without any riparian buffer zone to trap runoff. The impact is worse in streams that are channelized because they no longer have a functioning flood plain and cannot expel sediment during flooding. Oxygen levels must also be considered, because phosphorus is released from sediment at higher rates under anoxic conditions.

There is no numerical phosphorus criterion established in the Ohio Water Quality Standards, but there is a narrative criterion that states phosphorus should be limited to the extent necessary to prevent nuisance growths of algae and weeds (Administrative Code, 3745-1-04, Part E). Phosphorus loadings from large volume point source dischargers in the Lake Erie drainage basin are regulated by the National Pollutant Discharge Elimination System (NPDES). The permit limit is a concentration of 1.0 mg/l in final effluent. Research conducted by the Ohio EPA indicates that a significant correlation exists between phosphorus and the health of aquatic communities (Miltner and Rankin, 1998). It was concluded that biological community performance in headwater and wadeable streams was highest where phosphorus concentrations were lowest. It was also determined that the lowest phosphorus concentrations were associated with the highest quality habitats, supporting the notion that habitat is a critical component of stream function. The report recommends WWH criteria of 0.08 mg/l in headwater streams (<20 miles^2 watershed size), 0.10 mg/l in wadeable streams (>20-200 miles^2) and 0.17 mg/l in small rivers (>200-1000 miles^2).

Organic Enrichment and Low Dissolved Oxygen

The amount of oxygen soluble in water is low and it decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion. Drainage practices such as channelization eliminate turbulence produced by riffles, meanders, and debris snags. Although plant photosynthesis produces oxygen by day, it is consumed by the reverse process of respiration at night. Oxygen is also consumed by bacteria that decay organic matter, so it can be easily depleted unless it is replenished from the air. Sources of organic matter include poorly treated waste water, livestock waste, sewage bypasses, and dead plants and algae. Dissolved oxygen criteria are established in the Ohio Water Quality Standards to protect aquatic life. The minimum and average limits are tiered values and linked to use designations (Administrative Code 3745-1-07, Table 7-1).

Ammonia

Ammonia enters streams as a component of fertilizer and manure run-off and wastewater effluent. Ammonia gas (NH_3) readily dissolves in water to form the compound ammonium hydroxide (NH_4OH). In aquatic ecosystems an equilibrium is established as ammonia shifts from a gas to undissociated ammonium hydroxide to the dissociated ammonium ion (NH_4^{+1}). Under normal conditions (neutral pH 7 and 25°C) almost none of the total ammonia is present as gas, only 0.55% is present as ammonium hydroxide, and the rest is ammonium ion. Alkaline pH shifts the equation toward gaseous ammonia production, so the amount of ammonium hydroxide increases. This is important because while the ammonium ion is almost harmless to aquatic life, ammonium hydroxide is very toxic and can reduce growth and reproduction or cause mortality.

The concentration of ammonia in raw sewage is high, sometimes as much as 20-30 mg/l. Treatment to remove ammonia involves gaseous stripping to the atmosphere, biological nitrification and de-nitrification, and assimilation into plant and animal biomass. The nitrification process requires a long detention time and aerobic conditions like that provided in extended aeration wastewater treatment plants. Under these conditions, bacteria first convert ammonia to nitrite and then to nitrate. Nitrate can then be reduced by bacteria through the de-nitrification process and nitrogen gas and carbon dioxide are produced as by-products.

Ammonia criteria are established in the Ohio Water Quality Standards to protect aquatic life. The maximum and average limits are tiered values based on sample pH and temperature and linked to use designations (Administrative Code 3745-1-07, Tables 7-2 through 7-8).

Metals

Metals can be toxic to aquatic life and hazardous to human health. Although they are naturally occurring elements many are extensively used in manufacturing and are by-products of human activity. Certain metals like copper and zinc are essential in the human diet, but excessive levels are usually detrimental. Lead and mercury are of particular concern because they often trigger fish consumption advisories. Mercury is used in the production of chlorine gas and caustic soda and in the manufacture of batteries and fluorescent light bulbs. In the environment it forms inorganic salts, but bacteria convert these to methyl-mercury and this organic form builds up in the tissues of fish. Extended exposure can damage the brain, kidneys, and the developing fetus. The Ohio Department of Health (ODH) issued a statewide fish consumption advisory in 1997 advising women of child bearing age and children six and under not to eat more than one meal per week of any species of fish from waters of the state because of mercury. Lead is used in batteries, pipes, and paints and is emitted from burning fossil fuels. It affects the central nervous system and damages the kidneys and reproductive system. Copper is mined extensively and used to manufacture wire, sheet metal, and pipes. Ingesting large amounts can cause liver and kidney damage. Zinc is a by-product of mining, steel production, and coal burning and used in alloys such as brass and bronze. Ingesting large amounts can cause stomach cramps, nausea, and vomiting.

Metals criteria are established in the Ohio Water Quality Standards to protect human health, wildlife, and aquatic life. Three levels of aquatic life standards are established (Administrative Code 3745-1-07, Table 7-1) and limits for some elements are based on water hardness (Administrative Code 3745-1-07, Table 7-9). Human health and wildlife standards are linked to either the Lake Erie (Administrative Code 3745-1-33, Table 33-2) or Ohio River (Administrative Code 3745-1-34, Table 34-1) drainage basins. The drainage basins also have limits for additional elements not established elsewhere that are identified as Tier I and Tier II values.

Bacteria

High concentrations of either fecal coliform bacteria or *Escherichia coli* (*E. coli*) in a lake or stream may indicate contamination with human pathogens. People can be exposed to contaminated water while wading, swimming, and fishing. Fecal coliform bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may infect humans. This is especially a problem if the feces contained pathogens or disease producing bacteria and viruses. Reactions to exposure can range from an isolated illness such as skin rash, sore throat, or ear infection to a more serious wide spread epidemic. Some types of bacteria that are a concern include *Escherichia*, which cause diarrhea and urinary tract infections, *Salmonella*, which cause typhoid fever and gastroenteritis (food poisoning), and *Shigella*, which cause severe gastroenteritis or bacterial dysentery. Potential waterborne viruses that are a concern include polio, hepatitis A, and encephalitis. Disease causing parasitic microorganisms such as cryptosporidium and giardia are also a concern.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by on-lot wastewater treatment systems, are a more continuous problem. Bacterial contamination from combined sewer overflows are associated with wet weather events. Animal sources are usually more intermittent and are also associated with rainfall, except when domestic livestock have access to the water. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly as it may seep into field tiles or travel overland during precipitation events.

Bacteria criteria for the recreational use are established in the Ohio Water Quality Standards to protect human health. The maximum and average limits are tiered values and linked to use designation, but only apply during the May 1-October 15 recreation season (Administrative Code 3745-1-07, Table 7-13). The standards also state that streams must be free of any public health nuisance associated with raw or poorly treated sewage during dry weather conditions (Administrative Code 3745-1-04, Part F).

Sediment Contamination

Chemical quality of sediment is a concern because many pollutants bind strongly to soil particles and are persistent in the environment. Some of these compounds accumulate in the aquatic food chain and trigger fish consumption advisories, but others are simply a contact hazard because they can cause skin irritation, skin cancer and tumors. The physical and chemical nature of sediment is determined by local geology, land use, and contribution from manmade sources. As some materials enter the water column they are attracted to the surface electrical charges associated with suspended silt and clay particles. Others simply sink to the bottom due to their high specific gravity. Sediment layers form as suspended particles settle, accumulate, and combine with other organic and inorganic materials. Sediment is the most physically, chemically, and biologically reactive at the water interface because this is where it is affected by sunlight, current, wave action, and benthic organisms. Assessment of the chemical nature of this layer can be used to predict ecological impact.

Sediment chemistry results are evaluated by Ohio EPA using a dual approach, first by ranking relative concentrations based on a system developed by Ohio EPA (1996a) and then by determining the potential for toxicity based on guidelines developed by MacDonald et al (2000). The Ohio EPA system was derived from samples collected at ecoregional reference sites. Classes are grouped in ranges that are based on the median analytical value (non-elevated) plus 1 (slightly elevated), 2 (elevated), 4 (highly elevated), and 8 (extremely elevated) inter-quartile values. The MacDonald guidelines are consensus based using previously developed values. The system predicts that sediments below the threshold effect concentration (TEC) are absent of toxicity and those greater than the probable effect concentration (PEC) are toxic.

Sediment samples collected by the Ohio EPA are measured for a number of physical and chemical properties. Physical attributes included % particle size distribution (sand ≥60 µ, silt 5-59 µ, clay ≤4 µ), % solids, and % organic carbon. Due to the dynamics of flowing water, most natural streams in Central Ohio do not contain a lot of fine grained sediment and samples often consist mostly of sand. Fine grained sediments are deposited in flood plains of natural streams during periods of high flow. This scenario changes if the stream is impounded by a dam or channelized. Chemical attributes included metals, volatile and semi-volatile organic compounds, pesticides, and poly-chlorinated biphenyls (PCBs)

Biological and Water Quality Study of the Middle Great Miami River and Principal Tributaries

Miami, Shelby, Montgomery, and Clark Counties

INTRODUCTION

As part of the Total Maximum Daily Load (TMDL) process, an intensive ambient assessment of the middle Great Miami River watershed was conducted by the Ohio EPA during the 2009 field sampling season. The study area included the entire length of the Great Miami River (from Sidney to Dayton), principal tributaries, and all remaining minor conveyances possessing a drainage area of at least eight square miles. A total of 57 stations were sampled throughout the catchment, evaluating 22 named and unnamed streams. Ambient biology, macrohabitat quality, water column chemistry, and bacterial data were gathered from most locations. Diel water quality (DO, pH, conductivity, and temperature), and sediment chemistry (metals, organics, and particle size) were evaluated at selected stations. Cumulatively, 137 linear stream miles of the watershed were surveyed and assessed.

A station list was derived from a systematic census of the watershed, based upon drainage area. This method has proved rapid and efficient in generating an objective and comprehensive collection of potential sampling sites where an assessment of an entire catchment is desired. However, an unavoidable consequence of this method includes substantial data gaps in lower or larger stream segments. It was therefore necessary to target directly these higher order segments (or tributaries) to ensure an even distribution of sampling effort. Ohio EPA sampling resources were also allocated to evaluate public and private NPDES permitted entities. Lastly, areas that have been previously sampled and evaluated by the Ohio EPA were revisited for the purposes of trends assessment.

Specific sampling objectives included the following:

1) Systematically sample and assess the main stem and principal drainage network of the middle Great Miami River in support of the TMDL process,

2) Gather ambient environmental information (biological, chemical, and physical) from undesignated water bodies to objectively prescribe an appropriate suite of beneficial uses (e.g., aquatic life, recreation, water supply),

3) Verify the appropriateness of existing but unverified beneficial use designations, and recommend changes where appropriate,

4) Establish baseline ambient biological conditions at selected stations to evaluate the effectiveness of existing and future pollution abatement efforts,

5) Evaluate Wastewater Treatment Plants (WWTPs) and other NPDES permitted entities within the study area, and

6) Document any changes in the biological, chemical, and physical conditions of the study areas where historical information exists, thus expanding the Ohio EPA data base for statewide trends analysis.

Components of the TMDL process supported by this survey are principally the identification of impaired waters, verification (and redesignation if necessary) of beneficial use designations, gathering ambient information that will factor into the wasteload allocation, ascribing causes and sources of use impairment, and the derivation of basin specific pollutant loading goals or restoration targets for impaired waters. These data are necessary precursors to the development of effective pollution control or abatement strategies.

The reporting structure for the results contained within the following summary takes two basic forms: cumulative statistics for waters surveyed and assessed as part of the 2009 study area and linear, longitudinal or other spatial evaluations of selected named streams or subbasins where appropriate. These reporting structures serve multiple and important purposes. Cumulative catchment statistics provide a concise and efficient way to summarize status, condition, and principal causes and sources where use impairment is identified. However, an equally important consideration is the ease at which the results of State sponsored water resource surveys are communicated to the various publics with direct or indirect interest in the status and condition of waters of the State. Outside of resource specialists, aggregated statistics regarding the status of surface waters lack the specificity anticipated by the many publics served by Ohio EPA. End users of these consolidated data (entire watershed, subbasin, HUC, etc.) find it difficult to quickly extract information regarding a specific water body in which they may have a particular interest. Named linear wetted channels, namely brooks, streams and rivers exist not only on the landscape but also in the mind of the public. Therefore, to encourage interest in and conservation of all waters of the state, and to ensure that data gathered through public sponsored water surveys are informative, discrete named rivers, streams, or stream segments are treated narratively within summaries provided below as well as in the body of this document.

SUMMARY

Aquatic Life Use Attainment

Of the 137 linear stream miles of the middle Great Miami watershed surveyed and assessed in 2009, 128.1 miles (93.5%) were found to fully support existing and recommended aquatic life uses. Partial use attainment was indicated for 8.9 miles (6.5%). Wholly impaired waters (non-attainment) were nowhere observed. It is important to emphasize that aquatic life use impairment was limited to segments of only four of the 22 waterbodies evaluated in 2009. The vast and overwhelming majority of monitoring stations were found to support diverse and well organized assemblages of fish and benthic macroinvertebrates, possessing high taxa richness (including a high proportion of environmentally sensitive forms), a high degree of functional and structural organization, and a very low incidence of disease or other anomalies commonly associated with degraded or otherwise substandard water quality. In terms of aquatic life use attainment, the middle Great Miami River catchment stands as one of the most intact in Ohio. A detailed list of waters assessed as part of this survey, performance of community and habitat indices (by station, reach, or subbasin) and aquatic life attainment status for the middle Great Miami River watershed are presented in Table 1 and Figures 1 and 2.

Of the 8.9 impaired miles, aggregated causes of aquatic life impairment were, natural or sundry background conditions (45.3%), ammonia-N (30.8%), nutrient enrichment (17.1%) and sedimentation (6.8%). Associated aggregate sources of impairment included, natural or background sources (41.3%), major WWTPs (33.0%), impoundment (downstream effects, 18.3%), and channelization (7.4%). Selected impaired waterbodies were affected by multiple or a combination of these causes and sources.

Specifically, departures from the applicable biological criteria were indicted for segments of the Great Miami River (3.6 miles), upper Mosquito Creek, (2.0 miles), upper Rush Creek (2.5 miles), and lower Honey Creek (0.8 miles). As the magnitude and scope, and associated causes and sources, of aquatic life use impairment identified on these waterbodies varied, the environmental conditions of each impacted segment are summarized below.

Aquatic life use impairment on the Great Miami River was indicated for a 3.6 mile reach beginning immediately downstream from Tri-Cities North Regional Wastewater Authority WWTP. The magnitude and extent of the impact was modest (partial attainment) and was delineated by the macrobenthos alone, as fish community performance remained well within the exceptional range. Water quality monitoring found ammonia-N elevated through this reach, with maximum values approaching 0.5 mg/l. While not a Water Quality Standards (WQS) criterion violation, this value is nearly an order of magnitude greater than background levels. Operating reports from Tri-Cities indicate that nearly half of all NPDES violations reported over the past four years were for ammonia-N, and fully half of those occurred in 2009. Treatment irregularities respecting ammonia-N were attributed to operation issues, rather than plant capacity or other structural deficiencies. Furthermore, results from the previous biosurvey of the middle Great Miami in 1994 found nearly identical conditions downstream from the facility, only at that time it was managed by Miami Conservancy District. Given the multiple lines of evidence (historical results, contemporary ambient biology and chemistry, and supporting operational information), the area of partial attainment downstream from Tri-Cities WWTP appeared a result of low level, chronic ammonia toxicity.

Partial attainment of the WWH biocriteria was indicated for the upper limits of Mosquito Creek, an indirect Great Miami tributary, contained within the Tawawa Creek subbasin. The affected reach began immediately downstream from Kaiser Lake, a modest impoundment on Mosquito Creek's headwaters, and extended downstream for a distance of two miles. Aquatic life use impairment was delineated by the macrobenthos alone, but ambient

Table 1. Aquatic Life use attainment from the middle Great Miami River basin, 2009.

River Miles Fish/Invert.	IBI	Miwb[1]	ICI[a]	QHEI	Landmark	Attainment Status[b]	Cause(s)[g]	Source(s)[g]
Great Miami River (14-001) 2009								
Eastern Corn Belt Plains (ECBP) - EWH Aquatic Life Use Designation (Existing)[d]								
130.0[B,c,R]	56	10.2	46	70.0	SR 47, North St.	FULL		
127.7[B]	59	10.4	44[ns]	79.0	Dst. Sidney WWTP	FULL		
123.9[B]	57	9.8	50	73.5	Kuther Rd.	FULL		
120.0[W]	54	10.3	44[ns]	83.0	Locking Ham Rd.	FULL		
117.5[B]/118.5[R]	57	10.2	52	70.0	Adj. SR 66	FULL		
Eastern Corn Belt Plains (ECBP) - WWH/EWH Aquatic Life Use Designation (Existing/Recommended)[d]								
115.4[B]	58	10.5	52	76.5	ust. Piqua Dam	FULL		
Eastern Corn Belt Plains (ECBP) - EWH Aquatic Life Use Designation (Existing)[d]								
114.0[B]/114.1	54	10.2	48	74.0	Dst. Piqua Dam	FULL		
112.4[B]/112.3	54	10.8	54	80.0	Peterson Rd.	FULL		
110.1[B,c]	56	10.0	52	76.0	Eldean Rd.	FULL		
106.0[B]/106.1[R]	52	10.3	44[ns]	70.5	SR 41	FULL		
104.7[B]/104.3	53	10.3	48	83.0	Dst. Troy WWTP	FULL		
100.8[B,R]	53	10.4	44[ns]	88.0	Tipp-Elizabeth Rd.	FULL		
98.5[B,c]	54	10.2	52	89.5	SR 571	FULL		
95.6[B]/95.7	54	10.6	46	80.5	Ross Rd.	FULL		
92.5[B]/93.1	54	10.2	48	78.5	Dst. Taylorsville Dam (flow-thru)	FULL		
88.7[B]	53	10.2	42[ns]	86.0	Rip-Rap Rd.	FULL		
87.0[B]/87.7	54	10.1	44[ns]	76.0	Ust. Tri-Cities WWTP	FULL		
85.9[B]/85.8	52	10.8	38*	70.5	Dst. Tri-Cities WWTP	PARTIAL	**Ammonia** (modest toxicity)	**Major WWTP** (Tri-Cities WWTP)
Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)								
81.6[B]/82.1	58	10.7	MG[ns]	64.0	Ust. Mad River/dst. Loramie Creek	FULL		

Table 1. continued.

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Landmark	Attainment Status[b]	Cause(s)[g]	Source(s)[g]
Tawawa Creek (14-060)2009								
				Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)				
1.2[W]	57	9.8	50	74.5	At Tawawa Park	FULL		
Mosquito Creek (14-061)2009								
				Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)				
7.8[H]/7.7	46	NA	F*	47.0	Dst Kaiser Lake	PARTIAL	**Rheopalustrine** ▪ Elevated ammonia-N **Nutrient Enrichment** ▪ Low DO	**Natural** ▪ Former swamp stream **Natural/Structural** ▪ Plankton export from Kaiser Lake dam pool.
1.0[W]	45	8.5	46	63.5	McCloskey School Rd.	FULL		
Leatherwood Creek (14-062)2009								
				Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)				
6.4 [H]	48	NA	MG[ns]	55.0	Suber Rd.	FULL		
3.3[H]	56	NA	G	65.5	Sidney-Plattsville Rd.	FULL		
1.2[H]	51	NA	48	74.5	McCloskey School Rd.	FULL		
Mill Branch (14-058)2009								
				Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)				
0.3[H]	48	NA	VG	83.0	Kuther Rd.	FULL		
Rush Creek (14-052)2009								
				Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)				
5.3[H]	34*	NA	MG[ns]	55.5	Vandermark Rd.	PARTIAL	**Transitional Segment (PHW- HW)** ▪ Pethodontid salamanders abundant and pioneering fish taxa dominant, both indicating intermittent/interstitial and associated structural limitations.	**Natural**
1.7[H]	46	NA	G	61.5	Hetzler Rd.	FULL		

Table 1. continued.

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Landmark	Attainment Status[b]	Cause(s)[g]	Source(s)[g]
Rush Creek (14-052)2009								
Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)								
0.3[H]	44	NA	VG	63.5	North Dixie Dr.	FULL		
Spring Creek (14-050) 2009								
Eastern Corn Belt Plains (ECBP) - EWH Aquatic Life Use Designation (Existing)								
8.4[H]	52	NA	E	79.0	SR 36	FULL		
3.5[W]	50	9.4	48	74.0	Rusk Rd.	FULL		
0.8[W]	53	9.1[ns]	44[ns]	72.5	Troy-Piqua Rd.	FULL		
Boone Creek (14-097)2009								
Eastern Corn Belt Plains (ECBP) - Undesignated/WWH Aquatic Life Use Designation (Existing/Recommended)								
- /0.3	-	-	G	-		NA		
0.1[W]	50	8.6	VG	73.5	At mouth	FULL		
Peters Creek (14-096)2009								
Eastern Corn Belt Plains (ECBP) - Undesignated/WWH Aquatic Life Use Designation (Existing/Recommended)								
0.2[H]	46	NA	G	65.0	Dixie Rd/Old US 25	FULL		
Lost Creek (14-048)2009								
Eastern Corn Belt Plains (ECBP) - EWH/WWH Aquatic Life Use Designation (Existing/Recommended)								
11.7[H]	52	NA	VG	65.0	Peterson Rd.	FULL	Note: historical data not consistent with EWH	
Eastern Corn Belt Plains (ECBP) - EWH/CWH Aquatic Life Use Designation (Existing/Recommended)								
9.8[W]	50	8.7	VG	78.5	Troy-Urbana Rd.	FULL	CWH ratio[f]: 1/6, Temp: 17.1-21.9 C	
4.3[W]	42	8.9	54	65.5	Knoop Rd.	FULL	CWH ratio[f]:1/4, Temp: 15.9-20.5 C	
Eastern Corn Belt Plains (ECBP) - EWH/WWH Aquatic Life Use Designation (Existing/Recommended)								
0.4[W]	46	8.1[ns]	42	59.5	Tipp-Elizabeth Rd.	FULL	Note: losing stream at mouth	
West Branch Lost Creek (14-278)2009								
Eastern Corn Belt Plains (ECBP) - Unlisted/WWH Aquatic Life Use Designation (Existing/Recommended)								
0.5[H]	58	NA	VG	67.5	US 36	FULL		

Table 1. continued.

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Landmark	Attainment Status[b]	Cause(s)[g]	Source(s)[g]
East Branch Lost Creek (14-049)2009								
Eastern Corn Belt Plains (ECBP) - EWH/WWH Aquatic Life Use Designation (Existing/Recommended)								
6.4[H]	56	NA	E	77.0	Sodom-Ballou Rd.	FULL	Note:1999 results not consistent with EWH	
5.2[H]	48	NA	VG	77.5	Burr Oak Rd.	FULL		
Eastern Corn Belt Plains (ECBP) - EWH/CWH Aquatic Life Use Designation (Existing/Recommended)								
0.7[H]	52	NA	E	64.0	Peterson Rd.	FULL	CWH ratio[f]: 1/6, Temp. 17.9-21.4 C	
Middle Branch Lost Creek (14-277)2009								
Eastern Corn Belt Plains (ECBP) - Unlisted/WWH Aquatic Life Use Designation (Existing/Recommended)								
1.2[H]	58	NA	42	71.0	SR 589	FULL		
Little Lost Creek (14-276)2009								
Eastern Corn Belt Plains (ECBP) - Unlisted/E-CWH[e] Aquatic Life Use Designation (Existing/Recommended)								
0.3[H]	56	NA	48	64.5	Casstown Rd.	FULL	CWH ratio[f]: 1/7, Temp. 16.4-20.7 C	
Honey Creek (14-043)2009								
Eastern Corn Belt Plains (ECBP) - EWH/WWH Aquatic Life Use Designation (Existing/Recommended								
9.9[W]	45	8.5	52	64.5	Ust. New Carlisle WWTP	FULL		
8.1[W]	42	8.8	38	73.5	Dst. New Carlisle WWTP	FULL		
Eastern Corn Belt Plains (ECBP) - EWH Aquatic Life Use Designation (Existing)								
3.2[W]	52	10.4	54	74.0	Rudy Rd.	FULL		
0.8[W]	44*	10.3	46	57.5	SR 202	PARTIAL	**Sedimentation** (non-silt) ▪ Shifting and unstable sand bed load, likely a product of original channel incision, native upland and alluvial bed material, and reduced gradient as Honey Creek enters the greater GMR valley.	**Channel Modification** (historical) **Natural/Structural**
Pleasant Run (14-275)2009								
Eastern Corn Belt Plains (ECBP) - Unlisted/E-CWH[e] Aquatic Life Use Designation (Existing/Recommended)								
0.5[H]	54	NA	E	76.5	Rudy Rd.	FULL	CWH ratio[f]: 1/5, Temp: 17.8-20.5 C	

Table 1. continued.

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Landmark	Attainment Status[b]	Cause(s)[g]	Source(s)[g]
East Fork Honey Creek (14-047)2009								
					Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life Use Designation (Existing)			
5.9[H]	48	NA	MG[ns]	58.0	Ayres Rd.	FULL		
3.6[H]	42	NA	G	47.0	St. Paris Rd.	FULL		
- /1.6	-	-	E	-	Sigler Rd.	NA		
0.1[H]	56	NA	54	74.0	At Mouth	FULL		
West Fork Honey Creek (14-046)2009								
					Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life us Designation (Existing)			
1.3[H]	46	NA	VG	57.0	SR 235	FULL		
0.1[W]	50	9.3	52	77.0	At Mouth	FULL		
Indian Creek (14-044)2009								
					Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life us Designation (Existing)			
4.9[H]	52	NA	E	81.0	Walnut Grove Rd.	FULL		
					Eastern Corn Belt Plains (ECBP) - WWH/CWH Aquatic Life us Designation (Existing/Recommended)			
- /1.5	-	-	56	-	SR 201	(FULL)	CWH ratio[f]: - /6, Temp: 18.0-20.6 C	
0.1[W]	46	9.2	E	82.0	At mouth	FULL	CWH ratio[f]: 2/5, Temp: 16.7-19.1 C	
Dry Creek (14-045)2009								
					Eastern Corn Belt Plains (ECBP) - WWH Aquatic Life us Designation (Existing)			
1.2[H]	40	NA	G	29.5	Walnut Grove Rd.	FULL	Note: Strong ground water influence mitigated habitat deficit.	

Table 1. continued.

H - Headwaters: sites draining areas ≤20 miles^2.
W - Wadable streams: sites draining areas > 20 miles^2.
B - Boat sites (large waters).
R - Ecoregional Reference Site.
1 - MIwb not applicable for waters draining <20 miles^2.
a - ICI narrative equivalent derived from qualitative assessment (E-exceptional, VG-very good, G-good, MG-marginally good, F-fair, LF-low fair, P-Poor).
b - Attainment status derived from one organism group is parenthetically expressed.
c - Stations so identified are assessed through ambient biological samples collected as part of the upper Great River survey, 2008.
d - Although not indicated within the body of this table, small segments of the middle Great Miami River main stem are designated WWH. Reaches so identified correspond to selected dam pools through the cities of Sidney, Piqua and Troy.
e - Dual aquatic life use water bodies identified as Exceptional Coldwater Habitat (E-CWH), where both CWH and EWH criteria apply.
f - Ratio of cool water fish taxa and macroinvertebrate taxa.
g - Categorical Causes and Sources of aquatic life use impairment are listed in bold. Indicators, other lines of evidence, abbreviated rationale, or general comments are summarized below each Cause and Source.
ns - Non-significant departure from the biocriteria (≤4 IBI and ICI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI and ICI units or >0.5 MIwb units). Poor to very poor results are underlined.

Ecoregional Biocriteria (OAC 3745-1-07, Table 7-15)

Eastern Corn Belt Plain (ECBP) Ecoregion

Index-Site Type	WWH	EWH	MWH[h]
IBI-Headwater/Wading	**40**	**50**	**24**
MIwb-Wading	**8.4**	**9.4**	**6.2**
IBI-Boat	**42**	**48**	**24**
MIwb-Boat	**8.2**	**9.6**	**5.8**
ICI	**36**	**46**	**22**

h - Modified WWH (MWH) for eligible channel modified or impounded waters.

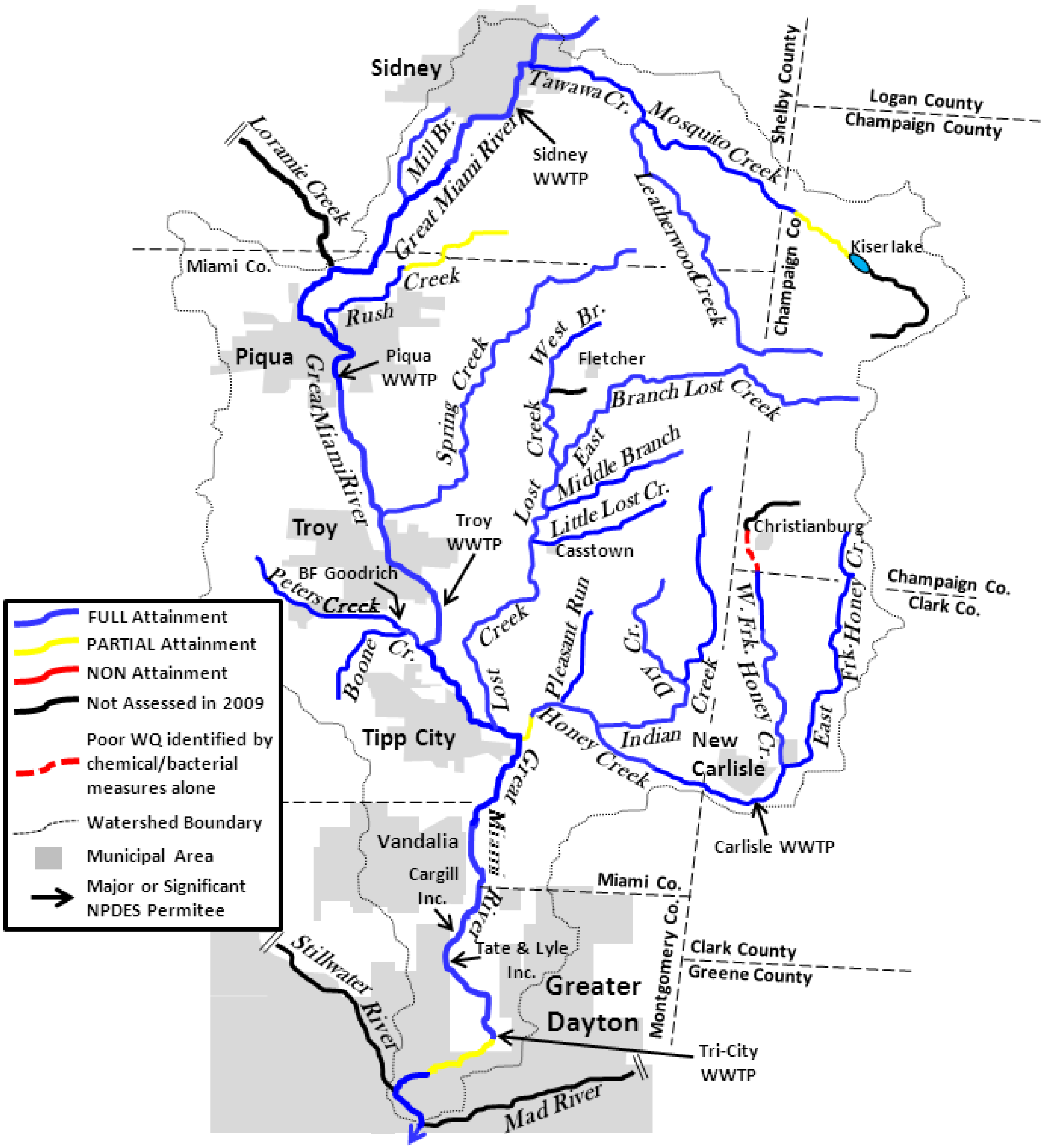


Figure 1. Map of surface waters of the middle Great Miami River study area, color coded to attainment status of existing and recommended aquatic life use designation, 2009.

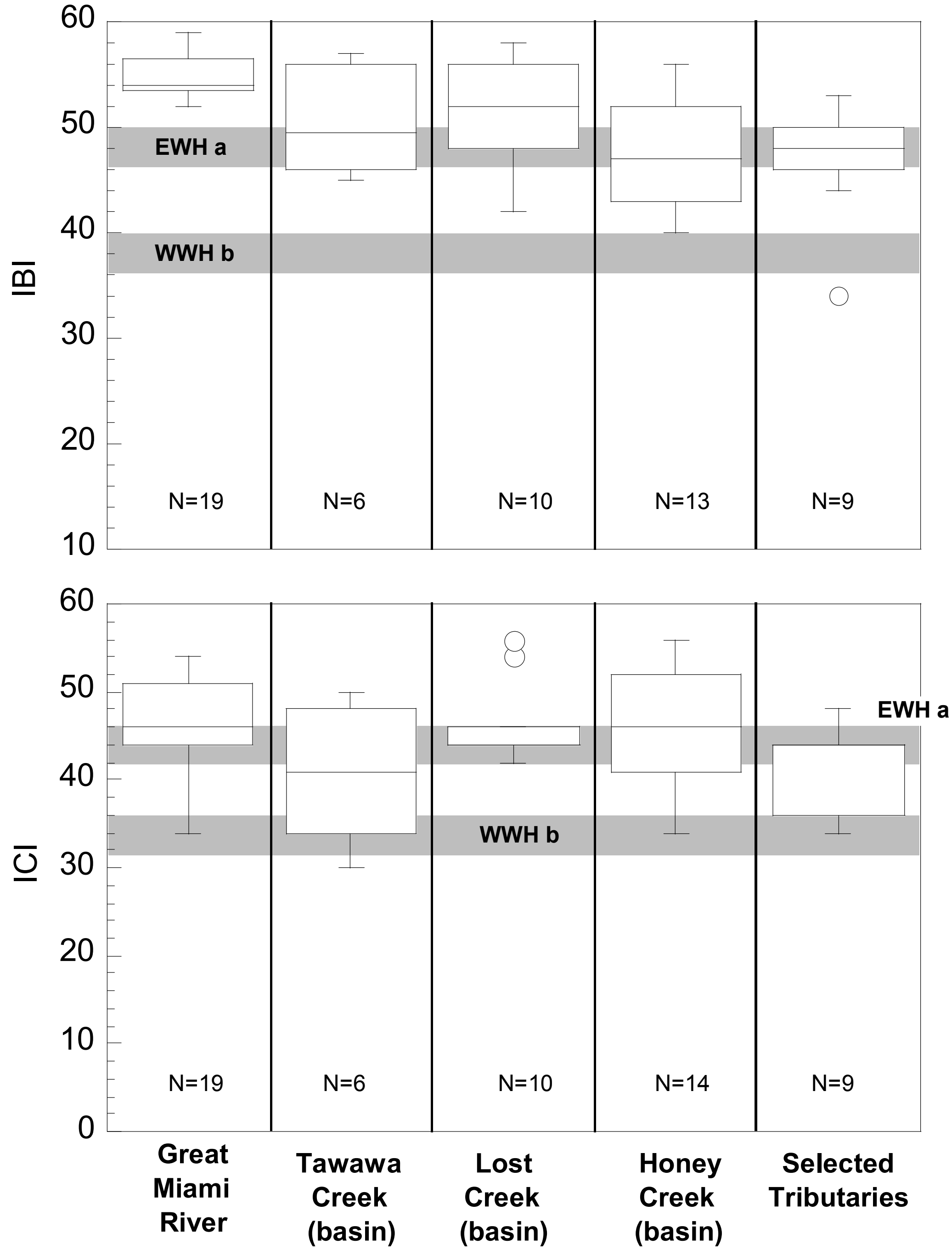


Figure 2. Aggregated performance of the IBI (upper) and ICI (lower) from the Great Miami main stem, associated subbasins, and selected tributaries, 2009. Shaded bars, *a* and *b*, represent associated EWH and WWH biocriteria, respectively.

water column chemistry, local physiography, and field observations provided important lines of evidence in determining associated causes and sources of impairment. Specifically, upper Mosquito Creek appeared affected by the combination of near-field reservoir effects, stimulatory in nature, resulting from the export of plankton rich water (functionally particulate phosphorus) from the photic layer of Kaiser Lake, and residual limiting effects of rheopalustrine or wetland habitats, these associated with post glacial peat deposits that correspond to the affected reach. Here, nutrients, particularly phosphorus, were elevated and exceeded reference target values. These results stood in contrast to all other waters evaluated within the Tawawa Creek subbasin, where nutrients were at or near background levels. Ammonia-N was also elevated and likely had as its source the chemically reduced, relic or partially drained wetlands through which upper Mosquito Creek flows. The anoxic summer hypolimnion of Kaiser Lake was excluded as a possible source of ammonia-N because it is a top release reservoir. A depressed DO regime was also identified and could be attributed to either diel DO flux associated stimulated productivity or wetland influences, or both. The innate limitations of rheopalustrine habitats, relative to riverine water quality criteria, and the deleterious near-field effects of impoundments are well documented in Ohio. Thus, steams so affected are viewed as being impaired by natural/structural causes and sources.

Aquatic life use impairment on Rush Creek was limited to the upper 2.5 miles. As observed elsewhere in the study area, the magnitude of the impairment was very modest, and manifested in the fish assemblage alone. A combination of direct field observations and analysis of the functional organization of the fish assemblage strongly suggested that the segment of upper Rush Creek represented a transitional cline between primary headwaters and standard headwaters. Key indicators supporting this conclusion included an abundance of pethodontid salamanders, dominance of pioneering fish taxa, overall good water quality (no violations or exceedences of the WQS criteria or target reference values), and adequate macrohabitat quality. Pethodontids typical occupy upper trophic levels of small waters only in the absence of an organized resident fish assemblage. Fish communities dominated by pioneering species are typically associated with ephemerality or indicate a waterbody recovering from an event, natural or anthropogenic, that effectively depopulated the stream. Pioneering fish taxa are the first species to reinvade areas previously rendered inhospitable. In the absence of pethodontids, the structure of the fish community would have suggested that upper Rush Creek labored under the consequences of a fish kill, periodic dewatering, or other episodic stress. However, the simultaneous occurrence of plethodontids, pioneering fish taxa, good chemical water quality, and adequate macrohabitat indicate that the flow regime of upper Rush Creek is not likely compatible with a persistent WWH fish community. Given its apparent transitional nature, consecutive monitoring over the course of several years would likely find upper Rush Creek swinging in and out of minimum WWH attainment, depending upon the season's hydrology. Draining 7.2 miles^2, upper Rush Creek is not an ideal or otherwise eligible candidate for primary headwater designation; rather, failure here to support a WWH fish community is best ascribed to natural or structural limitations.

Aquatic life impairment identified on Honey Creek was limited to the lower 0.8 miles. The magnitude of the impairment was not great, as only one of the three biometrics failed to meet the requisite benchmark. Specifically, the IBI missed the EWH criterion by only two points, while both the MIwb and ICI easily met or exceeded their respective criteria. Minor departure of the IBI from the associated biocriterion was a result of an increase in the proportion of environmentally tolerant and ecological generalist fish taxa. Given the exceptional condition of aquatic communities upstream at Rudy Rd. (RM 3.2), it is doubtful that the effects of the wasteload (treated or otherwise) from the New Carlisle, located further upstream, served as the primary causal agent. Furthermore, stations on upstream tributaries (Indian Creek and Pleasant Run) supported good to excellent biological assemblages and good water quality. The shift to a more generalized fish community appeared a response to previous channelization and locally reduced gradient. Lower stream power attendant to low gradient waters affects nearly every aspect of the fluvial processes responsible for channel formation and maintenance, and can serve to protract the natural recovery of previously channelized waterbodies. Detrimental aspects of this that were most readily discernible through lower Honey Creek included a dominance of finer substrates (sand and pea gravel) and low energy channel form. Inherently unstable and lacking the macrointerstices common to coarser bed material, an overabundance of sandy substrates can serve as a significant limiting factor. Although much natural recovery was evident within the wetted channel, macrohabitat quality of lower Honey Creek was well below that commonly associated with exceptional streams. Respecting aquatic life use impairment, the combination of past channelization and the overarching natural factors described above appeared the primary determinants.

In addition to physical limitations, chemical water quality monitoring on lower Honey Creek found ammonia-N levels elevated, with maximum values approaching 0.1 mg/l (nearly twice background concentrations). The source of ammonia is not clear at this time. Upstream sources were not apparent, as the adjacent upstream station (Rudy Rd.), as well as stations on upstream tributaries yielded ammonia-N concentrations at or very near background levels. Many portions of the Honey Creek catchment are approved for the application of sludge (class B farmlands) including areas adjacent to the lower mile, but most active application areas are concentrated in the headwaters. Regardless of the source, the very modest nature of the use impairment, manifested exclusively in a single fish community index, would suggest that the effects of elevated ammonia-N were best secondary or very likely tertiary in nature.

Water Quality and Recreational Use Attainment

Water quality throughout the middle Great Miami River watershed was generally good. Exceedences of water quality criteria were few and typically consisted of low dissolved oxygen at a few tributary sites. Ammonia-N concentrations, while low throughout much of the watershed, were elevated above reference values near the unsewered community of Christiansburg in the upper reaches of West Fork Honey Creek and in Mosquito Creek downstream from Kaiser Lake. Total phosphorus levels were elevated throughout much of the watershed, especially in the main stem and in the Honey Creek subwatershed. Overall, 88% of main stem sites (15 of 17) and 26% of tributary sites (11 of 42) had median phosphorus concentrations above target reference levels. Nitrate-nitrite-N concentrations were also elevated in both the Honey Creek and Lost Creek sub watersheds. Elevated nutrient levels in the middle Great Miami River watershed are attributable to both WWTPs and agricultural sources. Additionally, for the 15 sites (eight in the main stem) sampled for organic parameters, a total of nine compounds were detected with the plasticizer bis(2-Ethylhexyl)phthalate and the herbicide atrazine, detected in 82% and 69% of the samples, respectively.

Recreational water quality as measured by elevated *E. coli* bacteria levels was mixed. Evaluation of *E. coli* results revealed that 17 of the 27 locations (63%) sampled failed to attain the applicable geometric mean criterion, indicating an impairment of the recreation use at these locations. Agriculture, the predominant land use in the watershed, was a suspected source of contamination at most of the impaired sites.

Aquatic Life Use Attainment Trends Summary
Multiple data sets were available to assess ambient biological performance in the middle Great Miami River watershed through time. The entire length of the main stem and selected tributaries have been assessed by Ohio EPA for the field years 1982, 1994, and 2009. Over this 27 year period, additional fragmentary fieldwork has been performed on portions of the main stem and selected tributaries, supporting various water quality management goals (e.g., NPDES, stream regionalization, use attainability analysis, and reference site monitoring). The first significant attempt to evaluate the entire basin was undertaken in 1982. Surveys in both 1994 and 2009 were systematic in nature, but the 2009 fieldwork represented the most comprehensive effort to date. Aggregated performance of selected community indexes through time are presented in Figure 3.

As indicated by the resident aquatic biology, environmental conditions of surface waters that constitute the middle Great Miami River have, in very fundamental ways, improved significantly since the original 1982 survey. At that time just over 50% of the main stem miles met the prescribed biocriteria. Leading causes of aquatic life use impairment were associated with the various WWTPs (Sidney, Piqua, etc.). Low dissolved oxygen and elevated ammonia-N were regularly observed, stemming from both limited nitrification at these facilities and high oxygen demand of associated effluents. The degree of recovery documented in 1994 was profound, as nearly the entire length of the middle Great Miami River was found to fully support WWH communities. Moreover, conditions had so improved that the existing WWH aquatic life use had to be reconciled with the higher or restored level of biological performance documented in 1994. Therefore, much of the middle Great Miami was recommended for redesignation to the EWH aquatic life use (Ohio EPA 1996b). Gauged against this more stringent standard, only a small fraction of the river was identified as being impaired, affected by what was then the MCD North Regional WWTP, and now identified as Tri-Cities North Regional WWTP. This departure was modest as only the macrobenthos failed to meet the prescribed biocriterion.

Significant improvement in the environmental conditions documented in 1994 followed the implementation of the US EPA National Municipal Policy and the supporting Construction Grants program contained within the Federal Water Pollution Control Act (AKA Clean Water Act), as amended in 1977 and 1981. This initiative required most major WWTPs to meet advanced treatment standards so as to comply with water quality-based effluent limits by 1988. Federal grants and loans, administered by the states, were made available to eligible entities to facilitate significant upgrades and improvements to municipal wastewater infrastructure. The practical in-stream results of advanced waste treatment upon the affected segments of the middle Great Miami River included significant reductions in the loadings of both putrescible or oxygen demanding wastes and ammonia-N, from all major WWTPs (Ohio EPA 1996b). The associated ambient water quality improvements facilitated the recovery of aquatic communities. In most ways the 2009 results paralleled those observed in 1994, namely the persistence of 90 plus percent full aquatic life use attainment statistics, with impairment on the main stem, again, limited to a small segment affected by the Tri-Cities WWTP.

Historical ambient biological monitoring data collected between the field years 1982 and 2003 were available from five direct and indirect middle Great Miami River tributaries: Tawawa Creek, Spring Creek, Lost Creek, East Branch Lost Creek (Lost Creek tributary) and Honey Creek. Aggregated results from stations and waterbodies common to the field years 1994 and 2009 are presented in Figure 4. Taken together; these data indicate a trend of modest improvement, with generally higher scores and higher median values.

Through the period of record, single station monitoring was performed on Tawawa, Spring, and East Branch Lost Creek. More robust, multiple station, longitudinal monitoring efforts have been undertaken on the main stems of Lost and Honey Creek. Environmentally stable conditions were documented on Lost and Spring Creek, where fish and macroinvertebrate communities characterized as good to very good have persisted between 1982 and 2009. Significant improvements were identified on Tawawa and East Brach Lost Creek, with both waterbodies now supporting fully exceptional communities. Regular monitoring of Honey Creek since 1982 has documented considerable spatial and temporal variation in biological measures. However, gauged against aquatic use attainment, this based upon recommended uses, stations common to the various field years typically yielded community indexes consistent with the associated biocriteria. Notable declines in community performance and water quality measures were limited to the reach immediately downstream of the New Carlisle WWTP. Despite this, fish and benthic macroinvertebrate communities continued to meet the minimum biocriteria downstream from this facility.

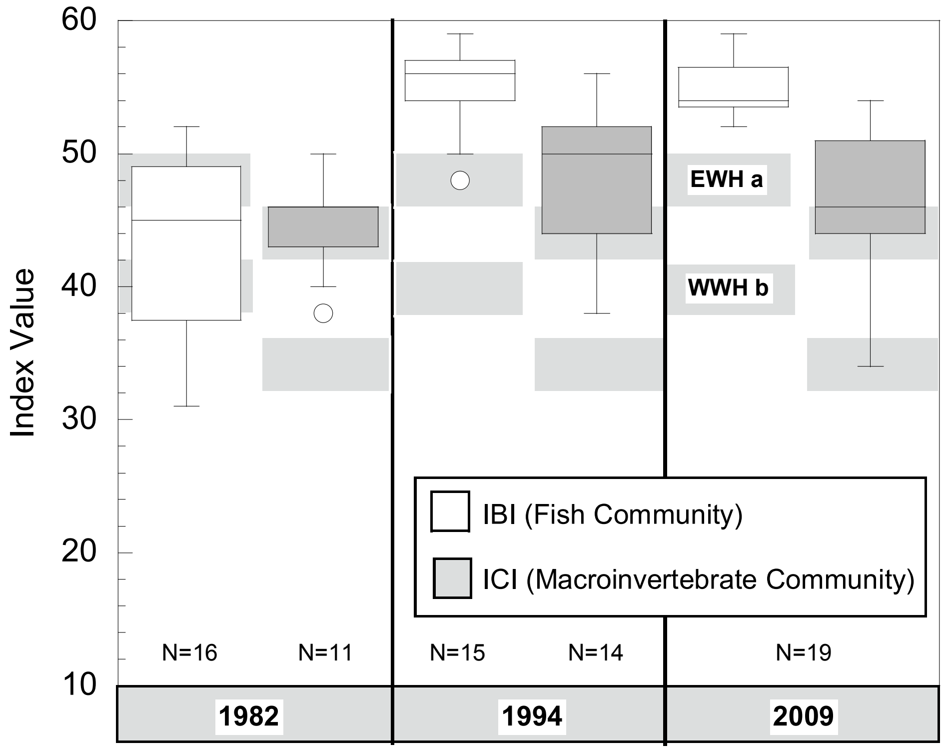


Figure 3. Aggregated performance of community indexes for the free flowing portions of the middle Great Miami River common to the field years 1982, 1994 and 2009. Shaded horizontal areas, a and b, correspond to the EWH and WWH, biocriterion, respectively.

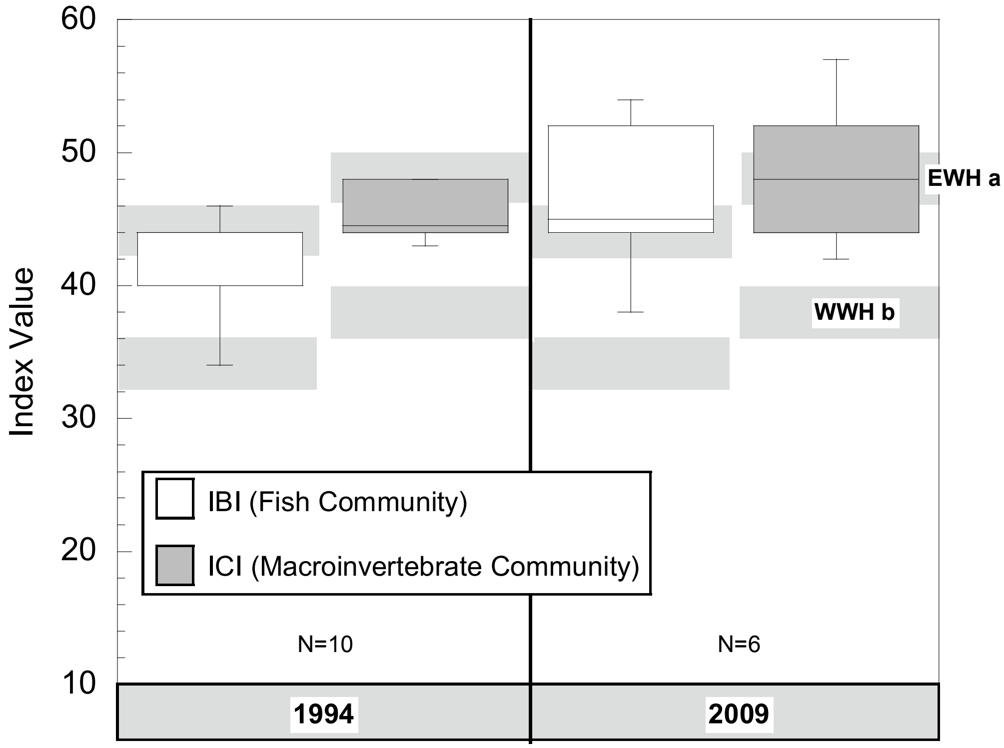


Figure 4. Aggregated performance of community indexes for middle Great Miami River tributaries common to the field years 1994 and 2009. Shaded horizontal areas, a and b, correspond to the EWH and WWH, biocriterion, respectively.

RECOMMENDATIONS

Status of Aquatic Life Uses

Many of the waterbodies sampled as part of the middle Great Miami River study area were originally designated for aquatic life use(s) in the 1978 and 1985 state water quality standards. The techniques in use at that time did not include standardized approaches to the collection of in-stream biological data or numeric biocriteria. This study represents the first comprehensive use of these types of ambient biological data to inform the use designation process. While some of the recommendations may appear to constitute "downgrades" (i.e., EWH to WWH) or "upgrades" (i.e., WWH to EWH) any change should not be construed as such because these, in most instances, constitute the first application of an objective and robust data driven process to ascertain the appropriate aquatic life use designation. Ohio EPA is obligated by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation.

Existing and recommended aquatic life use(s) resulting from the 2009 intensive survey are summarized in Table 2. Justification for redesignation or verification of existing aquatic life uses, and other pertinent information are presented below.

Middle Great Miami River

Per the findings, recommendations, and related assessments derived from the previous intensive survey of the study area (Ohio EPA 1996b), the current suite of aquatic life uses assigned to the middle Great Miami River includes both EWH and WWH designations. Three small reaches corresponding to three low head dams (and pools) located on the main stem are presently designated WWH. These segments include recreational impoundments (not directly associated with municipal water production) located at Piqua (EGS Dam), Troy (Troy Dam) and within the northern limits of the greater Dayton metropolitan area (Island Park Dam). The remaining free flowing reaches and two small river segments impounded to serve as a source of drinking water (Piqua, Water Works Dam and Dayton, well field Dam) are designated EWH.

The only modification recommended to the existing aquatic life uses on the middle Great Miami proper is limited to a minor adjustment of the upper boundaries of the Piqua dam pool. New and more detailed sampling in 2009 found free-flowing, riverine conditions and associated EWH communities downstream to RM 115.2 (Wood St.). Prior assessments identified the upper dam pool boundary as being at RM 116.7. In light of these new findings an additional 1.5 miles are recommended as EWH. Specific segments and associated existing and recommended aquatic life use designations for the middle Great Miami River are presented in Table 2a.

Tawawa Creek

Formed by the confluence of Mosquito and Leatherwood Creeks, Tawawa Creek was evaluated in 2009 at RM 1.2 (Tawawa Park in Sidney). The monitoring station was found to support an assemblage of aquatic organisms fully consistent with its existing and previously verified WWH aquatic life use.

- Entire length WWH (verified and affirmed)

Table 2a. Existing and recommended waterbody use designations for the middle Great Miami River. All recommendations based on 2009 monitoring and assessment.

Water Body Segment	Use Designation													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRw	PWS	AWS	IWS	BW	PCR	SCR	
Middle Great Miami River														
• Sidney Water Works Dam (RM130.2) to SR 66 (RM 116.7)			+						+	+		+[A]		Existing
• SR 66 (RM 116.7) to upper limit of Piqua Dam Pool at Wood St. (RM 115.2)		+	▲						+	+		+[A]		WWH to EWH
• Piqua Dam Pool (RM 115.2-114.0)		+							+	+		+[A]		Existing
• Piqua Dam (RM 114.0) to upper limit of Troy Dam pool (RM 108.0)			+						+	+		+[A]		Existing
• Troy Dam Pool (RM 108.0-107.0)		+							+	+		+[A]		Existing
• Troy Dam (RM 107.0) to B&O RR (RM 84.5)			+						+	+		+[A]		Existing
•B&O RR (RM 84.5) to Mad River (RM 81.5)		+							+	+		+[A]		Existing
• RMs 86.6, 90.3, 118.5 and 130.2			+					+	+	+		+[A]		PWS Intakes
Tawawa Creek														
• RM 0.14		+						+	+	+		*/+[B]		PWS Intake
• all other segments		+							+	+		*/+[B]		
Mosquito Creek		*/+							*/+	*/+		*/+[B]		Verified
Leatherwood Creek		*/+							*/+	*/+		*/+[B]		Verified
Mill Branch		*/+							*/+	*/+		*/+[B]		Verified
Rush Creek		*/+							*/+	*/+		*/+[B]		Verified
Spring Creek			+						+	+		+[B]		Existing
Boone Creek		▲							▲	▲		▲[B]		Previously Undesignated
Peters Creek		▲							▲	▲		▲[B]		Previously Undesignated
Lost Creek														
• Headwaters to E. Branch (RM 10.8)		▲	+						+	+		+[B]		EWH to WWH
• East Branch (RM 10.8) to Knoop Rd. (RM 4.3)			+			▲			+	+		+[B]		EWH to CWH
• Knoop Rd. (RM 4.3) to mouth		▲	+						+	+		+[B]		EWH to WWH Loosing stream
West Branch Lost Creek		▲							▲	▲		▲[B]		Previously Unlisted

Table 2a. continued.

Water Body Segment	Use Designation													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRw	PWS	AWS	IWS	BW	PCR	SCR	
East Branch Lost Creek														
• Headwaters to Loy Rd. (RM 2.0)		▲	*						*/+	*/+		*/+B		EWH to WWH
• Loy Rd. (RM 2.0) to mouth			*			▲			*/+	*/+		*/+B		EWH to CWH
Middle Branch Lost Creek		▲							▲	▲		▲B		Previously Unlisted
Little Lost Creek														
• Headwaters to first tributary, dst. Rugged Hill Rd. (RM 2.2)		*							▲	▲		▲B		Previously Unlisted Unclear if HWs support E-CWH
• First trib., dst. Rugged Hill Rd. (RM 2.2) to mouth			▲			▲			▲	▲		▲B		Previously Unlisted Dual Use
Honey Creek														
• Headwaters to Indian Cr. (RM 3.68)		▲	+						+	+		+B		EWH to WWH
• Indain Cr. (RM 3.68) to mouth			+						+	+		+B		Existing
Pleasant Run														
• Headwaters to Elizabeth Rd. (RM 1.0)		*							*	*		*		Previously Unlisted
• Elizabeth Rd. (RM 1.0) to mouth			▲			▲			▲	▲		▲B		Previously Unlisted Dual Use
East Fork Honey Creek		*/+							*/+	*/+		*/+B		Verified
West Fork Honey Creek		*/+							*/+	*/+		*/+B		Verified
Indian Creek														
• Headwaters to first UN tributary dst. Widener Rd. (RM 2.4)		*/+							*/+	*/+		*/+B		Verified
• UN tributary dst. Widener Rd. (RM 2.4) to mouth		*				▲			*/+	*/+		*/+B		WWH to CWH
Dry Creek		*/+							*/+	*/+		*/+B		Verified

* - Unverified, existing or recommended Use Designation.
+ - Verified Use Designation.
▲ - New recommendation and verified Use Designation based on the findings of this report.
*/+ - Verification of an existing yet unverified Use Designation based on the findings of this report.
A - Class A primary contact recreation
B - Class B primary contact recreation
C - Class C Primary contact recreation

Ohio WQS Beneficial Uses (OAC3745-1-07)
SRW = state resource water.
WWH = warmwater habitat.
EWH = exceptional warmwater habitat.
MWH = modified warmwater habitat.
SSH = seasonal salmonid habitat.
CWH = coldwater habitat.
LRW = limited resource water.
PWS = public water supply.
AWS = agricultural water supply.
IWS = industrial water supply.
BW = bathing water.
PCR = primary contact recreation.
- Class A
- Class B
- Class C

SCR = secondary contact recreation

Mosquito Creek

A Tawawa Creek tributary, Mosquito Creek was evaluated at RMs 7.8 (downstream Kaiser Lake) and 1.0 (McCloskey School Rd.). Modest aquatic life use impairment was documented at RM 7.8, associated with both natural rheopalustrine conditions and the export of plankton rich water to Mosquito Creek from the upper photic layer of Kaiser Lake. The innate limitations of rheopalustrine habitats and the near field effects of a large impoundment to the receiving stream, in terms of both water quality and ambient biological performance, are both well documented in Ohio, and thus streams so affected are viewed as impaired by natural/structural causes and sources. The lower limit of impairment was determined to be approximately two miles, corresponding to the extent of post glacial peat deposits (Pavey et al. 1999) and proximity to the Kaiser Lake spillway. The remaining downstream segment was found to support WWH aquatic assemblages. Given the modest nature of the impairment (magnitude of the departure and relatively short stream length affected), antecedents of the impairment and the presence of WWH communities through the majority of the eight mile segment evaluated in 2009, retention of the WWH aquatic life use designation is recommended.

- Entire length WWH (verified)

Leatherwood Creek

A Tawawa Creek tributary, Leatherwood Creek was evaluated at three station, RMs 6.43 (Suber Rd.), 3.34 (Sidney-Plattsville Rd.), and 1.2 (McCloskey School Rd.). All stations were found to support aquatic communities fully consistent with the existing WWH aquatic life use designation.

- Entire length WWH (verified)

Mill Branch

A small direct tributary to the Great Miami River, Mill Branch was evaluated at a single location at RM 0.34 (Kuther Rd.) This station was found to support an assemblage of aquatic organisms fully consistent with the existing aquatic life use.

- Entire length, WWH (verified)

Rush Creek

A significant direct Great Miami River tributary, Rush Creek was evaluated at three locations: RMs 5.3 (Vandermark Rd.), 1.7 (Hetzler Rd.), and 0.3 (North Dixies Dr.). Aquatic life use impairment was limited to the upper 2.5 miles and based upon monitoring results from the station at RM 5.3. The magnitude of the impairment was very modest and manifest in the fish assemblage alone. A combination of direct field observations and analysis of the functional organization of the fish assemblage strongly suggested that the segment of upper Rush Creek evaluated in 2009 represented a transitional cline between primary headwaters and standard headwaters. Key indicators supporting this conclusion included an abundance of pethodontid salamanders and a dominance of pioneering fish taxa. Pethodontids typically occupy upper trophic levels of small waters only in the absence of a resident fish assemblage. A fish assemblage dominated by pioneering species is typically associated with ephemerality or a waterbody in the process of recovery following an event, natural or anthropogenic, that effectively depopulated the stream. Pioneering taxa are the first species to reinvade areas previously rendered inhospitable to fish. In the absence of pethodontids, the structure of the fish community would have suggested that upper Rush Creek labored under the consequences of a fish kill or other episodic lethal/sublethal stress. The concurrence of these indicators argues that the flow regime of upper Rush Creek is not likely compatible with a persistent resident fish community. Given its apparent transitional nature, a consecutive monitoring effort over the course of several years would likely find that upper Rush Creek vacillates in and out of WWH attainment, based upon the seasonal flow regime.

The remaining downstream reach was found to support fish and benthic macroinvertebrate assemblages fully consistent with the WWH biocriteria. The presence of WWH communities through most of Rush Creek coupled with the observations regarding the upper reaches presented above, supports the retention of the existing WWH aquatic life use is recommended.

- RM 5.3 (Vandermark Rd.) to mouth WWH (verified)

Spring Creek
A significant direct tributary to the Great Miami River, Spring Creek was evaluated at three locations: RMs 8.4 (SR 36), 3.5 (Rusk Rd.), and 0.8 (Troy Piqua Rd.). All stations were found to support an assemblage of aquatic organisms fully consistent with its existing and previously verified EWH aquatic life use.

- Entire length EWH (verified and affirmed)

Boone Creek
A small direct tributary to the Great Miami River, Boone Creek was evaluated at a single station located near its mouth at RM 0.1 (downstream from Peters Creek). Presently unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 0.1 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the WWH biocriteria. Based upon this finding, the WWH aquatic life use is recommended for this waterbody.

- Presently unlisted, WWH (recommended)

Peters Creek
A small tributary to the Boone Creek, Peters Creek was evaluated at a single station located near its mouth at RM 0.2 (Dixie Rd./Old US 25). Presently unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 0.2 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the WWH biocriteria. Based upon this finding, the WWH aquatic life use is recommended for this waterbody.

- Presently unlisted, WWH (recommended)

Lost Creek

A major direct tributary to the middle Great Miami River, Lost Creek was evaluated at four locations: RMs 11.7 (Peterson Rd.), 9.8 (Troy-Urban Rd.), 4.3 (Knoop Rd.), and 0.4 (Tipp-Elizabeth Rd.). Lost Creek receives four significant tributaries, and these include, West Branch Lost Creek, East Branch Lost Creek, Middle Branch Lost Creek, and Little Lost Creek. Presently, the entire length of Lost Creek is designated EWH, verified. The 2009 survey results found only the uppermost reaches of Lost Creek, evaluated at RM 11.7, to support exceptional aquatic communities. All remaining downstream sites, the vast majority of Lost Creek, failed to consistently yield EWH assemblages. Furthermore, ample historical ambient biological data exists for the lower ten mile of Lost Creek from field years 1994, 2001, and 2003, and these efforts too, failed to consistently yield EWH aquatic communities. Justification for the verification of the EWH use was made in Ohio EPA (1996b). Regarding subpar community performance observed at that time, it was attributed to background conditions and, as it appeared unrelated to any water quality issue, the EWH use was retained. However, given the persistent failure of Lost Creek to perform up to an exceptional level over the past 15 years, a reappraisal of the existing aquatic life use designation is proper and warranted at this time so as to honestly recognize demonstrated ambient biological performance/potential and reconcile this with an appropriate aquatic life designation(s).

Multiple lines of evidence (chemical, physical, biological, and observational) from the 2009 survey were employed to first explain existing conditions/performance, augmented by the historical data, so as to establish reasonable biological potential of Lost Creek over time. It now is abundantly clear that Lost Creek was a very poor candidate for a designation reserved for exceptional or otherwise outstanding waters.

Two factors are primarily responsible for the consistent failure of Lost Creek to meet the EWH criteria. The first of these includes a strong groundwater influence upon the middle segment, roughly between RMs 10.8 (East Fork confluence) and 4.3 (Knoop Rd.). Through this reach, ambient water temperature during the summer field season was well within the parameters set for CWH designation, with values as low as 15.9°C observed. This segment receives two tributaries, both which also bear considerable ground water (East Fork Lost Creek and Little Lost Creek), and undoubtedly contribute to the cold or cool thermal regime of the middle main stem. Additionally, between four and seven cool water benthic macroinvertebrate taxa and a single key cool water fish species were found within this segment, providing conclusive evidence of a strong and sustained ground water influence. Other features of the fish community also were indicative of cool or cold water habitats, namely structural measures (e.g., MIwb and selected IBI metrics). As counterintuitive as it may appear, persistently cool or cold water can serve to actually suppress structural measures – measures it must be noted that were regionally calibrated to mid-western warmwater conditions – through thremal limitation of in-stream productivity. This phenomenon, as it relates to bioassessment, has been amply observed and described from Ohio's few significant cold water streams contained within the upper Mad and Clear Fork Mohican catchments. From these waters and other select streams, biological indices, rarely, in total, exceed the WWH biocriteria, and at times fail even to meet this basic standard. Given that larger cool or cold water streams are rare in Ohio, resources have yet to be allocated to the development of biocriteria specifically for these waters. Therefore “impairments” associated with cool or cold water environments often reflect the absence of calibrated biometrics or assessment tools, rather than poor water quality or other related environmental degradation.

The second explanatory variable regarding the lack of EWH performance on Lost Creek is significant dewatering near its mouth. Based upon direct field observations made in 2009, surface flow of the lower four miles of Lost Creek is periodically entrained to the hyporheic zone, as the stream enters the alluvial valley of the Great Miami River. Excepting residual pools, found mainly in and around entrenched and scoured woody debris, much of lower Lost Creek was effectively dry or otherwise lacking sustained surface flow by mid-July. Although smaller waters have been shown to support exceptional communities in times of drought within residual pools, larger, non-headwaters do not possess or support fish communities specifically adapted to highly variable flow regimes. Furthermore, much of this river reach was directly channelized in the past and is bounded by levees. Although evidence of regular, formal or otherwise structured maintenance was not apparent, these past actions can be viewed as contributory, regarding sub-exceptional performance, as reflected in measures of macrohabitat quality. As a result, lower Lost Creek appeared structurally incapable of supporting exceptional communities. The 2009 results, as well as historical sampling through lower Lost Creek, were much more consistent with WWH.

Based upon these lines of evidence and resulting argument presented above, the cool or coldwater middle 6.5 miles of Lost Creek are recommended to CWH aquatic life use designation, replacing the existing EWH designation. The lower 4.3 miles of the main stem, is recommended to WWH, replacing the existing EWH designation. Given the lack of sustained surface flow during the summer, historical modifications (leveed and channelized), the consistent failure of the ambient biology to meet the EWH biocriteria over the past 15 years, and the absence of any chemical water quality issue, it is evident that lower Lost Creek is structurally excluded from consistently supporting an exceptional fauna. The remaining upper 1.2 miles (evaluated at RM 11.7) is recommended to WWH as well. Even though this segment was found to support an EWH community in 2009, it represents but a small portion of the main stem, and in isolation does not warrant a separate designation. Specific segments and associated, existing and recommended aquatic life use designations for Lost Creek are presented in **Table 2.**

- Headwaters to East Branch Lost Creek, EWH (existing) WWH (recommended)
- East Branch Lost Creek to Knoop Rd., EWH (existing) CWH (recommended)
- Knoop Rd. to Mouth, EWH (existing) WWH (recommended)

West Branch Lost Creek

West Branch Lost Creek, a small Lost Creek tributary, was evaluated at a single location at RM 0.5 (US 36). Presently unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 0.5 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the WWH biocriteria. Based upon this finding, the WWH aquatic life use is recommended for this waterbody.

- Presently unlisted, WWH (recommended)

East Branch Lost Creek

A significant Lost Creek tributary, East Branch Lost Creek was evaluated at three locations: RMs 6.4 (Sodom-Ballou Rd.), 5.2 (Burr-Oak Rd.), and 0.7/0.95 (Peterson Rd.). The entire length was originally designated EWH, unverified, as part of the 1978 WQS. Despite a field assessment in 1999 the existing aquatic life use has remained unverified.

Considering both recent and historical data, East Branch Lost Creek has not consistently demonstrated exceptional characteristics over the past 10 years. Results from 2009 found aquatic communities within the exceptional range (EWH), but previous sampling in 1999 (at RMs 6.5 and 5.2) found the conditions no better than good (WWH). In recognition of this real variation in biological performance, the unverified EWH use on the upper five miles is recommended to be replaced by the WWH use.

The lower East Branch easily met the abiotic and biotic criteria for CWH designation: six cool water benthic macroinvertebrate taxa, a single key cool water fish species, and a summer thermal regime ranging between 17.9 and 21.4°C. As such, the unverified EWH use designation on the lower two miles of the East Branch is recommended to be replaced by the CWH use.

- Headwaters to Loy Rd., EWH (existing) WWH (recommended)
- Loy Rd. to Mouth, EWH (existing) CWH (recommended)

Middle Branch Lost Creek

Middle Branch Lost Creek, a small Lost Creek tributary, was evaluated at a single location at RM 1.2 (SR 589). Presently unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 1.2 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the WWH biocriteria. Based upon this finding, the WWH aquatic life use is recommended for this waterbody.

- Presently unlisted, WWH (recommended)

Little Lost Creek

Little Lost Creek, a small Lost Creek tributary, was evaluated at a single location at RM 1.2 (Casstown Rd.). Presently unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 1.2 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the EWH biocriteria. Furthermore, Little Lost Creek easily met the abiotic and biotic criteria for CWH designation: seven cool water benthic macroinvertebrate taxa, a single key cool water fish species, and a summer thermal regime ranging between 16.4 and 20.7°C. Based upon these findings, a dual aquatic life use designation is recommended for this waterbody, CWH/EWH (i.e., exceptional coldwater). Given the unique and exacting criteria for waters so designated and the absence of monitoring data well upstream from RM 1.2, this recommendation is limited to the lower 2.2 miles. The remaining upstream reach is recommended to the WWH default, but shall remain unverified.

- Presently unlisted, Headwaters to Rugged Hill Rd. WWH (listed, but unverified)
- Presently unlisted, Rugged Hill Rd. to mouth, CWH/EWH (dual use recommended)

Honey Creek

A major direct tributary to the Great Miami River, Honey Creek was evaluated in 2009 at four locations: RMs 9.9 (upstream New Carlisle WWTP), 8.1 (downstream New Carlisle WWTP), 3.2 (Rudy Rd.), and 0.8 (SR 202). Honey Creek receives five direct and indirect tributaries, and these include Pleasant Run, West Fork, East Fork, Indian Creek and Dry Creek. Presently, the entire length of Honey Creek is designated EWH, verified.

Regularly monitored since 1982, there exists a wealth of information regarding the environmental conditions and status of Honey Creek through time. Specifically, biomonitoring was conducted on Honey in the 1982, 1994, 2001, 2003, and 2009 field seasons. These efforts were centered around a seven mile segment located between the headwaters (RM 10.1-9.6, upstream from New Carlisle) to Rudy Rd. (RM 3.2-3.3, approximately six miles downstream from New Carlisle), with additional sampling allocated to lower Honey Creek in 2009 at SR 202 (RM 0.8). Over the past 27 years, no station has been found to support consistently, both exceptional fish and benthic macroinvertebrate communities (Table 2b). Instead, these data portray erratic performance, showing at times, a very high degree of spatial and temporal variation. At a station or small reach scale, a single organism group (fish or macrobenthos) and an associated biometric (IBI, MIwb or ICI) may achieve an exceptional level of performance in a given year, but this invariably failed to align or otherwise agree with the remaining concurrent indices. As such, strong and compelling EWH performance has yet to be observed on Honey Creek, even for areas outside of the influence of permitted dischargers or other know stressors. The persistent failure of this waterbody to support EWH communities combined with considerable inter and intra site variation through the period of record calls into question the legitimacy of the original EWH designation and its subsequent verification in 1994.

Some of the aforementioned variation appeared attributable to the effects of treated wastewater discharged by the New Carlisle WWTP, particularly for the results from 1994 and 2009. However, the impact from this facility, delineated by a full suite of environmental measures in both years, was manifested primarily at a single monitoring station located immediately downstream at RMs 8.1-8.0. Although full agreement with the existing EWH use and associated biocriteria between and among the various biometrics was never observed at this location, WWH assemblages have persisted.

Equal or greater variation, including persistent non-attainment, have been observed from areas outside of the influence of New Carlisle, including stations situated both up and well downstream from the WWTP. Evaluated in 1982, 1994, 2003, and 2009, upper Honey Creek (upstream from New Carlisle) failed to support exceptional communities, but did consistently yielded WWH assemblages. As measured by the QHEI, macrohabitat quality here was never found to be indicative of strong EWH potential. Water column chemical monitoring indicated no significant water quality problems, and both ambient chemical and biological monitoring on the lower East and West Forks, tributaries that together form Honey Creek proper, found good water quality and strong WWH fish and macrobenthos communities. Consistent WWH performance on upper Honey Creek and principal upper tributaries, an absence of demonstrated water quality problems and/or impacts on said waters, and macrohabitat quality nearer the WWH mark, taken together, form a persuasive argument against the retention of the EWH designation. Regarding this basic question (use attainability), the upper sites function as a control, defining, albeit imperfectly, background conditions or biotic potential. Therefore, it is not unreasonable to assume that the natural limits described above are also operative on contiguous reaches extending through and downstream from New Carlisle. This is not to argue that the WWTP is without effects, or that said effects should be discounted; rather, the purpose here is to appraise the merits of holding upper Honey Creek (and a municipal permittee) to an EWH standard that now, in light of decades of monitoring, appears unjustified.

Table 2b. Honey Creek EWH attainment status, 1982-2009.

River Mile	Year	IBI	MIwb	ICI	EWH Attainment[a]	Landmark
10.1-9.9	2009	45*	8.5*	52	PARTIAL	Ust. New Carlisle WWTP
	2003	44*	8.1*	-	(**NON**)	
	1994	44*	8.6*	44[ns]	PARTIAL	
	1982	43*	9.1[ns]	-	(PARTIAL)	
9.6	2003	42*	7.6*	-	(**NON**)	Ust. New Carlisle WWTP
8.1-8.0	2009	42*	8.8*	38*	**NON**	Dst. New Carlisle WWTP
	1994	48[ns]	9.2[ns]	30*	PARTIAL	
3.3-3.2	2009[b]	52	10.4	54	**FULL**	Rudy Rd.
	2003	51	8.8*	52	PARTIAL	
	2001	48[ns]	8.0*	40*	PARTIAL	
	1994	48[ns]	9.4	40*	PARTIAL	
	1982	48[ns]	9.5	-	(PARTIAL)	
0.8	2009	44*	10.3	46	(PARTIAL)	SR 202, near mouth

a - Attainment status derived from one organism group is parenthetically expressed.
b - 2009 results from RM 3.2, marks first full EWH attainment on Honey Creek.
ns - Non-significant departure from the biocriteria (≤4 IBI and ICI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI and ICI units or >0.5 MIwb units).

Ecoregional Biocriteria (OAC 3745-1-07, Table 7-15)

Eastern Corn Belt Plain (ECBP) Ecoregion

Index-Site\ Type	WWH	EWH
IBI-HW/Wade	40	50
MIwb-Wade	8.3	9.4
ICI	36	46

Proceeding downstream, community performance at Rudy Rd. (RMs 3.2-3.1), was found fully consistent with the EWH biocriteria in 2009. Although wide swings between and among the various biometrics have been observed at this station between 1982 and 2003, all community indexes comported with prescribed EWH biocriteria in 2009. The downstream reach of Honey Creek was evaluated at SR 202 (RM 0.8) in 2009. Although the site failed to support fully the EWH use, two of the three biological indexes met or exceeded the EWH criteria. Partial EWH attainment was driven by a very modest departure of the IBI (one of two fish community indexes), which missed the minimum criterion by only two index units. This was attributed primarily to previous channelization and locally reduced gradient. Lower stream power attendant to low gradient waters can serve to protract the natural recovery of waterbodies so affected. In addition to these physical limitations, chemical water quality monitoring found ammonia-N levels elevated, with maximum values approaching 0.1 mg/l (nearly twice background concentrations). The source of ammonia is not clear at this time, as the adjacent upstream station (Rudy Rd., RM 3.2), as well as stations on upstream tributaries (Indian Creek and Pleasant Run) yielded both, good to excellent biological assemblages and ammonia-N concentration at or very near background levels. As ambient biological performance here very nearly met the EWH criteria, a community-wide response to elevated ammonia-N was not evident. The effects of ammonia-N were considered secondary or tertiary in nature.

Both contemporary and historical survey results provide compelling evidence regarding the universal applicability of the EWH aquatic life use on Honey Creek. Given the prevalence of WWH attributes documented in upper Honey Creek, retention of the EWH aquatic life use for this segment is not justified. The verification of the EWH use in 1994 was a product of both a limited data and an overly optimistic assumption regarding biological potential. Therefore, the 6.3 mile stream segment beginning at the confluence of the East and West Forks of Honey Creek (headwaters) to the Indian Creek confluence (RM 3.7) is recommended to the more appropriate WWH aquatic life use designation. Retention of the existing EWH use designation is recommended for the lower 3.7 miles Honey Creek, due to documented exceptional performance.

- Headwaters to Indian Creek, EWH (existing), WWH (recommended)
- Indian Creek to Mouth, EWH (existing)

Pleasant Run

Pleasant Run, a small direct Honey Creek tributary, was evaluated at a single location at RM 0.5 (Rudy Rd.). Presently, unlisted in the Ohio WQS, the 2009 sampling effort represented the first attempt to designate this waterbody in terms of aquatic life use. Results from RM 0.5 found the site to support a fish and benthic macroinvertebrate assemblage fully consistent with the EWH biocriteria. In addition, Pleasant Run demonstrated support for CWH designation: five cool water benthic macroinvertebrate taxa, a single key cool water fish species, and a summer thermal regime ranging between 17.8 and 20.5°C. Based upon these findings, a dual aquatic life is recommended for this waterbody, CWH/EWH (i.e., exceptional coldwater). Given the unique and exacting criteria for waters so designated and the absence of monitoring data well upstream from RM 0.5, this recommendation is limited to the lower mile. The remaining upstream reach is recommended to the WWH default designation, but shall remain unverified.

- Presently unlisted, Headwaters to Elizabeth Rd. WWH (listed but, unverified)
- Presently unlisted, Elizabeth Rd. to mouth, CWH/EWH (duel use recommended)

East Fork Honey Creek

A significant direct tributary to Honey Creek, the East Fork was evaluated at four locations: RMs 5.9 (Ayres Rd,), 3.6 (St. Paris Rd.), 1.6 (Sigler Rd.), and 0.1 (at mouth). The entire six mile length was found to support an assemblage of aquatic organisms fully consistent with the existing WWH aquatic life use.

- Entire length, WWH (verified)

West Fork Honey Creek
A direct Honey Creek tributary, the West Fork was evaluated at two locations: RMs 1.3 (SR 235) and 0.1 (at mouth). Both stations were found to support an assemblage of aquatic organisms fully consistent with the existing WWH aquatic life use.

- Entire length, WWH (verified)

Indian Creek
Indian Creek, a small direct Honey Creek tributary, was evaluated at three locations: RMs 4.9 (Walnut Grove Rd.), 1.5 (SR 201), and 0.1 (at mouth). Presently, Indian Creek is designated WWH, unverified. Sampling results from all stations found fish and benthic macroinvertebrate communities in form, structure, and functional organization fully consistent with WWH biocriteria. Furthermore, the lower two sampling sites possessed specific biotic and abiotic features of cool or cold water streams, namely, five to six cool water benthic macroinvertebrate taxa, two key cool water fish species (mottled sculpin and American brook lamprey), and a summer thermal regime ranging between 16.7 and 20.7°C. Based upon these findings, the lower 2.4 miles of Indian Creek are recommended to CWH, and the remaining reach upstream shall retain the WWH aquatic life use.

- Headwaters to RM 2.4, WWH (verified)
- RM 2.4 to mouth, CWH (recommended)

Dry Run
A direct Indian Creek tributary, Dry Creek was evaluated at a single location at RM 1.2 (Walnut Grove Rd.). Presently, Dry Creek is designated WWH, unverified. Ambient biological performance was found fully consistent with the existing WWH aquatic life use.

- Entire length, WWH (verified)

Status of Non-Aquatic Life Uses
The existing Industrial and Agricultural Water Supply use designations for the middle Great Miami River and designated tributaries should remain in place. These designations were also broadly applied to all previously undesignated or unlisted streams within the study area (Table 2).

Given its size and regular recreational use, including the presence of multiple canoe liveries, the class A primary contact recreation use designation is affirmed for the entire length of the middle Great Miami River main stem. The class B primary contact recreation use designation is recommended for all other waterbodies evaluated in 2009 as part of the middle Great Miami River survey (Table 2).

Future Monitoring Needs and Other Recommendations
- A complete reevaluation of the middle Great Miami River watershed should be conducted in either 2019 or 2024, as provided for the TMDL and NPDES permit cycles.

- A persistent ammonia-N impact from the Tri-Cities Wastewater Authority WWTP (formerly known as MCD North Regional WWTP) resulting in aquatic life use impairment on the middle Great Miami River has been identified over the past two reporting cycles (15 years). A preliminary investigation by Tri-Cities has identified multiple factors responsible for reduced nitrification. Given the longstanding nature of this issue, every effort should be made to restore, or enhance if needed, the facility's nitrification capacity so as to abate the modest, but persistent in-stream impact.

- Identify and abate the source(s) of ammonia-N contamination on lower Honey Creek. A possible source may include waste apllication to designated Class B farmland adjacent to the lower mile of Honey Creek.

- Imposition of the WWH use on the upper 6.8 miles Honey Creek must not result in a significant lowering of water quality to the point of aquatic life use impairment. Associated permit modifications must account fully for the maintenance of existing WWH conditions immediately downstream from New Carlisle, as well as existing EWH conditions for the lower 3.2 miles of Honey Creek.

- Located in the headwaters of the West Fork Honey Creek, the unsewered community of Christiansburg has rendered an approximate one-mile segment of the upper West Fork septic, through the apparent collection of multiple private septic systems to a common storm sewer that empties to the West Fork Honey Creek. The affected reach was found significantly deficient in DO, including multiple violations of the minimum criterion, with highly elevated concentrations of ammonia-N and gross fecal bacteria contamination. As of the publication date of this report, the village of Christiansburg is developing plans to eliminate discharges from their storm sewer system.

  Based upon water quality monitoring results, diffuse pollutant loads from fields approved for sludge application (class A and B farmlands) adjacent to and upstream from the affected reach and other effects of livestock production to the West Fork Honey Creek, upstream from Christiansburg, appeared to be contributory sources. Implementation of best management practices regarding sludge application, livestock, and other sundry agricultural activities are strongly encouraged.

- Total phosphorus levels were elevated throughout much of the watershed, especially in the main stem and in the Honey Creek subwatershed. Overall, 88% of main stem sites (15 of 17) and 26% of tributary sites (11 of 42) had median phosphorus concentrations above target reference levels. While the vast majority of the waterbodies of the middle Great Miami basin are presently supporting their existing and recommended aquatic life uses, indicating that wasteloads are safely assimilated in almost all instances, the assimilative capacity of these waters is not infinite. Although not a pressing issue at this time for most of the study area, consideration must be given to the long-term management of nutrient loads basin-wide, if the high quality conditions documented over the past 15 years (two reporting cycles) are to be conserved or otherwise persist into the foreseeable future.

METHODS

All chemical, physical, and biological field, EPA laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2006b), Biological Criteria for the Protection of Aquatic Life, Volumes II - III (Ohio Environmental Protection Agency 1987b, 1989b, 1989c, 2008a, 2008b), The Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Rankin 1989), and Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (Ohio EPA 2006a). Sampling locations for the Ohio Brush Creek basin are listed in Table 6.

Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-15). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Three attainment status results are possible at each sampling location - full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table 1) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995, Ohio EPA 2006a). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of in-stream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Sediment and Surface Water Assessment

Fine grain sediment samples were collected in the upper 4 inches of bottom material at each location using decontaminated stainless steel scoops. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2001). Sediment grab samples were homogenized in stainless steel pans (material for VOC analysis was not homogenized), transferred into glass jars with teflon lined lids, placed on ice (to maintain 4^{o}C) in a cooler, and shipped to the Ohio EPA Division of Environmental Services. Sediment data is reported on a dry weight basis. Surface water samples were collected, preserved and delivered in appropriate containers to either an Ohio EPA contract lab or the Ohio EPA Division of Environmental Services. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and Ohio Sediment Reference Values (Ohio EPA 2003).

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from the natural habitats. The artificial substrate collection provided quantitative data and consisted of a composite sample of five modified Hester-Dendy multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample was also collected. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, and margin). Detailed discussion of macroinvertebrate field and laboratory procedures is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989c, Ohio EPA 2008b).

Fish Community Assessment

Fish were sampled using pulsed DC electrofishing methods. Fish were processed in the field, and included identifying each individual to species, counting, weighing, and recording any external abnormalities. Discussion of the fish community assessment methodology used in this report is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989c, Ohio EPA 2008b).

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

STUDY AREA

Arising in west central Ohio, at the convergence of three counties, Auglaize, Harden and Logan, the Great Miami River is formed from the aggregation of headwater tributaries behind the dams and levees that form Indian Lake. The Great Miami River presently originates as the outlet of this canal era impoundment. Draining all or parts of 15 counties of southwestern Ohio (5371 miles^2), the Great Miami flows in a generally southwesterly direction for a length of approximately 170 miles, coursing through the municipalities of Russell's Point, Tip City, Sidney, Piqua, Troy and greater Dayton metropolitan area, before joining the Ohio River, west of Cincinnati, near the Indian-Ohio border.

Figure 5. Middle Great Miami River watershed, 2011.

The middle Great Miami River, the focus of this investigation, drains 430.7 mile^2, and is defined as the river reach (and associated tributaries) between the village of Sidney and the city of Dayton, terminating at the Mad confluence. Principal tributaries include Tawawa, Loramie, Lost, and Honey creeks, and the Stillwater River. Lessor or otherwise minor tributaries include Mill Branch, Rush Creek, Spring Creek, Boone Creek, and Dry Creek. Excluding Loramie Creek and Stillwater River, both of which were previously evaluated by Ohio EPA in 2008 and 1999, respectively, all major and minor tributaries and subbasins indicated above were evaluated in 2009. Relevant features, geographic context, land use, and distribution of sampling stations within the study area are presented in Figures 5 and 6. A list of all environmental monitoring stations, waterbodies, associated sample types and other supporting information are presented in Table 3.

The 2009 study area included three 10-digit Hydrologic Unit Codes (HUCs) and fifteen 12-digit Watershed Assessment Units (WAUs) draining all or portions of Clark, Shelby, Champaign, Miami, and Montgomery counties. An additional site on the Great Miami River main stem in Dayton, from WAU 05080002-01-05, was included, and demarked the lower limits of the study area. Summarized WAUs are presented in Table 4.

The topography of the study area has been influenced by glaciation that left distinctive landforms and thick deposits of silt, sand, and gravel. The Great Miami River basin is contained wholly in the Till Plains section of the Central Lowlands Physiographic Province, a region, in practical terms, corresponding to the ECBP Ecoregion in Ohio (Omernick 1987, Omernick and Gallent 1988). Throughout the study area, the effects of glaciation and associated postglacial erosion have resulted in a level to gently sloping landscape, dissected by shallow and narrow alluvial valleys of low to moderate gradient.

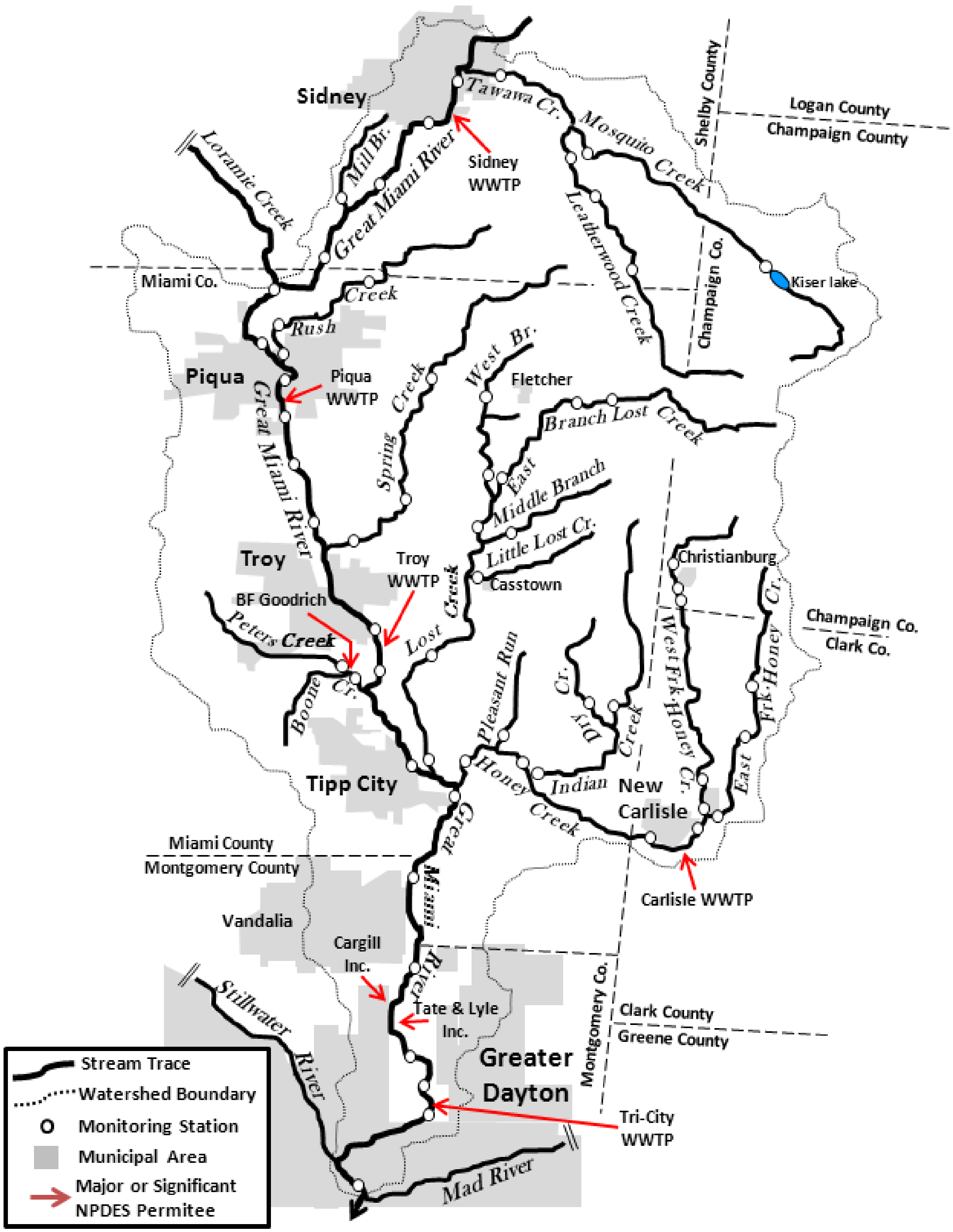


Figure 6. The middle Great Miami River study area showing principle streams and tributaries, population centers, major pollutions sources, and the location of water resource monitoring stations, 2009.

Table 3. Sampling locations in the middle Great Miami River study area, 2009 (C-conventional water chemistry, O-organic water chemistry, P-pathogen, S-sediment, D-datasonde monitor, B-macroinvertebrate sample, F-fish sample [Latitude/longitude coordinates are provided in WGS84 datum.]. Note: The river miles listed below are the STORET location Point of Record (POR) identifiers. Sample type river mile collection locations may vary slightly from the POR listing.

Stream River Mile	Sample Type	Latitude/Longitude	Location	USGS Quad
Great Miami River (main stem)				
130.0	F,B,C,D,S,P,O	40.2868/-84.1499	SR 47	Sidney
127.7	F,B,C,D,S,O	40.2664/-84.1653	Adj River Rd. (Sidney)	Sidney
123.9	F,C,B	40.2241/-84.2050	Kuther Rd.	Piqua East
120.0	F,B,C,D,S,P	40.1889/-84.2336	Piqua-Lockington Rd.	Piqua East
118.5	B,C,S	40.1736/-84.2573	Dst Swift Run Lake outlet	Piqua West
117.5	F	40.1628/-84.2489	Adj. SR 66	Piqua West
115.4	F,B	40.1474/-84.2348	Ust. Piqua dam pool	Piqua East
114.1	B,C,D,S,P,O	40.1309/-84.2355	Dst Piqua dam and WWTP	Piqua East
114.0	F	40.1293/-84.2351	Dst. Piqua dam and WWTP	Piqua East
112.4	F,B,C	40.1081/-84.2312	Farrington Rd/Peterson Rd	Troy
110.1	F,B,C,D,P	40.0779/-84.2165	Eldean Rd.	Troy
106.1	F,B,C,D,S,P,O	40.0306/-84.1875	SR 41 (Troy)	Troy
104.7	F,B,C,D	40.0117/-84.1828	Adj. SR 202, Dst Troy WWTP	Troy
100.8	F,B,C,D,S,P	39.9678/-84.1662	Tipp-Elizabeth Rd.	Tipp City
98.5	F,B	39.9533/-84.1419	SR 571	Tipp City
95.6	F,B,C	39.9156/-84.1638	Old Springfield Rd.	Tipp City
93.0	B,C,D,S,P,O	39.8728/-84.1642	Dst Taylorsville Dam	Dayton North
92.5	F	39.8729/-84.1642	Dst. Taylorsville Dam	Dayton North
88.7	F,B,C,D,S,O	39.8273/-84.1671	Wagner Ford Rd.	Dayton North
87.7	B	39.8288/-84.1540	Needmore Rd.,ust Tri-Cities WWTP	Dayton North
87.05	F,C,D,P	39.8202/-84.1562	Needmore Rd. ust Tri-Cities WWTP	Dayton North
85.9	F,B,C,D,S,O	39.8053/-84.1531	Adj. SR 202, dst. Tri-Cities WWTP	Dayton North
82.49	P	39.7771/-84.1982	Island Park - Helena St	Dayton North
82.1	B	39.7738/-84.1932	Ust. Mad River/dst. Stillwater R.	Dayton North
81.6	F	39.7691/-84.1873	Ust. Mad River/dst. Stillwater R.	Dayton North
80.74	C,P,O	39.7632/-84.2019	Monument Ave. (Dayton)	Dayton North
Tawawa Creek				
1.2	F,B,C,	40.2886/-84.1287	Tawawa civic park (Sidney)	Sidney
0.22	C,D,S,P,O	40.2909/-84.1438	SR 47	Sidney
Mosquito Creek				
7.75	F,B,C	40.2023/-83.9870	Licklider Rd, dst Kiser Lake	Saint Paris
1.0	F,B,C,S,P	40.2531/-84.0814	McCloskey School Rd.	Port Jefferson
Leatherwood Creek				
6.43	F,B,C	40.2000/-84.0572	Suber Rd.	Fletcher

Table 3. continued.

Stream River Mile	Sample Type	Latitude/Longitude	Location	USGS Quad
3.34	F,B,C	40.2332/-84.0765	Sidney-Plattsville Rd	Fletcher
Leatherwood Creek				
1.2	F,B,C,S,P	40.2535/-84.0896	Mccloskey School Rd	Port Jefferson
Mill Branch				
0.34	F,B,C,P	40.2277/-84.2074	Kuther Rd.	Piqua East
Rush Creek				
5.3	F,B,C	40.1932/-84.1934	Vandemark/Troy-Sidney Rd.	Piqua East
1.68	F,B,C,D,S,P,O	40.1715/-84.2400	Hetzler Rd.	Piqua East
0.3	F,B,C	40.1567/-84.2384	N Dixie Dr.(near Piqua)	Piqua East
Spring Creek				
8.44	F,B,C	40.1475/-84.1591	US 36	Piqua East
3.5	F,B,C,D,S,P,O	40.0900/-84.1696	Rusk Rd.	Troy
0.84	F,B,C	40.0725/-84.1991	Troy-Piqua Rd.	Troy
Lost Creek				
11.7	F,B,C,S,P	40.1025/-84.1310	Peterson Rd (Casstown)	Troy
9.74	F,B,C	40.0776/-84.1343	Troy-Urbana Rd.	Troy
4.3	F,B,C,D,S,P,O	40.0180/-84.1578	Knoop Rd.	Troy
0.45	F,B,C	39.9698/-84.1581	Tipp-Elizabeth Rd.	Tipp City
West Branch Lost Creek				
0.5	F,B,C	40.1461/-84.1328	US 36 (Fletcher)	Piqua East
East Branch Lost Creek				
6.4	F,B,C	40.1397/-84.0650	Sodom-Ballou Rd.	Fletcher
5.24	F,B,C	40.1377/-84.0840	Burr Oak Rd.	Fletcher
0.7	F,B,C,S,P	40.1018/-84.1222	Peterson Rd.	Christiansburg
M Br Lost Creek				
1.2	F,B,C	40.0767/-84.1178	SR 589	Christiansburg
Little Lost Creek				
0.27	F,B,C	40.0567/-84.1358	Casstown Rd.	Troy
Boone Creek				
0.3	B	40.0038/-84.1952	Dixie Rd./Old US 25	Troy
0.1	F,B,C,S,P	40.0022/-84.1914	Near mouth	Troy
Peters Creek				
0.59	C,B	40.0087/-84.2007	Dixie Rd./Old US 25	Troy
0.2	F	40.0067/-84.1942	Dst. Dixie Rd., at RR/Bike Path	Troy
Honey Creek				
9.96	F,B,C,D	39.9404/-84.0171	New Carlisle Pike	New Carlisle
8.08	F,B,C,D,S,O	39.9355/-84.0411	SR 571, dst New Carlisle WWTP	New Carlisle
3.18	F,B,C,D,S,P,O	39.9694/-84.1092	Rudy Rd.	New Carlisle

Table 3. continued.

Stream River Mile	Sample Type	Latitude/Longitude	Location	USGS Quad
Honey Creek				
0.84	F,B C,D,	39.9698/-84.1390	SR 202, near mouth	Tipp City
East Fork Honey Creek				
5.9	F,B,C	40.0081/-83.9899	Ayres Pike	Thackery
3.6	F,B C	39.9833/-83.9922	New Carlisle-St Paris Rd	Donnelsville
1.58	C,S,P,B	39.9573/-84.0012	Sigler Rd.	New Carlisle
0.1	F,B	39.9467/-84.0128	At Mouth	New Carlisle
West Fork Honey Creek				
9.52	C,P	40.0612/-84.0335	East St (Christiansburg)	Christiansburg
8.9	C,P	40.0535/-84.0295	SR 55 (Christiansburg)	Christiansburg
8.04	C,O	40.0440/-84.0291	Addison-New Carlisle Rd.	Christiansburg
1.3	C,D,S,F,B	39.9636/-84.0144	SR 235	New Carlisle
0.1	C,P,F,B	39.9471/-84.0130	Near mouth	New Carlisle
Indian Creek				
4.95	C,F,B	39.9971/-84.0620	Walnut Grove Rd.	New Carlisle
1.52	C,P,F,B	39.9660/-84.0808	SR 201	New Carlisle
0.1	F,B	39.9652/-84.1044	At mouth	New Carlisle
Dry Creek				
1.2	C,F,B	39.9979/-84.0748	Walnut Grove Rd.	New Carlisle
Pleasant Run				
0.5	C,F,B	39.9818/-84.1197	Rudy Rd.	New Carlisle
Poplar Creek				
0.70	P	39.8646/-84.1797	Dst Brown School Rd.	Dayton North

Relief is generally less than 50 ft., excepting locale or subregional glacial features (e.g., end moraines, kames, and eskers).

Nearly all of the Great Miami River downstream from Loramie Creek is underlain by a buried valley aquifer composed of highly permeable sands and gravel from past glacial events. There is a direct hydraulic connection between the aquifer and the main stem, which in some instances adds to the flow and in others recharges the aquifer. Lost Creek is typical of many tributaries in that it flows across glacial till in its upper reaches and over the buried valley aquifer near the river. As such, it is not unusual for the lower reaches of Lost Creek and other tributaries to disappear into the ground during dry conditions.

Within the ECBP ecoregion, the middle Great Miami River basin study area lies almost completely within one distinct subecoregion. The majority is in the 55b, Loamy High Till Plains (ftp://ftp.epa.gov/wed/ecoregions/in/ohin_front.pdf). Streams in this sub-ecoregion are often recharged by groundwater. Soils in this sub-ecoregion developed from loamy, limy, glacial deposits of Wisconsinan age and typically have better natural drainage than

Table 4. Watershed Assessment Units (WAUs) in the 2009 middle Great Miami River study area.

12-digit WAU	Description	Acreage / mi^2
10-Digit HUC: 05080001-07 Tawawa Creek-Great Miami River		[Total: 94,735 / 148.0]
05080001-07-01	Leatherwood Creek	10,843 / 16.9
05080001-07-02	Mosquito Creek	24,512 / 38.3
05080001-07-03	Brush Creek-Great Miami River	19,318 / 30.2
05080001-07-04	Rush Creek	12,015 / 18.8
05080001-07-05	Garbry Creek-Great Miami River	28,047 / 43.8
10-Digit HUC: 05080001-08 Lost Creek-Great Miami River		
12-digit WAU	Description	Acreage / mi^2 [Total: 88,383 / 138.1]
05080001-08-01	Spring Creek	16,300 / 25.5
05080001-08-02	Headwaters Lost Creek	9,021 / 14.1
05080001-08-03	East Branch Lost Creek	9,183 / 14.3
05080001-08-04	Little Lost Creek - Lost Creek	20,310 / 31.7
05080001-08-05	Peters Creek- Great Miami River	33,569 / 52.5
10-Digit HUC: 05080001-20 Honey Creek-Great Miami River		
12-digit WAU	Description	Acreage / mi^2 [Total: 92,549 / 144.6]
05080001-20-01	East Fork Honey Creek	8,318 / 13.0
05080001-20-02	West Fork Honey Creek	13,380 / 20.9
05080001-20-03	Indian Creek	16,541 / 25.8
05080001-20-04	Pleasant Run-Honey Creek	19,457 / 30.4
05080001-20-05	Poplar Creek-Great Miami River	34,853 / 54.5
10-Digit HUC: 05080002-01 Wolf Creek-Great Miami River		
12-digit WAU	Description	Acreage
05080002-01-05	Town of Oakwood-Great Miami River	

those in the 55a sub-ecoregion. The soils also tend to have less need for subsurface drainage systems. Compared to the upper portion of the Great Miami River watershed there are fewer streams that have been altered to maintain field drainage for agriculture. Waterbodies within the study area are generally perennial, due to a complex of buried preglacial valleys and shallow bedrock aquifers. For many waters, a significant component of summer base flow is provided by these ground water sources.

The aquifer is the primary source of drinking water for many cities and villages in the watershed. Troy, Tipp City, and Dayton all have high capacity well fields adjacent to the river that overlie the aquifer. Dayton also recharges the aquifer below their well field with surface water drawn from the river. Piqua draws its raw drinking water from three sources: a system of three lakes (Swift Run Lake, Echo Lake, and Franz Pond) connected by a hydraulic canal, the Great Miami River, and an abandoned gravel pit. One or a combination of these sources may be used at any given time during the year based on seasonal conditions. Sidney obtains its raw water from a combination of ground water and surface water sources. Approximately, one third of Sidney's supply is obtained from four limestone wells adjacent to the Great Miami River. The balance is drawn from Tawawa Creek (one intake) and the Great Miami River (two intakes). Tawawa Creek is the preferred surface water supply and is utilized except during low flow periods. Sidney is in the process of developing a new supply in a gravel pit adjacent to Loramie Creek.

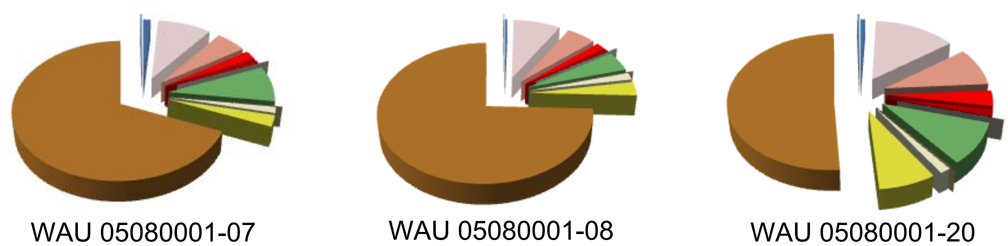
Data from the 2006 National Land Classification Dataset (NLCD) show that agriculture is the predominant land use within the middle Great Miami River drainage, accounting for 68.98% of the study area. Of areas so identified, row crop production (corn, soy beans and wheat) is dominant (64.39%), with the remaining 4.59% devoted to hay production or livestock. Developed areas, as classified by NLCD, comprise just over 20% percent of the watershed. From early successional stages to mature hardwood, forests cover types account for 7.8%. All surface waters (lacustrine, fluvial and palustrine) occupy just over one percent of the land surface of the basin (Table 5 and Figure 7.). Most of the development is concentrated along the river and Interstate Route 75 in the cities of Sidney, Piqua, Troy, Tipp City, and Dayton. Four of the 15 WAUs in the study account for 78.33% of the developed land uses. Most of the other WAUs approach or exceed 80% of their acreage in agriculture and less than 10% of their area is developed.

Beneficial use designations within the watershed include those for aquatic life, recreation and public water supply. The aquatic life use designation in effect for the majority of streams in the middle Great Miami River watershed in 2009 was WWH. Free-flowing sections of the Great Miami River main stem from below Sidney (RM 127.6) to just above Dayton RM 81.8) are designated EWH. Portions of the river designated WWH include those areas within Piqua, Troy and Dayton that have been impounded by lowhead dams, and affected by levee construction and channelization for flood protection by the Miami Conservancy District. Tributaries in the study area that are designated EWH include Honey Creek, Spring Creek, Lost Creek, and East Branch Lost Creek. Recreation use designation for all of the sites studied in the middle Great Miami River watershed in 2009 was Primary Contact Recreation (PCR). Inlets for public water supplies in the watershed that utilize surface water result in Public Waters Supply (PWS) designations for several locations. These include the city of Sidney, which maintains inlets on the MGMR (RM 130.2) main stem and Tawawa Creek (RM 0.14). The city of Piqua also has an inlet on the main stem (RM 118.5) and owns the Swift Run Lake as a reservoir while Dayton's use of the river for ground water recharge also adds PWS designations (RMs 86.6 and 90.3). Communities in the watershed include Sidney, Piqua, Troy, Dayton (portions), Tipp City, New Carlisle, Huber Heights, Vandalia, Fletcher, Casstown, and Christiansburg. There are numerous municipal wastewater treatment plants (WWTPs) in the middle Great Miami River study area including the New Carlisle WWTP on Honey Creek and four major (*i.e.,* ≥ 1 million gallons per day (mgd)) WWTPs on the Great Miami River main stem. These include Sidney, Piqua, Troy, and Tri-Cities North Regional (which serves Huber Heights, Tipp City and Vandalia). Discharge points for these facilities are indicated in Figure 8.

Riparian habitats along the river are generally good to excellent in all areas away from the cities. Within the cities, there are levees for flood protection and often the channel has been straightened and maintained. In addition to this impact there are dams within each city that impound water creating a degraded condition. As a result there is no riparian corridor within any of the cities.

Table 5. Percent Land Use in the middle Great Miami River watershed (NLCD 2006).

Land Use	Watershed Assessment Unit (WAU 05080001)		
	07	08	20
Open Water	1.26%	0.41%	0.80%
Developed, Open Space	9.20%	8.11%	14.10%
Developed, Low Intensity	5.27%	5.09%	9.06%
Developed, Medium Intensity	2.16%	1.64%	3.67%
Developed, High Intensity	0.83%	0.63%	1.70%
Barren Land	0.04%	0.01%	0.02%
Deciduous Forest	8.44%	4.71%	9.98%
Evergreen Forest	0.04%	0.04%	0.08%
Mixed Forest	0.02%	0.00%	0.05%
Scrub/Shrub	0.00%	0.00%	0.00%
Grassland/Herbaceous	1.40%	1.66%	1.48%
Pasture/Hay	2.67%	3.28%	7.80%
Cultivated Crop	68.39%	74.23%	50.88%
Woody Wetlands	0.00%	0.00%	0.00%
Emergent Herbaceous Wetlands	0.29%	0.18%	0.39%



A significant feature of the watershed is the number of dams impounding stream and river reaches. There are seven dams on the main stem of the Great Miami in this study area that have been built for various purposes. Sidney (RM 131.2), Piqua (RM 118.55), and Dayton (RM 86.64) all maintain lowhead dams (less than 15 feet in height) as part of their water supply infrastructure. Sidney and Piqua draw water directly from the river while Dayton diverts river water into golf course ponds that serve as ground water recharge basins. Three other dams are maintained for recreational opportunities. In Dayton (RM 82.17) and Troy (RM 106.98) the dams are owned by the Miami Conservancy District (MCD) while in Sidney a private boat club maintains a rock rubble structure. The Piqua Power dam was built to provide cooling water to the now decommissioned municipal power plant.

The largest dam on the river is Miami Conservancy District's Taylorsville dam (RM 92.6), one of five dams built to protect the cities along the Great Miami from flooding. Taylorsville is a dry dam designed to water flows above 55,000 cfs. The inundation zone for this dam at peak storage volume would cover 11,000 acres and reach upstream 14 miles to SR 41 in Troy. Because this basin empties after each flooding event, there is little or no effect on water quality.

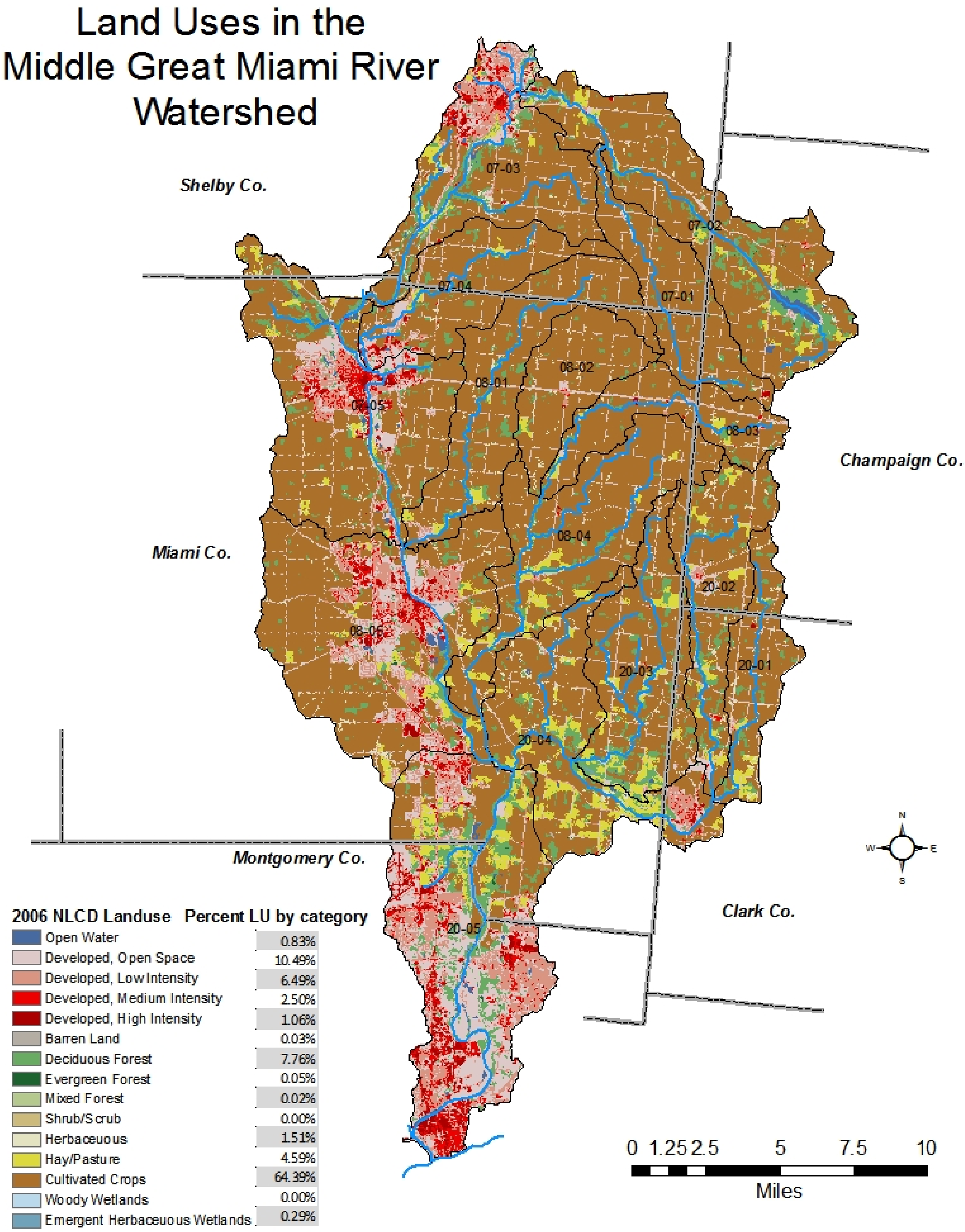


Figure 7. Land uses for the middle Great Miami River study area, circa 2006.

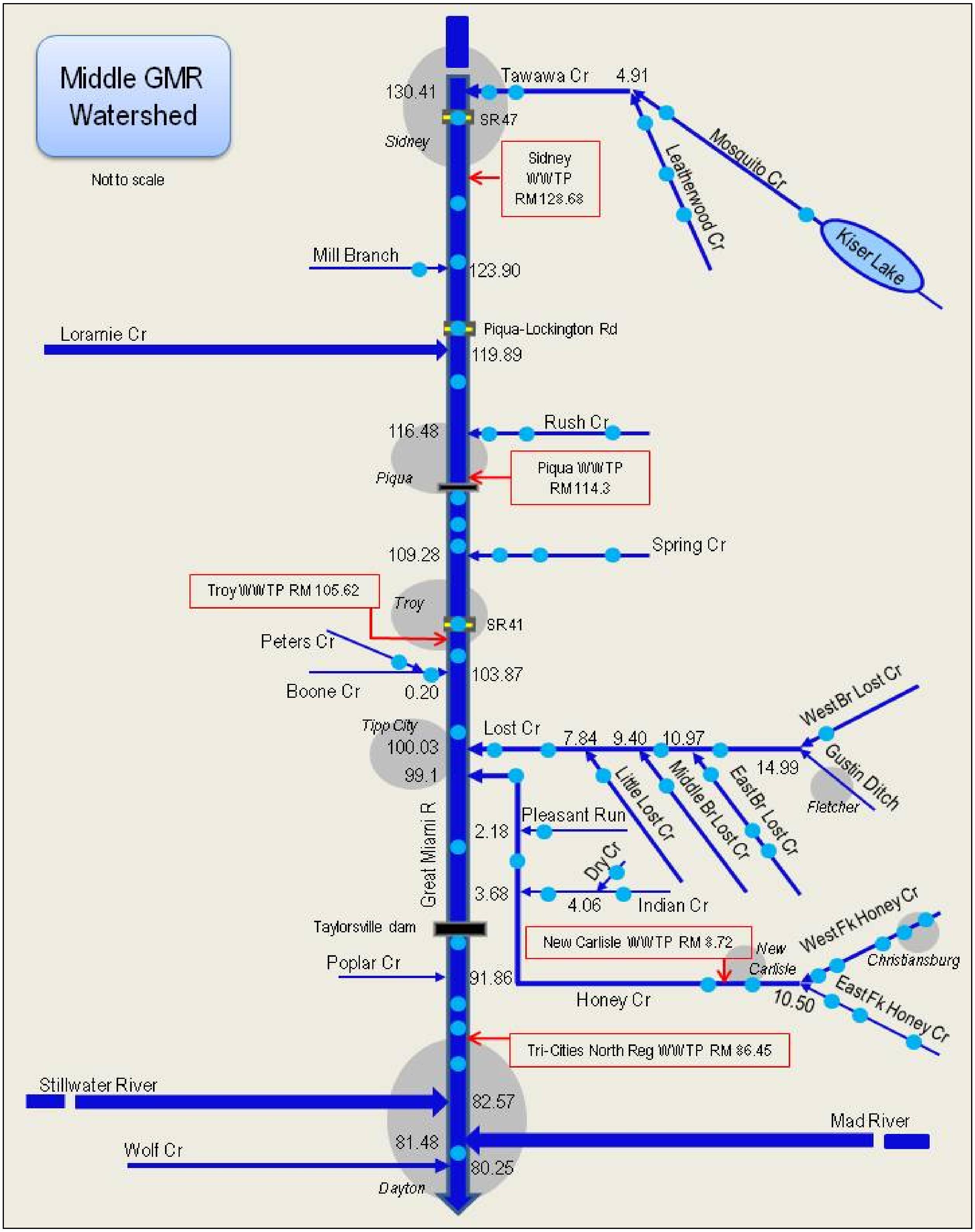


Figure 8. Schematic representation of the middle Great Miami River watershed. River miles are indicated for stream confluences and five of the WWTP discharges in the watershed. Water chemistry sampling locations are indicated by blue circles.

Several other impoundments in the watershed were created for specific purposes. Kiser Lake, a 396 acre impoundment of Mosquito Creek, is owned by the Ohio Department of Natural Resources and is open to the public as a state park. Sidney owns a small dam on Tawawa Creek to impound water for a water supply intake. The city of Piqua owns two reservoirs for water supply and recreation; Swift Run Lake is 38 acres in size and Echo Lake is 14 acres.

There is one active watershed group in the study area. The Honey Creek Watershed Association was first organized in 1997 by the Miami County Park District, the Miami SWCD and the Miami County Cooperative Extension Service. It covers all of the Honey Creek-Great Miami River basin (HUC 0508000120). The group has received Section 319 grants and Ohio DNR Watershed Coordinator grants to implement water quality improvement projects in the watershed. A new group titled Protect Our Water Ways (POWW) has recently formed in the Piqua area with the intent of protecting water quality in the area.

RESULTS

Pollutant Loads

Numerous and varied, public and private, National Pollution Discharge Elimination System (NPDES) permitted facilities discharge treated wastewater, storm water, and other sundry regulated effluents to the main stem and tributaries within the middle Great Miami study area (Table 6). Monthly effluent loadings are reported to Ohio EPA by all NPDES permitted entities. These Monthly Operating Reports (MORs) provide the quantity and character of pollutant loadings through the period of record for each entity evaluated within the 2009 middle Great Miami River study area. For major Publically Owned Treat Works (POTWs) pollutant loadings trends typically include, but are not limited to, ammonia-N, demand parameters (e.g., $cBOD_5$), solids (TDR or TDS), nitrate+nitrite-N, and conduit flow. Parameters or regulated effluent constituents from private industrial entities vary depending entirely upon the nature of the enterprise and attendant NPDES permit structure, and thus a standard suite of performance indicators is not applicable.

Table 6. NPEDES permitted facilities (public and private) contained within the middle Great Miami River study area, 2009.

NPDES	Type	Size	Facility	Receiving Stream[a]	River Mile[b]	Associated Municipality
Montgomery County						
1PD00020	P	Major	Tri-Cities North Regional Wastewater Authority	Great Miami River	86.43	Riverside
1IN00044	I	Minor	Cargill Inc. Dayton	Great Miami River	89.1	Dayton
1IN00016	I	Minor	Tate & Lyle Citric Acid	Great Miami River	88.9	Dayton
1IN00267	I	Minor	Gayston Corp.	Great Miami River	84.55	Dayton
1IN00089	I	Minor	Behr Dayton Thermal Products	Great Miami River	83.7-84.5	Dayton
1IN00134	I	Minor	Gem City Chemicals Inc.	Great Miami River	83.2-84.5	Dayton
1IN00163	I	Minor	DAP Inc. Wassall USA Holdings Inc.	Via GMR Trib.	84.4	Dayton
1II00117	I	Minor	Montgomery Co. Ash Management Facility	GMR at 90.65	0.1	Dayton
1IG00014	I	Minor	Stevens Aviation Co	North Cr. trib. at 0.95	1.55	Vandalia
1IN00096	I	Minor	Delphi Automotive Systems LLC	GMR Trib. at 84.5	1.1	Dayton
1IC00004	I	Minor	Electrical Power Systems - Vandalia	Poplar Cr. trib. At 1.79	1.2	Vandalia
1IC00045	I	Minor	Delphi Thermal Systems Vandalia Operations	North Creek	2.5	Vandalia
Miami County						
1PD00008	P	Major	Piqua WWTP	Great Miami River	114.08	Piqua
1PD00019	P	Major	Troy WWTP	Great Miami River	105.6	Troy
1PT00110	P	Minor	Piqua Springcreek Elementary School	Garby Creek	1.95	Piqua
1PV00109	P	Minor	Paris Court MHP	Rush Cr. Trib. at 3.9	0.8	Piqua
1PW00039	P	Minor	Country Meadows Condo Assn.	Echo Lake Trib.	2.1	Piqua
1PT00054	P	Minor	Western Ohio Japanese Language School	Spring Creek	1.1	Troy

Table 6. continued.

NPDES	Type	Size	Facility	Receiving Stream[a]	River Mile[b]	Associated Municipality
1IJ00011	I	Minor	Piqua Materials Inc. Piqua Minerals Div.	Great Miami River	114.35	Piqua
1IN00260	I	Minor	Kimberly-Clark *	Great Miami River	106.75	Troy
1IC00021	I	Minor	Goodrich Aircraft Wheels & Brakes	Peters trib. at 1.55	0.4	Troy
1IJ00137	I	Minor	Troy Sand & Gravel	Peters trib. at 0.13	1.0	Troy
Shelby County						
1PD00009	P	Major	Sidney STP	Great Miami River	128.6	Sidney
1PT00103	P	Minor	Fairlawn High & Middle School	Tawawa Trib. at 4.8	0.8	Sidney
1PV00037	P	Minor	Hidden Valley MHP	Tawawa Creek	3.3	Sidney
1PG00101	P	Minor	Hickory Dell Estates WWTP	Brush Cr trib. at 1.0	0.25	Orange Twp.
1PT00083	P	Minor	Fair Haven Shelby Co Home WWTP	Mill Branch	2.25	Sidney
1IJ00052	I	Minor	Barrett Paving Materials Inc. Vandemark	Great Miami River	125.7	Sidney
1IW00161	I	Minor	Sidney WTP	Tawawa Creek	Near mouth	Sidney
1IJ00033	I	Minor	Barrett Paving Materials - Miami River Quarry	Great Miami River	125.7	Sidney
1IJ00045	I	Minor	Barrett Paving Materials - Rock Run Quarry	Mill Branch	0.2	Sidney
1IN00061	I	Minor	Ross Casting and Innovation LLC	Mill Branch and Mill Br. Trib. at 3.0	2.9(main stem) and 0.2(tributary)	Sidney
Champaign County						
1IY00310	I	Minor	Christiansburg Water Works	W. Br. Honey Creek	9.25	Christiansburg
Clark County						
1PD00018	P	Minor	New Carlisle WWTP	Honey Creek	8.7	New Carlisle

P - Publically Owned Treatment Works (POTW)
I - Private/Industrial Entity
Major - Treatment works/Facility with a design flow greater than 1 MGD.
Minor - Treatment Work/Facility with a design flow less than 1 MGD.
a - Great Miami River abbreviated as GMR.
b - River mile or river segment at which waterbody receives wastewater, storm water, and other sundry regulated effluents.

Sidney WWTP
Permit:1PD00009*OD (expires January 31, 2016)
Outfall 001:Great Miami River: RM 128.68, 40.27/-84.3194
Monitoring 801:Old Truss Bridge: 40.278889/-84.153056
Monitoring 901:Sulphur Heights Rd.: 40.265000/-84.163333

The Sidney WWTP is located in Shelby County at 1091 Children's-Home Road in Sidney, Ohio and provides wastewater treatment services to the City of Sidney, the Village of Port Jefferson, and other businesses outside of the City of Sidney limits. Sidney's wastewater facility was constructed in 1955 and expanded in 1988 to meet secondary treatment requirements. The wastewater facility is an advanced treatment facility consisting of an influent pumping station, grinder pump, flow equalization, fine screen, grit removal, primary clarification, extended aeration, secondary clarification, chlorination, dechlorination and cascade aeration. The collection system contains Sanitary Sewer Overflows (SSOs) with the entire service area sewered. The city owns and maintains five lift stations located at Mason Rd, Kuther Rd, SR 47 East, Plum Ridge and Hoewisher Roads (only backup generator operated at this location). Sidney currently does not have design considerations for nutrient removal (nitrogen and phosphorus). Pollutant loadings through time are presented in Figures 9 and 10.

The City of Sidney's WWTP receives 45% of flow and 65% of loading from industrial customers (Honda, Cargill, Freshway Foods, etc.). Sidney WWTP has eight FTE staff members operating the treatment works, relying heavily on automation and continuous monitoring. The wastewater treatment facility is staffed for one shift, Monday through Friday and checked on the weekends. Ohio EPA conducted a facility inspection in 2008 that was rated as satisfactory.

In 2001, construction was completed of a major expansion that increased the average daily design flow rating from 5 Million Gallons per Day (MGD) to 7 MGD, with a peak flow rating of 14 MGD. Additional improvements in 2001 included; expansion to the influent pump station increasing pumping capacity from 21 MGD to 36 MGD, installation of a mechanical fine screen, addition of chemical addition to the influent for odor control, Expansion to the aeration basins to increase hydraulic and organic loading capacity, addition of a secondary clarifier, replaced outdated disinfection equipment, addition of centrifuge dewatering for biosolids, major improvements to automation and monitoring equipment (SCADA system). The upgrade in 2001 did not include solids treatment. Process control equipment that was not replaced during the 2001expansion is nearing the end of its serviceable life.

In 2004, modifications to the influent sewers were completed including the replacement of a mechanical bar screen with a 40 MGD capacity channel grinder. The City of Sidney's ultimate disposal of generated solids is land applied and disposed of at agronomic rates. The next upgrade recommendations are; increase solids treatment capacity, increase hydraulic capacity, increase backup generator capacity, bring in UV disinfection and energy recovery projects.

The pretreatment program has grown from 21 permitted industrial users in 1985 to 34 permitted industrial users. The volume of waste stream is comprised of approximately half industrial and half sanitary wastewater. Although the city has permitted 34 of its Industrial

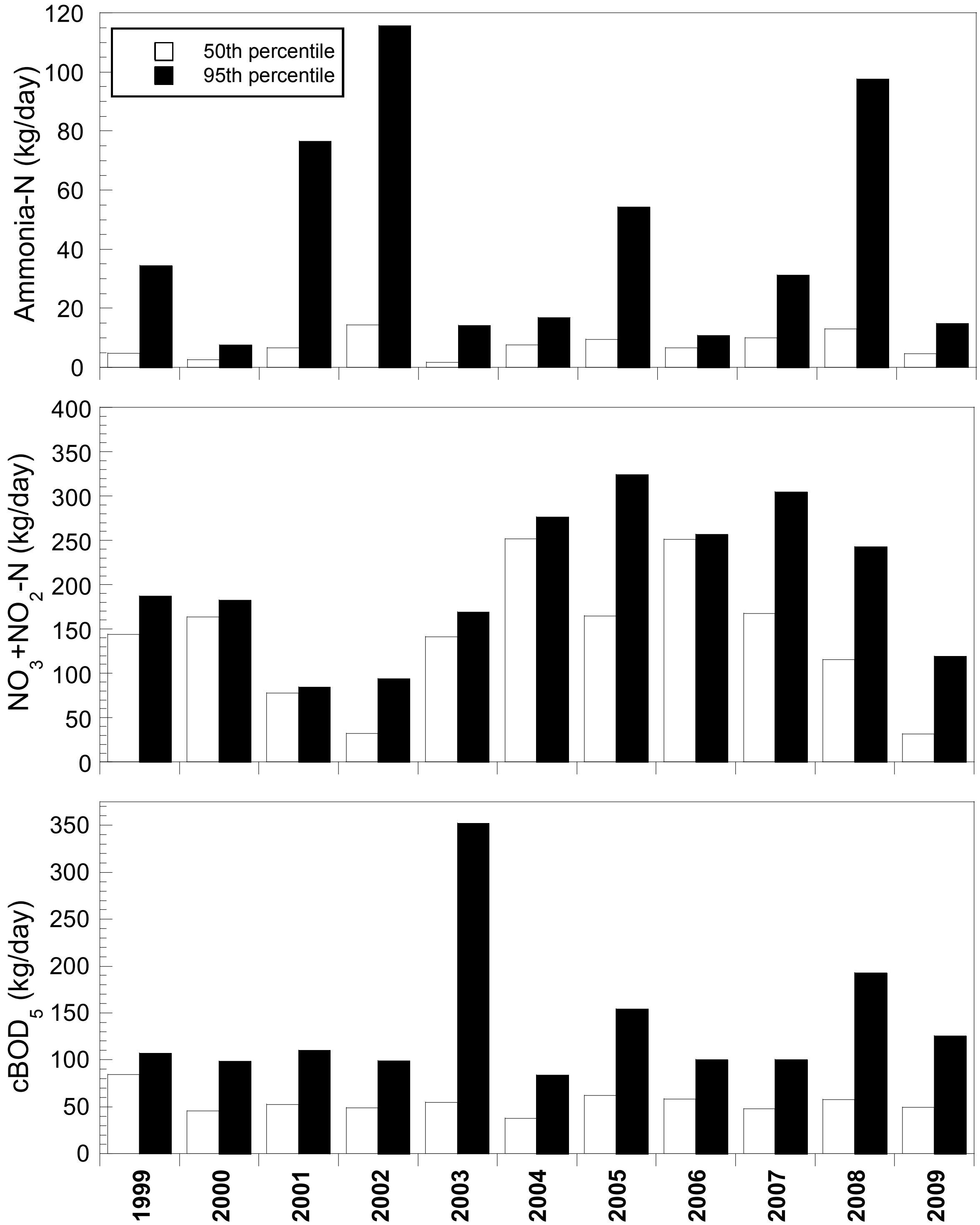


Figure 9. Annual, third-quarter loads (kg/day) of Ammonia-N, Nitrate+Nitrite-N, and $cBOD_5$ from the Sidney WWTP, 1999-2009.

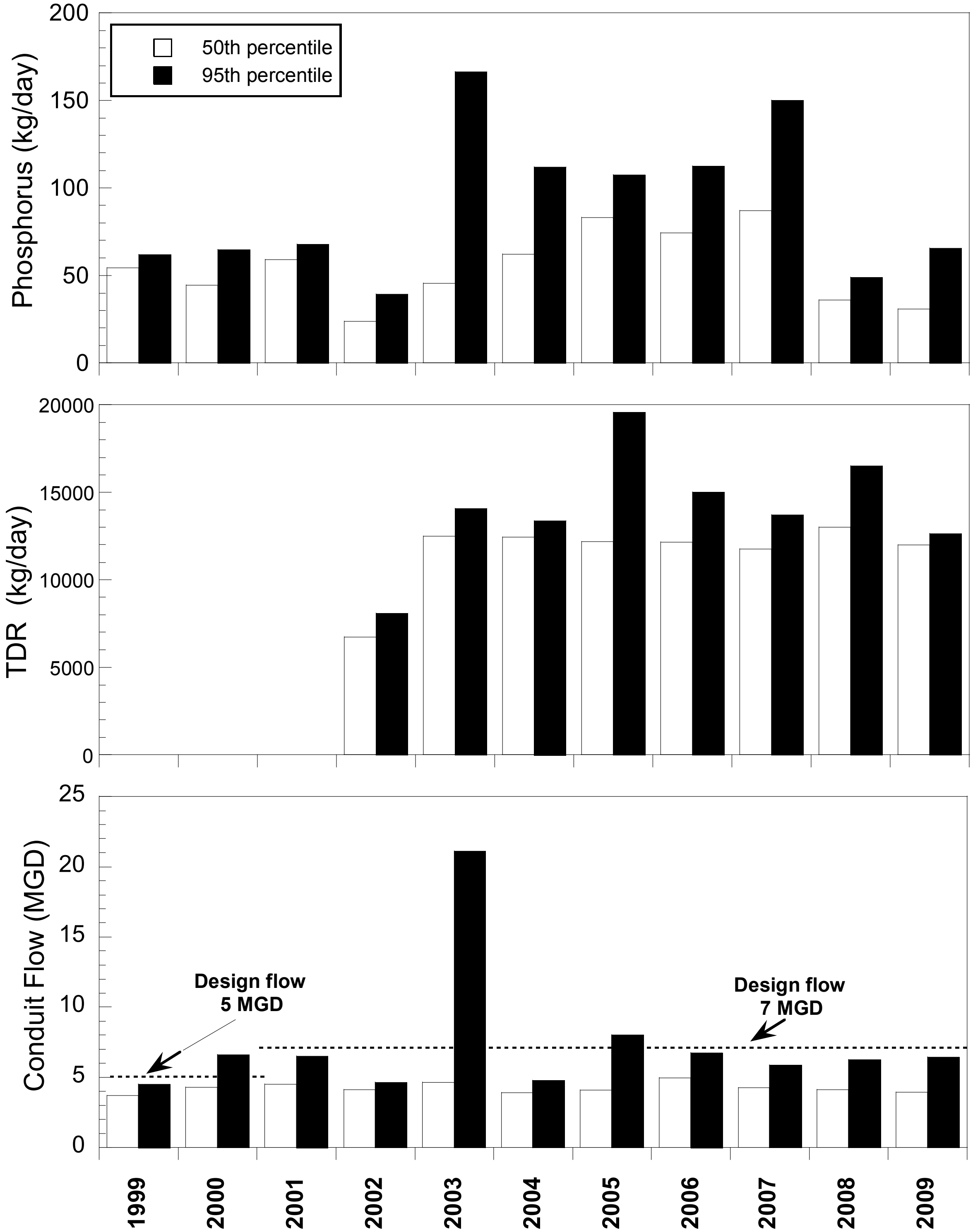


Figure 10. Annual, third-quarter loads (kg/day) of Phosphorus and Total Dissolved Residue [TDR, AKA Total Dissolved Solids (TDS)], and Conduit Flow (MGD) from the Sidney WWTP, 1999-2009.

users, it has identified a total of 59 Industrial Users currently discharging wastewater to the wastewater treatment plant. There are eleven *significant* industrial users in categories of metal finishing, electroplating, coil coating, metal holding and casting.

Historically, manual bypassing occurred at the facility due to wet weather events and the need to prevent backups into citizens' residences and facility washouts. The facility has the capability of bypassing after primary clarification and chlorination prior to discharge to the Great Miami River. The average flow rate in 2009 was 4.7636 MGD where maximum flow rates have been as high as 19.38 MGD exceeding the peak flow design for the facility.

Facility bypassing events have been triggered with rainfalls of one inch or greater, especially in March with snow saturated ground. Bypassing has occurred annually at a rate of two to three bypasses a year. Bypassing sends millions of gallons of partially treated sewage to the Great Miami River. Inflow and infiltration (I/I) of antiquated collection systems promotes overburdening of the treatment process whereby bypassing maintains balance for normalized treatment. Historically, since 1984, the City of Sidney expended over $6.2 million dollars on sewer system rehabilitation to address I&I in the collection system by utilizing camera and smoke testing to find illegal connections and deteriorated pipes. Illegal connections of residential sump pumps continue to increase flow at the facility.

Active sewer overflow locations are mostly discovered by citizen complaints or city employees that are checking storm basins. No dry weather sanitary sewer overflows have been reported by the City of Sidney.

Numeric violations within the NPDES permit were evaluated for outfall 001, from 2005 to 2009. For the five years of data, evaluated through SWIMS, 23 violations, of predominately ammonia-N, dissolved oxygen, and cBOD5, were noted, increasing in frequency by 2008. Approximately half of the violations occurred in summer months. No NPDES permit violations or significant operational problems were attributed to industrial users. Significant equipment failures attributed to violations in 2008.

Frequency violations of the NPDES permit were evaluated at outfall 001, from 2005 until 2009. Sixty-four violations of predominately chlorine, dissolved oxygen, pH and flow rate were reported. Eighty-nine percent of the violations occurred in June 2009.

Code violations of the NPDES permit were evaluated at outfall 001, from 2005 to a portion of 2009. For the five years of data, evaluated through the Surface Water Information Management System (SWIMS), six violations were reported in 2008**.**

Ohio EPA conducted acute screening bioassays of Sidney WWTP outfall 001 effluents, upstream and mixing zone waters, in the spring of 1999, fall and winter of 2004**,** and spring of 2009. Four toxicity sampling events resulted in no toxicity endpoints for both test organisms.

Piqua WWTP
Permit: 1PD00008*RD (expires January 31, 2016)
Outfall 001: Great Miami River, RM 114.3 (dam Pool) and 114.13 (dst. dam)
40.130280/-84.235000
Outfall 005: eliminated in 2010
Monitoring 801:Main St.
Monitoring 901:Farrington Rd.

The Piqua WWTP is located in Miami County at 121 Bridge St. in Piqua, Ohio. The facility was built in 1958 and became an activated sludge plant in 1984. The facility rehabilitation expansion was completed in 1991, which increased the average daily design flow to 4.5 MGD and added dechlorination, aeration tanks, clarifiers, and a new grit and grease removal system. The Piqua WWTP is a secondary treatment facility consisting of an influent pump station, screening grit removal, scum removal, pre-aeration, primary clarification, activated sludge aeration with four anoxic zones, final clarification, chlorine gas disinfection, sulfur dioxide dechlorination and post aeration. Pollutant loadings through time are presented in Figure 11 and 12.

The annual average flow in 2009 was 2.2161 MGD. Expansion of wastewater facilities is encouraged at 80% of the Average Daily Design Flow (ADDF). As all in-flow is not presently accounted for, flow metering is recommended for the next upgrade cycle. Lift stations in the collection system are located at the Piqua Mall, Candlewood, Maplewood, Stratford and Orchard Drive areas.

Sludge is land applied at agronomic rates to over 1000 acres on fields surrounding Piqua and extends southward to just north of Englewood. If climate and soil conditions are not conducive for land application, the city has a reserve plan allowing landfilling of sewage sludge at Stony Hollow Landfill. All processes are contracted through Burch Hydro Company.

Piqua historically maintained two direct discharges outfalls (001 and 005) to the Great Miami River. Outfall 005 was situated immediately upstream of the Piqua Power dam at RM 114.3, the other (001) is located downstream at RM 114.13. Operators had the option of discharging to either location. Historically, discharge from the treatment plant was always directed to the dam pool from outfall 005 to cool the power plant dam pool. The discharge from the power plant was eliminated by 2005. Deterioration of outfall 005 resulted in the eventual closure and elimination of the discharge point in 2010.

Inflow and infiltration issues have been problematic in Piqua's collection system. Operators have historically throttled flow to force in-line storage during high flow events. However, to prevent backup and property damage, a bypass gate SSO south of the power plant relieves the collection system by discharging into the Great Miami River. An estimated 100 overflow occurrences were reported by the City

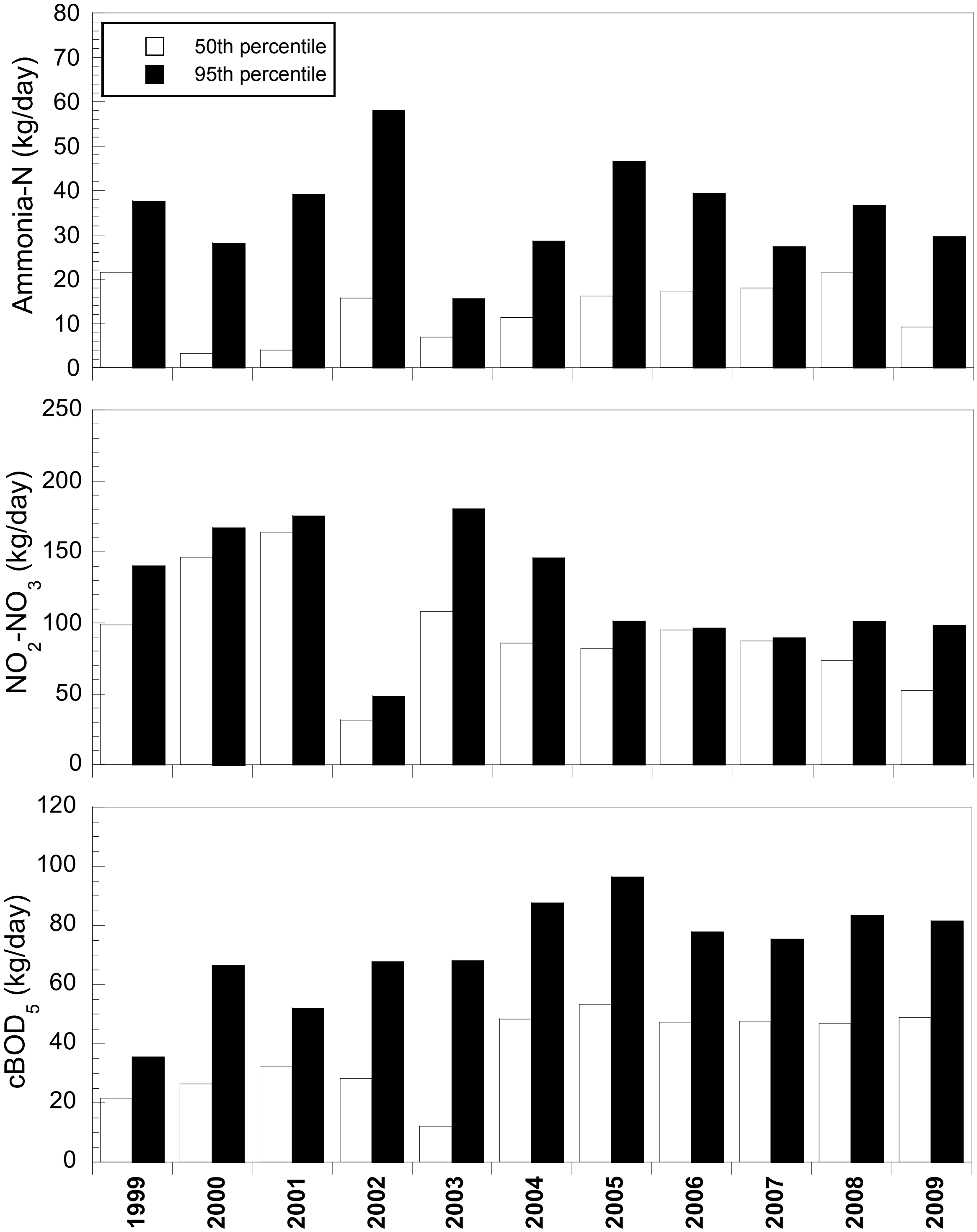


Figure 11. Annual, third-quarter loads (kg/day) of Ammonia-N, Nitrate+Nitrite-N, and $cBOD_5$ from the Piqua WWTP, 1999-2009.

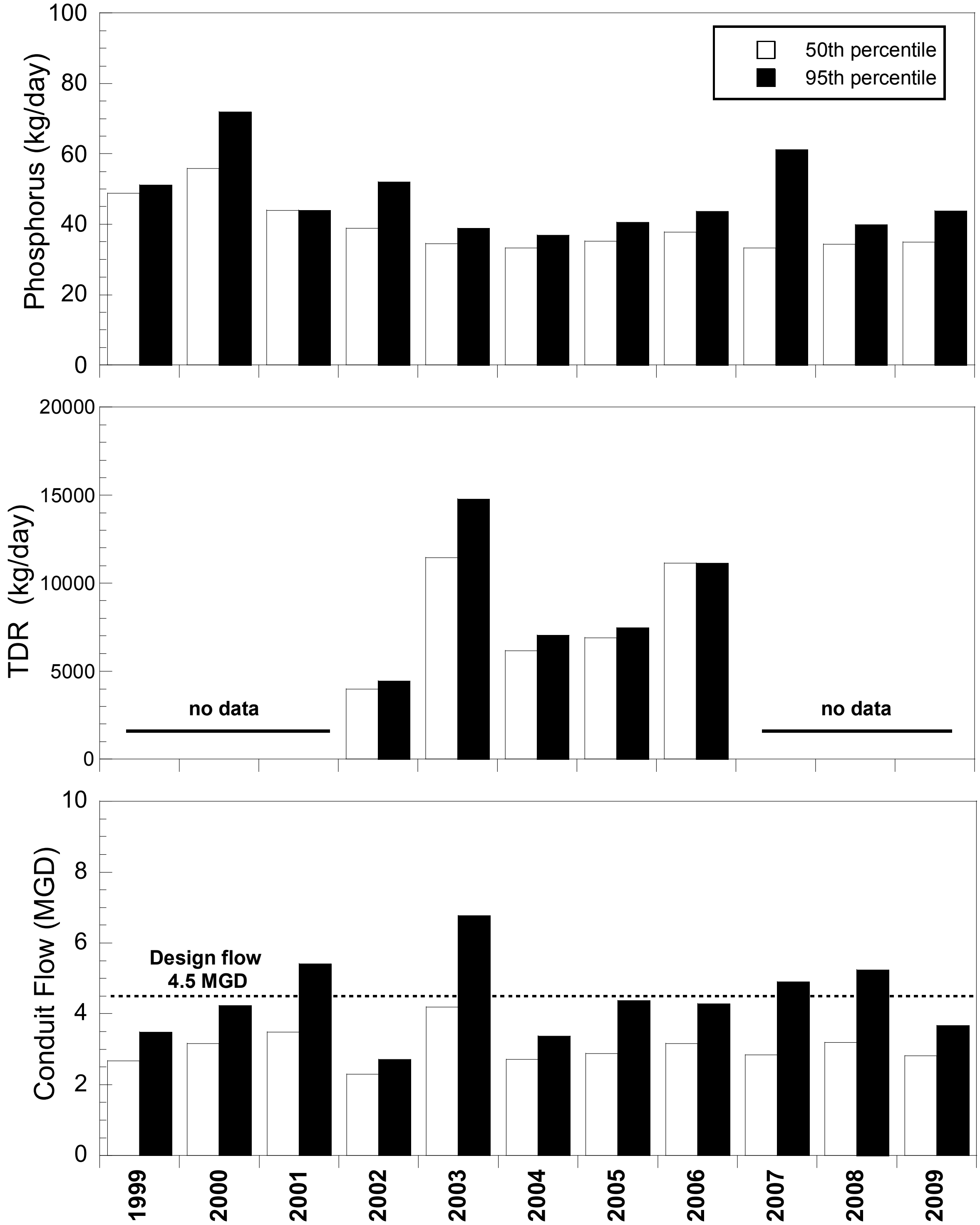


Figure 12. Annual, third-quarter loads (kg/day) of Phosphorus and Total Dissolved Residue[TDR, AKA Total Dissolved Solids (TDS), and Conduit Flow (MGD) from the Piqua WWTP, 1999-2009.

of Piqua from 2000 until 2006. An I/I study in 2007 estimated one MGD of groundwater infiltrates the collection system pipes. In January 2007, a one inch rainfall upon saturated ground bypassed approximately 0.3 million gallons (MG) over four days. Sanitary sewer overflows in February and March 2007 discharged a combined total of 4.5 MG to the Great Miami River. In February 2009, a recorded 0.78 inch rain was the catalyst for an estimated one million gallon overflow. Other problems such as basement backups of sewage have been attributed to roots in the mainline.

In 2007, Ohio EPA issued a sanitary sewer overflow elimination schedule to the City of Piqua. In 2010, construction of an equalization basin was completed with the capability of equalizing flows from storm events for the east interceptor. This has stabilized minor storm events up to one million gallons. Spring rains in March 2010, measured just over one inch of rain, resulting in a discharge of over 0.5 MG of raw sewage from a bypass gate (chronic overflow location behind the now defunct Piqua Power Plant) into the Great Miami River. Another storm event in March of 2010, at the same overflow location, sent three MG into the Great Miami River over a 4 day period.

Possible future phases of SSO elimination could include the addition of pumping to utilize the full two and a half million gallon capacity of the equalization tank, a second equalization basin with the same capacity, and pumping capabilities for a second tank." In early 2011, a sewer lining project was completed on the west sewer interceptor to address structural problems previously identified to be the source of river intrusion.

Limit violations of the NPDES permit were evaluated for outfall 001, from 2005 to 2009. For the five years of data, evaluated through SWIMS, one violation of dissolved oxygen was reported. Violation totals in a SSO community can make tracking difficult due to the flow characteristics, nature of overflows of raw sewage outside of collection systems, and dilution.

Ohio EPA conducted toxicity testing (acute bioassays) at Troy WWTP outfall 001 with effluents, upstream and mixing zone waters. The tests were conducted in May 1999, October 2004, December 2004 and December 2008. No toxicity endpoints occurred for any of the tests, for either of the test organisms. These tests do not address the possibility of chronic toxicity and are generally conducted during unannounced inspections of the facility.

Troy WWTP
Permit: 1PD00019*KD (expires January 31, 2016)
Outfall 001: Great Miami River, RM 105.62, 40.025/-84.185278

The Troy WWTP is located in Miami County at 1400 Dye Mill Rd in Troy, Ohio and was built in 1939's. Troy's wastewater facility is a conventional activated sludge plant and is currently operated in the contact stabilization mode (two aeration tanks are used therefore wastewater enters the aeration tanks and organic biodegradable materials are removed rapidly by biological processes during a relatively short contact time). The treatment facility processes consist of an influent pump station, grit removal, primary settling, activated sludge aeration, secondary clarification, ultraviolet disinfection and post aeration. Two, one million gallon equalization basins, are utilized during storm events in excess of facility treatment capacity. The average daily flow in 2009 was 4.077 MGD and the average daily flow from January 2009 to June 2010 was 4.485 MGD. During storm events, inflow is diverted to the equalization basins until the wastewater treatment process stabilizes and can properly treat this additional stored wastewater. The Three Year Compliance Status by Quarter charts (as part of the USEPA Enforcement and Compliance Online reporting (ECHO) obtained at http://wwwapp.epa.ohio.gov/dsw/gis/npdes/index.php), indicates from the last quarter of 2008 until the end of 2010, nine quarters of compliance were reported. Pollutant loadings through time are presented in Figure 13 and 14.

Upgrades at the Troy wastewater facility occurred in 1995 and 2001. By 2001, Troy completed an expansion of the secondary clarification process and installed odor control technology on its biosolids treatment process. The town of Casstown connected to Troy sewers in 2009.

As of 2009, the collection system has eight lift stations of which none are alarmed or have permanent standby power; however, half can be powered by generator (Southview, Dorsett and Kirk Lane). The other half require bypass pumping to manholes during an outage. Lift stations are visited three times a week and spare pumps have been obtained for emergencies. Five categorical industrial users and three significant, non-categorical industrial users contribute approximately 1.3 MGD to the wastewater plant.

In 2007 and 2008, SSOs occurred at the W. Main St. manhole, Dorset Rd lift station and at manholes in the Hawk's Nest subdivision at the junction of routes 718 and 55. Some overflows at the Dorset Rd. lift station continued for 24 hours emitting approximately 25 gallons per minute (GPM) of raw sewage to the Great Miami River. Twenty manholes at the Peak Foods Inc. facility has had discharges that created grease blockages in the collection lines which resulted in wet weather pump station overflows at Camp Troy off County Rd 25A. Overflows into Troy residents' basements occurred in 2009 due to debris and roots in sanitary sewer lines in the Westbrook neighborhood off Rt. 41 (W. Mains St) near Menke Park and I-75. Clogged pumps at lift stations failed due to clogging by debris. Removal of debris by personnel resolved the problem. Purchasing screened pumps and self-cleaning impeller pumps, that virtually eliminate built-up debris, may change the clogging events.

In 2008, an I/I study was undertaken by the City of Troy. Fifteen manholes were subsequently sealed that contributed flow to the Dorset Rd lift Station and eight more were sealed system wide. Additional locations of sewer needing slip lining were identified and work commenced in 2010. There were no reported SSOs from 2009 to 2011.

In 2005, EPA personnel stopped at the facility for an unannounced site visit at the end of the disinfection season. Facility personnel were discovered emptying and power washing the chlorine contact tank, sending massive amounts of solids to the stream. Ohio EPA personnel addressed the proper procedures for post disinfection season. Ohio EPA inspection of the lab and collection system findings in 2010, rated the overall facility as satisfactory.

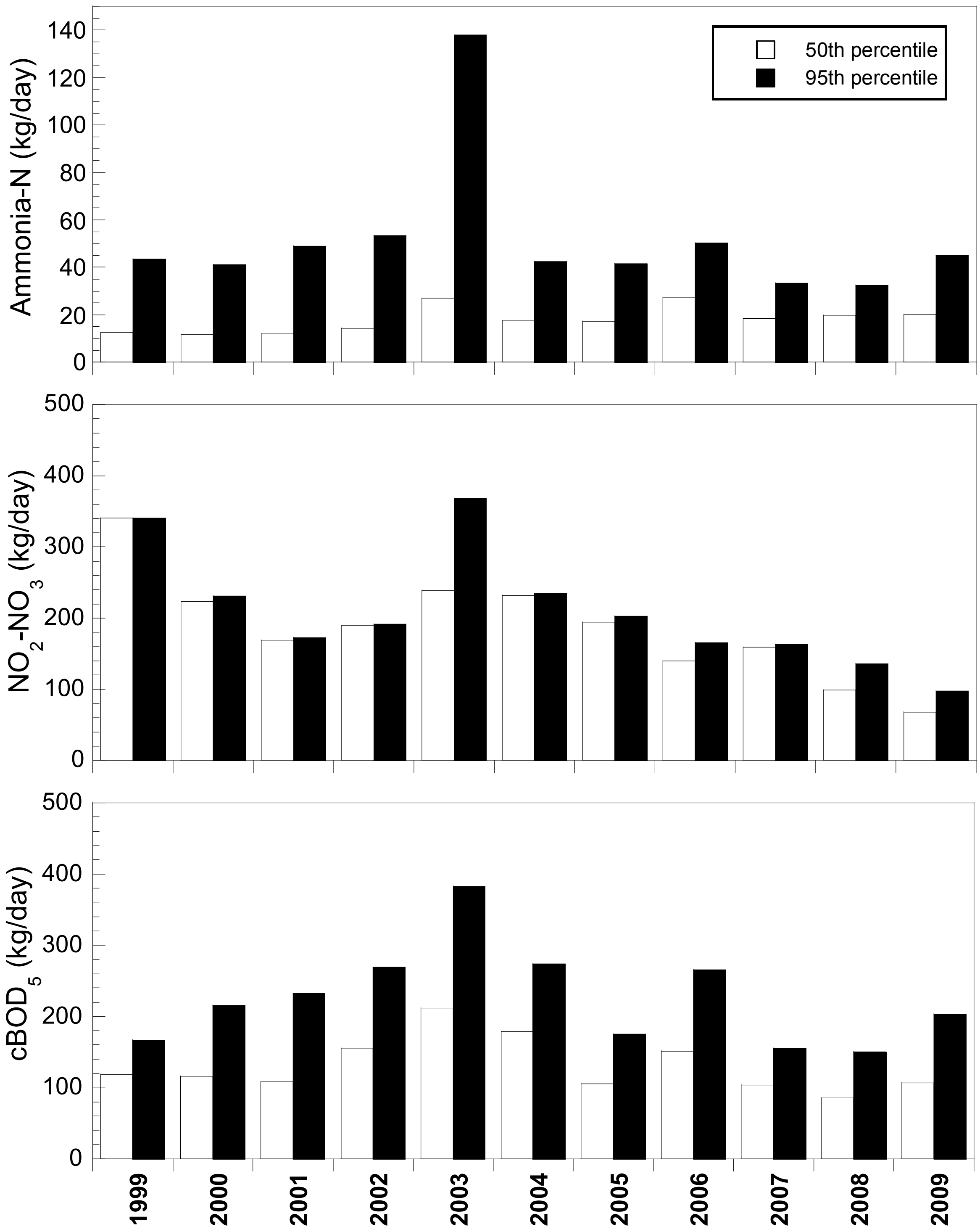


Figure 13. Annual, third-quarter loads (kg/day) of Ammonia-N, Nitrate+Nitrite-N, and $cBOD_5$ from the Troy WWTP, 1999-2009.

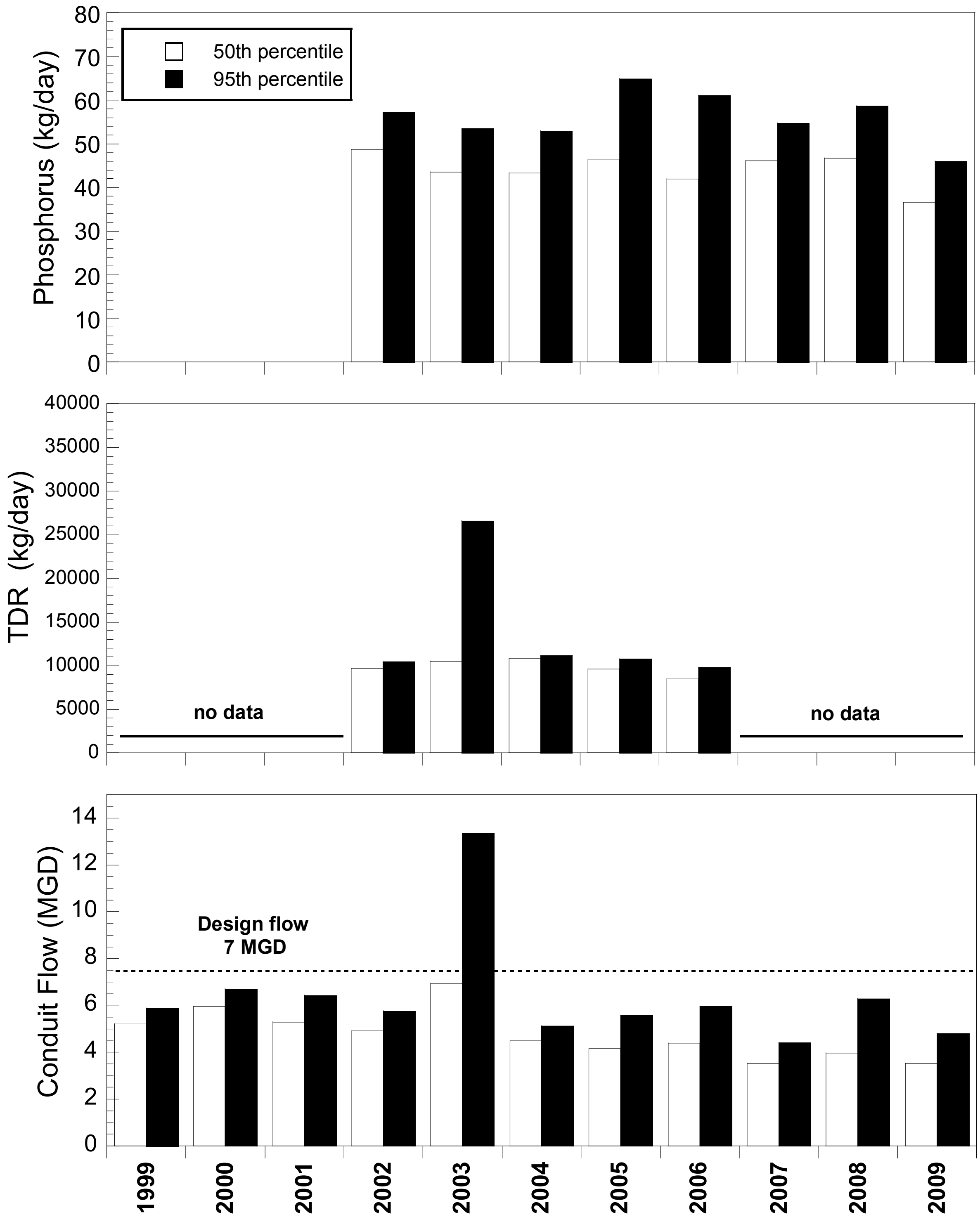


Figure 14. Annual, third-quarter loads (kg/day) of Phosphorus and Total Dissolved Residue [TDR, AKA Total Dissolved Solids (TDS)], and Conduit Flow (MGD) from the Troy WWTP,1999-2009.

Historically, Class A biosolids were land applied on approximately 145 acres of farmland north of the City of Troy in Monroe and Bethel Township. That treatment process recently ceased and currently the biosolids are hauled to Jay County Indiana landfill, a mixed waste disposal facility.

Limit violations of the NPDES were evaluated at outfall 001, from 2005 to 2009. For the five years of data, evaluated through SWIMS, 35 violations of predominately TSS and cBOD5 were reported. Eighty-nine percent of the violations were in 2007 and 2008 and occurred mostly in March, May and June. Violations were reported due to either, excessive flow (2007, 2008) or in-house laboratory analysis deficiencies that were addressed by 2007. Oil and grease violations were reported due to food producers, Peak and Conagra Foods Inc. and have been addressed through industry protocol changes.

Frequency violations of the NPDES were evaluated at outfall 001, from 2005 to 2009. For the nearly five years of data evaluated through SWIMS, 37 violations were reported, comprised mostly of oil and grease and occurring primarily in 2006 and 2007.

Ohio EPA conducted toxicity testing (acute bioassays) at Troy WWTP outfall 001 with effluent, upstream and mixing zone waters. The sampling for the tests was unannounced to the facility prior to the events and was conducted in May 1999, November 2004, May 2005, December 2008 and February of 2009. No toxicity endpoints occurred for any of the tests, for either of the test organisms. These tests do not address the possibility of chronic toxicity. Based on categorical criteria for Troy WWTP, no effluent limits or monitoring requirements are proposed for whole effluent toxicity.

B.F. Goodrich (Aircraft Wheels and Brakes)
Permit: 1IC00021*ED
Outfall 001: Great Miami River-RM 103.5, via Peters Creek, 40.023610/-84.221940

B.F. Goodrich Aircraft is located in Miami County at 101 Waco St. southwest of Troy, Ohio. Goodrich Aircraft is a global supplier of systems and services to the Aerospace and Defense industry. Goodrich produces commercial, regional, business and military wheels and brakes. Originally B.F. Goodrich had four discharge points from outfall 001 to outfall 004. Prior to August 2008, the discharge consisted of non-contact cooling water, boiler blowdown, air conditioner condensate, fire system test water and storm water. Since then, the non-contact cooling water, which was a source of residual chlorine, was eliminated making the facility eligible for coverage under the Industrial Stormwater General Permit only. The NPDES permit was not required as of 2009.

Limit violations of the NPDES were evaluated from 2005 to 2009 which revealed 18 violations of primarily chlorine. Seventeen percent of the total occurred from 2008 until 2009.Frequency violations of the NPDES were evaluated from 2005 until 2009. Ten (10) violations, of primarily pH, were documented from 2005 until 2007.

Cargill Inc.
Permit: 1IN00044*GD
Outfall 001: Great Miami River: RM 89.10, via unnamed tributary
39.827778/-84.174167
Outfall 002: Location to be determined through next permit cycle.

Cargill, Inc. is located in Montgomery County at 3201 Needmore Rd. in Dayton, Ohio. Cargill, Inc. is a corn wet milling facility which uses #2 yellow corn as the raw material to produce corn syrup, corns starch, high fructose corn syrup, corn germ, corn gluten meal and gluten feed. Molasses is used as the raw material to produce sucrose.

The industrial stormwater runoff flows to a 50,000 gallon storm water basin that is tributary to the final outfall 001. All process tanks are located within the process buildings and all process wastewater as well as the silo sump pump goes into the sanitary sewer system. The stormwater basin is cleaned on a monthly basis, pumps are used to lower the basin to a preset level and the vacuumed solids are solidified and disposed of at a sanitary landfill in Columbus. Scale inhibitors added to the non-contact cooling water settles iron out as orange sediment, beneath the outfall. The average daily design flow for non-contact cooling water and effluent loadings calculations is 2.68 MGD. Outfall 002 receives facility operations that contribute stormwater runoff such as wash-downs at the facility.

Outfall 001 is a combination of non-contact cooling water from the facility's wells, stormwater from one drain north of the settling basin and may contain overflow from the settling pond during certain rain events. The concrete basin collects material from the majority of outside drains throughout the corn plant. Challenges continue for Cargill to reduce volume in its stormwater settling basin between precipitation events. The goal being to increase retention volume and minimize overflows from the basin to outfall 001.

In 2008, there was a release of a black material into the Great Miami River observed from the confluence of the side channel of the Great Miami River that Cargill and Tate and Lyle discharge into and the Great Miami River extending up to Cargill. Cargill was not aware of any spills or releases from the company. Black solids, resembling those in-stream, were noted at outfall 002. The source of the plume went unresolved. Since 2008, however Cargill has enacted measures to prevent and reduce pollutants to its stormwater collection by changing wash station protocols, ground cleaning and pumping the stormwater basin to the City of Dayton.

Limit violations of the NPDES were evaluated at outfall 001, from 2005 to 2009. For the five years of data, evaluated through SWIMS, 12 violations were reported. Most occurrences were in 2007 and 2008 and none reported from November to February. The majority of violations were $cBOD_5$ and TSS. Representative sampling methods and quantifying volumes have been discussed with the company in 2010**.**

Frequency violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the five years of data, evaluated through SWIMS, 23 violations were recorded. Fourteen percent of the violations occurred in 2009 with no reported occurrences in 2008. Most were evenly divided between BOD_5, TSS and oil and grease respectively and occurred in all months except April-August.

Code violations of the NPDES were evaluated from 2005 to 2009. For the five years of data, evaluated through SWIMS, 45 violations of water temperature occurred in January and February of 2008 only. Entity conducted acute bioassay testing occurred in 1998, 1999 and 2000 at outfall 001. No toxicity endpoints occurred for any of the tests or either of the test organisms.

Tate and Lyle Citric Acid Inc.
Permit: 1IN00016*GD
Outfall 001: Great Miami River-RM 88.83, 39.825000/-84.170830

Tate and Lyle Citric Acid is located in Montgomery County at 5600 Brentlinger Dr. in Dayton, Ohio. The Tate & Lyle Citric Acid facility is a single product unit producing the common food additive, citric acid, utilizing the production processes of fermentation, filtration, liquid extraction, activated carbon absorption and crystallization. Tate and Lyle produce citric acid by the fermentation of corn. The feedstock they use is dextrose, a simple sugar derived from corn.

The citric acid is purified and sold as a common acidulant in food, beverages and pharmaceutical industries. Other processes utilized are crystallization and packaging processes. The process wastewater generates non-contact process cooling water (~940,000GPD), and demineralized backwash water (11,000 GPD). The average daily design flow is 0.150 MGD. All above ground storage tanks are equipped with secondary containment to prevent material escape to stormwater. General floor drains and the compressor and boiler room drains are piped to an oil and water separator. The water is discharged to the City of Dayton sanitary sewer and the oil is discharged to an underground storage tank prior to being hauled off-site for disposal/reuse.

Overflows and spills of acidic substances have been reported through the years with most being contained and only a few reaching the river. The acidic nature of the raw materials and byproducts could be accelerating deterioration of Tate and Lyle’s infrastructure such as valve, pipe and line breakages, causing spills and overflows. Perhaps infusion of capital to upgrade this facility is needed to reduce the number of releases at this facility.

Limit violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the five years of data, evaluated through SWIMS, 11 violations were reported. Most occurrences were pH, reported in 2007 and 2008, and not reported from January to April. In July of 2008, Tate and Lyle installed a well to replace their reliance on city water. The violations in 2008 were attributed to the start-up of the ion exchange system used for softening well water.

Frequency violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the five years of data, evaluated through SWIMS, 23 violations were recorded. Thirty-nine percent of the violations occurred from 2008 and 2009 and mostly from January through February.

Tri-Cities North Regional Wastewater Authority (TCA) WWTP
Permit:1PD00020*ID
Outfall 001: Great Miami River, RM 86.45-39.808890/-84.152778

Tri-Cities North Regional Wastewater Authority (TCA) is located in Montgomery County at 3777, Old Needmore Rd. in Dayton, Ohio. The facility was originally built for the City of Huber Heights' wastewater collection, in joint ownership with the Miami Conservancy District (MCD) in 1985. MCD then sold the wastewater treatment facility to the three city joint venture of Huber Heights, Vandalia and Tipp City. A joint board was formed under the Tri-Cities Sewer Authority. The Tri-Cities Sewer Authority contracts with Veolia water to operate and maintain the North Regional WWTP and the three communities' trunk sewers. The cities of Huber Heights, Tipp City and Vandalia maintain their own collection systems. Huber Heights contracts with United Water Works to oversee its collection system.

The Tri-Cities North Regional treatment facility consists of grit and scum removal, flow equalization, two primary clarifiers, four random media filters, two intermediate clarifiers, two nitrification towers, two final clarifiers, chlorination, and dechlorination. The average daily design flow is 11 MGD with a peak flow of 16 MGD. The Three Year Compliance Status by quarter charts (as part of the USEPA Enforcement and Compliance Online reporting (ECHO) obtained at http://wwwapp.epa.ohio.gov/dsw/gis/npdes/index.php), indicates from mid-2008 until the end of 2010, eight out of ten quarters were in non-compliance for ammonia-N. Pollutant loadings through time are presented in Figure 15 and 16.

Waste activated sludge is pumped from the treatment plant to holding tanks located at the sludge fields off SR 40 and Sullivan Rd. A dedicated pipeline used to pump sludge to the farm fields was built by MCD in 1985, the same year the treatment plant was built. In 1996, MCD turned over operations of the entire system to Tri City Sewer authority. Sludge disposal is to land application at agronomic rates. The sludge application sites have groundwater monitoring wells in order to monitor any impacts to the underlying aquifer. Elevated nitrate levels have been detected near drinking water wells.

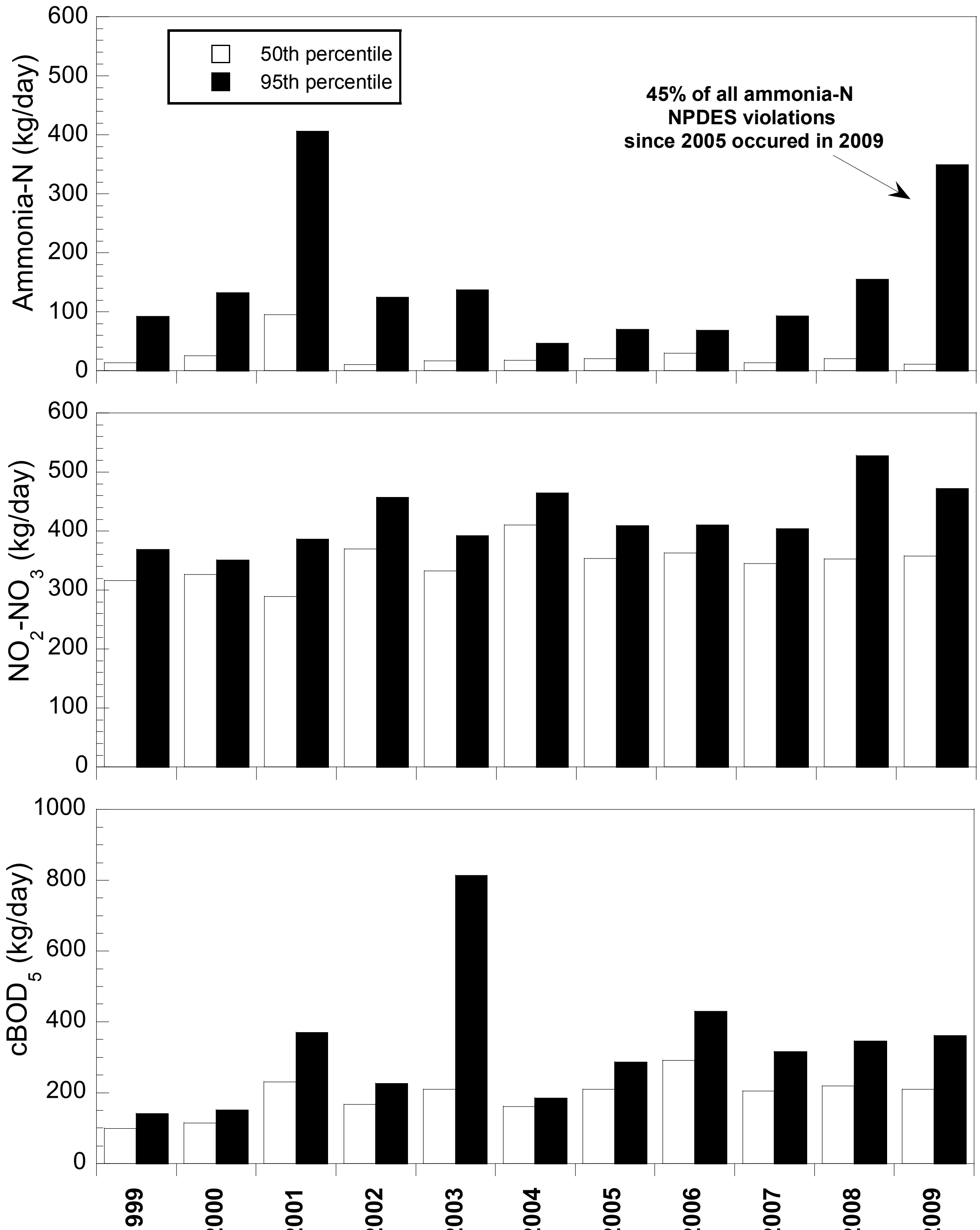


Figure 15. Annual, third-quarter loads (kg/day) of Ammonia-N, Nitrate+Nitrite-N, and $cBOD_5$ from the Tri-Cities Regional Wastewater Authority WWTP, 1999-2009.

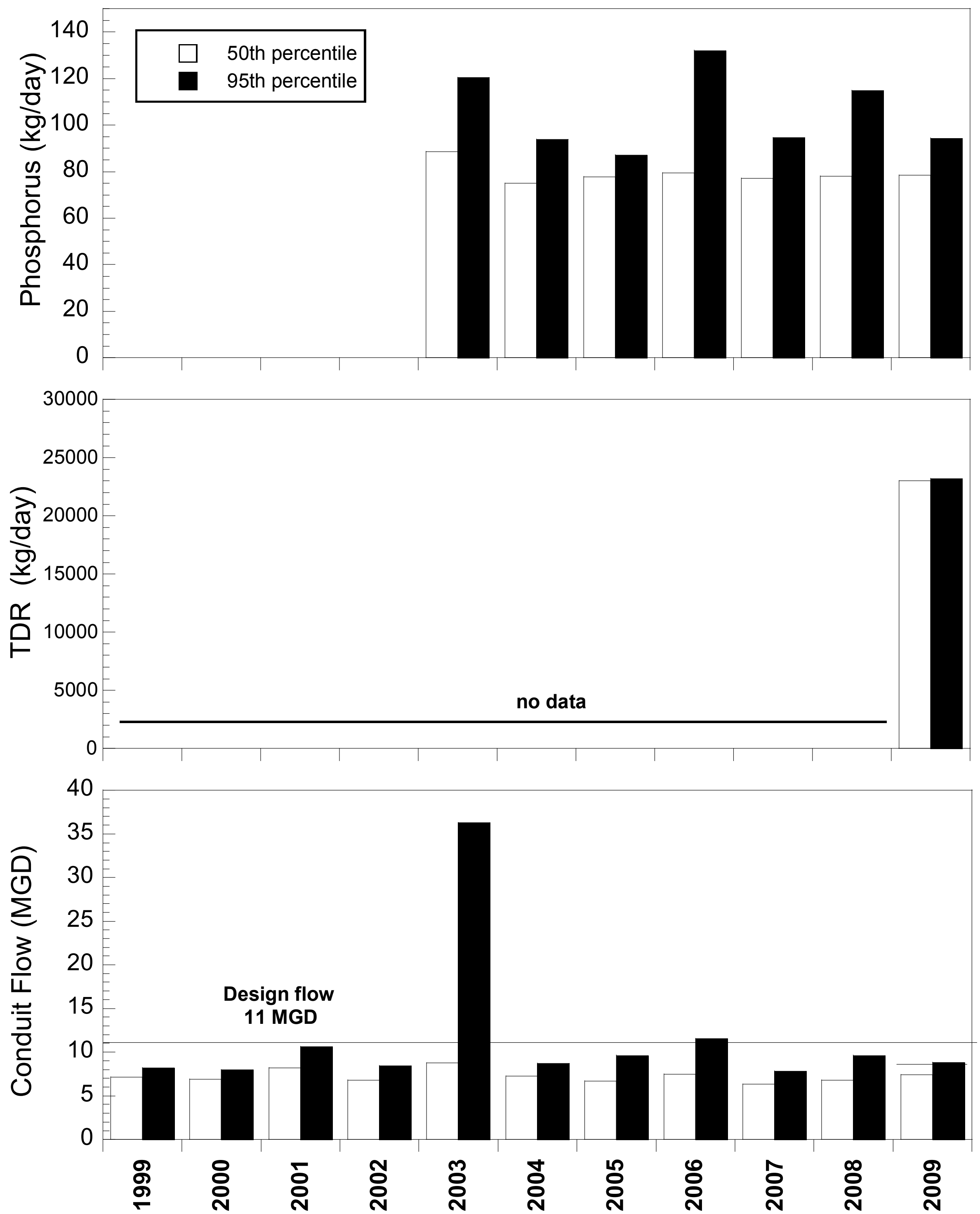


Figure 16. Annual, third-quarter loads (kg/day) of Phosphorus and Total Dissolved Residue [TDR, AKA Total Dissolved Solids (TDS)], and Conduit Flow (MGD) from the Tri-Cities Regional Wastewater Authority WWTP, 1999-2009.

The Tri-Cities sewer authority contracts with Veolia Water to operate and maintain the main interceptor sewers that all three communities (Huber Heights, Tipp City, and Vandalia). This includes 10.09 miles of gravity sewer, 4.34 miles of force main, two siphons, and one lift station. The interceptors have experienced problems with SSOs. Infiltration and inflow into the system is the main cause. There are three main overflow points in the system, Little York Siphon (discharges to Great Miami River), Tipp City Metering Station (discharges to Great Miami River), and MH 40 (discharges to interstate 70 ditch to Great Miami River). From 2004 to 2008, Veolia reported 91 SSOs. From 2009 to 2011, Veolia reported 11 SSOs. Upgrades within the community systems along with the installation of a relief force main and Ross Rd. pump station upgrade have helped to reduce, significantly, the number of overflows.

Huber Heights has the most miles of gravity sewers totaling 137 miles, more than the other cities' combined, contributing 52% of the flow to TCA. The Huber Heights collection system has two main SSO points, the Charlesgate lift station, and Old Troy Pike lift station. Collection system-wide there were 11 SSOs reported in 2010. Huber Heights has one satellite community which is a section of the community of Riverside east of SR 202. Previous sewer work in Huber Heights in the 1990s still incorporated vitreous clay sewer pipe, however, PVC is now being employed. Huber Heights has no industrial users but many commercial enterprises, and only one problematic restaurant contributing unmanageable amounts of grease.

At 28% volume, Vandalia is the second largest contributor of wastewater flow to TCA. Only south Vandalia wastewater ultimately is diverted over to the City of Dayton wastewater collection system. Vandalia has one satellite community, the City of Dayton Airport, whereby the waste flow is split between Vandalia and the City of Dayton wastewater treatment systems. Vandalia has two main overflow points, Marview and Koch Avenues. Collection system wide, there was one overflow reported in 2010. Vandalia has two lift stations with no reported overflows. There are 28 industrial users in the system of which two are categorical industrial users.

Basement backups occur within the City of Vandalia's collection jurisdiction. In 2008, at least two documented occurrences of sewage diverted to storm sewers to avoid backups in residential basements were reported. To aid in reduction of overflow occurrences from the collection system, an inflow program called the Foundation Drain Disconnect (FDD) Program has eliminated an estimated 75% of wet weather flow into the sanitary sewer system from Vandalia.

Tipp City contributes 20% of the total wastewater flow to TCA and has three satellite subdivisions that eliminated package plants but are sources of inflow and infiltration for Tipp City. Tipp City has two lift stations. The Main Street lift station is the primary SSO point in the collection system. Collection system wide there was one SSO reported in 2010.

Ohio EPA conducted toxicity testing (acute bioassays) at Tri-cities WWTP outfall 001 with effluents, upstream and mixing zone waters. Testing was conducted in April and July of 2007. No toxicity endpoints occurred for any of the tests for either of the test organisms. These tests do not address the possibility of chronic toxicity and supporting effluent samples are collected unannounced. Entity conducted acute bioassay testing is required by Ohio EPA. Testing for this facility occurred in 2007, resulting in no toxicity endpoints for either test organism.

Limit violations of the NPDES were evaluated at outfall 001, from 2005 to 2009. Forty-nine violations occurred during this time and 98% percent were ammonia-N. Forty-five percent of the ammonia-N violations occurred in 2009, primarily from June through September. Violations of ammonia-N have been attributed to flow issues primarily, as well as sloughing (reduction of biological growth on filter media) and increased ambient temperatures that reduces treatment efficiency. Remediation measures include increasing effluent recycling, diverting flow to another nitrification tower, increased air to the final clarifiers, and adding more random media filters. Piping options to improve flow distribution and return options as well as forced ventilation to improve nitrification tower performance are also being evaluated.

Frequency violations of the NPDES were evaluated at outfall 001, from 2005 until 2009. Thirty-two violations of predominately ammonia-N, TSS and oil and grease were reported. All the violations occurred up to February of 2008. Numerous sludge reporting violations also occurred throughout this evaluated period of record.

Code violations of the NPDES were evaluated at outfall 001, from 2005 to a portion of 2009. For the five years of data, evaluated through SWIMS, 366 violations were reported up to March of 2008. Violations from 2007 to 2008 occurred mostly from January to September. January and March respectively, had the most reported violations through the period of record evaluated.

New Carlisle WWTP
Permit: 1PD00018
Outfall 001: Honey Creek, RM 8.72, 39.929722/-84.033056

The New Carlisle WWTP is located in Clark County at 403 Garfield Ave. in New Carlisle, Ohio. The New Carlisle WWTP was built in 1981 with the last major modification in 1991. New Carlisle's collection system serves the Village of North Hampton, Honey Creek Mobile Home Park (MHP), Brookwood MHP, Park Terrace MHP and about 200 rural users totaling approximately 7,080 people. The treatment facility wastewater process consists of bar screens, influent pumps (2), aerated grit chamber, comminutor, primary clarification (2), oxidation towers, intermediate clarifier, Rotating Biological Contactors (RBCS), secondary clarification, final clarifier, rapid sand filters, chlorine gas disinfection, post aeration, sulfur dioxide and dechlorination. The collection system has four lift stations: North Hampton (owned by North Hampton), Honey Creek Village, the New Carlisle lift station and one at SR 571. Fine screening (5/8inch) will be expected of facilities that land apply sludge. Recommended upgrades include Influent pump sludge motors on primary clarifier, grit pumps, aeration and sand filter rehabilitation. The average daily design flow since 1981 is one MGD. In 2009, the flow rate minimum, average and maximum were 0.6425, 0.7642948 and 1.1485 MGD respectively. Pollutant loadings through time are presented in Figure 17 and 18.

New Carlisle monitors flow at their influent lift station minus a major return flow of filter backwash. This meter is calibrated annually. The average flow for 2009 was approaching the design flow of one MGD while the maximum exceeded the design flow. The collection system is antiquated and in need of upgrades. Inflow and infiltration in town has been reported as minimal; however, there are I/I issues from mobile home parks. Excessive I/I from both the collection system of Chateau Estates and unlined and unsealed manhole covers. The collection system is on separate sewers with overflow points that can have been documented as active with one inch rainfall totals. In 2002, Brookwood MHP reduced I/I with sliplining.

Although city personnel report overflows when observed, the possibility of more frequent overflows in the sanitary collection system exist and include the following locations; W. Lake Avenue, N. Church St., West Jefferson St. and South Main St. Backups occur due to heavy precipitation or root, grease or trash debris in the lines or the homeowners own lateral becoming blocked. There were a few homes reported with backups due to debris in lines in 2008 and 2009. Records back to 2002 are absent of reported residential backups.

Authorized Class B farmland is available for sludge land application with over 1000 acres on fields east, southeast and northeast of the City of New Carlisle approved but may not all be active**.** The City of New Carlisle, as well as other wastewater entities, has land application sites in these locations. The bulk of the sites listed in Ohio EPA Interactive Maps (http://wwwapp.epa.ohio.gov/dsw/gis/sludge/index.php) would drain to the Mad River watershed; however, several sites are aligned with Honey Creek watershed. The East Fork of Honey Creek has the greatest potential for impact from land application of sewage. The West Fork of Honey Creek watershed has 4-5 sites for Troy WWTP up in the Christiansburg area. Class A sludge fields are not enumerated for purposes of this study. West of New Carlisle there exists approximately 170 acres authorized for land application.

Limit violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the nearly five years of data, evaluated through SWIMS, 24 violations of chlorine, $cBOD_5$ and ammonia-N were reported (respectively). Most occurrences were reported in July of 2005 and 2006. Seventeen percent occurred in 2009 and were all residual chlorine. Reasons for violations range from reporting errors to chlorine equipment failure, plumbing failures for dechlorination unit, (chlorine exceedence) and a chlorine contact tank offline to avoid an oil leak from the effluent pumps.

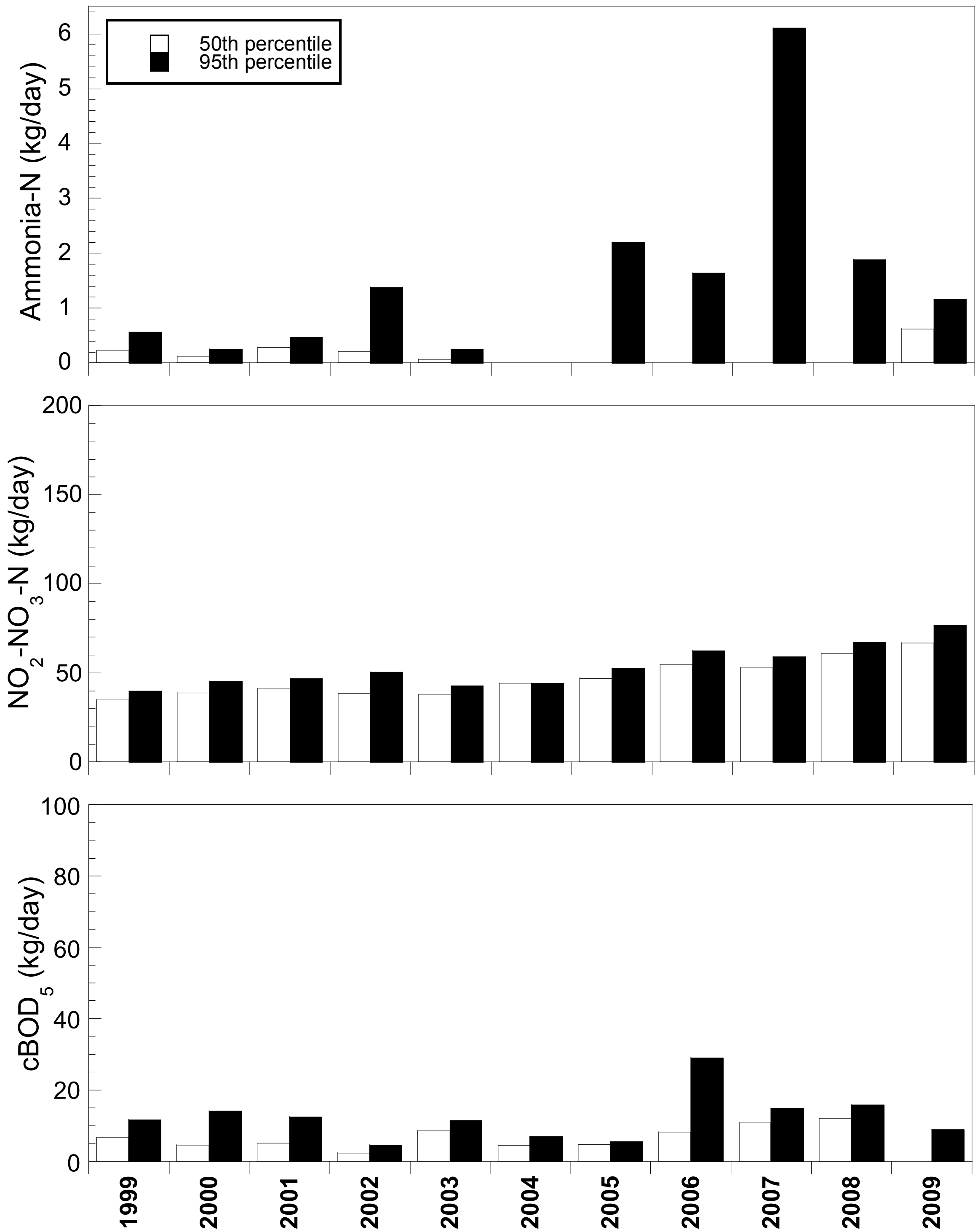


Figure 17. Annual, third-quarter loads (kg/day) of Ammonia-N, Nitrate+Nitrite-N, and $cBOD_5$ from the New Carlisle WWTP, 1999-2009.

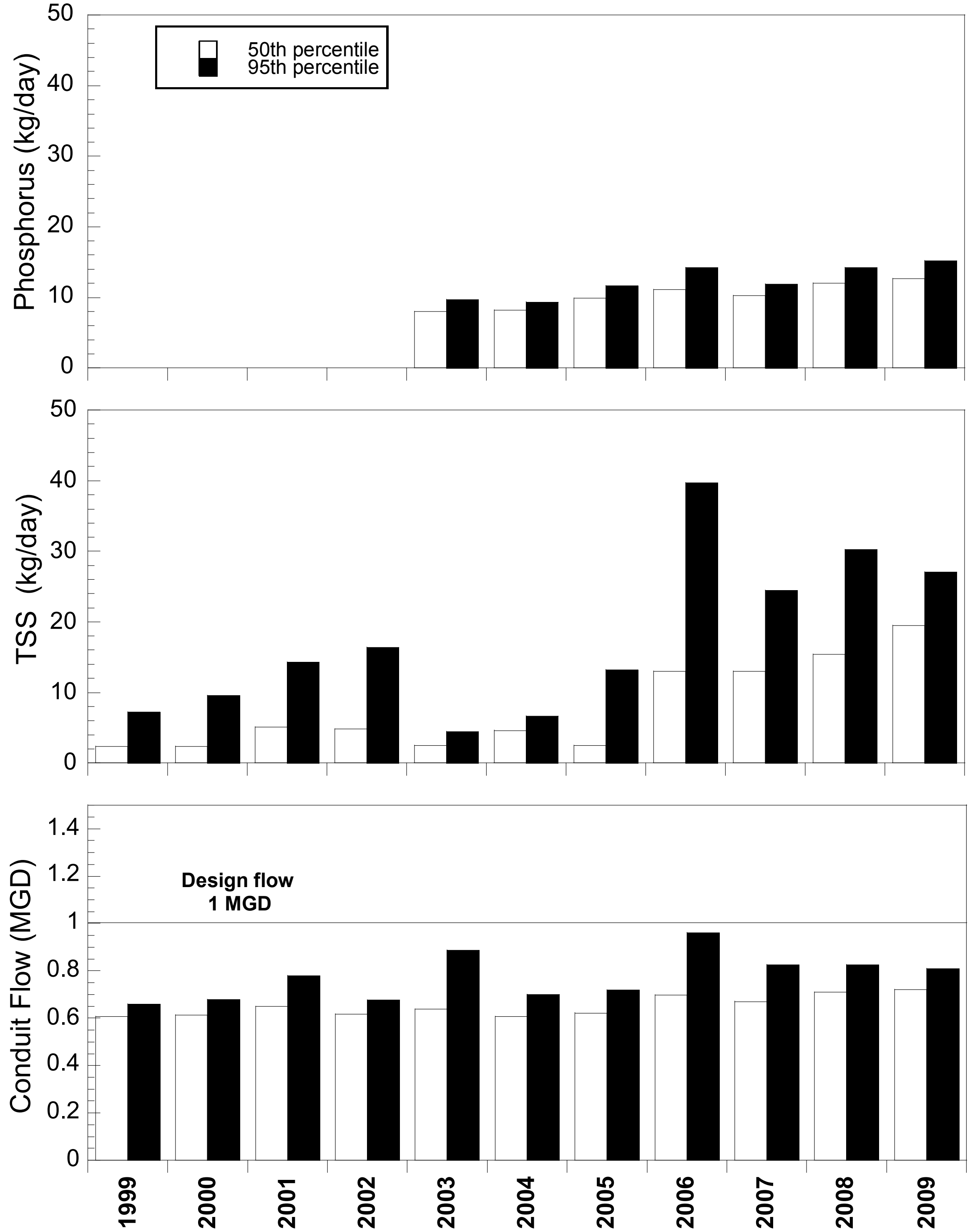


Figure 18. Annual, third-quarter loads (kg/day) of Phosphorus and Total Dissolved Residue[TDR, AKA Total Dissolved Solids (TDS)], and Conduit Flow (MGD) from the New Carlisle WWTP, 1999-2009.

Frequency violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the five years of data evaluated through SWIMS (Surface Water Information Management System), 39 violations of phosphorus, DO and pH were recorded respectively. Twenty-three percent (23%) of the violations occurred from 2008 to 2009.

Code violations of the NPDES were evaluated from 2005 to 2009 at outfall 001. For the five years of data, evaluated through SWIMS, three (3) violations were reported.

Chemical Water Quality

Inorganic water chemistry grab samples were collected and concurrent field measurements made every other week (five times) at 59 sites, between July 14 and September 16, 2009. Seventeen monitoring stations were allocated to the main stem, with the remaining 42 distributed among the direct and indirect tributaries (Table 3). All samples were analyzed for a variety of parameters including nutrients and metals. Fifteen sites, including eight on the main stem, were also sampled for organic compounds (Table 7). Samples from these sites were scanned for 59 volatile organic compounds, 53 semi-volatile compounds, 45 pesticide compounds and seven polychlorinated biphenyl (PCB) congeners. Monthly water samples were also collected at nine sentinel stations within the watershed, between February, 2009 and April, 2010. These stations were established on free-flowing sections of the Great Miami River main stem, Tawawa Creek, Rush Creek, Spring Creek, Lost Creek, and Honey Creek, to assemble a statistically robust characterization of ambient water quality of the study area. Lastly, Datasonde continuous monitors recorded hourly dissolved oxygen (DO), temperature, pH, and specific conductivity for a 48-hour period at 21 sites distributed onn the main stem and selected tributaries. Laboratory results and field measurements for all stations and analytes are presented in Appendix Tables A1-A6.

Summarized bacteria results (*E. coli*) are listed in Table 8 and the complete dataset is reported in Appendix Table A-3. Downloadable bacteria results are also available from the Ohio EPA geographic information systems (GIS) interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx. Twenty-seven (27) locations in the watershed were tested for *E. coli* levels seven to fourteen times from June 4 through October 28. Evaluation of *E. coli* results revealed that 17 of the 27 locations failed to attain the applicable geometric mean criterion, indicating an impairment of the recreation use at these locations. The locations not attaining the recreation use were most likely not attaining because of a variety of possible sources. However, agriculture, the predominant land use in the watershed, is a suspected source of contamination at most of the impaired sites.

Water chemistry results from daytime grab samples exceeding State of Ohio water quality criteria are presented in Table 9. Additionally, although nitrate and phosphorus water quality criteria for the protection of aquatic life have not yet been incorporated into the Ohio Water Quality Standards (WQS), the Ohio EPA has identified target levels for maintaining biological integrity in rivers (Ohio EPA 1999). An evaluation of ammonia-N, total kjeldahl nitrogen (TKN), nitrate-nitrite-N, and total phosphorus data compared to these recommended targets is detailed in Table 10.
Many of the graphs within the following summaries include dotted lines representing percentile concentrations from least impacted regional reference sites of similar size (Ohio

EPA 1999). Statistical data were segregated by ecoregion (ECBP) and further stratified by stream drainage area for these analyses as follows: headwater streams (0-20 miles^2); wadeable streams (> 20-200 miles^2); small rivers (> 200-1000 miles^2) and large rivers (>1000 miles^2).

Table 7. Frequency of organic compounds detected in stream water samples in the middle Great Miami River watershed during 2009. (Number of water quality criteria exceedences / Number of detections).

Parameter	Great Miami River	Middle Great Miami River Watershed (WAU 05080001)							TOTAL
		07-02	07-04	08-01	08-04	20-04		20-02	
		Tawawa Creek RM 0.22	Rush Creek RM 1.68	Spring Creek RM 3.50	Lost Creek RM 4.30	Honey Creek RM 8.08	Honey Creek RM 3.18	W Fk Honey Cr. RM 8.04	
Number of sites/samples	8/11	1/2	1/2	1/2	1/2	1/1	1/2	1/1	**15/23**
Acetochlor*	*/2	-	-	-	-	-	-	-	***/2**
Aldicarb sulfoxide	0/1	-	-	-	-	-	-	-	**0/1**
Atrazine*	*/9	*/2	*/1	*/2	-	*/1	*/1	-	***/16**
α-Hexachlorocyclohexane	0/7	0/2	0/1	0/1	-	-	-	-	**0/11**
γ-Hexachlorocyclohexane (Lindane)	-	-	0/1	-	-	-	-	-	**0/1**
bis(2-Ethylhexyl)phthalate	0/9	0/2	0/2	0/2	0/1	0/1	0/1	0/1	**0/19**
Diethylphthalate	0/1	-	0/1	-	-	-	0/1	-	**0/3**
Metolachlor*	*/6	-	*/2	*/1	*/1	-	-	-	***/10**
Simazine	-	-	0/1	0/1	-	-	-	-	**0/2**
TOTAL	**0/35**	**0/6**	**0/9**	**0/7**	**0/2**	**0/2**	**0/3**	**0/1**	**0/65**

* Parameter was detected but no applicable water quality criteria are available.

Table 8. Ohio EPA bacteriological (*E. coli*) sampling results in the middle Great Miami River study area during 2009. All values are expressed as colony forming units (cfu) or most probable number (MPN) per 100 ml of water. Values above criteria are highlighted in red. *

Stream RM	12- Digit WAU [a]	Location	Year	Samples (#)	*E. coli* Geometric Mean	*E. coli* Max Value	Attainment Status	Suspected Sources of Bacteria [b]
***Great Miami River** - PCR-Class A*								
129.99	07-03	SR 47 (Sidney)	2009	12	**239**	**2420**	**NON**	G,H
120.5	07-03	Upstream Loramie Cr @ Piqua Lockington Rd.	2009	7	**133**	**750**	**NON**	H
114.1	07-05	Dst Piqua Dam and WWTP	2009	8	**168**	**600**	**NON**	G,H
110.1	07-05	Eldean Rd.	2009	8	75	**420**	FULL	
106.1	08-05	SR 41 (Troy)	2009	13	69	**2420**	FULL	
100.8	08-05	Tipp-Elizabeth Rd.	2009	8	57	200	FULL	
93.00	20-05	Dst Taylorsville Dam (near Vandalia)	2009	13	106	**2420**	FULL	
87.05	20-05	Needmore Rd.	2009	8	**157**	**540**	**NON**	G
82.49	20-05	Helena St (Island Pk) Dst Stillwater River	2009	7	94	**1800**	FULL	
80.74	01-05	Monument Ave. (Dayton)	2009	11	**276**	**13000**	**NON**	G
***Tawawa Creek** - PCR Class B*								
0.22	07-02	SR 47 (Sidney)	2009	14	**185**	**1550**	**NON**	G,H
***Mosquito Creek**- PCR Class B*								
1.00	07-02	McCloskey School Rd.	2009	8	**537**	**4300**	**NON**	**H**
***Leatherwood Creek** – PCR Class B*								
1.2	07-01	McCloskey School Rd.	2009	8	**281**	**2200**	**NON**	H
***Mill Branch** – PCR Class B*								
0.34	07-03	Kuther Rd.	2009	8	**184**	**1500**	**NON**	H
***Rush Creek** - PCR Class B*								
1.68	07-04	Hetzler Rd.	2009	10	**679**	**2800**	**NON**	H
***Spring Creek** - PCR Class B*								
3.5	08-01	Rusk Rd.	2009	12	122	**2100**	FULL	
***Boone Creek** - PCR Class B*								
0.1	08-05	Near mouth (Troy)	2009	8	82	**1000**	FULL	
***Lost Creek** - PCR Class B*								
11.7	08-02	Peterson Rd.	2009	7	**187**	**2800**	**NON**	B,D,H
4.3	08-04	Knoop Rd.	2009	13	115	**980**	FULL	
***East Branch Lost Creek** - PCR Class B*								
0.7	08-03	Peterson Rd.	2009	7	57	240	FULL	

Table 8. Ohio EPA bacteriological (*E. coli*) sampling results in the middle Great Miami River study area during 2009. All values are expressed as colony forming units (cfu) or most probable number (MPN) per 100 ml of water. Values above criteria are highlighted in red. *

Stream RM	12- Digit WAU [a]	Location	Year	Samples (#)	*E. coli* Geometric Mean	*E. coli* Max Value	Attainment Status	Suspected Sources of Bacteria [b]
***Honey Creek** - PCR Class B*								
3.18	20-04	Rudy Rd. (New Carlisle)	2009	12	**276**	**1550**	**NON**	H
***East Fork Honey Creek** - PCR Class B*								
1.58	20-01	Sigler Rd.	2009	8	**345**	**3100**	**NON**	B.H
***West Fork Honey Creek** - PCR Class B*								
9.52	20-02	East St. (Christiansburg)	2009	8	**267**	**2900**	**NON**	H
8.9	20-02	SR 55 (Christiansburg)	2009	7	**1757**	**47000**	**NON**	B,D,H
0.01	20-02	Near mouth	2009	7	111	**830**	FULL	
***Indian Creek** - PCR Class B*								
1.52	20-03	SR 201	2009	8	**170**	**630**	**NON**	H
***Poplar Creek** - PCR Class B*								
0.7	20-05	Dst. Browns School Rd. (Vandalia)	2009	8	**388**	**10000**	**NON**	G

* Samples were collected from June 4 - October 28, 2009. Attainment status is based on the seasonal (May 1- October 31) geometric mean if more than one measurement is available and on the single sample maximum if only one measurement is available (Ohio Administrative Code 3745-1-07).

Subcategory	Seasonal geometric mean	Single sample maximum
Bathing Water	126	235
Class A primary contact recreation	126	298
Class B primary contact recreation	161	523
Class C primary contact recreation	206	940
Secondary contact recreation	1030	1030

a See Table 4.

b **Suspected Sources of Bacteria:**

A - Failing home sewage treatment systems
B - Livestock access to stream
C - Wastewater treatment plant
D - Unsewered community
E - Combined sewer overflow (CSOs)
F - Sanitary sewer overflows (SSOs)
G -Urban runoff (city, village, etc.)
H - Agricultural runoff
I - Wildlife (geese, etc)
J - Unknown

Table 9. Exceedences of Ohio EPA Water Quality Standards (WQS) (OAC 3745-1) for chemical/physical water parameters measured in grab samples taken from the middle Great Miamia River study area during the summer of 2009 (units are µg/l for metals and organics, C° for temperature, SU for pH, µmhos/cm for specific conductance, and mg/l for all other parameters).

Stream Beneficial Uses[a,b]		**Parameter (value)**
HUC-12	**River Mile**	
Mosquito Creek (WWH,PCR,AWS,IWS)		
07-02	7.75	Dissolved Oxygen (4.99‡)
Lost Creek (EWH,PCR,AWS,IWS)		
08-04	0.45	Dissolved Oxygen (5.95‡)
East Branch Lost Creek (EWH,PCR,AWS,IWS)		
08-03	6.4	Dissloved Oxygen (5.97‡)
08-03	5.24	Dissolved Oxygen (4.72‡‡,5.92‡)
Honey Creek (EWH,PCR,AWS,IWS)		
20-02	8.08	Dissolved Oxygen (4.22‡‡)
West Fork Honey Creek (WWH,PCR,AWS,IWS)		
20-02	9.52	Dissolved Oxygen (2.93‡‡,3.95‡‡,4.80‡)
20-02	8.9	Ammonia-N (2.38*) Dissolved Oxygen (4.65‡,3.48‡‡)

‡ Value below the EWH minimum 24-hour average DO criterion (6.0mg/l) or value is below the WWH minimum 24-hour average DO criterion (5.0mg/l) or value is belwo the MWH or value is below the MWh minimum 24-hour average DO criterion (4.0mg/l) as applicable.

‡‡ Value is below the EWH minimum at any time DO criterion (5.0mg/l) or value is below the WWH minimum at any time DO criterion (4.0mg/l) or value is below the MWH or value is below the MWH minimum at any time DO criterion (4.0mg/l) as applicable.

a Exceedences, violations, and related observations based upon existing uses, not recommended use resulting from this investigation.

b - **Beneficial Use Designation**

Aquatic Life
EWH-Exceptional Warmwater habitat
WWH-Warmwater Habitat
MWH-Modified Warmwater Habitat
LRW-Limted Resource Water

Water Supply
PWS-Public Water Supply
AWS-Agricultural Water Supply
IWS-Industrial Water Supply

Other
SRW-State Resource Water

Recreation
PCR-Primary Contact
- Class A
- Class B
- Class C

SCR-Secondary Contact
BWR-Bathing Water

Table 10. Nutrient sampling results in the middle Great Miami River watershed, summer 2009. Values above applicable reference values (targets) are highlighted in yellow.*

Stream RM	AU[a]	DA[b] (mi^2)	Ortho-P (mg/l) Median[#]	Ammonia-N (mg/l)		TKN (mg/l)		Nitrate-nitrite-N (mg/l)		Phosphorus-T (mg/l)	
				Median[#]	Target*	Median[#]	Target*	Median[#]	Target*	Median[#]	Target*
Great Miami River (EWH from Sidney waterworks dam (RM 130.2) to SR 66 (RM 116.7) and from downstream Piqua dam (RM 114.0) to RM 108.0 and from the Troy dam (RM 107.0) to the CSX RR bridge (RM 84.5); all other segments WWH)											
130.00	LRAU	541	0.058	0.050	0.074	0.52	1.10	1.14	1.65	0.083	0.100
127.70	LRAU	548	0.452	0.050	0.074	0.63	1.10	1.56	1.65	0.293	0.100
123.90	LRAU	561	ns	0.050	0.074	0.49	1.10	1.40	1.65	0.209	0.100
120.46	LRAU	568	ns	0.050	0.074	0.55	1.10	1.73	1.65	0.255	0.100
118.50	LRAU	839	ns	0.050	0.074	0.64	1.10	1.48	1.65	0.257	0.100
114.10	LRAU	869	0.281	0.050	0.074	0.68	1.10	1.60	3.06	0.286	0.170
112.45	LRAU	876	ns	0.051	0.074	0.80	1.10	1.16	1.65	0.261	0.100
110.07	LRAU	889	ns	0.050	0.074	0.81	1.10	1.07	1.65	0.233	0.100
106.13	LRAU	927	0.179	0.050	0.074	0.72	1.10	0.88	1.65	0.226	0.100
104.70	LRAU	936	ns	0.056	0.074	0.81	1.10	1.28	1.65	0.337	0.100
100.84	LRAU	971	ns	0.050	0.074	0.68	1.10	1.44	1.65	0.269	0.100
95.68	LRAU	1143	ns	0.050	0.299	0.61	1.50	1.27	3.08	0.248	0.150
93.00	LRAU	1149	0.222	0.050	0.299	0.63	1.50	1.14	3.08	0.200	0.150
88.69	LRAU	1157	0.211	0.053	0.299	0.96	1.50	1.01	3.08	0.241	0.150
87.05	LRAU	1167	ns	0.050	0.299	0.61	1.50	0.93	3.08	0.172	0.150
85.90	LRAU	1170	0.324	0.050	0.299	0.78	1.50	1.61	3.08	0.328	0.150
80.74	LRAU	2511	0.113	0.054	0.299	0.59	1.50	1.51	4.14	0.161	0.300
Tawawa Creek (WWH)											
1.20	07-02	54.1	ns	0.050	0.096	0.68	0.90	0.66	2.80	0.049	0.100
0.22	07-02	54.7	0.010	0.050	0.096	0.65	0.90	0.72	2.80	0.042	0.100
Mosquito Creek (WWH)											
7.75	07-02	9	ns	0.106	0.100	1.19	1.03	0.22	2.24	0.084	0.080
1.00	07-02	26.9	ns	0.053	0.096	0.62	0.90	0.52	2.80	0.068	0.100
Leatherwood Creek (WWH)											
6.43	07-01	8.7	ns	0.050	0.100	0.46	1.03	1.39	2.24	0.030	0.080
3.34	07-01	13.8	ns	0.054	0.100	0.51	1.03	0.84	2.24	0.050	0.080
1.20	07-01	16.8	ns	0.050	0.100	0.55	1.03	1.07	2.24	0.055	0.080
Mill Branch (WWH)											
0.34	07-03	3.6	ns	0.050	0.100	0.32	1.03	0.47	2.24	0.092	0.080
Rush Creek (WWH)											
5.30	07-04	7.2	ns	0.050	0.100	0.33	1.03	0.54	2.24	0.043	0.080
1.68	07-04	14.4	0.021	0.050	0.100	0.34	1.03	0.30	2.24	0.030	0.080

Stream RM	AU[a]	DA[b] (mi^2)	Ortho-P (mg/l) Median[#]	Ammonia-N (mg/l)		TKN (mg/l)		Nitrate-nitrite-N (mg/l)		Phosphorus-T (mg/l)	
				Median[#]	Target*	Median[#]	Target*	Median[#]	Target*	Median[#]	Target*
Rush Creek (WWH)c											
0.30	07-04	18.3	ns	0.050	0.100	0.34	1.03	0.76	2.24	0.027	0.080
Spring Creek (EWH)c											
8.44	08-01	11.6	ns	0.050	0.100	0.55	1.03	0.84	0.98	0.056	0.050
3.50	08-01	20.9	0.034	0.050	0.096	0.30	0.90	0.86	0.84	0.052	0.050
0.84	08-01	24.6	ns	0.050	0.096	0.30	0.90	1.29	0.84	0.037	0.050
Boone Creek (undesignated-WWH apply)c											
0.10	08-05	31.7	ns	0.05	0.096	0.26	0.90	0.70	2.80	0.024	0.100
Peters Creek (undesignated-WWH apply)c											
0.59	08-05	18.3	ns	0.050	0.100	0.31	1.03	0.71	2.24	0.016	0.080
Lost Creek (EWH)c											
11.70	08-02	14.1	ns	0.050	0.100	0.51	1.03	1.33	0.98	0.040	0.050
9.74	08-04	30.4	ns	0.050	0.096	0.31	0.90	1.17	0.84	0.036	0.050
4.30	08-04	58	0.010	0.050	0.096	0.29	0.90	1.52	0.84	0.013	0.050
0.45	08-04	62.4	ns	0.050	0.096	0.32	0.90	1.79	0.84	0.040	0.050
West Branch Lost Creek (undesignated-WWH apply)c											
0.50	08-02	6.7	ns	0.050	0.100	0.30	1.03	2.49	2.24	0.050	0.080
East Branch Lost Creek (EWH)c											
6.40	08-03	7.8	ns	0.050	0.100	0.54	1.03	1.79	0.98	0.026	0.050
5.24	08-03	8.9	ns	0.050	0.100	0.46	1.03	1.44	0.98	0.038	0.050
0.70	08-03	13.4	ns	0.050	0.100	0.37	1.03	1.31	0.98	0.034	0.050
Middle Branch Lost Creek (undesignated-WWH apply)c											
1.20	08-04	8	ns	0.050	0.100	0.25	1.03	1.57	2.24	0.032	0.080
Little Lost Creek (undesignated-WWH apply)c											
0.27	08-04	9.7	ns	0.050	0.100	0.22	1.03	0.79	2.24	0.039	0.080
Honey Creek (EWH)c											
9.96	20-04	34	ns	0.050	0.096	0.24	0.90	1.78	0.84	0.029	0.050
8.08	20-04	39	1.640	0.050	0.096	0.74	0.90	7.63	0.84	0.878	0.050
3.18	20-04	73	0.149	0.050	0.096	0.43	0.90	2.35	0.84	0.139	0.050
0.84	20-04	87.8	ns	0.050	0.096	0.35	0.90	1.89	0.84	0.115	0.050
West Fork Honey Creek (WWH)c											
9.52	20-02	7.3	ns	0.109	0.100	0.73	1.03	1.30	2.24	0.157	0.080
8.90	20-02	7.6	ns	0.487	0.100	1.24	1.03	0.70	2.24	0.611	0.080
8.04	20-02	8.8	0.163	0.057	0.100	0.56	1.03	0.72	2.24	0.190	0.080
1.30	20-02	20.1	ns	0.050	0.096	0.22	0.90	1.41	2.80	0.033	0.100
0.01	20-02	20.9	ns	0.050	0.096	0.29	0.90	1.12	2.80	0.025	0.100

Stream RM	AU[a]	DA[b] (mi^2)	Ortho-P (mg/l) Median[#]	Ammonia-N (mg/l)		TKN (mg/l)		Nitrate-nitrite-N (mg/l)		Phosphorus-T (mg/l)	
				Median[#]	Target*	Median[#]	Target*	Median[#]	Target*	Median[#]	Target*
East Fork Honey Creek (WWH)c											
5.90	20-01	5.2	ns	0.050	0.100	0.41	1.03	0.15	2.24	0.018	0.080
3.60	20-01	8.8	ns	0.050	0.100	0.44	1.03	2.77	2.24	0.023	0.080
1.58	20-01	11.3	ns	0.050	0.100	0.45	1.03	3.62	2.24	0.016	0.080
Indian Creek (WWH)c											
4.95	20-03	7.6	ns	0.050	0.100	0.20	1.03	2.38	2.24	0.025	0.080
1.52	20-03	22.3	ns	0.050	0.096	0.30	0.90	3.28	2.80	0.012	0.100
Dry Creek (WWH)c											
1.20	20-03	4.8	ns	0.104	0.100	0.73	1.03	1.42	2.24	0.136	0.080
Pleasant Run (undesignated-WWH apply)c											
0.50	20-04	6.1	ns	0.050	0.100	0.20	1.03	3.92	2.24	0.026	0.080

* Target values per *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* –Tables 1 and 2, Appendix Tables 1 and 2 (Ohio EPA Technical Bulletin MAS/1999-1-1).

ECBP Ecoregion	Headwater (0-20mi^2)		Wadeable (>20-200 $miles^2$)		Small River (>200-1000 $miles^2$)		Large River (>1000 $miles^2$)	
	WWH	EWH	WWH	EWH	WWH	EWH	WWH	EWH
NO_3-N (mg/l)	2.24	0.98	2.80	0.84	3.06	1.65	4.14	3.08
Phosphorus-T (mg/l)	0.08	0.05	0.10	0.05	0.17	0.10	0.30	0.15
NH_3-N (mg/l) (90^{th}%tile)	0.1		0.096		0.074		0.299	
TKN (mg/l) (90^{th}%tile)	1.03		0.90		1.1		1.5	

a - AU (Assessment Unit)
LRAU (Large River Assessment Unit)
See Table 4 for 12-digit watershed assessment units.

b - Drainage area

c - Aquatic Life Uses are existing designations, not recommended Aquatic Life Uses.

- Data medians from summer sampling July- September 2009.

ns - no sample

Great Miami River (main stem)

Precipitation records for select stations in the MGMR watershed are presented in Table 11 (MCD 2009) and regional precipitation is presented in Table 12 (Ohio DNR 2009). Total rainfall at the eight stations for the six-month period from May through October ranged from 21.13 inches in Piqua to 27.04 inches in Dayton. Stations in the southern portion of the watershed typically received more precipitation than those in the north. While individual stations varied, the Palmer Drought Severity Index (PDSI) indicated the west central region of Ohio (excludes Montgomery County) experienced ‘incipient’ to ‘mild’ drought until October. October precipitation in the region ranked as the 10^{th} wettest on record (126 years).

Stream flows and sundry frequencies from May through October 2009 as measured by USGS gage stations in the Great Miami River at Sidney, Troy, Taylorsville and Dayton are presented in Figure 19 (USGS 2000 and 2009). Flow patterns at the four stations were similar. Flows exceeded the 10% duration exceedence flow in early May but generally declined throughout the rest of May and June. Virtually all mean daily flows for May and June were above the 50% (median) duration exceedence flows at all gages. Conversely, 68% (Dayton) to 87% (Sidney) of mean daily flows measured from July through October were less than 50% duration exceedence flows. (The 50% duration exceedence flow represents the discharge which was equaled or exceeded 50% of the time over the period of record.) Peak flows followed scattered showers and thunderstorms. On water chemistry sampling days in the MGMR watershed during the summer survey the lowest mean daily flows were recorded on September 15-16 and ranged from 46 cfs in Sidney to 393 cfs in Dayton. Highs at the four stations occurred on July 14 and ranged from 109 cfs (Sidney) to 1640 cfs (Dayton). On bacteria sampling days the lowest mean daily flows occurred on October 1 and ranged from 45 cfs at the most upstream gage (Sidney) to 411 cfs at the Dayton gage. Highs occurred at gages in Sidney (319 cfs) and Dayton (2180 cfs) on October 28 while the Troy (556 cfs) and Taylorsville dam (561 cfs) gages recorded highs on June 4.

Daytime grab dissolved oxygen concentrations in the main stem remained above water quality criteria with median percent saturations ranging from 83% (RM 104.7) to a supersaturated 157% upstream of Mill Branch at Kuther Road (RM 123.9) (Figure 20) Datasonde continuous monitors documented supersaturated DO concentrations and wide swings in diel DO and pH at many of the main stem sites evaluated from July 21-22 (Figure 21). Datasondes also documented numerous pH values (6 of 19) at RM 100.8 (Tipp-Elizabeth Road) minimally exceeding the maximum pH criterion. Supersaturated DO concentrations and wide swings in diel DO and pH are indicative of nutrient enrichment. Conversely, August 25-27 datasonde DO concentrations remained relatively stable with median percent saturations at the majority of sites in the 90-100% range. The lowest datasonde dissolved oxygen levels in the main stem occurred in August at RM 88.7 (Rip-Rap Road) where 54% of concentrations fell below 6.0 mg/l (the 24-hour average water quality criterion). Temperatures at this site (median 26.39 C) were significantly elevated compared to other main stem sites while pH was much lower (median 7.7 SU). This site is downstream of both Cargill (RM 89.1) and Tate and Lyle Citric Acid (RM 88.83)

Table 11. Precipitation (inches) at select stations in the middle Great Miami River watershed May-October, 2009 (MCD 2009).

Station	Total Precipitation/Departure (inches)						
	May	June	July	August	Sept	Oct	Total
Alcony	4.13/-0.49	3.16/-0.73	4.95/+0.48	2.60/-0.50	2.47/-0.79	4.91/+2.09	22.22/+0.06
Dayton	4.71/+0.71	6.18/+2.21	3.79/+0.17	3.68/+0.60	3.57/+0.70	5.11/+2.55	27.04/+6.94
New Carlisle	3.91/-0.24	3.52/-0.73	5.72/+1.74	3.84/+0.28	2.71/-0.17	5.03/+2.45	24.73/+3.33
Piqua	2.84/-1.06	2.67/-1.61	5.58/+1.64	4.15/+0.86	1.12/-1.81	4.77/+2.05	21.13/+0.07
Sidney	2.58/-1.21	3.14/-0.89	5.37/+1.41	5.19/+1.70	1.34/-1.62	4.40/+1.72	22.02/+1.11
Taylorsville Dam	4.14/-0.10	5.94/+1.69	3.76/-0.07	2.73/-0.72	4.12/+1.14	5.30/+2.64	25.99/+4.58
Tipp City	3.83/-0.34	4.65/+0.40	5.36/+1.44	2.55/-0.54	3.04/0.0	4.82/+2.25	24.25/+3.21
Troy	3.68/-0.27	4.27/+0.17	5.21/+1.48	2.01/-1.11	4.94/+2.15	4.32/+1.82	24.43/+4.24

Table 12. Precipitation (inches) in the West Central region of Ohio May-October, 2009 (ODNR 2009)*

Month	May	June	July	August	Sept	Oct
Average rainfall (inches)	3.24	3.49	4.34	2.86	1.68	4.74
Departure from Normal**	-0.76	-0.40	+0.23	-0.38	-1.05	+2.41
% of normal rainfall	81%	90%	106%	88%	62%	203%
PDSI* **	**-0.9**	**-1.7**	**-0.9**	**-1.1**	**-0.8**	**+0.8**

* Includes Clark, Champaign, Miami, Darke, Shelby, and Logan counties (excludes Montgomery County)

** Base period 1951 - 2000

*** PDSI (Palmer Drought Severity Index)

Above +4 = Extreme Moist Spell
3.0 to 3.9 = Very Moist Spell
2.0 to 2.9 = Unusual Moist Spell
1.0 to 1.9 = Moist Spell
0.5 to 0.9 = Incipient Moist Spell
0.4 to -0.4 = Near Normal
-0.5 to -0.9 = Incipient Drought
-1.0 to -1.9 = Mild Drought
-2.0 to -2.9 = Moderate Drought
-3.0 to -3.9 = Severe Drought
Below -4.0 = Extreme Drought

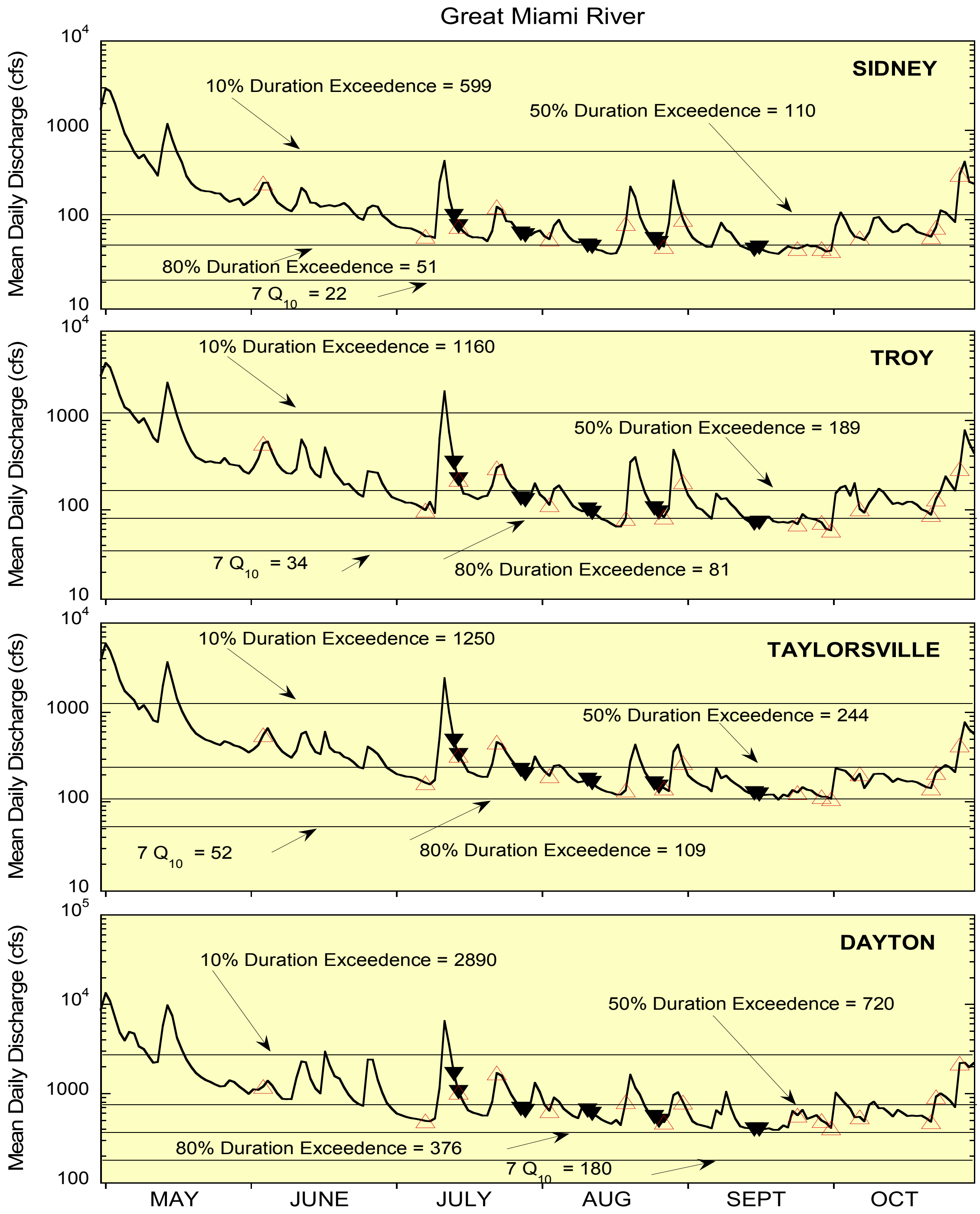


Figure 19. May through October, 2009 flow hydrographs for the Great Miami River at Sidney (USGS station # 03261500), the Great Miami River at Troy (USGS station # 03262700), the Great Miami River at Taylorsville (USGS station # 03263000), and the Great Miami River at Dayton (USGS station # 03270500). Solid triangles indicate river discharge on water chemistry sampling days in the Great Miami River watershed. Open triangles indicate river discharge on bacteriological sampling days. (Duration exceedence and $7Q_{10}$ flow lines represent May-Nov period of record 1926-1997 (Sidney), May-Nov period of record 1962-1997 (Troy), May-Nov period of record 1921-1997 (Taylorsville), and May-Nov period of record 1913-1997 (Dayton)).

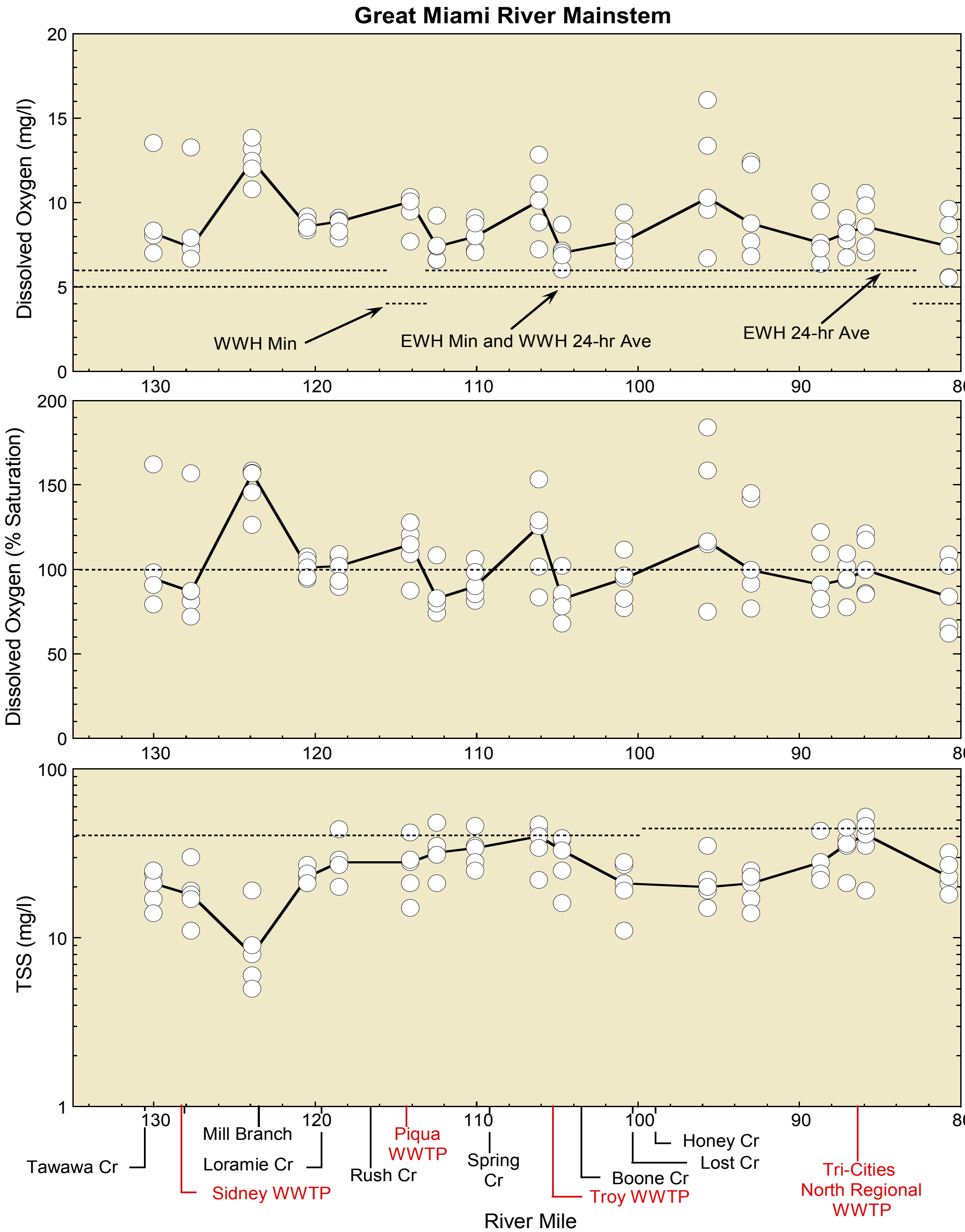


Figure 20. Longitudinal scatter plots of daytime grab dissolved oxygen concentration, dissolved oxygen percent saturation, and total suspended solids (TSS) in the main stem Great Miami River during 2009. The solid line depicts the median value at each river mile sampled. Water quality criteria are shown in the dissolved oxygen concentration plot. Dashed horizontal lines in the TSS plot represent applicable reference values from sites of similar size in the ECBP ecoregion.

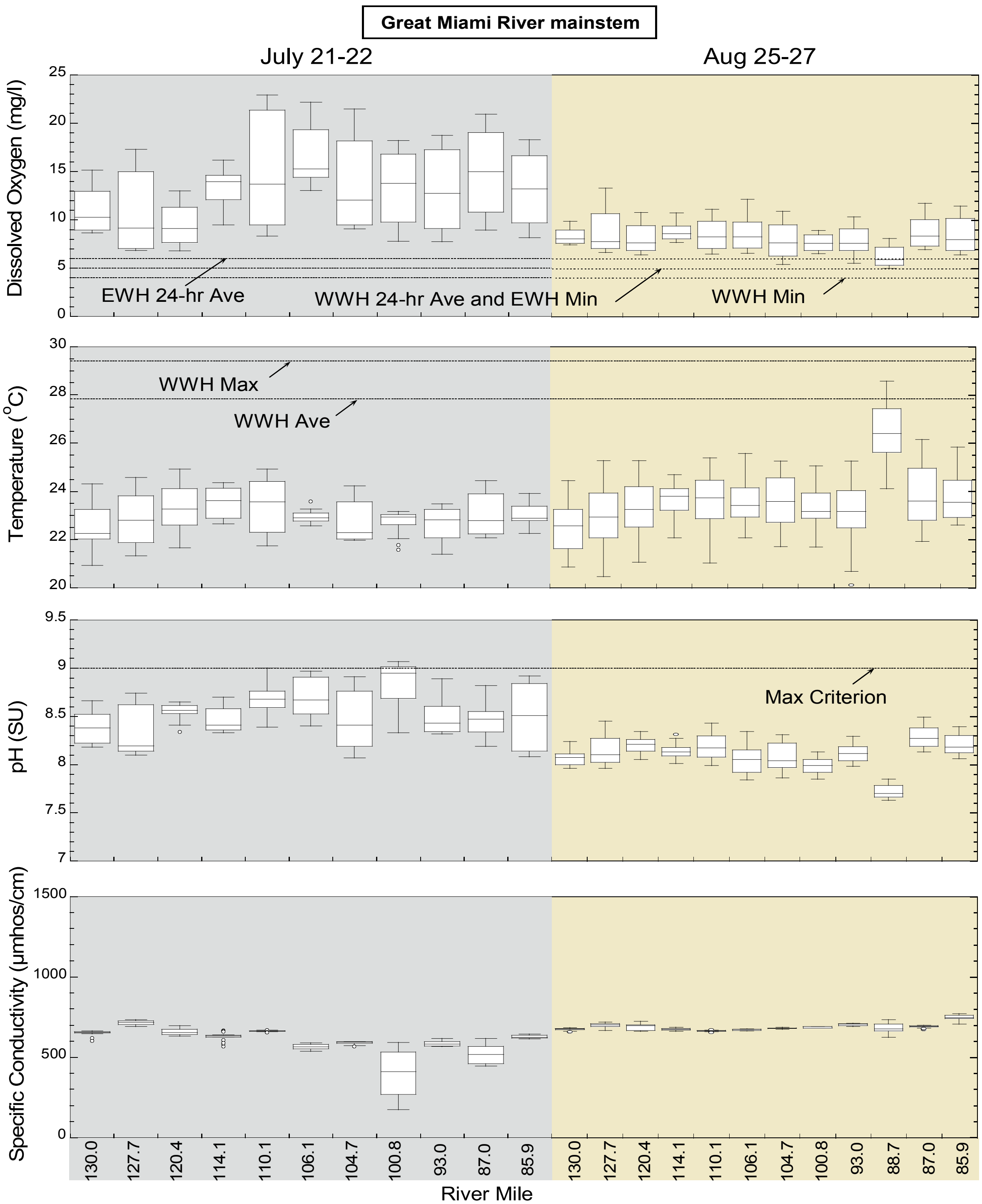


Figure 21. Dissolved oxygen, temperature, pH, and specific conductivity recorded hourly with datasonde continuous monitors in the Great Miami River July 21-22 and August 25-27, 2009. (Each box encloses 50% of the data with the median value of the variable displayed as a line. The top and bottom of the box mark the limits of ± 25% of the variable population. The lines extending from the top and bottom of each box mark the minimum and maximum values within the data set that fall within an acceptable range. Values outside of this range are displayed as individual points.)

Ammonia-N levels in the main stem were generally low with medians typically below target reference values and the majority (67%) of values less than or equal to the reporting limit of 0.05 mg/l (Figure 22 and Table 10). The highest single ammonia-N concentration in the main stem (0.438 mg/l) occurred at RM 85.90 downstream of Tri-Cities North Regional WWTP on August 26 (ammonia-N concentration reported by the facility on this day was 8.53 mg/l.) Although this facility recorded numerous final effluent ammonia-N violations throughout the summer in its self monitoring reports, no other elevated ammonia-N concentrations were documented by Ohio EPA in the river at this site during the summer survey. Ammonia-N was also elevated above applicable targets on occasion south of Sidney adjacent River Road (RM 127.7), at Peterson Road (RM 112.45), at Eldean Road (RM 110.07), and adjacent SR 202 (RM 104.70). Most of these sites are downstream of WWTP discharges. Additionally, while below the target reference value, an ammonia-N concentration of 0.166 mg/l was recorded at Rip-Rap Road (RM 88.69) downstream of Cargill and Tate and Lyle Citric Acid.

While nitrate-nitrite-N medians were typically below target reference levels, median total phosphorus increased markedly from 0.083 mg/l at SR 47 (RM 130.0) to 0.293 mg/l (RM 127.7) reflecting the impact of nutrient loading from the Sidney WWTP (Figure 22 and Table 10). Longitudinally, additional loadings from both wastewater treatment plants and agricultural sources in the watershed maintained phosphorus well above target levels throughout the main stem. The overall median nitrate-nitrite-N concentration for the 17 main stem sites sampled was 1.34 mg/l while the overall median total phosphorus concentration was 0.231 mg/l.

Eight main stem sites were sampled for organic compounds during the survey (Table 7, Appendix Table A-2). Seven organic compounds were detected. The plasticizer bis(2-ethylhexyl)phthalate (DEHP) and the herbicide atrazine were detected in 82% of the samples, including near the Sidney water intakes. (The widespread use of DEHP (e.g. polyvinyl chloride (PVC), wire insulation, food packaging, etc) has made the compound ubiquitous. DEHP enters the environment mainly via direct releases to air and waste water, from sewage sludge and from solid waste.) Other organic compounds detected included acetochlor, aldicarb sulfoxide, α-hexachlorocyclohexane (an isomer of the insecticide Lindane), diethylphthalate, and metolachlor. The most likely source of the majority of these contaminants in the main stem is the application of pesticides to cropland. Additionally, while not included in this study, it should be noted that Swift Run Lake, one of Piqua's drinking water sources, was impaired for the public water drinking supply beneficial use designation from atrazine. Additional information can be found in the 2012 Integrated Water Quality Monitoring and Assessment Report at:
http://www.epa.ohio.gov/portals/35/tmdl/2012IntReport/IR2012_SectionH.pdf.

Bacteria samples collected in the MGMR main stem indicate that the primary contact recreation (PCR) Class A use was not attained at several sites (Table 8 and Figure 23). Potential sources of bacteria include general agricultural and urban runoff.

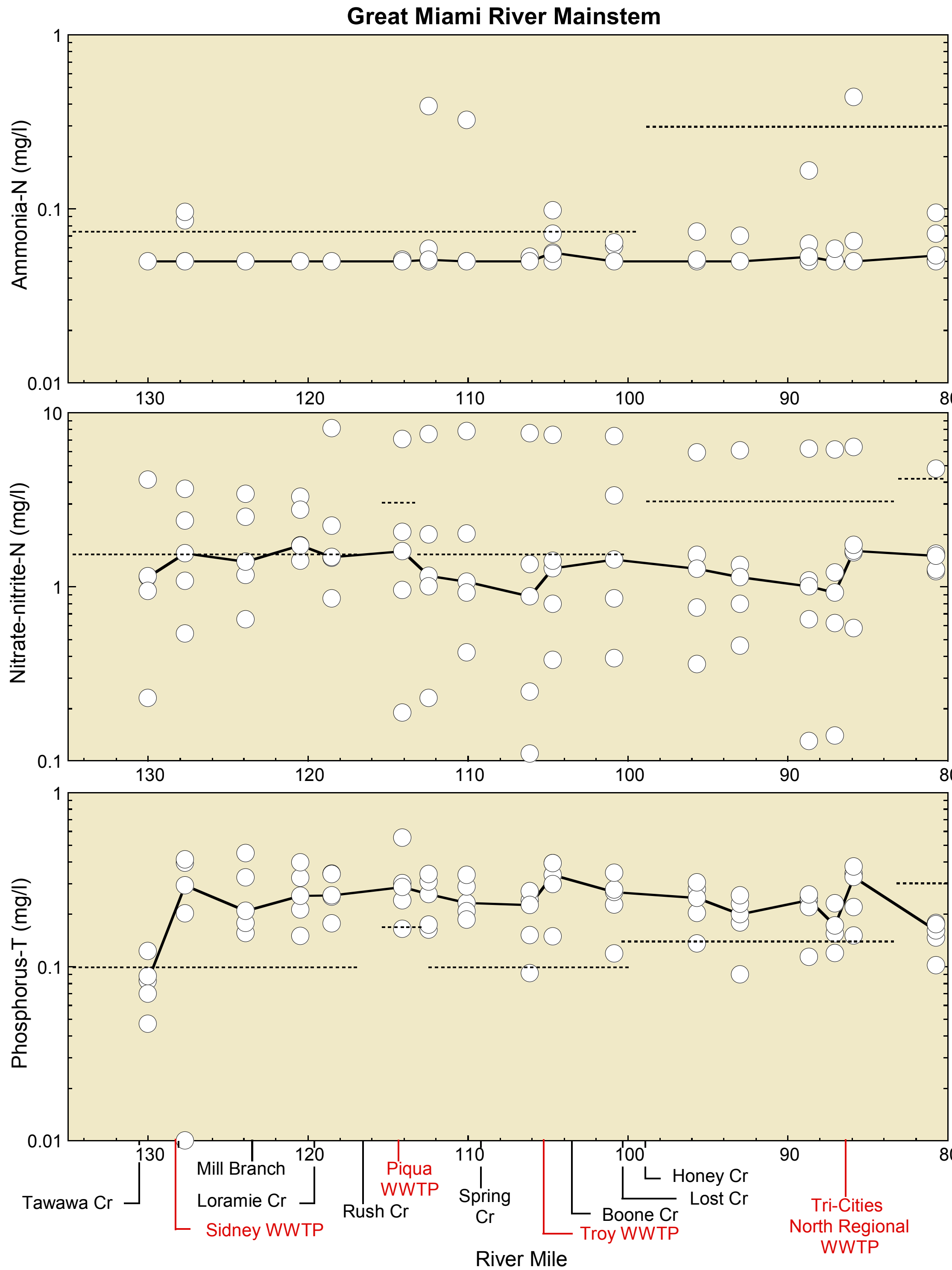


Figure 22. Longitudinal scatter plots of ammonia-nitrogen, nitrate-nitrite-nitrogen, and total phosphorus in the main stem Great Miami River during 2009. The solid line depicts the median value at each river mile. Dashed horizontal lines represent applicable reference values from sites of similar size in the Eastern Corn Belt Plains (ECBP) ecoregion.

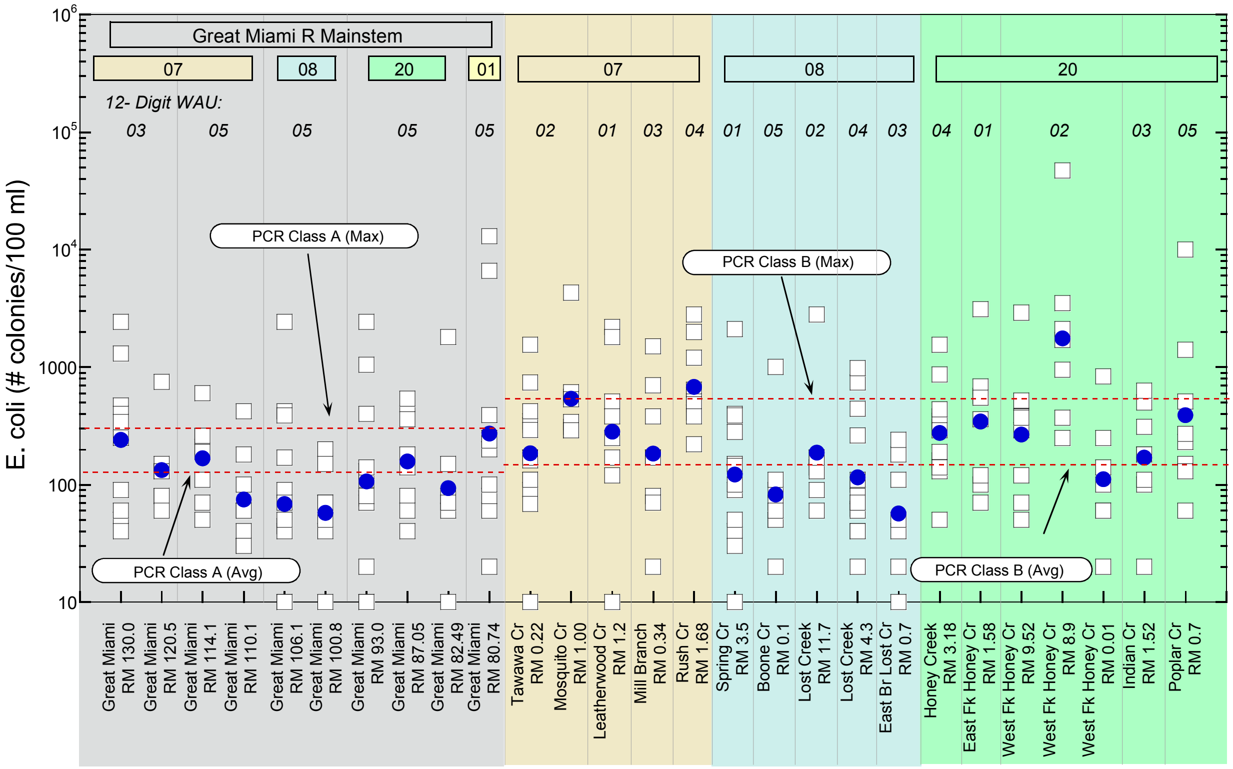


Figure 23. Scatter plots of *E. coli* concentrations in the main stem of the Great Miami River and select tributaries during the 2009 survey (WAU 05080001). The 10-digit WAU is provided in the enclosed boxes near the top of the graphic. Dotted lines represent primary contact recreational (PCR) use water quality criteria. Solid circles represent the geometric mean at each site sampled.

Tawawa Creek (subbasin)

Two sites (RM 1.20 and 0.22) were sampled on Tawawa Creek which drains 54.7 miles^2 and enters the Great Miami River at RM 130.41 in Sidney. The City of Sidney uses Tawawa Creek as a drinking water supply. Other tributaries sampled in this small watershed included Leatherwood Creek (RMs 6.43, 3.34, and 1.20) and Mosquito Creek (RMs 7.75 and 1.00). The watershed also contains Kiser Lake (396 acres) which was created by constructing a dam across Mosquito Creek at RM 8.22.

Kiser Lake was sampled in 2009 and 2010. (Downloadable results are available from the Ohio EPA geographic information systems (GIS) interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx.) Lakes are currently designated EWH with respect to aquatic life habitat use designation in water quality standards (WQS). However, while biological criteria apply to rivers and streams, no biocriteria apply to lakes. In 2008, Ohio EPA proposed revisions to WQS which would create a lake habitat (LH) aquatic life use designation with a suite of numeric chemical criteria. An assessment of Kiser Lake based on the proposed criteria indicates that the lake would not attain the LH use designation due to elevated levels of chorophyll a, and low dissolved oxygen. Total phosphorus and nitrates were also elevated. Summary results may be found in the 2012 Integrated Water Quality Monitoring and Assessment Report at the link: http://www.epa.ohio.gov/portals/35/tmdl/2012IntReport/IR2012_SectionI.pdf.

Daytime grab dissolved oxygen levels in Tawawa Creek were stable with saturations near 100% at both sites. A datasonde continuous monitor at RM 0.22 indicated minimal diurnal variation (Figure 24). With the exception of supersaturated DO levels (median 138%) at the headwater site in Leatherwood Creek (Suber Rd. RM 6.43), daytime grab DO concentrations in this tributary were also stable with median saturations near 95%. (headwater site had minimal woody riparian and an open canopy conducive to algal growth). In Mosquito Creek, 0.5 miles downstream of the Kiser Lake impoundment at Licklider Rd. (RM 7.75), daytime grab DO levels were relatively low (median saturation 69%) with concentrations minimally below water quality criterion on one occasion (Table 9).

While ammonia-N, TKN, and total phosphorus concentrations in Mosquito Creek at RM 7.75 downstream of Kiser Lake were elevated above target reference levels, nutrient levels throughout the rest of the Tawawa Creek watershed were quite low with concentrations typically well below reference targets (Table 10). The overall median nitrate-nitrite-N concentration for the entire watershed was 0.66 mg/l while the median total phosphorus concentration was 0.052 mg/l.

Tawawa Creek was also sampled for organic compounds twice during the survey in Sidney at SR 47 (RM 0.22). The herbicide atrazine, α-Hexachlorocyclohexane (an isomer of the insecticide Lindane), and the plasticizer bis(2-ethylhexyl)phthalate were detected in both samples (Table 7).

Bacteria samples collected at three sites in the watershed (Tawawa Creek RM 0.22, Mosquito Creek RM 1.00, and Leatherwood Creek RM 1.20) indicate non-attainment of the PCR Class B use designation (Figure 23 and Table 8). Potential sources include agricultural and urban runoff.

Mill Branch

One site (RM 0.34) was sampled on Mill Branch, a high gradient stream draining 3.94 miles^2 and entering the Great Miami River at RM 123.9. Bellefontaine Recycling LLC discharges to this stream at RMs 2.9 and 2.85 while the Fair Haven Shelby County Home WWTP discharges at RM 2.25. Water quality was generally quite good with only phosphorus levels minimally elevated above target reference levels (median 0.092 mg/l). Bacteria samples collected at the site indicate non-attainment of the PCR Class B use designation (Figure 23 and Table 8). Potential sources include agricultural runoff.

Rush Creek

Rush Creek drains 18.4 miles^2 and enters the main stem at RM 116.48 near Piqua. The only discharger in the watershed, Paris Court Mobile Home Park (MHP), discharges via an underground tile to a tributary which then enters Rush Creek at RM 3.9.

Daytime grab DO concentrations in Rush Creek were stable and median saturations approached 100% at the three sites sampled (RMs 5.30, 1.68, and 0.30). A datasonde continuous monitor deployed at Hetzler Rd. (RM 1.68) exhibited minimal diurnal variability (Figure 24). Both downstream sites occasionally experienced interstitial flows. However,

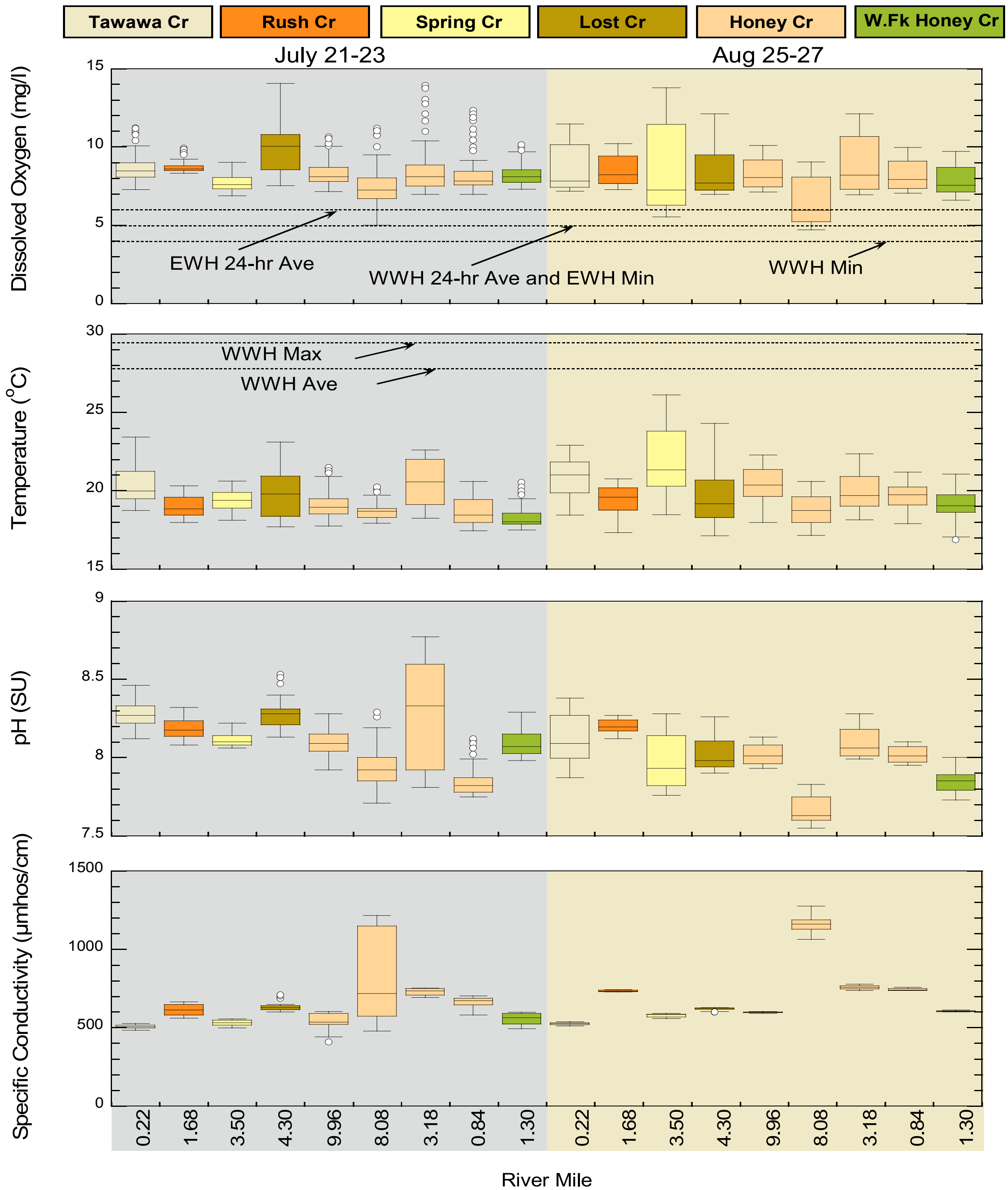


Figure 24. Dissolved oxygen, temperature, pH, and specific conductivity recorded hourly with datasonde continuous monitors in select tributaries July 21-23 and August 25-27, 2009. (Each box encloses 50% of the data with the median value of the variable displayed as a line. The top and bottom of the box mark the limits of ± 25% of the variable population. The lines extending from the top and bottom of each box mark the minimum and maximum values within the data set that fall within an acceptable range. Values outside of this range are displayed as individual points.)

Rush Creek upstream of North Dixie Rd. (RM 0.3) was frequently dry and may have been impacted by dewatering by quarries upstream. Flow downstream of the North Dixie bridge was augmented by flow emanating from a culvert. Nutrient levels remained low with the majority of ammonia-N, nitrate-nitrite-N, and total phosphorus concentrations well below target reference levels (Table 10).

Organic compounds detected at Hetzler Road (RM 1.68) included the persistent insecticide Lindane and its isomer α-Hexachlorocyclohexane, the plasticizers bis(2-ethylhexyl)phthalate and diethylphthlate, and the herbicides atrazine, metolachlor, and simazine (Table 7, Appendix Table A-2). The USEPA gradually began restricting the agricultural use of Lindane in the 1970s due to concerns over its effects on human health and the environment. By 2002, its use was limited to seed treatments and in 2007 these last uses were cancelled. Application of pesticides to cropland is the most likely source of many of the organic contaminants in the watershed.

Additionally, bacteria samples collected at RM 1.68 indicate that the PCR Class B use was not attained (Table 8 and Figure 23). Potential sources of bacteria include general agricultural runoff.

Spring Creek

Spring Creek drains 25.8 miles^2 and enters the main stem at RM 109.28 near Piqua. Water quality was generally good at the three sites sampled (RMs 8.44, 3.50, and 0.84). Daytime grab dissolved oxygen remained stable longitudinally with median saturations ranging from 82% to 95%. Although datasonde monitors recorded little variability at Rusk Road (RM 3.50) from July 21-23, significant diurnal variability (range of 8.23 mg/l) occurred from August 25-27 (Figure 24) with 20% of DO concentrations falling minimally below the EWH 24-hour water quality criterion average of 6.0 mg/l. Supersaturated DO concentrations and wide swings in diel DO and pH are indicative of nutrient enrichment. Nitrate-nitrite-N and total phosphorus were elevated above target on occasion at all three sites (Table 10).

Spring Creek was also sampled for organic compounds twice during the survey at Rusk Road (RM 3.50). The plasticizer bis(2-ethylhexyl)phthalate, α-Hexachlorocyclohexane (an isomer of the insecticide Lindane), and the herbicides atrazine, metolachlor, and simazine were detected (Table 7). Pesticide application to cropland is the most likely source of most of these contaminants.

Bacteria samples collected at RM 3.50 indicate full attainment of the PCR Class B use designation (Figure 23 and Table 8).

Boone and Peters Creek

Boone Creek drains 31.7 miles^2 and enters the main stem at RM 103.87 south of Troy. One site was sampled on Boone Creek (RM 0.1) and another site was sampled on Peters Creek (RM 0.59), a small channelized tributary draining 18.3 miles^2 entering Boone Creek at RM 0.20. While water quality in both streams was generally good, the highest daytime DO levels of the survey (median saturation 158%) occurred in Peters Creek. The modified and shallow channel combined with an open canopy, are conducive to increased light penetration. Subsequently, any impact from nutrient loading in the watershed from agricultural and residential sources may were likely exacerbated resulting in excessive filamentous algal growth. Excessive algal growth typically results in increased daytime DO saturation, resulting in acute swings in diurnal DO concentrations and ultimately, reduced stream quality.

Bacteria samples collected in Boone Creek near the mouth indicate full attainment of the PCR Class B use designation (Figure 23 and Table 8).

Lost Creek (subbasin)

Lost Creek drains 62.5 $miles^2$ and enters the main stem at RM 100.03 near Tipp City. Ten sites were sampled in this subwatershed including four sites in Lost Creek, one site each in the West Branch Lost Creek, Middle Branch Lost Creek and Little Lost Creek, and three sites in the East Branch Lost Creek.

Dissolved oxygen concentration fell minimally below water quality criteria in Lost Creek at Tipp-Elizabeth Road (RM 0.45) on August 11. Flows continued to diminish as the summer progressed and became interstitial during the last week of the survey such that no water samples could be collected. Dissolved oxygen concentrations also dropped below criteria on occasion in East Branch Lost Creek at Sodom-Ballou Road (RM 6.40) and Burr Oak Road (RM 5.24). Moderate diel variability was recorded by datasonde continuous monitors (Figure 24) in Lost Creek at Knoop Road (RM 4.30).

Nitrate-nitrite-N concentrations were elevated above target reference values throughout much of the Lost Creek subwatershed (Table 10) reflecting the agricultural land use.

One site on Lost Creek (Knoop Road RM 4.30) was also sampled for organic compounds twice during the survey. The plasticizer bis(2-ethylhexyl)phthalate and the herbicide metolachlor were each detected once (Table 7). The application of pesticides to cropland is the most likely source of metolachlor.

Bacteria sampling results in Lost Creek were mixed (Table 8 and Figure 24) with non-attainment of the PCR Class B use designation at Peterson Road (RM 11.7) but full attainment downstream at Knoop Road (RM 4.3). Agriculture, unrestricted cattle access, and wildlife (geese) were considered the most likely sources of bacteria at the upstream site. Bacteria samples were also collected in the East Branch Lost Creek at Peterson Road (RM 0.7) and indicate full attainment of the PCR Class B use designation.

Honey Creek (subbasin)

Honey Creek drains 89.4 $mile^2$ and enters the main stem at RM 99.1 near Tipp City. Sixteen sites were sampled in this subwatershed, including four sites in Honey Creek, five sites in West Fork Honey Creek, three sites in East Fork Honey Creek, two sites in Indian Creek, and one site each in Dry Creek and Pleasant Run. The New Carlisle WWTP discharges to Honey Creek at RM 8.72.

The main stem of Honey Creek originates northeast of New Carlisle downstream of the combined confluences of West Fork Honey Creek (RM 10.51) and East Fork Honey Creek (RM 10.50). While daytime grab DO concentrations were stable at New Carlisle Pike (RM

9.96), values fell downstream of the New Carlisle WWTP at SR 571 (RM 8.08) with one value below water quality criterion (Table 9 and Figure5). Median DO saturation measured by datasonde continuous monitors July 21-23 fell from 89% (RM 9.96) to 80% (RM 8.08) with 18% of concentrations at the downstream site below the EWH 24-hr water quality criterion average of 6.0 mg/l. The sag during the August 25-27 datasonde deployment was more pronounced with median DO saturations falling from 92% at the upstream site to 65% downstream with 51% of concentrations (27 of 53) at RM 8.08 below the 6.0 mg/l criterion and 9% of values (5 of 53) below the EWH minimum criterion of 5.0 mg/l (Figure 24). While DO levels were comparatively stable at the two downstream sites in Honey Creek (Rudy Road RM 3.18 and SR 202 RM 0.84), datasonde monitors recorded significant diurnal variability in pH and temperature July 21-23 at Rudy Road (Figure 24). Fields notes indicate the datasonde was sited in an area with no shade, moderate aquatic vegetation and brown algae.

In addition to algae and silt covered substrate, nitrate-nitrite-N and total phosphorus increased markedly at SR 571 (RM 8.08) reflecting the impact of nutrient loading from the New Carlisle WWTP discharge (Figure 25). Respective nitrate-nitrite-N and total phosphorus concentrations of 25.4 mg/l and 4.01 mg/l were documented in samples collected July 29, 2009 from the New Carlisle WWTP outfall. Median phosphorus concentrations increased from 0.029 mg/l upstream of the New Carlisle WWTP (RM 9.96) to 0.878 mg/l downstream of the discharge (RM 8.08) while respective median nitrate-nitrite-N levels increased from 1.78 mg/l to 7.63 mg/l. Longitudinally, phosphorus concentrations remained elevated above target reference values downstream with medians of 0.139 mg/l at Rudy Road (RM 3.18) and 0.115 mg/l at SR 202 (RM 0.84). While nitrate-nitrite-N concentrations spiked downstream of the New Carlisle WWTP, concentrations were elevated well above target reference levels throughout Honey Creek including upstream at New Carlisle Pike (RM 9.96). Elevated levels at this upstream site may be due to general agricultural runoff and the sustained impact of a large swine animal feeding operation on East Fork Honey Creek upstream of New Carlisle-St Paris Road.

Water quality in the lower reach of West Fork Honey Creek (RMs 1.30-0.10) was generally good. However, daytime grab dissolved oxygen levels in the headwaters fell below criteria both upstream (East St., RM 9.52) and downstream (SR 55 RM 8.90) of Christiansburg. Flows at the upstream site were sluggish throughout the survey and may have contributed to the lower oxygen levels. Additionally, while concentrations of ammonia-N and total phosphorus were elevated above target reference values at both of these sites, much higher levels occurred downstream of SR 55 (RM 8.90) including one exceedence of the ammonia-N criterion (Tables 9 and 10). Elevated levels at both sites reflect agricultural land use. However, field crews also observed unrestricted livestock access (cattle) at the downstream site. The downstream site is further impacted by waste entering through a large storm drain from the unsewered community of Christiansburg. Christiansburg is currently developing a plan to eliminate discharges from the village storm sewer system.

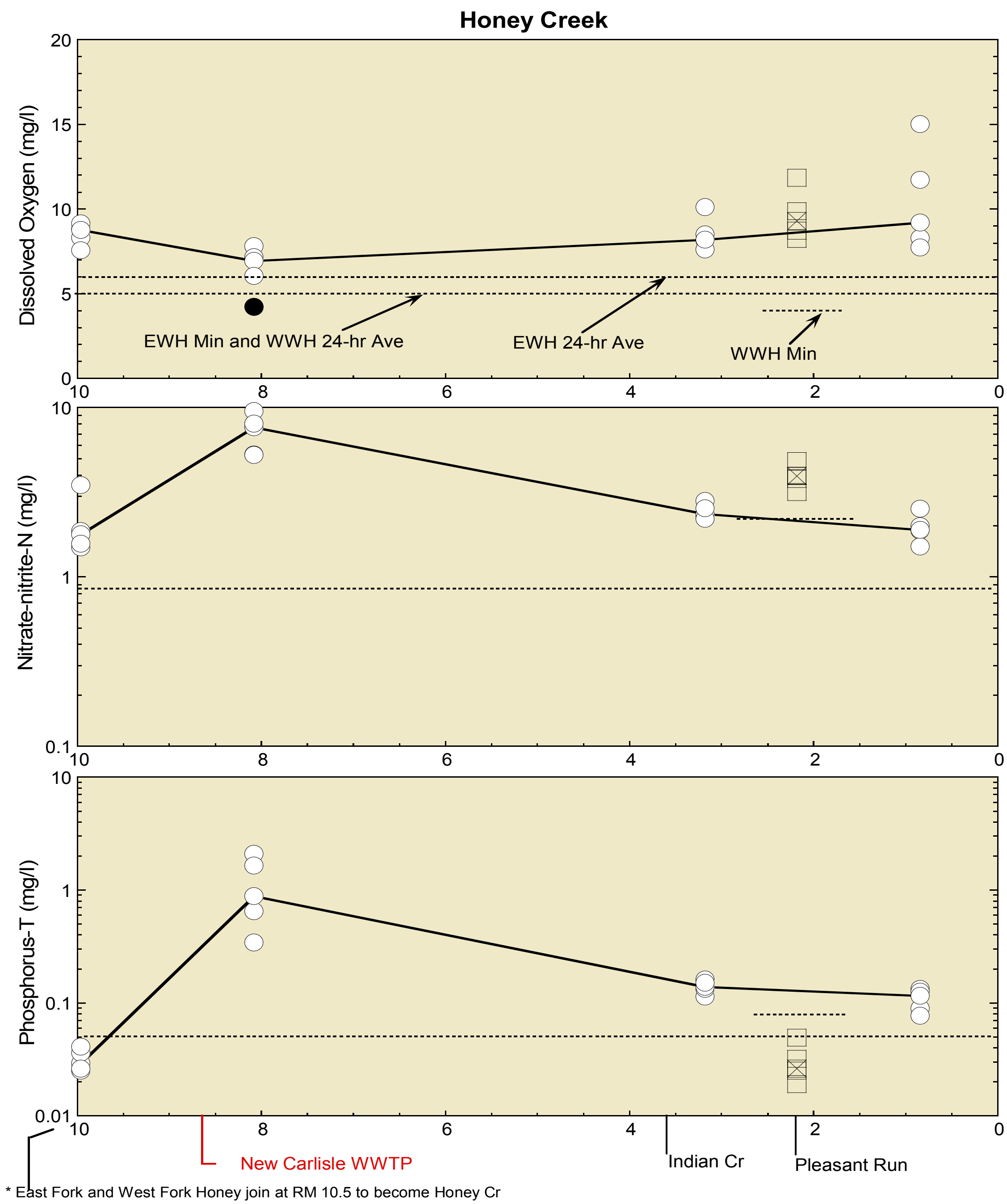


Figure 25. Longitudinal scatter plots of daytime grab dissolved oxygen, nitrate-nitrite-nitrogen, and total phosphorus in the main stem of Honey Creek (circles) and Pleasant Run RM 0.50 (squares) during 2009. The solid line depicts the median value at each river mile sampled in Honey Creek while an 'X' depicts the median in Pleasant Run. Water quality criteria are shown in the dissolved oxygen concentration plot. (Values not meeting criteria are shown as solid circles or squares.) Dashed horizontal lines represent applicable reference values from sites of similar size in the Eastern Corn Belt Plains (ECBP) ecoregion.

Ammonia-N and total phosphorus medians were elevated above target in Dry Creek, a small tributary entering Indian Creek at RM 4.06. Indicative of nutrient enrichment, field crews observed considerable duckweed at the site and noted a horse pasture immediately upstream and cattle downstream. With the exception of elevated nitrates, water quality in the remaining tributaries in the Honey Creek watershed was fairly good (Table 10). Median nitrate-nitrite-N concentrations were elevated above target in Pleasant Run, Indian Creek, and the two downstream sites in East Fork Honey Creek (New Carlisle-St Paris Road and Sigler Road). Longitudinally, nitrate-nitrite-N increased markedly in East Fork Honey Creek from a median of 0.15 mg/l at Ayres Road (RM 5.90) to 2.77 mg/l at New Carlisle-St Paris Road (RM 3.60) to 3.62 mg/l at Sigler Road (RM 1.58). A large swine animal feeding operation (AFO) was located approximately 0.5 miles upstream of the New Carlisle-St Paris Road site. Additionally, field crews observed unrestricted livestock access (cattle) upstream of Sigler Road during the survey.

Two sites in Honey Creek (SR 571 and Rudy Road) and one site in West Fork Honey Creek (Addison-New Carlisle Road) were sampled for organic compounds during the survey. Atrazine (an agricultural herbicide) and diethylphthalate were detected in the Honey Creek samples while the plasticizer bis(2-ethylhexyl)phthalate was detected in all samples (Table 7, Appendix A-2).

Five of the six sites sampled for *E. coli* in the Honey Creek subwatershed failed to attain the PCR Class B recreation use (Table 8 and Figure 25). General agricultural runoff was a contributing cause of non-attainment at all five sites. Additional sources impacting the two upstream West Fork Honey Creek sites include storm sewer system discharges from the unsewered community of Christiansburg and livestock access to the stream. Livestock (cattle) were also observed in East Fork Honey Creek upstream of Sigler Road (RM 1.58). Honey Creek at Rudy Road (RM 3.18) and Indian Creek at SR 201 (RM 1.52) exceeded the PCR Class B use designation most likely due to general agricultural runoff.

Poplar Creek

Poplar Creek at Brown School Road (RM 0.7) was sampled only for bacteria during the 2009 survey (Table 8 and Figure 25). Results indicated non-attainment of the PCR Class B use designation most likely due to urban runoff from the City of Vandalia and the I-70/I-75 interchange.

Sentinel Site Monitoring Program

Typically, Ohio EPA sampling occurs within the critical low flow period of the year during the summer season when the attainment status for biological water quality criteria can be assessed. However, recognizing the impact of non-point pollution sources on streams and the lack of water chemistry data available under varying flow and seasonal conditions, Ohio EPA developed a “sentinel site” approach in an effort to develop data sets over an annual period of varying climatic and flow conditions. In addition to assisting in the analysis of causes and sources of any observed non-attainment, the resulting data set supports water quality modeling efforts for pollutants where TMDLs may be necessary.

Sentinel site selection is based on several factors including proximity to the watershed boundary, drainage area size (≥ 20 miles^2), and varying land use (urban, agricultural, etc.). If possible, locations are selected that have USGS flow stations. Typically, however, bridge to water measurements are taken at each site using a weighted tape in conjunction with periodic in-stream flow measurements in order to develop predictive gage height to stream flow relationships.

Nine sites sampled during the intensive summer survey (July 14 - September 16) in the MGMR watershed were also sampled throughout the year as part of the sentinel site program. There were no exceedences of water quality criteria. Results for select parameters are presented in Table 13.

Table 13. Sampling results for select parameters at nine sentinel sites in the middle Great Miami River watershed (February 10, 2009 - September 15, 2010). Values above applicable reference (target) values are highlighted in yellow [c].

Date	Bridge to water distance (ft)[a]	Flow (cfs)[a]	NH_3-N (mg/l)	Nitrate-nitrite-N (mg/l)	Ortho-P (Dissolved) (mg/l) [b]	TKN (mg/l)	Phos-T (mg/l)
Great Miami River @ SR 47 (RM 130.0)							
2/10/09	-	2800[e]	0.061	6.16	ns	1.00	0.17
3/19/09	-	240	<0.050	2.42	ns	<0.20	0.023
4/16/09	-	1530	<0.050	5.84	<0.010	0.49	0.077
4/23/09	-	797	<0.050	4.56	ns	0.37	0.034
5/12/09	-	370	<0.050	3.13	ns	0.68	0.066
6/4/09	-	255	<0.050	2.69	0.046	0.61	0.106
7/14/09	-	109	<0.050	4.13	ns	0.73	0.083
7/22/09	-	74	<0.050	0.3	0.029	0.52	0.082
7/28/09	-	69	<0.050	1.14	ns	0.43	0.07
8/11/09	-	51	<0.050	0.23	<0.01	0.44	0.047
8/25/09	-	60	<0.050	1.15	0.188	0.57	0.123
9/15/09	-	46	<0.050	0.95	0.058	0.52	0.088
10/27/09	-	94	<0.050	1.09	0.044	0.58	0.065
10/28/09	-	319	<0.050	2.02	0.056	0.66	0.133
11/18/09	-	74	<0.050	0.82	0.024	0.39	0.06
1/19/10	-	313	<0.050	4.87	0.024	0.64	0.041
9/15/10	-	39	<0.050	0.83	0.031	0.38	0.062
Great Miami River at Troy @ SR 41 (RM 106.13)							
6/4/09	-	556	<0.050	2.27	0.123	0.64	0.166
7/14/09	-	333[e]	0.053	7.63	ns	1.08	0.24
7/22/09	-	186	<0.050	0.44	<0.010	0.92	0.157
7/28/09	-	133	<0.050	0.25	ns	0.67	0.092
8/11/09	-	100	<0.050	0.11	0.071	0.52	0.152
8/25/09	-	103	<0.050	1.35	0.254	0.72	0.271
9/15/09	-	70	<0.050	0.88	0.179	0.80	0.226
10/27/09	-	165	<0.050	1.06	0.146	0.58	0.187
10/28/09	-	289	<0.050	1.21	0.17	0.56	0.215
11/18/09	-	130	<0.050	1.09	0.155	0.49	0.488

Date	Bridge to water distance (ft)[a]	Flow (cfs)[a]	NH_3-N (mg/l)	Nitrate-nitrite-N (mg/l)	Ortho-P (Dissolved) (mg/l) [b]	TKN (mg/l)	Phos-T (mg/l)
Great Miami River at Troy @ SR 41 (RM 106.13) continued							
1/19/10	-	548	0.211	3.73	0.09	0.95	0.097
9/15/10	-	56	<0.050	0.23	0.077	0.69	0.300
Great Miami River downstream Taylorsville dam (RM 93.0)							
2/10/09	-	5910	0.138	6.79	ns	0.90	0.196
3/19/09	-	464	<0.050	2.74	ns	0.67	0.067
4/23/09	-	1490	<0.050	5.00	ns	0.45	0.066
5/12/09	-	815	<0.050	4.91	ns	0.63	0.119
5/18/09	-	1040	<0.050	5.98	0.072	0.39	0.087
6/4/09	-	561	<0.050	1.80	0.097	0.55	0.138
7/15/09	-	331	<0.050	6.09	ns	0.75	0.179
7/22/09	-	265	<0.050	0.81	0.021	1.27	0.171
7/29/09	-	202	<0.050	0.46	ns	0.61	0.09
Great Miami River downstream Taylorsville dam (RM 93.0)							
8/12/09	-	161	<0.050	0.80	0.137	0.63	0.20
8/26/09	-	146	<0.050	1.34	0.269	0.74	0.23
9/16/09	-	120	0.07	1.14	0.222	0.38	0.257
10/27/09	-	213	<0.050	1.17	0.187	0.51	0.196
10/28/09	-	432	<0.050	1.17	0.177	0.43	0.224
11/18/09	-	181	<0.050	1.34	0.164	0.39	0.169
1/19/10	-	730[e]	0.2	3.98	0.097	0.91	0.113
9/15/10	-	97	<0.050	<0.10	0.088	0.69	0.188
Great Miami River @ Monument (RM 80.74)							
2/10/09	-	11500	0.068	3.93	ns	0.62	0.131
3/19/09	-	1340	<0.050	2.27	ns	0.32	0.117
4/23/09	-	3050	<0.050	3.3	ns	0.23	0.084
5/12/09	-	2200	<0.050	2.28	ns	0.39	0.072
6/4/09	-	1200	ns	ns	0.083	ns	ns
7/15/09	-	1030	0.051	4.77	ns	0.72	0.147
7/29/09	-	632	<0.050	1.23	ns	0.54	0.102
8/12/09	-	590[e]	0.054	1.26	0.111	0.59	0.161
8/26/09	-	490	0.095	1.55	0.199	0.68	0.178
9/16/09	-	393	0.072	1.51	0.113	0.54	0.175
10/27/09	-	703	<0.050	1.75	0.098	0.71	0.164
10/28/09	-	2180	<0.050	1.56	0.13	0.71	0.279
11/18/09	-	645	<0.050	1.92	0.105	0.43	0.126
Tawawa Creek @ SR 47 (RM 0.22)							
2/10/09	12.43	409.42	<0.050	6.66	ns	0.72	0.108
3/19/09	13.71	18.87	<0.050	2.59	ns	<0.20	0.013
4/16/09	13.32	122.77	<0.050	6.05	<0.010	<0.20	0.03
4/23/09	13.51	56.51	<0.050	5.55	ns	<0.20	0.012
5/12/09	13.7	20.43	<0.050	4.12	ns	0.49	0.018
6/4/09	13.74	14.45	<0.050	2.03	0.024	0.57	0.043
7/14/09	13.65	28.78	<0.050	3.58	ns	0.78	0.047

Date	Bridge to water distance (ft)[a]	Flow (cfs)[a]	NH_3-N (mg/l)	Nitrate-nitrite-N (mg/l)	Ortho-P (Dissolved) (mg/l) [b]	TKN (mg/l)	Phos-T (mg/l)
Tawawa Creek @ SR 47 (RM 0.22) continued							
7/22/09	13.78	9.18	<0.050	0.7	<0.010	0.54	0.035
7/28/09	13.78	9.18	<0.050	1.49	ns	0.65	0.042
8/11/09	13.81	5.77	<0.050	0.72	<0.01	0.36	0.031
8/25/09	13.82	4.75	<0.050	0.28	0.125	0.7	0.044
9/15/09	13.83	3.80	0.072	0.27	0.01	0.63	0.033
10/27/09	13.63	32.37	<0.050	1.19	<0.010	0.68	0.021
10/28/09	13.02	163.53	<0.050	2.46	0.052	0.7	0.171
11/18/09	13.74	14.45	<0.050	1.02	<0.010	0.61	<0.010
1/19/10	13.35	94.73	<0.050	4.49	0.017	0.55	0.029
8/4/10	13.83	3.80	<0.050	0.20	0.022	0.45	0.043
8/18/10	13.79	7.99	0.061	0.71	0.032	0.45	0.064
Rush Creek @ Hetzler Rd (RM 1.68)							
2/10/09	10.32	582.43	0.101	7.12	ns	0.87	0.164
Rush Creek @ Hetzler Rd (RM 1.68)							
3/19/09	11.31	4.82	<0.050	3.47	ns	<0.20	<0.010
4/16/09	11.04	18.355	<0.050	6.77	0.012	0.27	0.021
4/23/09	11.19	9.27	<0.050	6.23	ns	<0.20	0.01
5/12/09	11.28	5.69	<0.050	5.15	ns	0.31	0.011
5/19/09	11.25	8.78	<0.050	5.60	<0.010	<0.20	<0.010
6/4/09	11.38	3.26	<0.050	3.37	0.018	<0.20	0.019
7/14/09	11.34	4.08	<0.050	5.83	ns	0.52	0.042
7/22/09	11.34	4.08	<0.050	0.78	0.015	0.46	0.037
7/28/09	11.51	1.54	<0.050	1.65	ns	0.34	0.015
8/11/09	11.67	0.58	<0.050	0.30	0.021	0.22	0.03
8/25/09	11.83	0.21	<0.050	0.19	0.132	0.44	0.035
9/15/09	11.88	0.15	<0.050	0.17	0.015	<0.2	0.019
10/27/09	11.36	3.65	<0.050	1.07	0.01	0.66	0.016
10/28/09	10.6	169.90	<0.050	2.02	0.038	0.6	0.101
11/18/09	11.20	8.79	<0.050	0.76	<0.010	0.37	<0.010
1/19/10	11.05	19.31	<0.050	6.61	0.018	0.44	0.017
4/12/10	11.128	11.688	<0.050	4.84	<0.010	0.28	<0.010
Spring Creek @ Rusk Rd RM (3.50)							
2/10/09	11.76	173.61	<0.050	7.58	ns	0.84	0.149
3/19/09	13.74	9.88	<0.050	5.86	ns	0.26	<0.010
4/16/09	13.225	39.989	<0.050	7.99	<0.010	<0.20	0.014
4/23/09	13.49	19.31	<0.050	7.01	ns	0.23	<0.010
5/12/09	13.59	15.15	<0.050	6.00	ns	0.37	0.012
5/19/09	13.54	18.33	<0.050	7.37	0.010	<0.20	<0.010
6/4/09	13.82	7.53	<0.050	3.58	0.033	0.33	0.041
7/14/09	13.69	11.51	<0.050	6.62	ns	1.31	0.048
7/22/09	13.94	4.518	<0.050	1.32	0.033	0.46	0.046
7/28/09	13.96	4.20	<0.050	3.18	ns	0.3	0.035
8/11/09	14.1	1.84	<0.050	0.86	0.034	0.23	0.062

Date	Bridge to water distance (ft)[a]	Flow (cfs)[a]	NH_3-N (mg/l)	Nitrate-nitrite-N (mg/l)	Ortho-P (Dissolved) (mg/l) [b]	TKN (mg/l)	Phos-T (mg/l)
Spring Creek @ Rusk Rd RM (3.50) continued							
8/25/09	14.22	0.59	<0.050	0.36	0.158	0.27	0.062
9/15/09	14.29	0.19	0.052	0.19	0.033	0.55	0.052
10/27/09	13.92	5.05	<0.050	2.04	<0.010	0.53	0.014
10/28/09	12.607	71.97	<0.050	2.67	0.025	0.5	0.078
11/18/09	11.12	270.84	<0.050	1.31	<0.010	0.36	0.014
1/19/10	13.33	27.02	<0.050	7.6	0.019	0.44	0.031
4/12/10	13.48	18.476	<0.050	6.06	<0.010	<0.20	<0.010
Lost Creek @ Knoop Rd (RM 4.30)							
2/10/09	5.05	1255.65	<0.050	7.26	ns	1.00	0.164
3/19/09	2.96	19.29	<0.050	2.95	ns	<0.20	<0.010
4/16/09	3.63	112.64	<0.050	7.28	0.011	0.3	0.02
4/23/09	3.33	61.36	<0.050	6.05	ns	<0.20	0.014
5/12/09	3.13	34.32	<0.050	4.47	ns	0.29	0.011
5/18/09	3.265	58.38	<0.050	6.15	0.017	0.23	<0.010
Lost Creek @ Knoop Rd (RM 4.30)							
6/4/09	2.94	17.91	<0.050	2.68	0.013	0.27	0.014
7/14/09	2.08	0.01	<0.050	5.2	ns	0.68	0.076
7/22/09	2.805	11.14	<0.050	1.48	<0.010	0.31	0.021
7/28/09	2.81	10.65	<0.050	2.22	ns	0.23	0.018
8/11/09	2.73	7.43	<0.050	1.52	<0.01	0.34	0.011
8/25/09	2.61	4.02	<0.050	0.91	0.093	0.29	0.013
9/15/09	2.61	4.02	<0.050	0.91	<0.01	0.24	0.011
10/27/09	2.84	12.09	<0.050	1.08	<0.010	0.37	<0.010
10/28/09	3.685	143.81	<0.050	0.82	<0.010	0.46	0.074
11/18/09	2.80	10.20	<0.050	0.98	<0.010	<0.20	<0.010
1/19/10	3.37	68.24	<0.050	6.18	0.039	0.53	0.046
4/12/10	3.19	48.457	<0.050	4.44	<0.010	<0.20	<0.010
Honey Creek @ Rudy Rd (RM 3.18)							
2/10/09	10.91	523.11	<0.050	5.15	ns	0.6	0.172
3/19/09	12.92	39.94	<0.050	2.67	ns	0.24	0.057
4/16/09	12.23	136.36	<0.050	4.83	0.034	0.43	0.058
4/23/09	12.52	89.29	<0.050	4.73	ns	<0.20	0.038
5/12/09	12.81	51.39	<0.050	3.6	ns	<0.20	0.073
5/18/09	12.645	73.13	<0.050	4.36	0.055	<0.20	0.05
6/4/09	13.03	30.04	<0.050	3.04	0.137	0.36	0.136
7/15/09	13.21	17.10	<0.050	2.81	ns	0.83	0.113
7/22/09	13.145	19.997	<0.050	2.37	0.115	0.41	0.145
7/29/09	13.23	15.90	<0.050	2.29	ns	0.51	0.133
8/12/09	13.31	11.58	<0.050	2.35	0.09	0.28	0.139
8/26/09	13.36	9.26	<0.050	2.20	0.25	0.43	0.16
9/16/09	13.41	7.22	0.052	2.54	0.149	0.3	0.15
10/27/09	13.17	19.63	<0.050	2.01	0.13	0.62	0.185
10/28/09	12.1	164.93	<0.050	1.53	0.148	0.77	0.273

Date	Bridge to water distance (ft)[a]	Flow (cfs)[a]	NH_3-N (mg/l)	Nitrate-nitrite-N (mg/l)	Ortho-P (Dissolved) (mg/l) [b]	TKN (mg/l)	Phos-T (mg/l)
Honey Creek @ Rudy Rd (RM 3.18) continued							
11/18/09	13.25	14.75	<0.050	2.17	0.123	0.31	0.136
1/19/10	12.58	80.51	<0.050	5.39	0.08	0.56	0.09
4/12/10	12.61	80.675	<0.050	3.26	0.038	<0.20	0.049
5/26/10	12.69	65.70	<0.050	4.89	0.067	0.38	0.082
7/22/10	13.23	13.713	<0.050	2.37	0.116	0.33	0.130
8/4/10	13.325	10.86	<0.050	2.54	0.153	0.40	0.173
8/18/10	13.37	8.83	<0.050	2.17	0.145	0.31	0.159

ns no sample
na not available
a Mean Daily flow for USGS flow measurements at following stations:
Great Miami River @ Sidney - USGS Station No. 03261500
Great Miami River @ Troy - USGS Station No. 03262700
Great Miami River @ Taylorsville - USGS Station No. 03263000
Great Miami River @ Dayton - USGS Station No. 03270500
Flows at tributary sites are "instantaneous flows"
b There are no applicable reference (target) values for orthophosphate.
c Target values per *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* – Tables 1 and 2, Appendix Tables 1 and 2 (Ohio EPA Technical Bulletin MAS/1999-1-1).

ECBP Ecoregion	Headwater (0-20miles^2)		Wadeable (>20-200 miles^2)		Small River (>200-1000 miles^2)		Large River (>1000 miles^2)	
	WWH	EWH	WWH	EWH	WWH	EWH	WWH	EWH
NO_3-N (mg/l)	2.24	0.98	2.80	0.84	3.06	1.65	4.14	3.08
Phosphorus-T (mg/l)	0.08	0.05	0.10	0.05	0.17	0.10	0.30	0.15
NH_3-N (mg/l) (90th%tile)	0.1		0.096		0.074		0.299	
TKN (mg/l) (90th%tile)	1.03		0.90		1.1		1.5	

e Estimated
p Provisional

Public Drinking Water Supplies

The public water supply beneficial use in the WQS (OAC 3745-1-33) currently applies within 500 yards of drinking water intakes and for all publicly owned lakes. Ohio EPA has developed an assessment methodology for this beneficial use, which focuses on source water contaminants not effectively removed through conventional treatment methods. The 2010 Integrated Water Quality Report describes this methodology and is available on Ohio EPA's website:http://www.epa.state.oh.us/dsw/tmdl/OhioIntegratedReport.aspx.

Impaired source waters may contribute to increased human health risk or treatment costs. For the case when stream water is pumped to a reservoir, the stream and reservoir will be evaluated separately. These assessments are designed to determine if the quality of source water meets the standards and criteria of the Clean Water Act. Monitoring of the safety and quality of treated finished drinking water is regulated under the Safe Drinking Water Act and evaluated separately from this assessment. For those cases when the treatment plant processes do not specifically remove a source water contaminant, the finished water quality data may be considered representative of the raw source water directly feeding into the treatment plant.

There are three public water systems (Sidney, Piqua, and Dayton) served by surface water sources within the study area. Sidney has an intake on the Great Miami River (RM 130.2) and on Tawawa Creek (RM 0.14), Piqua has intakes on the Great Miami River (RM 118.3), Swift Run Lake, and Ernst Gravel Pits, and Dayton has two intakes on the Great Miami River (RM 86.6 and 90.3). Table 14a provides a summary of water quality data for determining the PWS use.

<u>City of Sidney Public Water System</u>

The City of Sidney operates a community public water system that serves a population of approximately 21,229 people through 9,159 service connections. The water treatment system obtains its raw water from a combination of ground water and surface water sources. Approximately two-thirds of the raw water is drawn from Tawawa Creek and the Great Miami River. Tawawa Creek is the preferred surface water supply and is utilized except during low flow periods. Approximately one-third of the City's supply is obtained from four limestone wells (wells 1, 2, 3, and 6), approximately 200 feet deep, located adjacent to the Great Miami River along Canal Street. Since surface water sources are blended with ground water sources, finished water quality data is not indicative of surface water quality and cannot be used to determine drinking water impairments. The system's treatment capacity is approximately 10 million gallons per day, but current average production is 3.3 million gallons per day. The City of Sidney's water treatment processes include lime softening, coagulation, sedimentation, stabilization, rapid sand filtration, fluoridation, and disinfection. Powdered activated carbon is also used for taste and odor control.

Ohio EPA collected 18 water quality samples at Tawawa Creek (RM 0.22) upstream of the intake in 2009 and 2010 and collected 31 water quality samples at the Great Miami River (RM 130.0) just downstream of the intake in 2008, 2009, and 2010. To assess the PWS beneficial use, samples were analyzed for nitrate. The average nitrate concentration in

Tawawa Creek was 2.5 mg/l with a maximum concentration of 6.7 mg/l. The average nitrate concentration in the Great Miami River was 2.2 mg/l with a maximum concentration of 6.2 mg/l. The maximum nitrate concentration detected in the treated drinking water was 7.4 mg/l (June, 2008). Since all samples were less than 8 mg/l the streams are in full support of the PWS use and do not meet watch list criteria (based on the nitrate indicator). Four of the Great Miami River samples were analyzed for pesticides and two of the Tawawa Creek samples were analyzed for pesticides. Atrazine concentrations ranged from 0.20 to 0.83 ug/l and were below the WQS criterion. The maximum atrazine concentration detected in treated drinking water was 2.7 ug/l (June, 2008). Since stream atrazine samples were not collected during the critical high spring flow period and the minimum sample size of ten was not met, there is insufficient data to determine PWS use impairments based on the pesticide indicator.

City of Piqua Public Water System

The city of Piqua operates a community public water system that serves a population of approximately 20,522 people through 8,824 service connections. The city of Piqua draws water from the Great Miami River (RM 118.3), Piqua Hydraulic System, and Ernst Gravel Pit. The Piqua Hydraulic System is the primary source of water and includes Swift Run Lake, North Pond, Echo Lake, Frantz Pond and series of canals. The water supply intakes have multiple connections and the intake on the Great Miami River can either pump water directly to the treatment plant or to Swift Run Lake. The system's treatment capacity is approximately 7 million gallons per day, but current average production is 2.7 million gallons per day. The city of Piqua's water treatment processes include lime softening, coagulation, sedimentation, filtration, stabilization, fluoridation and disinfection.

Piqua participates in the Syngenta atrazine monitoring program. In 2008, Swift Run Lake had an annual raw water atrazine average concentration of 3.62 ug/l and exceeded the WQS criterion (3 ug/l). In addition, single sample maximum atrazine concentrations were over four times the WQS criterion in 2006 (15.1 ug/l), 2007 (13.0 ug/l), 2008 (26.8 ug/l), and 2010 (22.9 ug/l). The associated Garby Creek – Great Miami River Assessment Unit (05080001 07 05) is impaired for the Public Water System beneficial use due to pesticides. Finished drinking water had a maximum atrazine concentration of 3.35 ug/l (May, 2008).

Ohio EPA collected water quality samples at the Great Miami River (RM 118.5) near Piqua's public water system intake in 2009 and 2010, at the Piqua Hydraulic Canal just south of Piqua's intake in 2010 and 2011, and in Swift Run Lake and two tributaries to Swift Run Lake (McIntyre Run and Levering Run) in 2010 and 2011. The lake and tributary sampling were part of an effort to develop an atrazine TMDL for Swift Run Lake in response to the PWS Impairment. To further assess the PWS beneficial use and assist in TMDL modeling, samples were analyzed for nitrate and atrazine. The six samples collected near Piqua's Great Miami River intake and had an average nitrate concentration of 2.6 mg/l with a maximum concentration of 8.2 mg/l. Atrazine samples were not collected at that location. Sampling conducted near Piqua's intake on the Piqua Hydraulic Canal had an average nitrate concentration of 0.84 mg/l with a maximum concentration of 1.3 mg/l and an average atrazine concentration of 1.32 ug/l and a maximum concentration of 5.99 ug/l. Sampling conducted within Swift Run Lake and its tributaries had an average nitrate concentration of 2.6 mg/l with a maximum concentration of 9.0 mg/l and an average atrazine concentration of 10.4 ug/l and a maximum concentration of 182 ug/l.

There were no exceedences of the nitrate WQS criterion, however, two samples exceeded 8 mg/l, which places Piqua on a nitrate watch list. The maximum nitrate concentration in finished drinking water was 5.24 mg/l (June, 2010). The high concentrations of atrazine in the source water support maintaining the PWS Use impairment status.

City of Dayton Public Water System

The city of Dayton operates a community public water system that serves a population of approximately 456,302 people through 52,989 service connections. The public water system sells water to the City of Oakwood, Greene County, Montgomery County, Brookville, Trotwood, and Clayton. The system's treatment capacity is approximately 192 million gallons per day, but current average production is approximately 59 million gallons per day. The system obtains its raw water from 112 wells that are recharged through infiltration pits fed with surface water from two intakes on the Great Miami River. Since surface water sources are blended with ground water sources, finished water quality data is not indicative of surface water quality and cannot be used to determine drinking water impairments. The city of Dayton's water treatment processes include aeration, filtration, fluoridation, and disinfection.

Ohio EPA collected 18 water quality samples at Tawawa Creek (RM 0.22) upstream of the intake in 2009 and 2010 and collected 31 water quality samples at the Great Miami River (RM 130.0) just downstream of the intake in 2008, 2009, and 2010. To assess the PWS beneficial use samples were analyzed for nitrate. The average nitrate concentration was 2.1 mg/l with a maximum concentration of 7.0 mg/l. The maximum nitrate concentration detected in the treated drinking water was 1.9 mg/l. Since all samples were less than 8 mg/l the Great Miami River is in full support of the PWS use (based on the nitrate indicator). Two samples were analyzed for atrazine. Concentrations ranged from 0.20 to 0.22 ug/l and were below the WQS criterion. The maximum atrazine concentration detected in treated drinking water was 0.35 ug/l. Since stream atrazine samples were not collected during the critical high spring flow period and the minimum sample size of ten was not met, there is insufficient data to determine PWS use impairments based on the pesticide indicator.

Table 14a. Summary of available water quality data for parameters of interest at sampling sites near/at PWS intakes.

Location(s)	PDWS Parameters of Interest			
	Nitrate-Nitrite WQC = 10 mg/l[1]		Atrazine WQC = 3.0 ug/l[2]	
	Average/ (sample count)	Maximum (# samples >WQC)	Average / (sample count)	Maximum
Great Miami River at RM 130 (Sidney intake at RM 130.2)	2.2 mg/l n=31	6.2 mg/l (0)	0.41 ug/l[3] n=4	0.83 ug/l
Great Miami River at RM 118.5 (Piqua intake at RM 118.3)	2.6 mg/l n=6	8.2 mg/l (0)	No data	No data
Great Miami River at RM 86.13, 87.05, and 88.69 (Dayton intakes at RM 86.6 and 90.3)	2.1 mg/l n=19	7.0 mg/l (0)	0.21 ug/l[3] N=2	0.22 ug/l
Tawawa Creek at RM 0.22 (Sidney intake at RM 0.14)	2.5 mg/l n=18	6.7 mg/l (0)	0.23 ug/l[3] N=2	0.26 ug/l
Piqua Hydraulic Canal Just Downstream of Intake	0.84 mg/l n=8	1.3 mg/l (0)	1.32 ug/l N=9	5.99 ug/l
Swift Run Lake and Inlet Tributaries (Piqua Source)	2.6 mg/l n=24	9.0 mg/l (0)	10.4 ug/l N=22	182 ug/l

1 Nitrate Water Quality Criteria (WQC) evaluated as maximum value not to be exceeded, impaired waters defined as having two or more excursions about the criteria.

2 Atrazine WQC evaluated as annual average.

3 Insufficient data available to assess the annual average for the PDWS beneficial use. Need a minimum of ten samples collected during two seasons, including the critical spring runoff period.

Chemical Sediment Quality

Sediment samples were collected from 23 locations on the middle Great Miami River study area, ten stations on the main stem and 13 samples from nine of its tributaries. Evaluation of sediment quality requires, where practical and possible, the identification of freshly deposited material in the stream bed, with a bias toward fine grained material (<60 microns: silts, clays, muck). Multiple depositional zones throughout each station were sampled so as to form representative sediment composite. Samples are then analyzed for metals, volatile organic compounds, semivolatile organic compounds, organochlorinated pesticides, PCBs, nutrients, Total Organic Carbon (TOC), and particle size. Specific chemical parameters tested and results by waterbody and station are listed in Tables 14b-19.

Sediment organic samples were evaluated using the MacDonald Sediment Quality Guidelines (SQG) (2000) and the US EPA Region V RCRA Ecological Screening Levels (US EPA 2003). MacDonald Sediment Quality Guidelines are consensus-based sediment guidelines designed to evaluate ecotoxic effects. Organic compounds detected below the MacDonald Threshold Effect Concentration (TEC) are considered unlikely to cause harmful effects. Compounds detected over the MacDonald Probable Effect Concentration (PEC) indicate adverse effects are likely to occur, and compounds detected between the MacDonald TEC and PEC indicate adverse effects may occur. The USEPA Region V RCRA Ecological Screening Levels (ESL) are used on those compounds not evaluated by the MacDonald SQGs.The USEPA ESLs values are considered protective benchmarks.

Sediment metal samples are evaluated using the Ohio Sediment Reference Value (SRV) (Ohio EPA 2008c) for the ecoregion and the MacDonald Sediment Quality Guidelines. Sediment metals detected between the MacDonald TEC and PEC, but beneath the Ohio SRV will defer to Ohio's SRV. This will apply to arsenic, cadmium, copper and nickel. Sediment metals exceeding the MacDonald PEC (adverse effects usually or always occur) are referenced in Tables 15-19.

Table 14b. Concentrations of organic compounds (priority pollutant scan) detected in stream sediments in the middle Great Miami River watershed (WAU 05080001) in 2009. Individual compounds were evaluated by the MacDonald (2000) Sediment Quality Guidelines (SQG) and Ecological Screening Levels (USEPA Region V 2003).

Stream Landmark, River Mile TOC Texture	**Analysis Performed**	**Compound Detected**	**Result** (mg/kg unless noted)
Great Miami River SR 47 RM 130.0 TOC= 4.4% Fine Grain Material = 8%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Bis(2-Ethylhexyl)phthalate	1.04 ## BDL BDL BDL
Great Miami River River Rd. RM 127.7 TOC= 3.4% Fine Grain Material = 14%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BDL BDL BDL BDL
Great Miami River Lockington Rd. RM 120.46 TOC= 4.7% Fine Grain Material = 27%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Acetone	BDL BDL BDL 0.090 ##
Great Miami River SR 66 RM 118.5 TOC= 5.4% Fine Grain Material = 35%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BDL BDL BDL BDL
Great Miami River Dst. Piqua Dam RM 114.1 TOC= 3.3% Fine Grain Material = 9%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Chrysene Fluoranthene Phenanthrene Pyrene **Total PAH**	0.62 **#** 1.23 **#** 0.76 **#** 0.94 **#** **3.55 #** BDL BDL BDL
Great Miami River SR 41 RM 106. TOC= 6.2% Fine Grain Material = 27%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Fluoranthene	0.76 **#** BDL BDL BDL

Table 14b. Concentrations of organic compounds (priority pollutant scan) detected in stream sediments in the middle Great Miami River watershed (WAU 05080001) in 2009. Individual compounds were evaluated by the MacDonald (2000) Sediment Quality Guidelines (SQG) and Ecological Screening Levels (USEPA Region V 2003).

Stream Landmark, River Mile TOC Texture	**Analysis Performed**	**Compound Detected**	**Result** (mg/kg unless noted)
Great Miami River Tipp-Elizabeth Rd. RM 100.8. TOC= 7.2% Fine Grain Material = 14%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BDL BDL BDL BDL
Great Miami River Taylorsville Dam RM 93.0 TOC= not done Fine Grain Material = 34%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Pentachlorophenol	3.26 ++ BDL BDL BDL
Great Miami River Rip Rap Rd. RM 88.69. TOC= not done Fine Grain Material = 39%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Fluoranthene	0.88 **#** BDL BDL BDL
Great Miami River Troy Pk.. RM 85.90 TOC= not done Fine Grain Material = 15%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
Tawawa Creek SR 47 TOC= 3.9% Fine Grain Material = 37%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
Mosquito Creek McCloskey School Rd. TOC= 2.3% Fine Grain Material = 33%	1) BNA 2) Pesticides 3) PCBs 4) VOC	 Acetone	BRL BRL BRL 0.074 ##
Leather Wood Creek McCloskey School Rd. TOC= 3.9% Fine Grain Material = 31%	1) BNA 2) Pesticides 3) PCBs 4) VOC	 Acetone	BRL BRL BRL 0.066 ##
Rush Creek Hetzler Rd. TOC= 4.0% Fine Grain Material = 23%	1) BNA 2) Pesticides 3) PCBs 4) VOC	 Dieldrin	BRL 9.4 ug/Kg # BRL BRL
Spring Creek Rusk Rd. RM 3.50 TOC= 4.5% Fine Grain Material = 31%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
Lost Creek Peterson Rd. RM 11.70 TOC= 5.5% Fine Grain Material = 15%	1) BNA 2) Pesticides 3) PCBs 4) VOC	3&4 Methyl Phenol 2-Butanone Toluene	1.24## BRL BRL 0.79 ## 6.49 ##

Table 14b. Concentrations of organic compounds (priority pollutant scan) detected in stream sediments in the middle Great Miami River watershed (WAU 05080001) in 2009. Individual compounds were evaluated by the MacDonald (2000) Sediment Quality Guidelines (SQG) and Ecological Screening Levels (USEPA Region V 2003).

Stream Landmark, River Mile TOC Texture	**Analysis Performed**	**Compound Detected**	**Result** (mg/kg unless noted)
Lost Creek Knoop RM 4.30 TOC= 6.1% Fine Grain Material = 37%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Pentachlorophenol	1.42++ BRL BRL BRL
East Branch Lost Creek Peterson Rd. RM 0.70 TOC= 4.1% Fine Grain Material = 18%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
Boone Creek In Park. RM 0.10 TOC= 3.9% Fine Grain Material = 44%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
Honey Creek SR 571. RM 8.08 TOC= 4.4% Fine Grain Material = 35%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Bis(2-Ethylhexyl)phthalate Pentachlorophenol 4,4'-DDT 4,4'-DDE	0.80 ## 4.06 ++ 10.8 ug/Kg # 23.5 ug/Kg # BRL BRL
Honey Creek Rudy Rd. RM 3.18 TOC= 4.6% Fine Grain Material = 38%	1) BNA 2) Pesticides 3) PCBs 4) VOC	Acetone	BRL BRL BRL 0.106 ##
East Fork Honey Creek Sigler Rd.. RM 1.58 TOC= 4.6% Fine Grain Material = 100%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL
West Fork Honey Creek SR 235.. RM 1.30 TOC= 5.1% Fine Grain Material = 34%	1) BNA 2) Pesticides 3) PCBs 4) VOC		BRL BRL BRL BRL

Table 14b. Concentrations of organic compounds (priority pollutant scan) detected in stream sediments in the middle Great Miami River watershed (WAU 05080001) in 2009. Individual compounds were evaluated by the MacDonald (2000) Sediment Quality Guidelines (SQG) and Ecological Screening Levels (USEPA Region V 2003).

Stream Landmark, River Mile TOC Texture	**Analysis Performed**	**Compound Detected**	**Result** (mg/kg unless noted)

* Not evaluated
BRL Below Reporting Limit
TOC Total Organic Carbon

1) Base Neutral & Acid Extractables (BNA) U.S. EPA Method 8270
2) Pesticides U.S. EPA Methods 8082A
3) Polychlorinated biphenyls (PCBs) U.S. EPA Method 8082A

Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

<u>MacDonald (2000) Sediment Quality Guidelines (SQG)</u>

\+ **≤** TEC (Threshold effect concentration)
Harmful effects are unlikely to be observed
**>**TEC and ≤ PEC (Probable effect concentration)
Adverse effects may occur
■ > PEC (Probable effect concentration)
Adverse effects usually or always occur

USEPA Region V RCRA Ecological Screening Levels (ESL) 2003
++ **≤ ESL Protective**
>ESL

Table 15. Concentrations (mg/kg unless otherwise noted) of metals and nutrients in sediment samples collected in the main stem of middle Great Miami River during 2009. Parameter concentrations were evaluated based on Ohio EPA sediment metal reference sites (2008), MacDonald (2000) Sediment Quality Guidelines (SQG) and Persuad (1993). Values digressing from guidelines are highlighted.

Parameter	**Great Miami River Main stem** (Eastern Corn Belt)						***Reference***	
	SR47 RM130.0	River Rd. RM127.7	Lockington Rd. RM120.46	SR 66 RM118.5	Dst. Piqua Dam RM114.1	SR 41 RM106.13		
							Ohio SRV	**MacDonald** TEC -PEC
Al-T [O]	2820	4510	5910	5550	3650	8130	39000	*
As-T [OM]	3.23	4.62	4.97	4.94	3.08	4.19	18	9.79-33
Ba-T [O]	35.9	60.7	76.5	113	73.0	149	240	*
Ca-T [O]	64300	80500	71500	68000	60400	84200	120000	*
Cd-T [OM]	0.159	0.221	0.296	0.294	0.258	0.495	0.9	0.99-4.98
Cr-T [OM]	4.98	7.10	10.6	9.32	8.10	13.1	40	43.4-111
Cu-T [OM]	5.73	11.4	12.9	12.9	7.86	14.8	34	31.6-149
Fe-T [O]	7820	11200	11900	12800	9310	13800	33000	*
Hg-T [OM]	0.031	<0.034	<0.042	<0.035	0.034	<0.040	0.12	0.18-1.06
K-T [O]	<927	<1170	<1290	<1520	<1090	<1600	11000	*
Mg-T [O]	17300	28700	20500	22100	17000	22000	35000	*
Mn-T [O]	202	308	352	346	211	249	780	*
Na-T *	<2320	<2910	<3220	<3800	<2730	<4000	*	*
Ni-T [OM]	7.58	10.2	13.1	14.1	8.96	17.4	42	22.7-48.6
Pb-T [OM]	6.89	10.8	13.9	11.8	11.3	116	47	35.8-128
Se-T [O]	<0.93	<1.17	<1.29	<1.52	<1.09	<1.60	2.3	*
Sr-T [O]	121	127	213	205	143	288	390	*
Zn-T [OM]	32.2	53.3	65.6	116	69.1	109	160	121-459
							Ohio	**Persuad**
NH_3-N [P]	43	46	290	98	34	82	*	100
TOC(%) [P]	4.4	3.4	4.7	5.4	3.3	6.2	*	10.0%
pH (SU) *	8.0	7.8	7.8	7.6	7.9	7.7	*	*
P-T [P]	213	607	549	588	521	642	*	2000
%FGM [O]	8%↘	14%↘	27%↘	35%	9%↘	27%↘	30.0%	*

↘ Below the goal of 30% Fine Grain Material in sample
%FGM Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

* Not evaluated
O Evaluated by Ohio EPA (2003)
? Detection limit is greater than guideline
P Evaluated by Persuad (1993)
M Evaluated by MacDonald (2000)

Ohio Sediment Reference Values (SRV) Guidelines (2008)
\+ above reference value for ecoregion

Ontario Sediment Guidelines (Persuad 1993)
L > Open Water Disposal Guidelines; equivalent to the Lowest Effect Level (LEL)-applicable to NH_3-N only.
▲ > severe effect level (disturbance in benthic community can be expected)

MacDonald (2000) Sediment Quality Guidelines (SQG)
**>** TEC (Threshold effect concentration) and ≤ PEC (Probable effect concentration) Adverse effects frequently occur
■ > PEC (Probable effect concentration) -- Adverse effects usually or always occur.

Table 16. Concentrations (mg/kg unless otherwise noted) of metals and nutrients in sediment samples collected in the main stem of the middle Great Miami River during 2009. Parameter concentrations were evaluated based on Ohio EPA sediment metal reference sites (2008), MacDonald (2000) Sediment Quality Guidelines (SQG) and Persuad (1993). Values digressing from guidelines are highlighted.

Parameter	**Great Miami River,** Landmark, and River Mile						***Reference***	
	Tipp-Elizabeth RM 100.8	Taylorsville Dam RM 93.0	Rip Rap Rd. RM 88.69	Troy Pk. RM 85.90	-	-	**Ohio SRV** ECBP	**MacDonald** TEC -PEC
Al-T O	5360	6430	8100	11700	-	-	39000	*
As-T OM	3.81	3.72	5.11	6.48	-	-	18	9.79-33
Ba-T O	82.2	108	134	159	-	-	240	*
Ca-T O	79900	78700	79500	126000	-	-	120000	*
Cd-T OM	0.398	0.483	0.539	0.411	-	-	0.9	0.99-4.98
Cr-T OM	10.5	11.2	13.4	16.7	-	-	40	43.4-111
Cu-T OM	11.2	12.6	18.1	19.7	-	-	34	31.6-149
Fe-T O	11600	11900	13900	18200	-	-	33000	*
Hg-T OM	<0.034	<0.038	0.048	<0.039	-	-	0.12	0.18-1.06
K-T O	<1310	<1380	<1480	2290	-	-	11000	*
Mg-T O	24300	22500	27200	41400	-	-	35000	*
Mn-T O	264	234	241	513	-	-	780	*
Na-T *	<3270	<3460	<3710	<4220	-	-	*	*
Ni-T OM	13.3	14.0	17.7	20.1	-	-	42	22.7-48.6
Pb-T OM	13.3	14.2	23.4	17.6	-	-	47	35.8-128
Se-T O	<1.31	<1.38	<1.48	<1.69	-	-	2.3	*
Sr-T O	210	231	170	406	-	-	390	*
Zn-T OM	67.9	76.1	125	102	-	-	160	121-459
							Ohio	**Persuad**
NH_3-N P	56	90	140	96	-	-	*	100
TOC(%) P	7.2	---	----	---	-	-	*	10.0%
pH (SU) *	7.8	7.7	7.6	7.9	-	-	*	*
P-T P	521	734	613	677	-	-	*	2000
%FGM O	14%↘	34%	39%	15%↘	-	-	30.0%	*

↘ Below the goal of 30% Fine Grain Material in sample
%FGM Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

* Not evaluated M Evaluated by MacDonald (2000) P Evaluated by Persuad (1993)
O Evaluated by Ohio EPA (2003)
? Detection limit is greater than guideline

Ohio Sediment Reference Values (SRV) Guidelines (2008c)
\+ above reference value for ecoregion

Ontario Sediment Guidelines (Persuad 1993)
L > Open Water Disposal Guidelines; equivalent to the Lowest Effect Level (LEL)-applicable to NH_3-N only.
▲ > severe effect level (disturbance in benthic community can be expected)

MacDonald (2000) Sediment Quality Guidelines (SQG)
\# > TEC (Threshold effect concentration) and ≤ PEC (Probable effect concentration) Adverse effects frequently occur
■ > PEC (Probable effect concentration) -- Adverse effects usually or always occur.

Table 17. Concentrations (mg/kg unless otherwise noted) of metals and nutrients in sediment samples collected in tributaries of the middle Great Miami River, during 2009. Parameter concentrations were evaluated based on Ohio EPA sediment metal reference sites (2008), MacDonald (2000) Sediment Quality Guidelines (SQG) and Persuad (1993 Values digressing from guidelines are highlighted.

Parameter	Stream, Landmark, and River Mile					***Reference***	
	Tawawa Ck SR 47 RM 0.22	Mosquito Ck McCloskey Rd RM 1.00	Leather Wood McCloskey Rd RM 1.20	Rush Ck. Hetzler Rd RM 1.68	Spring Ck. Rusk Rd. RM 3.50		
						Ohio SRV ECBP	**MacDonald** TEC -PEC
Al-T [O]	5860	5530	4350	3240	4320	39000	*
As-T [OM]	5.43	6.61	4.97	3.04	3.65	18	9.79-33
Ba-T [O]	69.1	83.0	41.8	77.3	86.9	240	*
Ca-T [O]	70000	27700	59700	70900	88500	120000	*
Cd-T [OM]	0.273	0.232	0.263	0.171	0.268	0.9	0.99-4.98
Cr-T [OM]	8.35	8.44	7.66	5.14	6.66	40	43.4-111
Cu-T [OM]	10.7	9.14	8.16	6.77	7.98	34	31.6-149
Fe-T [O]	12500	12600	10700	8120	8630	33000	*
Hg-T [OM]	0.041	0.036	<0.025	0.035	0.027	0.12	0.18-1.06
K-T [O]	<1120	<1020	<1110	<1240	<1210	11000	*
Mg-T [O]	19000	10900	25000	28600	31300	35000	*
Mn-T [O]	324	310	219	280	258	780	*
Na-T *	<2810	<2550	<2780	<3100	<3020	*	*
Ni-T [OM]	11.5	10.5	9.62	8.25	8.84	42	22.7-48.6
Pb-T [OM]	10.2	9.16	7.72	7.21	7.56	47	35.8-128
Se-T [O]	<1.12	<1.02	<1.11	<1.24	<1.21	2.3	*
Sr-T [O]	205	72	113	71	205	390	*
Zn-T [OM]	60.2	63	45.9	58.6	63.1	160	121-459
						Ohio	**Persuad**
NH_3-N [P]	62	52	83	89	51	*	100
TOC(%) [P]	3.9	2.3	3.9	4.0	4.5	*	10.0%
pH (SU) *	7.6	7.9	7.6	8.0	7.8	*	*
P-T [P]	737	488	390	477	285	*	2000
%FGM [O]	37%	33%	31%	23%↘	31%	30.0%	*

↘ Below the goal of 30% Fine Grain Material in sample
%FGM Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

* Not evaluated [M] Evaluated by MacDonald (2000) [P] Evaluated by Persuad (1993)
O Evaluated by Ohio EPA (2003)
? Detection limit is greater than guideline

Ohio Sediment Reference Values (SRV) Guidelines (2008c)
\+ above reference value for ecoregion

Ontario Sediment Guidelines (Persuad 1993)
L > Open Water Disposal Guidelines; equivalent to the Lowest Effect Level (LEL)-applicable to NH_3-N only.
▲ > severe effect level (disturbance in benthic community can be expected)

MacDonald (2000) Sediment Quality Guidelines (SQG)
**>** TEC (Threshold effect concentration) and ≤ PEC (Probable effect concentration)
Adverse effects frequently occur
■ > PEC (Probable effect concentration) -- Adverse effects usually or always occur.

Table 18. Concentrations (mg/kg unless otherwise noted) of metals and nutrients in sediment samples collected in tributaries of the middle Great Miami River during 2009. Parameter concentrations were evaluated based on Ohio EPA sediment metal reference sites (2003), MacDonald (2000) Sediment Quality Guidelines (SQG) and Persuad (1993). Values digressing from guidelines are highlighted.

Parameter	Stream, Landmark, and River Mile					***Reference***	
	Lost Ck Peterson Rd RM 11.70	Lost Ck Knoop Rd RM 4.30	EBLost Ck Peterson Rd RM 0.70	Boone Ck Near mouth RM 0.10	Honey Ck SR 571 RM 8.08		
						Ohio SRV ECBP	**MacDonald** TEC -PEC
Al-T O	2360	4400	2740	6490	6270	39000	*
As-T OM	6.72	4.81	4.02	5.30	5.64	18	9.79-33
Ba-T O	66.2	113	55.3	103	87.3	240	*
Ca-T O	158000	129000	75600	73700	85200	120000	*
Cd-T OM	0.196	0.298	0.167	0.345	0.239	0.9	0.99-4.98
Cr-T OM	5.06	7.37	5.39	11.2	10.1	40	43.4-111
Cu-T OM	5.51	13.1	6.52	11.6	17.3	34	31.6-149
Fe-T O	7760	10800	6770	13900	12900	33000	*
Hg-T OM	<0.031	0.038	0.034	0.034	0.062	0.12	0.18-1.06
K-T O	<969	<1470	<1070	<1210	<1630	11000	*
Mg-T O	42800	39700	29200	25300	30800	35000	*
Mn-T O	154	243	148	340	404	780	*
Na-T *	<2420	<3670	<2670	<3030	<4070	*	*
Ni-T OM	8.58	11.7	7.74	14.2	13.0	42	22.7-48.6
Pb-T OM	3.74	8.61	5.31	13.7	15.9	47	35.8-128
Se-T O	<0.97	<1.47	<1.07	<1.21	<1.63	2.3	*
Sr-T O	896	485	138	171	138	390	*
Zn-T OM	45.4	72.9	57.6	79.9	68.2	160	121-459
						Ohio	**Persuad**
NH_3-N P	120	230	110	67	62	*	100
TOC(%) P	5.5	6.1	4.1	4.4	4.5	*	10.0%
pH (SU) *	7.7	7.6	7.8	7.8	7.8	*	*
P-T P	338	621	311	570	927	*	2000
%FGM O	15%↘	37%	18%↘	35%	43%	30.0%	*

↘ Below the goal of 30% Fine Grain Material in sample
%FGM Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

* Not evaluated M Evaluated by MacDonald (2000) P Evaluated by Persuad (1993)
O Evaluated by Ohio EPA (2003)
? Detection limit is greater than guideline

Ohio Sediment Reference Values (SRV) Guidelines (2008c)
\+ above reference value for ecoregion

Ontario Sediment Guidelines (Persuad 1993)
L > Open Water Disposal Guidelines; equivalent to the Lowest Effect Level (LEL)-applicable to NH_3-N only.
▲ > severe effect level (disturbance in benthic community can be expected)

MacDonald (2000) Sediment Quality Guidelines (SQG)
**>** TEC (Threshold effect concentration) and ≤ PEC (Probable effect concentration) Adverse effects frequently occur
■ > PEC (Probable effect concentration) -- Adverse effects usually or always occur.

Table 19. Concentrations (mg/kg unless otherwise noted) of metals and nutrients in sediment samples collected Tributaries of the middle Great Miami River during 2009. Parameter concentrations were evaluated based on Ohio EPA sediment metal reference sites (2003), MacDonald (2000) Sediment Quality Guidelines (SQG) and Persuad (1993). Values digressing from guidelines are highlighted.

Parameter	Stream, Landmark, and River Mile					Reference	
	Honey Ck Rudy Rd RM 3.18	EFHoney Ck Sigler Rd RM 1.58	WFHoney Ck SR 235 RM 1.30	-	-		
						Ohio SRV ECBP	**MacDonald** TEC -PEC
Al-T O	5340	6060	4440	-	-	39000	*
As-T OM	5.69	4.60	4.94	-	-	18	9.79-33
Ba-T O	112	107	98.9	-	-	240	*
Ca-T O	76300	109000	97100	-	-	120000	*
Cd-T OM	0.284	0.324	0.262	-	-	0.9	0.99-4.98
Cr-T OM	7.93	8.95	7.26	-	-	40	43.4-111
Cu-T OM	9.26	12.1	12.3	-	-	34	31.6-149
Fe-T O	11900	12100	11300	-	-	33000	*
Hg-T OM	<0.042	<0.033	<0.045	-	-	0.12	0.18-1.06
K-T O	<1620	<1860	<1340	-	-	11000	*
Mg-T O	25500	31400	30600	-	-	35000	*
Mn-T O	344	450	270	-	-	780	*
Na-T *	<4050	<4650	<3360	-	-	*	*
Ni-T OM	10.3	12.5	11.9	-	-	42	22.7-48.6
Pb-T OM	8.52	11.6	9.12	-	-	47	35.8-128
Se-T O	<1.62	<1.86	<1.34	-	-	2.3	*
Sr-T O	171	219	152	-	-	390	*
Zn-T OM	55.6	63.3	96.4	-	-	160	121-459
						Ohio	**Persuad**
NH_3-N P	270	86	70	-	-	*	100
TOC(%) P	4.6	4.6	5.1	-	-	*	10.0%
pH (SU) *	7.6	7.7	7.7	-	-	*	*
P-T P	495	735	674	-	-	*	2000
%FGM O	38%	100%	34%	-	-	30.0%	*

↘ Below the goal of 30% Fine Grain Material in sample
%FGM Percent Fine Grain Material in sediment sample (<60 micron or >30 seconds settling time)

* Not evaluated M Evaluated by MacDonald (2000) P Evaluated by Persuad (1993)
O Evaluated by Ohio EPA (2003)
? Detection limit is greater than guideline

Ohio Sediment Reference Values (SRV) Guidelines (2008c)
\+ above reference value for ecoregion

Ontario Sediment Guidelines (Persuad 1993)
L > Open Water Disposal Guidelines; equivalent to the Lowest Effect Level (LEL)-applicable to NH_3-N only.
▲ > severe effect level (disturbance in benthic community can be expected)

MacDonald (2000) Sediment Quality Guidelines (SQG)
> TEC (Threshold effect concentration) and ≤ PEC (Probable effect concentration) Adverse effects frequently occur
■ > PEC (Probable effect concentration) -- Adverse effects usually or always occur.

Great Miami River (main stem)

RM 130.0 WAU 05080001-07-03: The site is at the SR 47 in Sidney and the stream here has good cobble, gravel and sand substrate with little fine grained material available (8% in sample). None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. The organic compound Bis (2-Ethylhexyl) phthalate was detected at 1.04 mg/kg, above the USEPA ESL protective level. Bis (2-Ethylhexyl) phthalate is used as a plasticizer in flexible vinyl products and is a common contaminant suspected of being an endocrine disrupter.

RM 127.7 WAU 05080001-07-03: Located on River Rd. in Sidney, and the stream here was much like the upstream site with sandy, cobble and gravel. Fine grained material was in only 14% of the sample. No organic compounds were detected in the sample. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines.

RM 120.46 WAU 05080001-07-03: This site is located at the Piqua-Lockington Road Bridge in rural Shelby County. The smell of hog manure was reported in the air and the sediment ammonia (290 mg/kg) was above the Ontario open water disposal sediment guidelines. The organic analysis detected one compound, acetone at 0.090 mg/kg above the USEPA ESL protective benchmark. This is a common lab contaminant. None of the metal parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. Fine grained material was 27% of the sample, below the 30% goal.

RM 118.5 WAU 05080001-07-05: The site is located downstream of the Piqua low head dam and the Swift Run Lake overflow next to SR 66 adjacient to the Piqua water treatment plant. Fine grained material made up 35% of this sample. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected.

RM 114.1 WAU 05080001-07-05: This site is downstream of the Piqua Dam and had only 9% fine grained material in the sample. Four polyaromatic hydrocarbon compounds were detected in the organic analysis. chrysene (0.62 mg/kg), fluoranthene (1.23 mg/kg), phenanthrene (0.76 mg/kg) and pyrene (0.94 mg/kg) had a total PAH concentration of 3.55 mg/kg, between the MacDonald TEC and PEC, adverse effects may occur. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines.

RM 106.13 WAU 0508001-08-05: Samples were taken downstream from SR 41, in Troy. Some evidence of urban debris and car parts was found in the streambed. There was mostly sand, gravel and cobbles in the streambed making collection of a representative sample difficult. An extensive bed of macroyphytes (river left) held enough fine grained material (27%) to make a sample, but fell below the 30% guideline. Sediment lead (116 mg/kg) was over the OSRV guideline (47 mg/kg). All other metals were within or below the Ohio EPA, MacDonald, or Ontario guidelines. Fluoranthene (0.76 mg/kg) was detected between the MacDonald TEC and PEC, adverse effects may occur.

RM 100.8 WAU 0508001-08-05: A tan/grey sandy sediment was found downstream of the boat ramp near the Tipp-Elizabeth Rd. in Tipp City. Sampling near a bed of macrophytes yielded black soft muck. The sample had 14% fine grained material. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected.

RM 93.0 WAU 05080001-20-05: The site was located downstream of the Taylorsville Dam and was represented by mucky sediment taken river right with 34% fine grained material. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. Pentachlorophenol, a wood preservative, was detected at a concentration of 3.26 mg/kg, a level considered protective by the USEPA ESL benchmark.

RM 88.69 WAU 05080001-20-05: Located in north Dayton, the sample site was located at Rip-Rap Rd., downstream from the both Cargill Inc. and Tate & Lyle discharges. Fine grained material comprised 39% of the sample.

Sediment metals were below Ohio EPA, MacDonald, and Ontario guidelines. Sediment ammonia (140 mg/kg) was above the Ontario open water disposal sediment guidelines. Fluoranthene, a PAH, was detected at a concentration of 0.88 mg/kg. This level falls between the MacDonald TEC and PEC benchmarks of possible adverse effects

RM 85.9 WAU 05080001-20-05: Sediment samples from this stration were collected adjacient SR 202 (Troy St.) in Dayton, downstream from the Tri-Cities WWTP. Samples here contained only 15% fine grained material, but had calcium (126,000 mg/kg), magnesium (41,400 mg/kg), and strontium (406 mg/kg), greater than the Ohio SRV guidelines (e.g., values above ecoregional background levels). No organic compounds were detected in the sample and sediment nutrients were below Ontario guidelines.

Middle Great Miami River Tributaries

Tawawa Creek, RM 0.22 WAU 0508001-07-02: A heavy sediment load was present in Tawawa Creek downstream from SR 47, in Sidney. The sediment sample was 37% fine grained material. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines, nor were organic compounds were detected.

Mosquito Creek, RM 1.00 WAU 0508001-07-02: Personal all-terrain vehicles regularly travel this site at McCloskey School Rd. resulting in mucky and disturbed streambed. The sediment sample was 33% fine grained material. acetone was detected in organic scan at levels greater than the US EPAN ESL protective benchmark. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines.

Leatherwood Creek, RM 1.20 WAU 0508001-07-01: Also located on a bridge at McCloskey School Rd., acetone was detected in organic scan at levels greater than the US EPAN ESL protective benchmark. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. The sediment sample contained 31% fine grained material.

Rush Creek, RM 1.68 WAU 0508001-07-04: Cobble and gravel dominated sediment in the stream in the composite sample collected downstream of Hetzler Rd. The sample contained 23% fine grained material. The legacy pesticide, dieldrin (9.4 µg/kg), was detected between the MacDonald TEC and PEC. Dieldrin was banned from use in 1987. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines.

Spring Creek, RM 3.50 WAU 05080001-08-01: High banks have eroded into this creek downstream of the Rusk Road Bridge. The majority of streambed was cobble and gravel but 31% fine grained material was in the sample mostly due to the bank erosion. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected in the sample.

Lost Creek, RM 11.70 WAU 05080001-08-02: The site was located at Peterson Rd. and was dominated by sand, gravel and cobble substrate, with the resulting sediment particle size 15% fine grained material. The sediment ammonia was 120 mg/kg, above the Ontario open water disposal sediment guidelines. Manure from surrounding farms could be a possible source of ammonia.

Sediment calcium (158,000 mg/kg), magnesium (42,800 mg/kg) and strontium (896 mg/kg) were all over the Ohio SRV guidelines. This means these metals are above background levels for sediment metal concentration for this ecoregion.

The sediment organic analysis detected the wood preservative 3&4 methyl phenol (1.42 mg/kg), 2-Butanone (0.79 mg/kg), and toluene (6.49 mg/kg) each at levels over the USEPA ESL protective benchmark. Both 2-butanone (methyl ethyl ketone) and toluene are used as paint solvents.

Lost Creek, RM 4.30 WAU 05080001-08-04: This Lost Creek site is located over seven miles downstream on Knoop Road, also in farm country. The stream bed was dominated by sand, gravel and cobble substrate much like the upstream site. The sample contained 37% fine grained material. Sediment ammonia (230 mg/kg) was above the Ontario open water disposal sediment guidelines. Sediment calcium (129,000 mg/kg), magnesium (39,700 mg/kg) and strontium (485 mg/kg) were all over the Ohio SRV guidelines. This means these metals are above background levels for sediment metal concentration for this ecoregion. The wood preservative pentachlorophenol (1.42 mg/kg) wasconsidered protective by the USEPA ESL benchmark.

East Branch Lost Creek, RM 0.70 WAU 0508001-08-03: Cattle fence bracketed the sampling area starting at the Peterson Rd. Sediment ammonia (110 mg/kg) was over the Ontario open water disposal sediment guidelines. This stretch of creek had little sediment embeddedness and only 18% fine grained material in the sample. None of the metal parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected in the sample.

<u>Boone Creek, RM 0.10 WAU 0508001-08-05</u>: The only Boon Creek sampling site was located in the Miami County Park downstream of the confluence with Peters Creek. The United Scrap Lead Superfund site is located 0.6 mi upstream on Peters Creek at 25-A in Troy. In addition, a working gravel pit on Dye Mill Rd. drains to Boone Creek.

Gray, fine grained material was common upstream near the mouth of Peters creek. The sample had 39% fine grained material. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected in the sample.

<u>Honey Creek, RM 8.08 WAU 0508001-20-04</u>: Sampled downstream of the SR 571, this site is also downstream of the New Carlisle WWTP and a large nursery. Fine grained material made up 43% of the sediment sample. The legacy pesticide 4, 4'-DDT (10.8 µg/kg) and its dehalogenated breakdown product (4, 4'-DDE (23.5 µg/kg) were detected in sediment samples between the MacDonald TEC and PEC. DDT was banned from use in 1972. In addition, the organic analysis also detected bis (2-ethylhexyl) phthalate (0.80 mg/kg) over the protective USEPA ESL benchmark. Pentachlorophenol (a wood preservative) (4.06 mg/kg) was considered protective by the USEPA MSL benchmark. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines.

<u>Honey Creek, RM 3.18 WAU 0508001-20-04</u>: A great amount of gray fine grained agricultural sediment covered a sand and gravel substrate both upstream and downstream of the Rudy Road Bridge. The sample had 38% fine grained material. Sediment ammonia (270 mg/kg) was above the Ontario open water disposal sediment guidelines. None of the metal parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. Sediment organic analysis detected acetone (0.106 mg/kg) above the USEPA MSL bemchmark.

<u>East Fork Honey Creek, RM 3.7 WAU 0508001-20-01</u>: Sampled downstream of the Sigler Road Bd., the sediment had 100% fine grained material. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected in the sample.

<u>West Fork Honey Creek, RM 1.30 WAU 0508001-20-02</u>: Samples were taken downstream of the US 235 bridge. Fine grained material was in 35% of the sample. None of the metal or nutrient parameters were found to be above Ohio EPA, MacDonald, or Ontario guidelines. No organic compounds were detected in the sample

Physical Habitat for Aquatic Life

The assessment of the influence of physical stream features and riparian conditions on ambient biological performance for the middle Great Miami River basin will proceed in a longitudinal manner (upstream to downstream). The discussion of tributaries will either be treated in the aggregate, or if sufficiently large, tributaries or subbasins will be broken-out separately for discussion. For the purposes of continuity, this longitudinal reporting structure will also be applied to the assessment of ambient biological performance throughout this document.

Mean QHEI values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation. Reach average values at greater than 75.0 are generally considered adequate to support fully exceptional (EWH) communities (Rankin 1989 and Rankin 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat derived aquatic life use impairment, but should not be viewed as determinant.

Middle Great Miami River (main stem)

As part of the 2009 fish sampling effort, the quality of near and in-steam macrohabitats of the Great Miami main stem were evaluated at 19 sampling locations, assessing approximately 49 miles of the main stem between RM 130.0 (SR 47, Sidney) and RM 81.6 (immediately upstream form the Mad River). QHEI values ranged between 89.5 and 64.0, with a mean score of 77.3 (±13.59, 2 SD). A matrix of QHEI macrohabitat features, by stations, and the longitudinal performance of the QHEI for the Great Miami River are presented in Table 20 and Figures 26 and 27.

As measured by the QHEI, the quality of near and in-stream macrohabitat throughout the entire length of the middle great Miami River appeared fully capable of supporting a diverse, functionally organized, and well-structured assemblages of aquatic organisms, consistent with its existing EWH and WWH aquatic life uses. Nearly all sites contained a full complement of positive channel, substrate, and riparian features, displaying classic channel form and function typical of high quality till-plains streams of central and west-central Ohio. The channel configuration of the main stem was generally in a natural or recovered state, displaying a high degree of sinuosity. Riffle and run complexes were commonly observed throughout. Where evidence of previous channel modification was found, the process of natural restoration or recovery of more complex channel features, although incomplete, appeared well advance. Trench and lateral scour pools were regularly

Table 20. A matrix of QHEI scores and macrohabitat features of streams contained within the middle Great Miami River study area, 2009.

Key QHEI Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(14-001) Great Miami River																																		
Year: 2009																																		
127.7	79.0	5.71	■	■		■	■	■			■	■	7							0		●				●			●	●	●		5	0.13	0.75
123.9	73.5	8.13	■	■		■			■		■		5				♦		1		●			●	●			●	●	●		6	0.33	1.33
120.0	83.0	6.76	■	■		■	■	■	■	■	■	■	9				♦		1		●								●	●		3	0.20	0.50
118.5	70.0	5.10		■		■			■		■		4				♦		1	●	●				●			●	●	●		6	0.40	1.60
115.4	76.5	1.77	■	■		■		■		■	■	■	7							0						●			●				2	0.13	0.38
114.0	74.0	4.02	■	■		■			■	■	■	■	7				♦		1		●				●			●	●	●		5	0.25	0.88
112.4	80.0	4.02	■	■		■		■	■		■	■	7				♦		1		●			●	●			●	●	●		6	0.25	1.00
106.1	70.5	3.52		■		■	■		■	■	■	■	7				♦		1	●	●				●				●	●		5	0.25	0.88
104.7	83.0	3.52	■	■		■	■	■	■		■	■	8				♦		1		●				●				●	●		4	0.22	0.67
100.8	88.0	1.81	■	■		■	■	■	■		■		7							0		●				●				●	●		4	0.13	0.63
95.6	80.5	2.72	■	■		■		■	■		■		6							0		●			●	●			●	●	●		6	0.14	1.00
92.5	78.5	2.72	■	■		■	■	■			■	■	7				♦		1		●			●	●			●	●	●		6	0.25	1.00
88.7	86.0	2.03	■	■		■	■	■	■		■	■	8							0		●								●	●		3	0.11	0.44
87.0	76.0	6.37	■	■				■	■		■		5							0	●	●			●	●			●	●	●		7	0.17	1.33
85.9	70.5	6.45		■			■	■	■		■		5				♦		1	●	●			●	●			●	●	●		7	0.33	1.50
81.6	64.0	5.00		■							■	■	3				♦		1	●	●			●	●			●	●	●		7	0.50	2.25
Year: 2008																																		
130.0	78.0	12.34		■		■	■	■	■		■	■	7				♦		1	●	●				●				●	●		5	0.25	0.88
110.1	76.0	2.37	■	■		■	■		■		■	■	7				♦		1	●	●			●	●			●	●	●		7	0.25	1.13
98.5	89.5	1.81	■	■		■	■	■	■		■	■	8							0		●								●	●		3	0.11	0.44
(14-043) Honey Creek																																		
Year: 2009																																		
9.9	64.5	11.36		■							■	■	3				♦		1	●	●			●	●			●	●			6	0.50	2.00
8.1	73.5	15.38	■	■		■	■	■			■	■	7							0	●	●		●	●	●			●	●			7	0.13	1.00
3.2	74.0	5.21	■	■		■	■	■	■	■	■	■	9							0	●	●								●	●		4	0.10	0.50
0.8	57.5	2.11					■	■			■		3				♦		1	●	●			●	●			●	●	●		7	0.50	2.25
(14-044) Indian Creek																																		
Year: 2009																																		
4.9	81.0	26.32	■	■	■	■	■	■		■	■	■	9			♦			1									●				1	0.20	0.30
0.1	82.0	10.42	■	■		■	■	■	■	■	■	■	9							0														0	0.10	0.10
(14-045) Dry Creek																																		
Year: 2009																																		
1.2	29.5	19.61					■						1	♦	♦		♦	♦	4	●	●			●				●	●		●	6	2.50	5.50

Table 20. continued.

Key
QHEI
Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(14-046) West Fork Honey Creek																																		
Year: 2009																																		
1.3	57.0	18.87		■							■	■	3				♦		1	•	•		•	•	•			•	•	•		8	0.50	2.50
0.1	77.0	35.71	■	■		■	■	■		■	■	■	8						0				•					•				2	0.11	0.33
(14-047) East Fork Honey Creek																																		
Year: 2009																																		
5.9	58.0	18.87		■			■				■	■	4			♦	♦		2	•	•			•				•	•	•		6	0.60	1.80
3.6	47.0	90.91	■							■		■	3			♦	♦	♦	3		•			•			•	•	•			5	1.00	2.25
0.1	74.0	47.62	■	■		■	■	■		■	■	■	8				♦		1				•					•				2	0.22	0.44
(14-048) Lost Creek																																		
Year: 2009																																		
11.7	65.0	37.04		■	■					■	■	■	5			♦	♦		2	•				•				•				3	0.50	1.00
9.8	78.5	16.13	■	■	■	■	■	■		■	■	■	9				♦		1	•			•	•	•			•				5	0.20	0.70
4.3	65.5	45.45		■	■				■	■	■	■	6				♦		1	•				•	•			•		•		5	0.29	1.00
0.4	59.5	2.01			■					■	■	■	4				♦		1	•				•	•			•				4	0.40	1.20
(14-049) East Branch Lost Creek																																		
Year: 2009																																		
6.4	77.0	18.87	■	■		■	■	■	■	■	■	■	9						0	•	•								•			3	0.10	0.40
5.2	77.5	15.15	■	■		■	■	■		■	■	■	8				♦		1									•		•		2	0.22	0.44
0.7	64.0	20.83		■	■					■	■	■	5			♦	♦		2	•				•				•				3	0.50	1.00
(14-050) Spring Creek																																		
Year: 2009																																		
8.4	79.0	22.22	■	■		■	■	■		■	■	■	8						0		•			•				•				3	0.11	0.44
3.5	74.0	33.33	■	■		■	■	■		■	■	■	8						0		•							•	•			3	0.11	0.44
0.8	72.5	25.00	■	■		■	■	■		■	■	■	8				♦		1					•	•			•				3	0.22	0.56
(14-052) Rush Creek																																		
Year: 2009																																		
5.3	55.5	18.87	■	■						■			3			♦	♦	♦	3	•	•		•	•				•	•		•	7	1.00	2.75
1.7	61.5	20.00		■		■					■		3			♦	♦		2	•			•	•				•	•	•		6	0.75	2.25
0.3	63.5	25.64	■	■			■				■	■	5			♦	♦		2		•			•				•	•	•		5	0.50	1.33
(14-058) Mill Branch																																		
Year: 2009																																		
0.3	83.0	29.41	■	■		■	■	■		■	■	■	8						0				•					•				2	0.11	0.33
(14-060) Tawawa Creek																																		
Year: 2009																																		

Table 20. continued

Key
QHEI
Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(14-060) Tawawa Creek																																		
Year: 2009																																		
1.2	74.5	8.85		■		■	■	■	■	■	■		7				♦		1	●	●			●	●				●	●		6	0.25	1.00
(14-061) Mosquito Creek																																		
Year: 2009																																		
7.8	47.0	3.40						■			■	■	3	♦	♦	♦			3	●	●			●				●	●			5	1.00	2.25
1.0	63.5	10.31		■				■			■	■	4				♦		1	●	●		●	●	●			●	●	●		8	0.40	2.00
(14-062) Leatherwood Creek																																		
Year: 2009																																		
6.4	55.0	6.99						■		■	■	■	4	♦		♦	♦		3	●				●				●				3	0.80	1.40
3.3	65.5	20.41	■	■			■			■	■	■	6				♦		1		●			●				●	●			4	0.29	0.86
1.2	74.5	12.66	■	■			■	■			■	■	6						0	●	●			●				●	●	●		6	0.14	1.00
(14-096) Peters Creek																																		
Year: 2009																																		
0.5	65.0	9.71	■	■			■	■			■		5	♦		♦	♦		3		●			●				●	●		●	5	0.67	1.50
(14-097) Trib. to Great Miami R. (RM 103.87)																																		
Year: 2009																																		
0.1	73.5	30.30	■	■		■		■			■		5						0		●			●	●			●	●	●		6	0.17	1.17
(14-275) Pleasant Run																																		
Year: 2009																																		
0.5	76.5	25.00	■	■		■	■	■		■	■	■	8						0	●	●							●	●			4	0.11	0.56
(14-276) Little Lost Creek																																		
Year: 2009																																		
0.3	64.5	83.33		■		■		■			■		4			♦	♦		2	●	●			●				●	●	●		6	0.60	1.80
(14-277) Middle Branch Lost Creek																																		
Year: 2009																																		
1.2	71.0	27.78		■			■	■		■	■	■	6				♦		1	●	●		●	●				●	●			6	0.29	1.14
(14-278) West Branch Lost Creek																																		
Year: 2009																																		
0.5	67.5	25.64		■		■	■	■		■	■	■	7			♦	♦		2	●	●			●				●	●			5	0.38	1.00

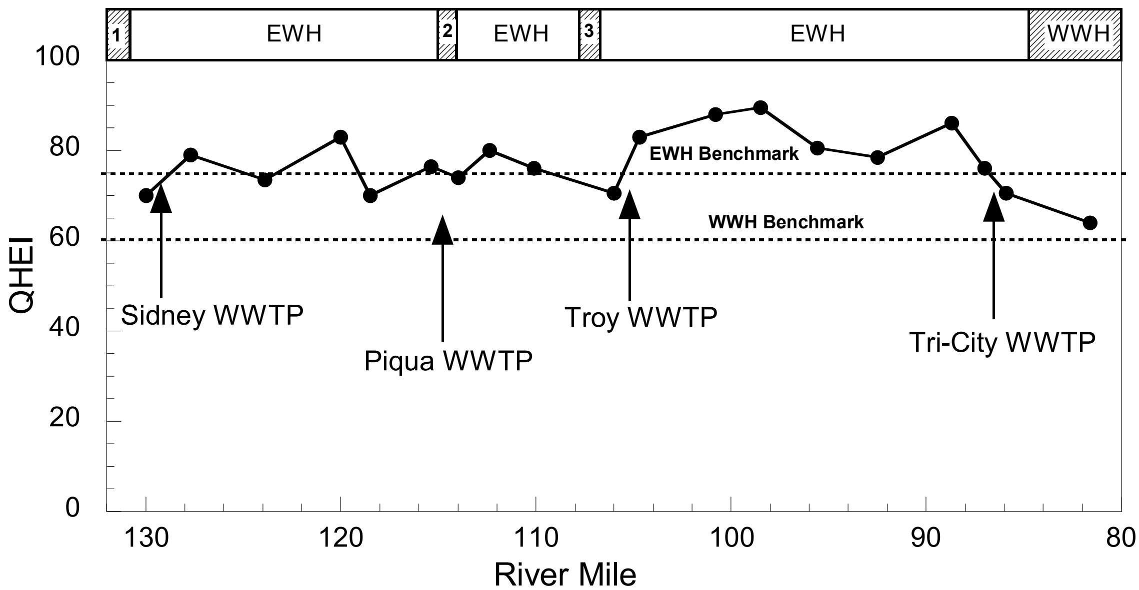


Figure 26. Longitudinal performance of the QHEI for the middle Great Miami River, 2009. Both existing and recommended, Exceptional Warmwater Habitat (EWH) and Warmwater Habitat (WWH), Aquatic Life Use designations are superimposed atop the figure. Enumerated segments: 1, 2, and 3, correspond to small low head dams and associated impounded river reaches of Sidney, Piqua, and Troy, respectively.

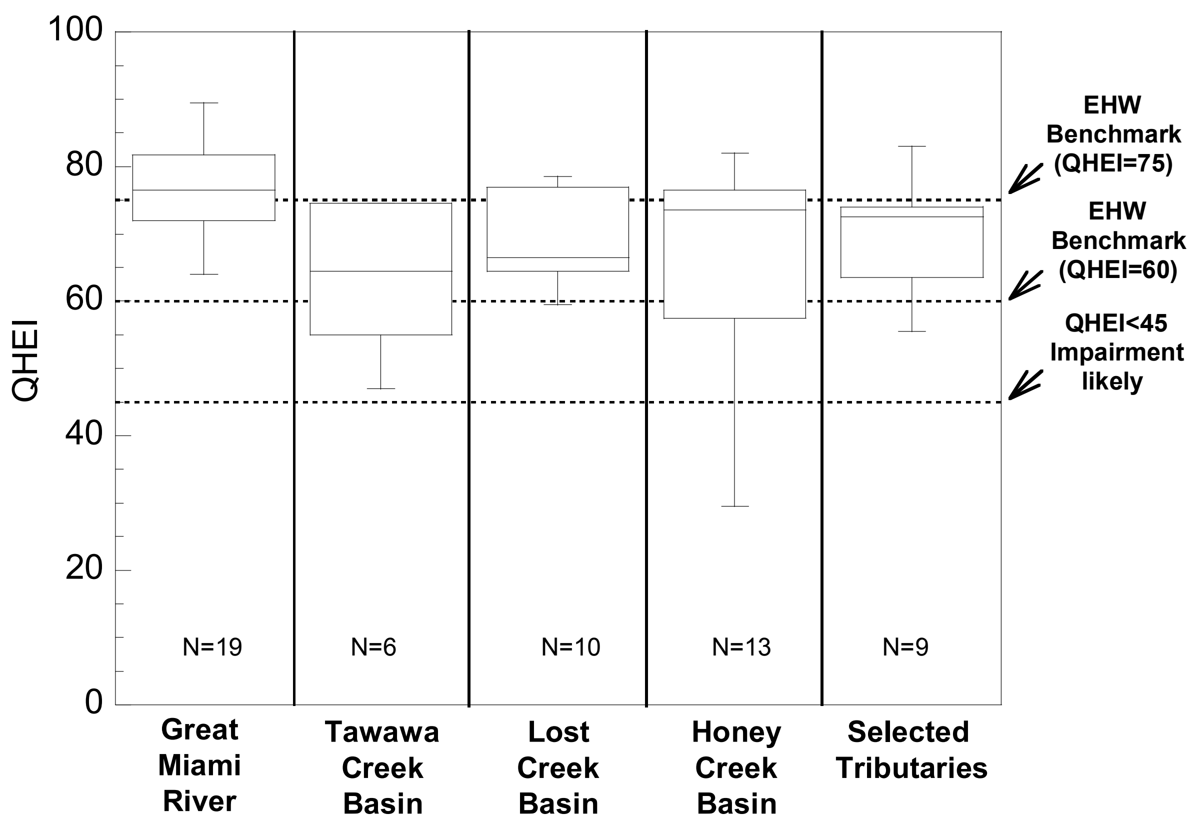


Figure 27. Aggregate performance of the QHEI, middle Great Miami River, 2009. Horizontal dashed lines mark, in descending order, thresholds or benchmarks associated with macrohabitat potential. In the absence of mitigating conditions, QHEI values below 45 typically predict limited macrohabitat potential.

observed and often found well-structured with woody debris and fallen timber. Dominant substrates were primarily derived from coarse glacial outwash and related alluvium and were generally unencumbered with extensive deposits of clayey silts. Riparian areas at most sites were vegetated, more often wooded, attenuating sunlight and providing in-stream structure in the form of woody debris and rootwad formations.

The central tendency of the middle Great Miami main stem is clearly within the exceptional range, as half of all stations yielded a QHEI score greater than the EWH benchmark of 75, and no station below the WWH benchmark of 60.0. Even the highly artificial river segments maintained by the MCD, through the developed areas of Piqua, Troy, and Dayton, provided adequate macrohabitat quality. These and other selected reaches were originally widened and channelized early in the 20th century to provide for the conveyance of flood waters through major population centers within the basin. Despite the extremely disproportionate width and other highly artificial features common to segments so affected, the wetted channel of the Great Miami meanders within its trapezoidal confines, giving rise to surprising macrohabitat complexity. This is a result of sufficient gradient and a super abundance of coarse glacial outwash and related alluvium throughout much of the middle Great Miami basin. The combination of adequate stream power and vast deposits of high quality bedload material allows the Great Miami River to serve, where needed, as an essential floodway for developed and well-populated areas, while also providing adequate macrohabitat for aquatic life.

Mention must be made of the several lowhead dams situated on the main stem within the confines of the 2009 study area. These would include dams in and around Sidney, Piqua, Troy, and the greater Dayton metropolitan area. The societal function of these structures varies, some supporting the production of drinking water, others are artifacts of defunct industries, and still others serve recreational purposes alone. Direct ambient monitoring of the impounded river channels behind these dams was not specifically undertaken in 2009; however, high quality aquatic assemblages were found immediately up and downstream from these impoundments. Similar findings were indicated from previous survey results (Ohio EPA 1996b), namely the maintenance of good to exceptional aquatic communities adjacent to the upper and lower limits of these impoundments. Based upon considerable experience garnered by Ohio EPA over the past thirty years regarding ambient biological performance within and around run-of-the-river impoundments, including the results from the previous biosurveys of the middle Great Miami River itself, the deleterious effects of these relatively small reservoirs are largely limited to the inundated river channel itself. As areas so affected are structurally incapable of fully supporting WWH assemblages (both fish and macrobethos), scarce field resources were not allocated in 2009 to directly sample and evaluate the dam pools within the study area. This post priori approach to ambient biological monitoring of impounded river segments is typical of what is now commonly practiced by Ohio EPA. Only in instances of strong local interest in dam removal are biological monitoring resources allocated to impoundments, so as to track and fully document pre and post impoundment conditions.

Tawawa Creek (subbasin)

The Tawawa Creek catchment consists of three primary waterbodies, Tawawa Creek (main stem) and two direct tributaries, Mosquito Creek and Leatherwood Creek. Six monitoring stations were deployed among these waters as part of the 2009 field sampling effort. QHEI values ranged between 74.5 and 47.0 with a mean score of 63.3 (±21.74, 2 SD). A matrix of QHEI macrohabitat features, by stations and aggregate QHEI performance of the subbasin are presented in Table 20 and Figure 27.

As indicated by the QHEI, significantly deficient macrohabitat was limited to a single station on Mosquito Creek, located at RM 7.87, downstream from Kaiser Lake. This reach had limited sinuosity and minimal channel development. Owing to its high proportion of high and moderate influence modified habitat attributes, this site yielded a QHEI score of only a 47.0; suggesting a high probability of habitat related aquatic life use impairment. The antecedents of past channelization must also be briefly discussed here, as they still have a direct bearing on ambient biological potential. Specifically, these include the original palustrine/rheopalustrine nature of upper Mosquito Creek. Relic peat lands and other related water bearing features still persist within this area and were in the past more extensive (Pavey et al. 1999). The demands of human habitation and productive agriculture necessitated improved drainage within the upper portion of the watershed, with Mosquito Creek serving as the primary outlet. In terms of physical-structural limitations, the combined effects of channelization and natural limits associated with rheopalustrine habitats may preclude upper Mosquito Creek from consistently supporting WWH fish and macrobenthos assemblages. Although not directly related to channel form, substrate composition or other measurable aspects of macrohabitat, the potential influence of Kaiser Lake must be articulated as an additional limiting factor. Specifically, the export of plankton rich water to Mosquito Creek from the photic layer of Kaiser Lake, during the summer months would likely have a near-field stimulatory effect on the macrobenthos.

Although by no means profoundly degraded, substandard habitat was observed on upper Leatherwood Creek, at Suber Rd. (RM 6.4). Like upper Mosquito Creek, upper Leatherwood Creek was also channelized in the past for local drainage needs. However, considerable natural recovery has taken place since the original channel incision, thus the contemporary habitat score was within the high fair range (QHEI=55.0). Multiple factors can diminish the anticipated negative effects of locally modified small streams, but flow augmentation by ground water is often the primary mitigant. Typically, sustained inputs from the water table to surface waters results in greater sustained surface flow, cooler in-stream temperatures, and improved chemical water quality. It has been regularly observed, state-wide, that the deleterious effects of degraded macrohabitat on ambient biological performance in small headwater streams can be largely mitigated by the influence of ground water. This phenomenon appeared operative in the headwaters of Leatherwood Creek, namely the positive effects of ground water mitigating the modest macrohabitat deficit.

All remaining monitoring stations within the Tawawa Creek subbasin were found to contain a full suite of macrohabitat features, fully consistent with, and at time in excess of, that associated with WWH assemblages of fish and benthic macroinvertebrates.

Selected Tributaries

Between the confluences of Tawawa Creek and Lost Creek, both major subbasins, four smaller direct tributaries join the Great Miami River main stem. Longitudinally, these include, Mill Branch, Rush Creek, Spring Creek, Boone Creek and Peters Creek, the latter being a direct Boone Creek tributary. Nine monitoring stations were allocated to evaluate these waterbodies. Being the largest of the suite, Rush Creek and Spring Creek each received three stations. The remaining three monitoring sites were divided equally among the remaining middle Great Miami River tributaries.

Diminished, substandard or otherwise potentially limiting macrohabitat was observed only at the uppermost Rush Creek station, at Vandermark Rd. (RM 5.3). Although not profoundly degraded, the stream was obviously modified in the distant past. Much physical recovery has occurred, as minimal channel form and function have been reestablished, as a QHEI score of 55.5 attests. As such, WWH aquatic faunas are not precluded per se. The greatest biological limitations of upper Rush Creek are not readily appraised by the QHEI; rather they are drawn from direct field observations. Expectation of diminished or otherwise limited biological potential appeared a result of upper Rush Creek's transitional nature, between primary headwaters (waters that naturally lack a resident fish fauna) and standard headwaters (waters that support resident and adapted fish assemblages). The principal variable for this determination is the constancy of surface flow or discharge. Although wetted at the time observations were made, macrohabitat evaluated, and ambient biological samples collected, upper Rush Creek, gave every indication of regular intermittency. Most of the observations leading to this conclusion were biological in nature and so will be more fully articulated in the following biological sections of this report.

All remaining streams and associated monitoring stations were found to contain a full complement of positive macrohabitat attributes, consistent with existing and recommended aquatic life use designation (Table 20 and Figure 27). Therefore, impairment derived solely from deficient stream habitat appeared unlikely for the evaluated reaches of Mill Branch, lower Rush Creek, Spring Creek, Boone and Peters Creek.

Lost Creek (subbasin)

The Lost Creek subbasin consists of five named streams: Lost Creek (main stem), West Branch Lost Creek, East Branch Lost Creek, Middle Branch Lost Creek, and Little Lost Creek. Ten monitoring stations were allocated to evaluate this major Great Miami River tributary system. The distribution of stations was as follows: Lost Creek (four sites), East Branch (three sites), and a single station placed on each of the remaining tributaries: West Branch, Middle Brach, and Little Lost. Aggregated QHEI values from this subbasin ranged between 59.5 and 78.5 with a mean score of 69.0 ($\pm$6.64 SD). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI for the Lost Creek main stem are presented in Table 20 and Figures 27 and 28.

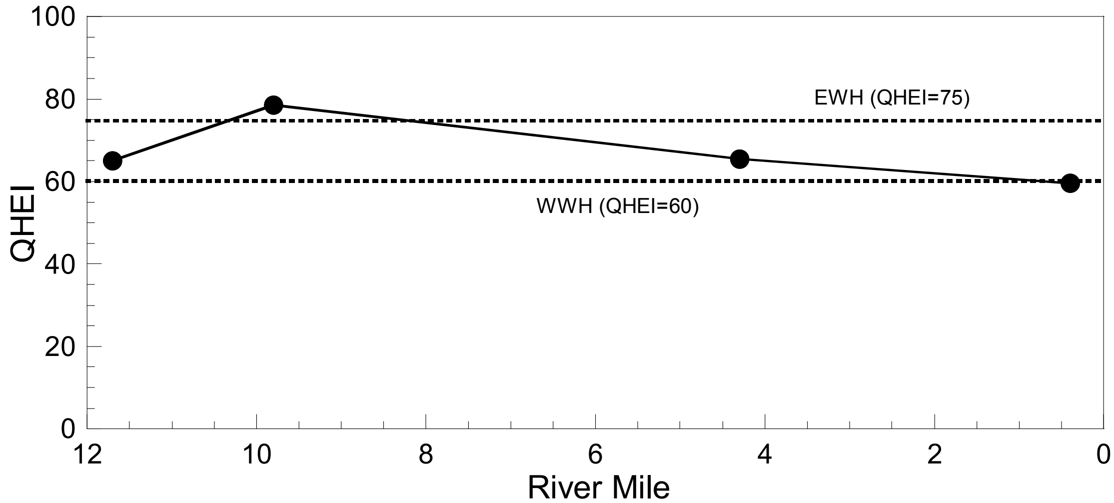


Figure 28. Longitudinal performance of the QHEI for Lost Creek, 2009. Dashed lines represent QHEI benchmarks associated with Exceptional Warmwater Habitat (EWH) and Warmwater Habitat (WWH) designations.

As measured by the QHEI, the central tendency of macrohabitat quality throughout the Lost Creek catchment appeared fully consistent with existing and recommended aquatic life use designations. Appraised against WWH biocriteria, nowhere is significant impairment, attributable to deficient macrohabitat, predicted or otherwise anticipated.

A modest departure from the WWH QHEI benchmark was observed at one monitoring site on lower Lost Creek main stem, at RM 0.4, Tipp-Elizabeth Rd. (QHEI 59.5). In service of locale drainage needs and regional flood control, much of Lost Creek has been channelized and selected reaches leveed. These activities appeared to have occurred many decades ago, the approximate age indicated by both the vegetative maturity of adjacent riparian areas and complexity of the wetted channel (e.g., depth heterogeneity, bedload sorting, vertical scour, and modest sinuosity) evident within the confines of the wholly artificial active channel. Presently, areas so modified, including RM 0.4, appeared to have recovered a minimal compliment of positive channel, substrate, and riparian characteristics, so as to have the potential of supporting WWH aquatic assemblages.

Despite the post channelization physical recovery of lower Lost Creek, direct field observations made in 2009, clearly indicated that surface flow was periodically entrained to the hyporheic zone, as the stream enters the broader alluvial valley of the Great Miami River. Excepting residual pools, found manly in and around entrenched and scoured woody debris, much of lower Lost Creek was effectively dry or otherwise lacking sustained surface flow by mid-July. This natural intermittency does not necessarily exclude WWH biological performance, as the residual pools, as previously noted, were decidedly cool in temperature, indicating direct contact with ground water. Furthermore, these pools were large enough so as to serve as adequate refugia for a basic WWH fish assemblage.

Honey Creek (subbasin)

The Honey Creek subbasin consists of six named streams: Honey Creek (main stem), Pleasant Run, West Fork Honey Creek, East Fork Honey Creek, Indian Creek, and Dry Creek. Thirteen monitoring stations were allocated to evaluate this major Great Miami River tributary system. Aggregated QHEI values from this subbasin ranged between 29.5 and 82.0, with a mean score of 65.5 (±30.58, 2 SD). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI for the Honey Creek main stem are presented in Table 20 and Figures 27 and 29.

As measured by the QHEI, areas of deficient macrohabitat were identified at five stations, among four streams: lower Honey Creek main stem (RM 0.8, QHEI=57.5), upper East Fork Honey Creek (RMs 5.9 and 3.6, QHEIs 58.0 and 47.0, respectively), upper West Fork Honey Creek (RM 1.3, QHEI=57.0), and Dry Fork (RM 1.2, QHEI=29.5). Over 38% of the stations in the Honey Creek subbasin were, to varying degrees, habitat deficient. Singularly or in combination, most of these values were reflective of macrohabitat quality within the high fair range, not profoundly degraded, but typically in a state of incomplete recovery post channelization, or directly affected by adjacent and upstream land use or other natural limiting factors. As the ultimate and proximate causes of sub-par macrohabitat varied considerably, each waterbody so identified will be discussed separately.

The lowest reach of Honey Creek, evaluated at RM 0.8, appeared to have been channelized in the distant past. Although much natural recovery was evident within the wetted channel, including modest parafluvial development, macrohabitat quality was well below that associated with its EWH use designation. In addition to channelization and its attendant effects, channel form and particularly substrate composition, through lower Honey Creek differed considerably in comparison with the upper stations. As observed elsewhere in the basin (e.g., lower Lost Creek), the lower segments of primary tributaries, upon entering the broader alluvial valley of the Great Miami River, change significantly. Gradients precipitously drop, reducing stream power, which in turn affects nearly every aspect of the fluvial processes responsible for channel form and maintenance. The negative effects of this that were most readily discernible through lower Honey Creek included a dominance of finer substrates (sand and pea gravel) and low energy channel form. The combination of past channelization and the overarching associated natural factors described above undoubtedly exerted negative pressure or otherwise served to limit ambient biological potential.

Deficient macrohabitat observed on upper East Fork Honey Creek ranged from modest to significant, and were identified at two locations, RMs 5.9 and 3.6. The uppermost site yielded a QHEI score of 58.0, the minor departure attributable to past channelization and riparian encroachment. Well within the high fair range, conditions here were by no means optimal, but adequate to support a minimal WWH assemblage. Progressing downstream to RM 3.6, macrohabitat assessment yielded a QHEI score within the low fair to high poor range (QHEI=47.0). Conditions here were not a result of anthropogenic action, rather,

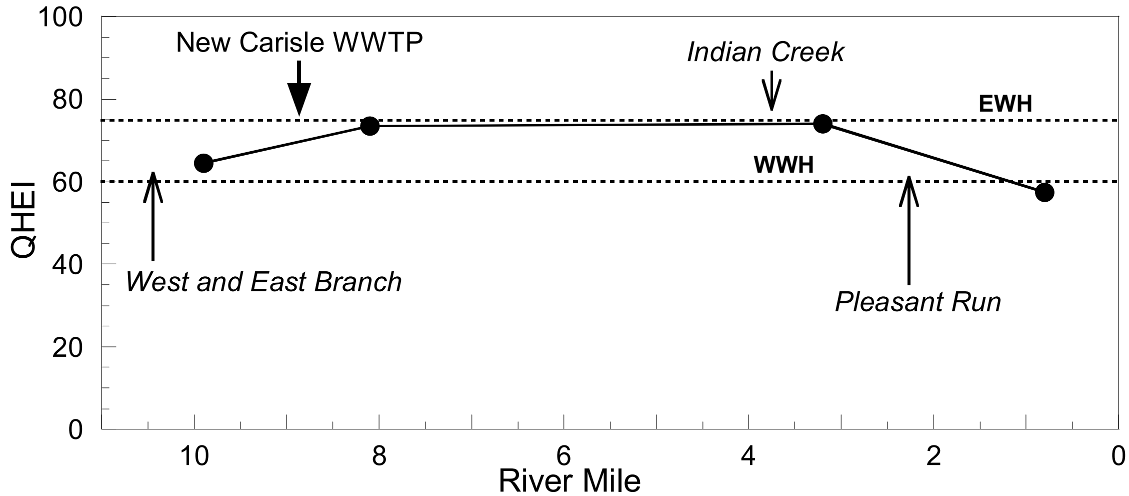


Figure 29. Longitudinal performance of the QHEI for Honey Creek, 2009. Dashed lines represent QHEI benchmarks associated with Exceptional Warmwater Habitat (EWH) and Warmwater Habitat (WWH) designations.

they appeared entirely natural in origin. Specifically, the reach evaluated consisted of a series of steep bedrock escarpments, each approximately two to four feet in height and separated by 30-40 meters of bedrock glide. This configuration, which must have extended considerable distance up and down stream, resulted in a gradient estimate of a remarkable 90.9 ft./mile. Development of complex macrohabitat features were simply not possible for a stream segment so configured. The site undoubtedly has limited ambient biological potential and in the absence of adequate macrohabitat upstream from this anomalous reach, the East Fork would not likely support even a WWH community. However, given the proximity of significantly better conditions upstream, it is likely that this physically barren reach is supported, biologically, by the more diverse, complex and productive stream segment upstream, effectively subsidizing the monotonous segment.

The lingering effects of past channel modification and modest sedimentation appeared the primary agents behind the modest macrohabitat deficit on upper West Fork Honey Creek (RM 3.1, QHEI=57.0). Although the relatively high ratio of moderate influence modified habitat attributes would suggest the presence of negative features, their overall effect appeared limited, and should not preclude the support and maintenance of a biological assemblage of fish and macroinvertebrates minimally consistent with the WWH biocriteria.

Dry Creek, an Indian Creek tributary, was evaluated at a single location at Walnut Grove Rd. (RM 1.2). As measured by the QHEI, macrohabitat quality or biological potential of this small headwater tributary was found severely limited. High and moderate influence modified habitat attributes were overwhelmingly dominant resulting in a QHEI score of 29.5, well within the poor range. The reach evaluated coursed through an open pasture, and contained ample evidence of unrestricted cattle access (false banks and an absent riparian corridor). Although the stream meandered, very little channel development was evident, as depth was a uniform 20-40cm, with an extremely sluggish current. Substrates were universally fine muck and silts, and cover types of any kind were nearly lacking. In many ways, Dry Creek maintained a psuedo-palutrine quality.

Multiple factors can, however, diminish the anticipated negative effects of locally modified or otherwise physically substandard streams. It has been regularly observed, state-wide, that the deleterious effects of degraded macrohabitat on ambient biological performance in small headwater streams can be largely mitigated by the influence of ground water. Typically, inputs from the water table to surface waters results in reduced in-stream temperatures and improved chemical water quality. Despite the significant macrohabitat deficit observed on Dry Creek, the water column was decidedly cool, indicating a non-trivial input of ground water to the stream and this apparently served as a sufficient mitigant. In the absence of ground water, Dry Creek would likely be reduced to intermittency, on an annual basis, or at a minimum its shallow pools would tend to septic conditions over the summer months.

All other streams, stream segments or monitoring stations within the Honey Creek subbasin were found to contain stream macrohabitat of adequate complexity so as to support and maintain aquatic communities consistent with their respective aquatic life use designations.

Ambient Biology: Macroinvertebrate Community

Middle Great Miami River (main stem)

There were 18 sample sites from RM 129.99 to RM 82.1 in the Great Miami River main stem for the 2008-2009 survey years. Seventeen survey samples were located in the designated EWH reach upstream from Sidney (RM 132.0) to the confluence with the Stillwater River at RM 82.57. Downstream from the Stillwater River confluence, the Great Miami River main stem is designated WWH, and one survey site was sampled in this reach at RM 82.1.

The seventeen Invertebrate Community Index (ICI) scores attaining EWH from the 2009 survey ranged from 42 (very good) to 54 (exceptional)Exceptional to very good performance was documented from RM 132 to RM 86 (Figure 30, Table 21). The one sample site not attaining EWH performance (at RM 85.8) scored an ICI of 38 (good). The one WWH, reach sampled at RM 85.8, scored an ICI of 34 which marginally met the WWH biocriteria.

The middle Great Miami River reach downstream from Tri-Cities WWTP did not attain EWH criteria standards (ICI=38) due to erratic plant operation causing intermittent elevated ammonia concentrations loads downstream from the discharge. The elevated ammonia loadings were the highest peak loadings and the highest concentrations (95th percentile)

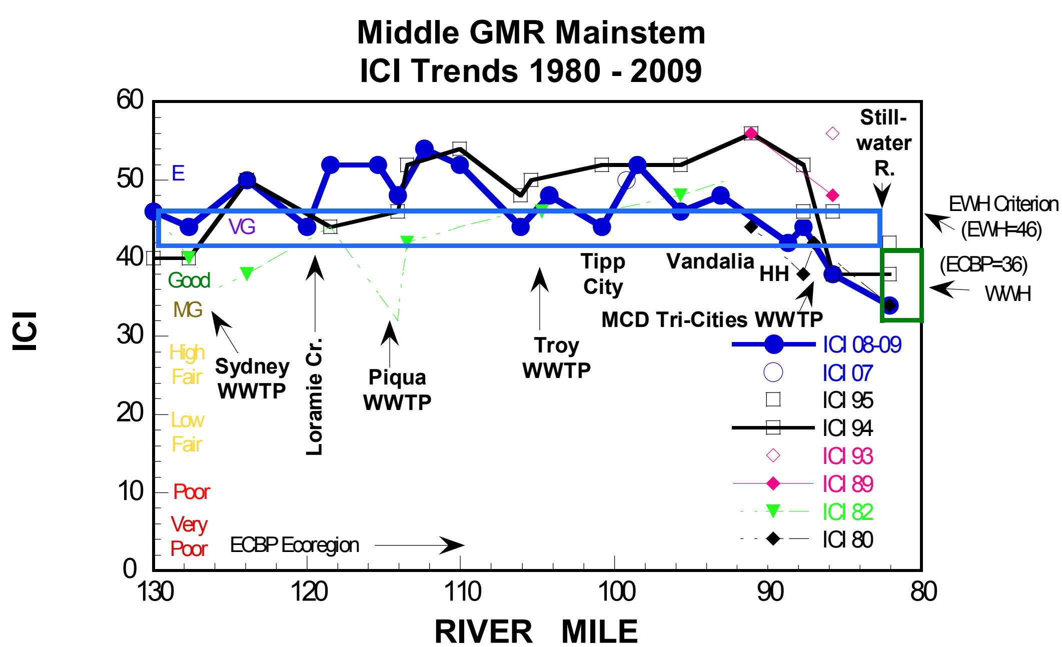


Figure 30. Macroinvertebrate ICI scores for the middle Great Miami River (RM 130 to RM 81.6) from 1980 to 2009.

Table 21. Benthic macrinvertebrate communtiy index values, narrative and descriptive statistics from the middle Great Miami River study area, 2009.

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings*)
EWH Use Designation									
Great Miami R. 2008	129.99	541	61 / 73	21 / 28	26 / 34	High / 5842	46	E	Tanytarsini midges (MI), Net-spinning caddisflies (F,MI), midges (F,MI)
Great Miami R.	127.7	548	57 / 76	19 / 24	23 / 33	Mod.-High/ 2453	44^{ns}	VG^{ns}	Net-spinning caddisflies (MI,F), tanytarsini midges (MI,I)
Great Miami R.	123.9	561	51 / 67	18 / 21	23 / 33	High / 1281	50	E	Net-spinning caddisflies (MI,F), flathead mayflies (MI,I) minnow mayflies (F,MI,I), bryozoa (F)
Great Miami R. RR	120.0	568	42 / 57	18 / 25	20 / 30	Mod.-High / 1756	44^{ns}	VG^{ns}	Minnow mayflies (F,MI,I), moth larvae (I), net-spinning caddisflies (MI,F), *Elimia* snails (MI), midges (F,MI,I)
Great Miami R.	118.5	839	39 / 59	18 / 24	23 / 35	Mod.-High/ 2285	52	E	Net-spinning caddisflies (MI,F), Chimarra (MI), minnow mayflies (F,MI,I), moth larvae (I)
WWH/EWH Use Designation (Existinf/Recommended)									
Great Miami R.	115.4	867	54 / 68	22 / 27	28 / 35	High / 2404	52	E	Minnow mayflies (F,MI,I), net-spinning caddisflies (F,MI)
EWH Use Designation									
Great Miami R.	114.1	873	50 / 60	16 / 18	23 / 25	Mod.-High/ 3822	48	E	Net-spinning caddisflies (MI,F), tanytarsini midges (MI), *Elimia* snails (MI), minnow mayflies (F,MI,I)
Great Miami R.	112.35	876	51 / 65	20 / 25	27 / 35	Mod.-High/ 2270	54	E	Net-spinning caddisflies (F,MI), tanytarsini midges (MI,I), moth larvae (I), minnow mayflies (F,MI,I)
Great Miami R. 2008	110.07	889	71 / 80	26 / 32	35 / 41	Mod.-High/ 3400	52	E	Minnow mayflies (F,MI), net-spinning caddisflies (F,MI), tanytarsini midges (MI)
Great Miami R. RR	106.1	927	53 / 62	20 / 25	22 / 28	Mod.-High / 3011	44^{ns}	VG^{ns}	Tanytarsini midges (MI), moth larvae (I), net-spinning caddisflies (MI,F), *Elimia* snails (MI), midges (F,MI,MT)
Great Miami R.	104.25	936	56 / 65	15 / 19	21 / 28	Mod.-High/ 1896	48	E	Net-spinning caddisflies (MI,F), tanytarsini & other midges (MI,F), minnow mayflies (F,MI,I)
Great Miami R. RR	100.8	971	51 / 58	23 / 24	28 / 30	Mod.-High/ 3351	44^{ns}	VG^{ns}	Net-spinning caddisflies (F,MI), tanytarsini & other midges (MI,F), minnow mayflies (F,MI,I), moth larvae (I)
Great Miami R.RR 2008	98.5	1125	75 / 85	22 / 28	28 / 35	Mod.-High/ 2324	52	E	Minnow mayflies (MI,F), net-spinning caddisflies (F,MI), tanytarsini & other midges (MI,F)
Great Miami R.	95.68	1143	55 / 64	22 / 25	30 / 34	Mod.-High/ 1974	46	E	Net-spinning caddisflies (MI,F), tanytarsini & other midges (MI,F), minnow mayflies (F,MI,I), moth larvae (I)
Great Miami R. 2008	93.1	1149	53 / 63	19 / 25	29 / 36	Mod.-High / 3158	48	E	Net-spinning caddisflies (F,MI), tanytarsini & other midges (MI,F), *Protoptila* caddisflies (I)
Great Miami R. X15	88.7	1157	51 / 59	21 / 21	24 / 29	Mod. / 1348	42^{ns}	VG^{ns}	Net-spinning caddisflies (F,MI), tanytarsini & others (F,MI)

Table 21. continued.

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	C W	S/T	Relative Density (# / $ft.^2$)	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
EWH Use Designation											
Great Miami R.	87.7	1166	55 / 67	23 / 26	27 / 33	NA	NA	Mod.-High/ 2601	44^{ns}	VG^{ns}	Net-spinning caddisflies (F,MI), tanytarsini & other midges (F,MI), moth larvae (I)
Great Miami R.	85.8	1170	39 / 43	15 / 17	20 / 23	NA	NA	Mod.-High/ 1891	**38***	**G***	Tanytarsini midges (MI), Net-spinning caddisflies (F,MI), midges (F,MT), moth larvae (I)
Tawawa Creek (WWH Use Designation) (HUC 050800010702)											
Tawawa Creek	1.2	54	60 / 38	17 / 18	18 / 29	1	18.0	Mod-Low/ 369	50	E	*Chimarra* (MI), Net-spinning caddisflies (F,MI), water pennies (MI),) flathead mayflies (F,M)
Mosquito Creek (WWH Use Designation) Confirmed WWH (HUC 050800010702)											
Mosquito Creek	7.75	9.0	34 / 34	7 / 7	3 / 3	0	0.3	High	--	F*	Net-spinning caddisflies (F), blackflies (F), flatworms (F), *Polypedilum flavum* (F), *Hyalella azteca* (scud) (F)
Mosquito Creek	1.0	26.9	32 / 32	10 / 12	10 / 19	0	2.5	Mod-Low / 737	46	E	Net-spinning caddisflies (F,MI), baetids (F), *Chimarra* (MI), *Rheotanytarsus* & *Polypedilum* midges (MI,F)
Leatherwood Creek (WWH Use Designation) Confirmed WWH (HUC 050800010701)											
Leatherwood Cr.	6.43	8.7	33 / 33	9 / 9	8 / 8	0	1.6	Moderate-Low	--	MG^{ns}	Snail-case caddisflies (MI), riffle beetles (F,MI), net-spinning caddisflies (F,MI)
Leatherwood Cr.	3.34	13.8	33 / 33	14 / 14	12 / 12	0	4.0	Moderate-High	--	G	Net-spinning caddisflies (F,MI), baetid mayflies (F), *Neophylax* (I), snail-case & *Polycentropus* caddisflies (MI), heptageneid mayflies (MI)
Leatherwood Cr.	1.2	16.8	38 / 54	16 / 19	17 / 24	0	8.5	Mod-Low / 352	48	E	Net-spinning caddisflies (F,MI), *Chimarra* (MI), *Neophylax* (I), *Helicopsyche* (MI), baetid mayflies (F)
Mill Branch (WWH Use Designation) Confirmed WWH (HUC 050800010703)											
Mill Branch	0.34	3.6	38 / 38	18 / 18	16 / 16	2	16.0	Moderate-Low	--	VG	Net-spinning caddisflies (F,MI), flathead mayflies (F,MI), *Neophylax* & *Helicopsyche* caddisflies ((I,MI)
Rush Creek (WWH Use Designation) Confirmed WWH (HUC 050800010704)											
Rush Creek	5.3	7.2	31 / 31	10 / 10	9 / 9	0	2.25	Moderate-Low	--	MG^{ns}	Hydroptilids (F), isopods (FI), baetid mayflies (F,I), riffle beetles (F), flathead mayflies (F)
Rush Creek	1.68	14.4	39 / 39	12 / 12	12 / 12	2	2.4	Moderate	--	G	Tanytarsini midges (MI), baetid mayflies (F,MI,I), *Helicopsyche* (MI), Net-spinning caddisflies (F,MI)
Rush Creek	0.3	18.3	37 / 37	16 / 16	16 / 16	1	16	Moderate-	--	VG	*Helicopsyche* and net-spinning caddisflies (F,MI),

Table 21. continued.

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	CW	S/T	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
								Low			tanytarsini midges (MI,I), baetid mayflies (F,I)
Spring Creek (EWH Use Designation) (HUC 050800010801)											
Spring Creek	8.44	11.6	43 / 43	20 / 20	21 / 21	0	21	Moderate-High	--	E	Baetid mayflies (F,MI,I), *Neophylax* (I) and *Chimarra* (MI) caddisflies, *Sphaerium* clams (F)
Spring Creek	3.5	20.9	38 / 51	19 / 20	18 / 27	2	38+	Mod.-Low / 377	48	E	Baetid mayflies (F), *Chimarra* (MI), water pennies (MI), net-spinning caddisflies (MI,F)
Spring Creek RR	0.84	24.6	42 / 55	18 / 19	22 / 27	0	7.33	Mod.-High/ 1896	44^{ns}	VG^{ns}	Baetids (F), hydropsychids (MI,F), and midges (MI,F)
Boone Creek (Unlisted Use Designation) Recommended WWH (HUC 050800010805)											
Boone Creek	0.28	13.0	45 / 45	12 / 12	17 / 17	1	2.43	Moderate-Low	--	G	Net-spinning caddisflies (F,MI), *Chimarra* (MI), riffle beetles (F), heptageneid mayflies (F), and *Rheotanytarsus* midges (F,MI)
Boone Creek	0.15	31.7	58 / 58	16 / 16	22 / 22	1	2.20	Moderate-Low	--	G	Baetid mayflies (F,I), *Helicopsyche* (MI), Petrophila moth larvae (I), *Elimia* snails (MI), and net-spinning caddisflies (F,MI)
Peters Creek (Unlisted Use Designation) Recommended WWH (HUC 050800010805)											
Peters Creek	0.25	18.4	47 / 47	13 / 13	16 / 16	0	2.29	Moderate-High	--	G	*Helicopsyche*, hydroptilid, polycentropid, & leptocerid caddisflies (F,MI), & heptageneid mayflies (F
Lost Creek (EWH Use Designation) Recommended WWH (HUC 050800010802)											
Lost Creek	11.7	14.1	52 / 52	16 / 16	16 / 16	0	2.29	High-Moderate	--	VG	*Chimarra* (MI), *Neophylax* (MI), *Helicopsyche* (MI) and net-spinning caddisflies (F,MI), & mayflies (F,MI,I)
Lost Creek (EWH Use Designation) Recommended CWH (HUC 050800010804)											
Lost Creek RR	9.8	30.4	38 / 66	18 / 21	21 / 34	6	34+	Moderate-Low/ 218	40 / X15	VG^{ns}	*Neophylax* (I) & *Chimarra* (MI) caddisflies, *Elimia* (MI), *Helicopsyche* (MI) and net-spinning caddisflies (F,MI)
Lost Creek	4.3	58	51 / 70	23 / 28	23 / 34	4	4.60	High-Mod./ 2182	54	E	Net-spinning caddisflies (MI,F), *Elimia* snails(MI), *Helicopsyche* and *Glossosoma* caddisflies (MI)
Lost Creek (EWH Use Designation) Recommended WWH (HUC 050800010804)											
Lost Creek (050800010804)	0.45	62.4	43 / 65	14 / 21	17 / 26	0	4.25	Mod./ 386	42^{ns}/ X15	VG^{ns}	Net-spinning caddisflies (MI,F), heptageneids (F,MI), and *Chimarra* (MI) caddisflies
West Branch Lost Creek (Unlisted Use Designation) Recommended WWH (HUC 050800010802)											
West Branch Lost Creek	0.5	6.7	43 / 43	14 / 14	14 / 14	0	2.80	Moderate-Low	--	VG^{ns}	*Elimia* (MI), baetid mayflies (F,I), hydroptilids (F), cased caddisflies *Helicopsyche* and *Neophylax* (MI,I)

Table 21. continued.

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	CW	S/T	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
East Branch Lost Creek (EWH Use Designation) Confirmed EWH (HUC 050800010803)											
East Branch Lost Creek	6.4	7.8	59 / 59	18 / 18	19 / 19	1	1.73	Moderate-Low	--	E	Baetid mayflies (F), Chimarra caddisflies (MI), net-spinning caddisflies (F,MI) heptageneid and *Caenis* mayflies (F)
East Branch Lost Creek	5.2	8.9	54 / 54	17 / 17	20 / 20	0	3.33	Moderate	--	VG[ns]	Baetid mayflies (F,I), net-spinning caddisflies (F,MI) heptageneid mayflies (F)
East Branch Lost Creek	0.95	13.4	56 / 56	23 / 23	27 / 27	6	13.5	Moderate	--	E	Baetid mayflies (F), Chimarra caddisflies (MI), net-spinning caddisflies (F,MI) heptageneid and *Caenis* mayflies (F)
Middle Branch Lost Creek (EWH Use Designation) Confirmed EWH (HUC 050800010804)											
Middle Branch Lost Creek	1.2	8.0	56 / 65	22 / 23	17 / 20	3	2.13	Mod.-Low / 100	42[ns]	VG[ns]	*Elimia* (MI), *Glossosoma* , *Chimarra*, & *Helicopsyche* caddisflies (MI)
Little Lost Creek (EWH Use Designation) Confirmed EWH (HUC 050800010804)											
Little Lost Creek	0.27	9.7	46 / 66	18 / 25	17 / 23	7	4.25	Mod. / 287	48	E	*Neophylax*, *Glossosoma* , & *Chimarra*, caddisflies (MI)
Honey Creek (EWH Use Designation) Recommended WWH (HUC 0508000102004)											
Honey Creek[RR]	9.96	34.0	53 / 68	19 / 19	17 / 21	2	2.13	Mod. / 285	52	E	*Chimarra*, *Neophylax*, & *Helicopsyche* caddisflies (MI,I), baetid & heptageneid mayflies (F,MI), *Elimia* (MI)
Honey Creek	8.08	39.0	43 / 56	9 / 10	5 / 6	0	0.50	High / 987	38	G	Net-spinning caddisflies (MI,F) midges (F,MI,)
Honey Creek (EWH Use Designation) Confirmed EWH (HUC 0508000102004)											
Honey Creek[RR]	3.18	73.0	58 / 80	22 / 24	22 / 28	0	2.75	Mod.-High / 872	54	E	Net-spinning caddisflies (MI,F), *Neophylax* (I), baetid mayflies (F), *Rheotanytarsus* & *Polypedilum* midges (MI,F), heptageneid mayflies (MI,F)
Honey Creek	0.8	87.8	55 / 72	20 / 24	14 / 23	2	2.0	Mod. / 460	46	E	Net-spinning caddisflies (F,MI), *Isonychia* and baetid mayflies (MI,F), burrowing mayflies (MI)
Pleasant Run (EWH Use Designation) Recommended EWH & CWH (HUC 0508000102004)											
Pleasant Run	0.5	6.1	54 / 54	21 / 21	27 / 27	5	9.0	Mod.- High	--	E	Net-spinning caddisflies (MI, CW,F), baetid mayflies (F,MI), *Neophylax*, *Helicopsyche*, & *Glossosoma* (CW) caddisflies (MI)
East Fork Honey Creek (WWH Use Designation) Confirmed WWH (HUC 0508000102001)											
East Fork Honey Creek	5.9	5.2	43 / 43	13 / 13	12 / 12	0	1.5	High - Low	--	MG[ns]	*Helicopsyche* and *Hydroptila* cased caddisflies (MI,F), *Elimia* (MI) & flatworms (F); *Neophylax* (I) in

Table 21. continued.

River	RM	Drain. Area	QI./Total Taxa	QI./Total EPT	Sens. Taxa Qual./Total	CW	S/T	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
											shade
East Fork Honey Creek (WWH Use Designation) Confirmed WWH (HUC 0508000102001)											
East Fork Honey Creek	3.64	8.8	34 / 34	12 / 12	11 / 11	0	11.0	Moderate	--	G	Baetids (F),net-spinning & *Helicopsyche* caddisflies (F,MI), *Elimia* (MI), isopods (F), & Neophylax (I)
East Fork Honey Creek[RR]	1.58	11.3	58 / 58	16 / 16	24 / 24	0	4.00	Mod.-High / 872	--	E	*Neophylax* (I), net-spinning caddisflies (F,MI), baetid & heptageneid mayflies (F,MI), *Elimia* (MI), riffle beetles (F), & Caenis mayflies (F)
East Fork Honey Creek[RR]	0.1	13.0	45 / 64	21 / 22	17 / 23	2	8.5	Mod.-Low / 167	54	E	Baetid mayflies (F,I), Rheotanytarsus midges (MI), *Elimia* (MI),*Neophylax* & *Helicopsyche* caddisflies(I,MI)
West Fork Honey Creek (WWH Use Designation) Confirmed WWH (HUC 0508000102001)											
West Fork Honey Creek[RR]	1.3	20.1	59 / 68	22 / 23	30 / 36	2	18.00	Mod. / 105	X15	VG[ns]	Net-spinning caddisflies (F,MI), baetid mayflies (F,MI,I), *Neophylax* (I) caddisflies, & *Elimia* (MI)
West Fork Honey Creek[RR]	0.1	20.3	48 / 64	21 / 23	22 / 33	1	16.5	Mod. / 306	52	E	*Neophylax* (I), net-spinning caddisflies (F,MI), baetid & heptageneid mayflies (F,MI), *Elimia* (MI), riffle beetles (F), & *Caenis* mayflies (F)
Indian Creek (WWH Use Designation) Confirmed WWH (HUC 0508000102003)											
Indian Creek	4.95	7.6	41 / 41	21 / 21	23 / 23	2	7.67	Moderate	--	E	*Elimia* (MI),net-spinning caddisflies (F,MI), *Helicopsyche* & *Neophylax* (I) caddisflies (MI,I), heptageneid mayflies (MI,F)
Indian Creek (WWH Use Designation) Recommended CWH (HUC 0508000102003)											
Indian Creek	1.52	22.3	56 / 80	21 / 30	26 / 43	6	14.33	High– Low / 166	56	E	*Glossosoma* and net-spinning caddisflies (MI,F), *Isonychia*, heptageneid, & baetid mayflies (I,MI,F)
Indian Creek	0.1	25.6	61 / 61	28 / 28	34 / 34	5	11.33	Moderate	--	E	Net-spinning caddisflies (MI,F), *Isonychia* & baetid mayflies (I,F,MI), *Glossosoma & Chimarra* caddisflies(MI)
Dry Creek (WWH Use Designation) Confirmed WWH (HUC 0508000102003)											
Dry Creek	1.2	4.8	56 / 56	15 / 15	16 / 16	0	**1.45**	Mod. / 306	--	G	*Helicopsyche*, hydropsychid, & hydroptilid caddisflies (MI,F), Bryozoa (F), and *Caenis* mayflies (F)

Table 21. continued.
Tolerance categories for taxa groups are parenthetically expressed: VT = Very Tolerant, T = Tolerant, MT = Moderately Tolerant, F = Facultative, MI = Moderately Intolerant, and I = Intolerant. **S/T** = Sensitive/Tolerant taxa. Sensitive taxa are those listed on the Ohio EPA macroinvertebrate taxa list as being either Moderately Intolerant (MI) or Intolerant (I). Tolerant taxa are those taxa listed on the Ohio EPA macroinvertebrate taxa list as being Moderately Tolerant (MT), Tolerant (T), or Very Tolerant (VT). **ICI =** Invertebrate Community Index. ICI not available for sampling locations with drainage area <20mi^2 (excluding reference sites), and are indicated by N/A. Dashed lines (--) indicate sites where quantitative data were not available due to small dranage area, vandalism, dessication, or some other disturbance of Hester Dendy artificial substrates (HDs). **EPT** = total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness. Data codes: X15 = current >0.0 feet per second but < 0.3 fps. **CW** = Coldwater taxa

since 2001 (> 240kg/day and >10 mg/l with a maximum of 12.25 mg/l) (loadings in plant description section (Figure 31). The median MCD Tri-Cities WWTP flows have been relatively steady at 7.0 – 9 MGD since 1990, but the CBOD5 loadings have increased since 2000 with peak in 2006-7 (250-300 kg/day) with increased peak ammonia-N discharges and decreasing but variable median discharge loads. TSS has increased to almost double the median discharge loads since 2000 (120 to 200 kg/day) with large peak flow increases in TSS since 2002 to > 400 to 500 kg/day (see loadings section).

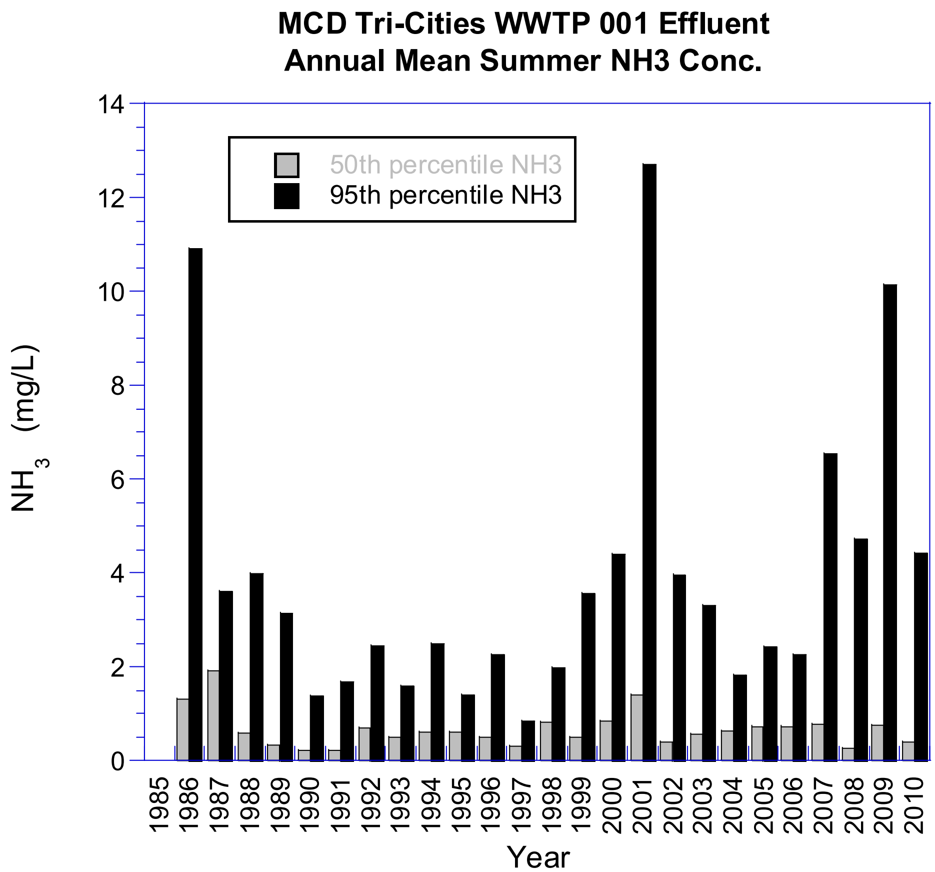


Figure 31. Mean summer ammonia-N concentrations in MCD Tri-Cities WWTP 001 effluent discharged to the middle Great Miami River.

There were 23 permit violations of various ammonia standards in 2009 with a history of bypasses in previous years. The US EPA is also working with the entity to eliminate present SO discharges from lines to Tri-Cities from Tipp City, Vandalia, and Huber Heights that discharge into nearby tributaries draining to the Great Miami River (pers. comm. with Joe Reynolds, 12/6/10). Based on overflow locations, probable tributaries receiving overflows were located at RMs 96.40, 95.83 (Poplar Cr.), 95.67 (at Springfield and Ross Rd.), 88.07 (Mud Run), and 88.06 (unnamed Great Miami River tributary). Recent improvements in the MCD Tri-Cities WWTP operation, equipment upgrades/replacement, and treatment system changes (including real-time in-plant monitoring) greatly improved plant performance in 2010 with only one ammonia violation as of September 30, 2010 (see Pollutant Loadings section of this report).

Middle Great Miami River Tributaries

Thirty-nine of 41 tributary sample sites (95%) on 20 streams met their respective biological criterion. Due to good substrates, groundwater augmentation, and overall riparian continuity, approximately 71% of sample survey sites were of very good to exceptional quality.

Tawawa Creek

Tawawa Creek (HUC 050800010702) was the upper most direct tributary sampled in the middle Great Miami River assessment. It is formed at the confluence of Mosquito Creek, which has Kiser Lake in its upstream reaches, and Leatherwood Creek (HUC 050800010701). This stream had good consistent flow (cool groundwater inputs) with predominately good rocky substrates (sand to boulders) which supported a quite diverse sensitive benthic community. Much of the lower reach of Tawawa Creek is contained within a city park with a good riparian canopy and stable in-stream habitat (Figure 32). The presence of 29 sensitive taxa and a Sensitive/Tolerant (S/T) ratio of 18 illustrated the high quality community present (Table 21). An exceptional ICI of 46 paralleled the exceptional fish scores of 57 (IBI) and MIwb of 9.7 which both demonstrate exceptional biological performance.

Figure 32. Tawawa Creek in Tawawa Park (RM 1.2).

Mosquito Creek

Mosquito Creek headwaters are influenced first by local historical wetland conditions. The stream was channelized and had an open canopy, which accumulated algal and aquatic macrophyte production from Kiser Lake and Non-point Source (NPS) inputs. Upstream from the sample site, Mosquito Creek appeared impounded with aquatic macrophytes (Figure 33). The only riffle observed on upper Mosquito Creek was an artificial perch under the bridge. It consisted of cobble/rubble stacked up to the surface, giving rise to a short run that merged into a meter deep pool downstream. (Figure 34). There was a predominantly facultative community that responded exponentially to enriched conditions: the filtering midge (*Polypedilum flavum*), *Cheumatopsyche* sp. caddisflies, flatworms, blackflies, and scuds. There were large algal strands attached to substrates, aquatic macrophytes, and suspended algae as well (green color) (Figure 34). A

Figure 33. Mosquito Creek downstream from Kiser Lake at Licklider Rd. (upstream view).

predominance of scuds pointed to more pooled conditions.

Figure 34. Mosquito Creek downstream Kiser Lake at Licklider Rd. (RM 7.75) downstream view).

Some tolerant taxa increased, including *Cricotopus sylvestris* (VT), *Cricotopus bicinctus*, and *Glyptotendipes (G.)* sp. midges. The S/T taxa ratio less than one (0.3) which usually indicates lower quality performance and decreased water quality, or perhaps indicative of lower biological expectations due to lentic conditions. There was a low DO recorded - due to natural wetland conditions or old biomass respiration. No baetid mayflies were collected which could be attributed to a more prevailing lentic habitat or slightly stressed conditions.

Figure 35. Mosquito Creek upstream McCloskey School Rd. RM 1.0 (upstream view).

Downstream at McCloskey School Rd. (RM 1.0) more natural habitat and better riparian corridor coverage in Mosquito Creek allowed for more nutrient assimilation from upstream sources and recovery (Figure 35). The benthic community improved dramatically with a total of nineteen sensitive taxa and an ICI of 46. Still some NPS silt inputs limited macroinvertebrate diversity outside of the riffle/run.

Leatherwood Creek (HUC 050800010701)
Leatherwood Creek had only marginally good performance at Suber Rd. (RM 6.43) because of channelization and straightening but still marginally met WWH criteria expectations. Rocky substrates and groundwater recharge (temp. 21.0 C.) ameliorated habitat limitations, and some sensitive mayflies, like *Macaffertium pulchellum*, and caddisflies were still present.

The Sensitive/Tolerant (S/T) taxa ratio increased from 1.6 at Suber Rd. (RM 6.43) to 4.0 downstream at Sidney-Plattsville Rd. (RM 3.34) and indicated increased quality community diversity. Habitat improved near an old mill dam trace with bedrock, boulder, and cobble substrates predominant. Sensitive and EPT taxa increased fifty percent from upstream with polycentropids and sensitive cased caddisflies (*Neophylax* and *Helicopsyche*) predominant in the run. Facultative caddisflies and baetids were predominant in the riffles.

The most downstream site at RM 1.2 had a highly developed habitat (QHEI= 74.5) with rocky substrates, good sinuosity, riffle/pool complexes and cooler stream temperatures (21.4°C.). There was a total of 19 EPT and 24 sensitive taxa, and the ICI scored a 48 (exceptional).

The macroinvertebrate community in Mill Branch, a tributary to the Great Miami River at RM 123.90, was very good quality with sensitive mayflies and caddisflies predominant. Excellent stream habitat development (QHEI= 83.0) allowed for the benthic community to have a very high S/T taxa of 16 (Table 21). Groundwater recharge inputs (14.0 C.) and closed canopy conditions allowed for the persistence of two coldwater taxa.

Rush Creek (HUC 050800010704)
Rush Creek at Vandermark Rd. (RM 5.3) was a cooler groundwater-fed stream with rocky substrates that still contained some sensitive benthic taxa. Three intolerant taxa present were two baetid mayflies (*Acentrella turbida* and *Plauditus dubius/virile*) and *Neoperla clymene complex* stoneflies. Decaying algal mats and sedimentation were sporadically present along margins and in the glides. Facultative taxa were predominant, and the overall narrative community quality assessment was marginally good which minimally met the WWH biocriterion.

The middle reach at Hetzler Rd. (RM 1.68) had increased flow, and the benthic community quality improved to good performance. The stream temperature decreased to 19.0 C. from upstream, and two CW taxa were collected in this reach. More sensitive taxa and increased caddisflies were also present. Marl was formed on cobble and boulders in open canopy areas (increased groundwater inputs and higher pH) with some embeddedness.

Near the mouth, at N. Dixie Dr. (RM 0.3), Rush Creek was diked historically and is a losing stream that was interstitial. Just downstream groundwater from springs near Rossville supplemented surface stream flows. Indicative of the large spring-water inputs (17.5 C), a

CW midge was collected in the mouth sample. Rush Creek was interstitial near mouth (RM 0.3). Despite the smaller surface stream size due to increased subsurface volume, the macroinvertebrate community quality improved to very good performance. The S/T ratio was 16.0 with 16 sensitive and EPT taxa each (Table 21).

Spring Creek (HUC 050800010801)

Spring Creek was an exceptional quality stream with good groundwater recharge, very good rocky substrates and good development. EPT taxa ranged from 18 to 20 and sensitive taxa totaled from 21 to 27 for all three-sample sites. The S/T ratios ranged from 7.3 to 38 plus (at RM 3.5) indicating high quality diverse benthic communities. For example, CW taxa and living cylindrical papershell mussels (*Anodontoides ferussacianus*) were observed during sampling at Rusk Rd. (RM 3.5) where the highest ICI of 48 (exceptional) was documented. Other noteworthy sensitive taxa collected in Spring Creek included *Diphetor* and *Acentrella* mayflies, the stonefly *Acroneuria frisoni*, and the tortoise-shell caddisfly *Protoptila* sp. (Figure 36) The EWH criterion was met at all three sample sites, though the ICI score of 44 (very good) at RM 0.84 minimally met the criterion.

Figure 36. Spring Creek upstream Troy-Piqua Rd. adjacent Spring Cr. Rd. (RM 0.84) (left), with *Protoptila* caddisfly cases on rock (right).

Boone Creek

Boone Creek downstream from the confluence with Peters Creek near the mouth (RM 0.15) with over 31 miles^2 drainage contained a more diverse benthic community with 16 EPT and 22 sensitive taxa (Table 21). There was more natural habitat inside the riverine park, and the channel looks like it is contained in an old main stem Great Miami River side channel. Larger rocky substrates increased in number, as riffles were mostly cobble and rubble with more coarse gravel and rubble in the runs. Baetid mayflies, which included good numbers of *Diphetor hageni* (I), sensitive *Petrophila* moth larvae, and snail-cased caddisflies (*Helicopsyche*) were among the predominant organisms collected. The community quality was good and narratively met the WWH biocriterion.

Peters Creek (HUC 050800010805)
Peters Creek was sampled near the mouth in the riverine park downstream from railroad trestles toward the mouth (RM 0.25). There were many aquatic macrophytes upstream from the railroad trestle (more open canopy within channelized reach) that sequestered NPS nutrient inputs from upstream. Habitat in the park was mostly a slow run-pool reach. Coarse gravel was predominant in the run with lots of rubble and some boulders. Despite the lack of lotic habitat (slow flow) there was good community diversity with thirteen EPT and sixteen sensitive taxa present. Cased caddisflies (*Helicopsyche*, leptocerid, hydroptilid and polycentropids) and mostly common heptageneid mayflies were predominant. The good quality community narratively met the WWH biocriterion.

Lost Creek (HUC 050800010802)
The West Branch Lost Creek was assessed as very good quality, and a tributary draining the unsewered Fletcher area (possibly named Bustin Ditch) from Lost Creek at RM 15.0. Stream chemistry at RM 11.7 (upstream from Peterson Rd.) indicated high *E. coli* bacteria and high nitrate-nitrite concentrations above reference target values. Correspondingly, the Lost Creek macroinvertebrate community sampled at RM 11.7 was still very good quality but enriched from NPS nutrients with moderate to high density macroinvertebrate community with increased facultative taxa. Lost Creek at Troy-Urbana Rd (RM 9.8) (HUC 050800010804), a regional reference site downstream from the confluence with East Branch Lost Creek (HUC 050800010803), also attained the EWH biocriterion with very good macroinvertebrate diversity. No tolerant taxa were collected in the benthic community sample which rendered a very high S/T ratio of 34 plus. The crystal-clear groundwater-fed reach supported six CW taxa (like the lower East Branch sample site near the mouth) (Figure 37). The CW taxa collected included *Glossosoma* sp., a sensitive tortoise-shelled caddisfly. There was general sand bedload that had embedded some larger rocky substrates, possible contributions from upstream channelization activities, including lower East Branch Lost Creek.

Figure 37. Lost Creek at Troy-Urbana Rd. (RM 9.8)

Lost Creek at RM 4.3 (Knoop Rd.) was similarly supported by groundwater with four CW taxa collected. The groundwater inputs ameliorated periodic local channelization activities (levee improvement), and the ICI, measured in a more stable reach, yielded an exceptional ICI of 54 (Figure 38). There were 28 total EPT taxa and 34 sensitive taxa (similar to upstream). There was additionally some nutrient enrichment, as the relative density increased tenfold from 218/ft.^{2} to 2182/ft.^{2}. The maximum DO was 14.04 mg/l with a range of 6.51 units in July (7.53-14.04 mg/l) and the third-highest maximum DO concentration recorded in August 2009 (12.1 mg/l) (Appendix A-4). Algal strands were present and rocks were matted along edges. Discontinuing the mechanical stream disturbances and allowing more natural development and riparian growth will decrease algal blooms through less NPS inputs and more shading (less algal production) in this reach.

Figure 38. Lost Creek at Knoop Rd (RM 4.3) (upstream view).

Lost Creek near the mouth (RM 0.45) was a losing stream composed of glides with very short riffles perched at the edge of unstable plunge pools. The main substrates were spongy and unstable gravel/cobble that had accumulated between levees with no room or energy to sort out substrates. The water quality was very good, and considering the limited habitat, there was still a quite diverse benthic community present. The HD, providing stable habitat, yielded an ICI of 42 (very good) which met the EWH biocriterion, despite low flow conditions. Removing the levee on one side would allow better stream development and channel definition. This action might be possible considering the adjacent parkland is on the Great Miami River floodplain.

East Branch Lost Creek

East Branch Lost Creek (HUC 050800010803) met the EWH biocriterion with very good to exceptional benthic community quality at each of three sample sites – RMs 6.4, 5.2, and 0.95 (Table 21). Sensitive and EPT taxa increased with progressive downstream sites to high totals of 27 and 23 taxa at Peterson Rd. (RM 0.95). Conversely, the number of tolerant taxa decreased from 11 to 2 with the S/T ratio ranging from 1.73 to a high of 13.5 at RM 0.95. The groundwater inputs of approximately 14.0 C ameliorated some land use effects at both the upstream site and lesser substrate quality at RM 5.2. With better habitat at RM 0.95 (upstream from Peterson Rd.) there were six CW taxa collected in the lower reach. This nice wooded reach with good substrates upstream was in contrast to the newly channelized and straightened reach downstream from Peterson Rd. (Figure 39).

Figure 39. East Branch Lost Creek, upstream (left) and downstream (right) from Peterson Rd., September 2009.

Middle Branch Lost Creek (HUC 050800010804)
Middle Branch Lost Creek, sampled near SR 589 (RM 1.2), was a similarly high quality stream with groundwater augmentation and a largely closed canopy. With 23 EPT, 20 sensitive and three CW taxa, the very good ICI of 42 illustrated its benthic community quality and diversity (Table 21). *Elimia* river snails, *Chimarra* caddisflies, and the CW tortoise-shelled caddisfly, *Glossosoma* sp., and were among the predominant organisms.

Little Lost Creek (HUC 050800010804)
Little Lost Creek was a very developed stream with coldwater seeps that contained abundant rubble/boulder riffles and large gravel/cobble runs bordered by boulders. Sensitive cased caddisflies were predominant: *Neophylax* sp., the CW *Glossosom*a sp., and *Chimarra aterrima*. The diverse benthic community contained seven CW taxa along with varied baetid or lotic mayflies (ICI=56, recommended EWH/CWH).

Honey Creek (HUC 0508000102004)
Honey Creek met EWH biocriterion at three of four sampled reaches. Upstream from New Carlisle below the confluence of the high quality East and West Forks of Honey Creek, a regional reference site, the ICI was 52 (RM 9.96). Fast riffles and runs through boulder and cobble substrates allowed for high quality benthic organisms, such as *Chimarra* and *Neophylax* caddisflies, to be predominant. Shaded canopy from the mostly intact riparian corridor kept densities lower (142/ft.^{2}), and stream temperatures cooler (18.0 C.).

Downstream from New Carlisle WWTP (RM 8.08), the ICI score was 38, which did not meet the EWH biocriterion. Nutrient enrichment precipitated excess algal production with a large increase of filtering caddisflies and facultative midges. Relative density of 987/ft.^{2} was a sevenfold increase from upstream. Large algal mats were present at the edge of Honey Creek with abundant growth on rocks in open canopy areas. Increased respiration from algae and suspended materials caused low diel DO that contributed to a decrease in sensitive macroinvertebrate taxa diversity.

Recovery was documented downstream in Honey Creek at Rudy Rd. (RM 3.18), as the regional reference site scored an ICI of 54. There was a more balanced benthic community structure, as the EPT and sensitive taxa totals at least doubled to 24 and 28, respectively from the upstream site totals. There was a high of 80 total taxa collected.

Honey Creek near the mouth at St. Rt. 202 (RM 0.8) contained more sand and gravel bedload but had deeper fast runs and riffles with some boulders. This habitat allowed *Isonychia* and burrowing mayflies to become more abundant along with hydropsychid caddisflies and baetid mayflies, yielding an ICI (46) consistent with the EWH biocriterion and community structure similar to that found upstream.

Pleasant Run (HUC 050800012004)
Pleasant Run contained diverse habitat despite a small portion being historically channelized (likely when bridge was rebuilt). There were good pools with large slabs and some macrophytes and rubble/cobble riffles.

The macroinvertebrate community in Pleasant Run (HUC 0508000102004) was exceptional quality with 21 EPT and 27 sensitive taxa collected. Sensitive caddisflies and mayflies were predominant with an S/T ratio of 9.0, clearly indicative of a high quality community. There were also five CW taxa, thus Pleasant Run should be recommended to the dual EWH/CWH use.

East Fork Honey Creek (HUC 0508000102001)
East Fork Honey Creek was sampled at four locations. The upstream site at Ayres Rd. (RM 5.9) was narratively evaluated as marginally good despite some excess nutrients and decaying algae present. Cold groundwater augmentation (14.5C) ameliorated some effects, as thirteen EPT taxa were present with a S/T ratio of 1.50, indicative of acceptable biological performance. More intolerant *Neophylax* cased caddisflies were present in the shaded reach of the sample site, whereas the population of hydroptilid caddisflies and flatworms increased in open canopy areas. *Elimia* river snails (left) and *Helicopsyche* caddisflies were predominant throughout the reach (Figure 40).

Figure 40. East Fork Honey Creek at Ayres Rd (RM 5.9)

East Fork Honey Creek near St. Paris Rd. (RM 3.64) was primarily a shallow, stair-stepped bedrock stream emerging out of a stable riparian corridor. The temperature was still only 19.3 C and shaded with less algae. The community quality improved to good performance meeting the ecoregional biocriterion, as the number of tolerant taxa decreased to one (the S/T ratio = 11.0) with less NPS nutrient inputs present. With limited pool habitat this reach functioned more like a very small headwater stream with less *Neophylax* cased caddisflies present. Perennial stream-obligate salamanders (two-lined and longtail salamanders) were readily present indicating less large predatory fish. The cracked bedrock riffle habitat allowed baetid mayflies and hydropsychids to be predominant, but other EPT taxa were similar to upstream.

Figure 41. East Fork Honey Creek upstream (upper) and downstream (lower) Sigler Rd. (RM 1.58).

The open canopy conditions upstream from Sigler Rd. (RM 1.58) increased temperatures and primary production with DO concentrations from 10-12 mg/l (>130% of normal saturation). The stable, wooded riparian canopy downstream with undisturbed groundwater seeps shaded the stream and cooled temperatures from 21-23°C. upstream, to 15.0 C, downstream (Figure 41). The habitat was improved, from mostly silt/sand after historical channelization to mostly rubble and cobble slab with coarse gravel on bedrock downstream, which allowed for high quality biological community performance. The macroinvertebrate community was stable with mostly sensitive or facultative taxa predominant. Twenty-four sensitive taxa were present, and the S/T ratio was 4.0, which decreased from upstream. The increase in some tolerant taxa was due to silt deposition in pools and slower glides from past erosion/bed load upstream in the open pasture, as the stream was recovering (some meanders) from tree removal and channelization.

East Fork Honey Creek near the mouth (RM 0.1) was an exceptional and balanced community with over 30 sensitive taxa and an ICI of 54 (which met the EWH biocriterion). There were cobble and boulder riffles and runs with deep pools–all habitats supporting good diversity and predominated by sensitive organisms (including *Neophylax* caddisflies and *Ephemera* burrowing mayflies).

West Fork Honey Creek (HUC 050800012002)

West Fork Honey Creek was biologically sampled at two locations. The sample site downstream from SR 235 (RM 1.3) had partially recovered from historical channelization and NPS inputs upstream. Minimal algal growth was observed, as the riparian corridor intercepted most NPS runoff from an adjacent golf course and crops. A little silt was present. Marginally exceptional conditions (narrative of very good) were observed with sensitive hydropsychid and *Neophylax* caddisflies and varied baetid mayflies predominant. The S/T ratio was high (18.0), as two other sensitive taxa of note were collected: *Petrophila* moth larvae and *Lype* caddisflies. The *Petrophila* moth larvae colonies were collected on larger rocks in lotic runs and riffles, and *Lype* caddisflies in cases were found on bark of submerged logs.

West Fork Honey Creek near the mouth (RM 0.1) narrowed and displayed more natural development with similar cool groundwater augmentation (17.8 C) to upstream. The CW tortoise-shell caddisflies, *Glossosoma sp*., were present in the riffles confirming cool stream conditions. A diverse macroinvertebrate community like upstream was observed (S/T Ratio= 16.5). Moderate to high diversity was present in all habitats sampled, including deeper pools where cool temperatures, higher oxygen content, and limited silts/fines allowed sensitive cased caddisflies (*Neophylax* sp., *Pycnopsyche* sp., and *Polycentropus* sp.) and burrowing mayflies (*Ephemera sp.*) to be predominant or common.

Indian Creek (HUC 0508000012003)

Indian Creek was documented to be a high quality subwatershed with much of its area either still natural and/or with a wide riparian corridor where some agriculture production occurs. The macroinvertebrate community was highly diverse with increased numbers of EPT, sensitive and CW taxa (Table 21). All sites were exceptional quality with an ICI of 56 at RM 1.52. Cold groundwater flows allowed for 5-6 CW taxa to be documented at the lower two sites (RMs 1.52 & 0.1). The measured temperatures ranged from 16.8-18.5 °C. The middle and lower Indian Creek sites had 28-30 EPT and 34-43 sensitive taxa collected – the highest or similar to the highest diversity totals of any middle Great Miami River tributary sampled (Figure 42).

Figure 42. Indian Creek at SR 201 (RM 1.52)

Dry Creek (HUC 0508000012003)

Dry Creek at Walnut Grove Rd (RM 1.2) was a pasture stream flowing through open pasture with some channelized reaches (Figure 43). Silt and algae from pastoral activities does accumulate in some areas limiting benthic colonization. No polycentropids and decreased baetid mayflies were collected. Ameliorating cooler water temperatures (17.5 C.) and enough available larger substrates were present in the riffle and in the pools to collect fifteen EPT taxa and sixteen sensitive taxa.

Figure 43. Dry Creek upstream (left) and downstream (right) from Walnut Grove Rd. (RM 1.2).

Ambient Biological: Fish Community

Great Miami River (main stem)

A total of 19,613 fish comprising 56 species and seven hybrids was collected from the Great Miami River between July and September, 2009. The survey effort included 35 sampling events, at 19 stations, evaluating 49 miles of the main stem between RM 130 (Sidney, SR 47) and RM 81.6 (Dayton, upstream from the Mad River).

Based on aggregated catch statistics, numerically predominant species (no./km) included golden redhorse (15.8%), spotfin shiner (13.5%), bluntnose minnow (9.2%), smallmouth bass (8.42%), black redhorse (5.8%), and sand shiner (5.6%). In terms of relative biomass (kg/km), dominant species were golden redhorse (37.4%), common carp (13.7%), black redhorse (12.2%), smallmouth redhorse (7.0%), smallmouth bass (5.53%), and channel catfish (4.5%). Remarkably, over 85% of all fish and fully 72.0% of total biomass collected from the main stem were pollution sensitive taxa.

Fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2009), included the river redhorse. Other highly intolerant, rare, declining or otherwise ecologically significant species included, bigeye chub, river chub, black redhorse, silver shiner, rosyface shiner, mimic shiner, brindled madtom, stonecat, and banded darter (Ohio EPA 1987b and 1996c). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be sensitive to a wide range of environmental disturbance, and therefore, their presence are considered indicative of high quality riverine habitats.

Community indices and accompanying narrative evaluations for the middle Great Miami River remained strongly exceptional throughout its entire length, with median community performance, as measured by the IBI and MIwb, of 54 and 10.3, respectively. Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 44. Summarized index scores and community statistics by station are presented in Table 22. Index metrics, scores and fish species and abundance data by sampling location are located in Appendix Tables A-7 and A-8.

As measured by the IBI and MIwb (the latter, where applicable), community performance through the entire length of the middle Great Miami River was found fully consistent with the existing EWH and WWH biocriteria. Every station was found to support an assemblage of fish possessing the expected structure, functional organization, and species richness comparable to reference conditions within the ecoregion. Environmentally sensitive taxa were extremely well represented and consistently comprised a significant proportion of the catch from each fish sampling station. The incidence of serious disease or other external anomalies was typically at or below expected levels, as mean values never exceeded 0.75% of individuals collected at any sampling site. As measured or otherwise indicated by the performance of the fish community, all point and non-point source pollutant loads currently delivered to the middle Great Miami River appeared safely assimilated.

Table 22. Fish community indices, descriptive statistics, and biological narratives for the middle Great Miami River study area, 2009. Entire study area is contained with the Eastern Corn Belt Plain (ECBP) Ecoregion.

Stream River Mile	Drainage Area (miles^2)	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (wt./km)[a]	QHEI	IBI	MIwb	Narrative
Great Miami River 2009 (14-001)								
			Aquatic Life Use EWH (Existing)					
130.0 [B,b]	541.0	29	678.0	146.6	70.0	56	10.2	Exceptional
127.7 [B]	548.0	30	910.0	175.9	79.0	59	10.4	Exceptional
123.9 [B]	561.0	33	837.0	168.9	73.5	57	9.8	Exceptional
120.0 [W]	568.0	28	1271.6	44.4	83.0	54	10.3	Exceptional
117.5 [B]	839.0	33	953.0	163.9	70.0	57	10.2	Exceptional
			Aquatic Life Use WWH/EWH (Existing/recommended)					
115.4 [B]	876.0	31	999.0	82.7	76.5	58	10.5	Exceptional
			Aquatic Life Use EWH (Existing)					
114.0 [B]	873.0	34	1169.0	131.7	74.0	54	10.2	Exceptional
112.4 [B]	876.0	29	1528.0	264.7	80.0	54	10.8	Exceptional
110.1 [B]	889.0	30	1674.0	186.2	76.0	56	10.0	Exceptional
106.0 [B]	927.0	41	1003.0	152.2	70.5	52	10.3	Exceptional
104.7 [B]	936.0	35	1613.0	173.2	83.0	53	10.3	Exceptional
100.8 [B]	971.0	33	1022.0	158.0	88.0	53	10.4	Exceptional
98.5 [B,b]	1125.0	36	907.0	101.3	89.5	54	10.2	Exceptional
95.6 [B]	1143.0	34	1009.0	150.8	80.5	54	10.6	Exceptional
92.5 [B]	1149.0	38	1426.0	112.3	78.5	54	10.2	Exceptional
88.7 [B]	1157.0	35	1393.0	169.0	86.0	53	10.2	Exceptional
87.0 [B]	1167.0	35	864.0	152.5	76.0	54	10.1	Exceptional
85.9 [B]	1170.0	36	1565.0	148.5	70.5	52	10.8	Exceptional
			Aquatic Life Use WWH (Existing)					
81.6 [B]	1853.0	35	1109.0	2222.1	64.0	58	10.7	Exceptional
Tawawa Creek 2009 (14-060)								
			Aquatic Life Use WWH (Existing)					
1.2 [W]	54.0	29	1183.5	23.2	74.5	57	9.8	Exceptional
Mosquito Creek 2009 (14-061)								
			Aquatic Life Use WWH (Existing)					
7.8 [H]	9.0	23	661.5	46.2	47.0	46	NA	Very Good
1.0 [W]	26.0	21	77.2	15.3	63.5	45	8.5	Good
Leatherwood Creek 2009 (14-062)								
			Aquatic Life Use WWH (Existing)					
6.4 [H]	8.7	18	1822.0	13.1	55.0	48	NA	Very Good
3.3 [H]	13.8	21	1107.0	15.5	65.0	56	NA	Exceptional
1.2 [H]	16.8	25	1546.5	653.4	74.5	51	NA	Exceptional
Mill Branch 2009 (14-058)								
			Aquatic Life Use WWH (Existing)					
0.3 [H]	3.6	18	1042.0	11.5	83.0	48	NA	Very Good

Table 22. continued.

Stream River Mile	Drainage Area (Miles^2)	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (wt./km)[a]	QHEI	IBI	MIwb	Narrative
Rush Creek 2009 (14-052)								
Aquatic Life Use Designation WWH (Existing)								
5.3 [H]	7.3	10	724.0	0.5	55.5	34*	NA	Fair
1.7 [H]	14.4	14	660.0	1.0	61.5	46	NA	Very Good
0.3 [H]	18.3	15	741.7	2.7	63.5	44	NA	Good
Spring Creek 2009 (14-052)								
Aquatic Life Use Designation EWH (Existing)								
8.4 [H]	11.6	15	1702.0	13.6	79.0	52	NA	Exceptional
3.5 [W]	20.0	20	2572.5	26.1	74.0	50	9.4	Exceptional
0.8 [W]	24.0	25	1561.5	13.4	72.5	53	9.1	Exceptional/V.Good
Boone Creek 2009 (14-097)								
Aquatic Life Use Designation Unlisted/WWH (Existing/Recommendation)								
0.1 [W]	31.0	21	470.0	9.1	73.5	50	8.6	Exceptional/Good
Peters Creek 2009 (14-096)								
Aquatic Life Use Designation Unlisted/WWH (Existing/Recommendation)								
0.2 [H]	18.4	17	444.0	16.8	65.0	46	NA	Very Good
Lost Creek 2009 (14-048)								
Aquatic Life Use Designation EWH/WWH (Existing/Recommended)								
11.7 [H]	14.1	24	850.0	25.5	65.0	52	NA	Exceptional
Aquatic Life Use Designation EWH/CWH (Existing/Recommended)								
9.8 [W]	30.0	21	988.5	14.3	78.5	50	8.7	Exceptional/Good
4.3 [W]	58.0	23	3444.0	11.4	65.5	42	8.9	Good/Very Good
Aquatic Life Use Designation EWH/WWH (Existing/Recommended)								
0.4 [W]	62.0	26	963.0	2.5	59.5	46	8.1[ns]	Good/M. Good
West Branch Lost Creek 2009 (14-278)								
Aquatic Life Use Designation Unlisted/WWH (Existing/Recommendation)								
0.5 [H]	6.7	19	1479.0	5.4	67.5	58	NA	Exceptional
East Branch Lost Creek 2009 (14-049)								
Aquatic Life Use Designation EWH/WWH (Existing/Recommended)								
6.4 [H]	7.8	17	1636.5	23.4	77.0	56	NA	Exceptional
5.2 [H]	8.9	16	780.0	12.1	77.5	48	NA	Very Good
Aquatic Life Use Designation EWH/CWH (Existing/Recommended)								
0.7 [H]	13.0	13	1219.5	8.8	64.0	52	NA	Exceptional
Middle Branch Lost Creek 2009 (14-277)								
Aquatic Life Use Designation Unlisted/WWH (Existing/Recommendation)								
1.2 [H]	8.0	15	2322.0	16.9	71.0	58	NA	Exceptional
Little Lost Creek 2009 (14-276)								
Aquatic Life Use Designation Unlisted/E-CWH (Existing/Recommendation)[c]								
0.3	9.7	17	1496.0	10.9	64.5	56	NA	Exceptional

Table 22. continued.

Stream River Mile	Drainage Area (Miles²)	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (wt./km)[a]	QHEI	IBI	MIwb	Narrative
Honey Creek 2009 (14-043)								
Aquatic Life Use Designation EWH/WWH (Existing/Recommended)								
9.9 [W]	34.0	23	1365.7	24.8	64.5	45	8.5	Good
8.1 [W]	39.0	19	2327.2	25.7	73.5	42	8.8	Good
Aquatic Life Use Designation EWH (Existing)								
3.2 [W]	73.0	32	3202.5	65.7	74.0	52	10.4	Exceptional
0.8 [W]	87.0	38	1889.2	40.7	57.5	44*	10.3	Good/Exceptional
Pleasant Run 2009 (14-275)								
Aquatic Life Use Designation Unlisted/E-CWH (Existing/Recommendation)[c]								
0.5 [H]	6.1	15	2764.0	25.2	76.5	54	NA	Exceptional
East Fork Honey Creek 2009 (14-047)								
Aquatic Life Use Designation WWH (Existing)								
5.9 [H]	5.2	11	2126.0	13.8	58.0	48	NA	Very Good
3.6 [H]	8.8	11	997.5	1.4	47.0	42	NA	Good
0.1 [H]	13.0	20	2330.0	19.2	74.0	56	NA	Exceptional
West Fork Honey Creek 2009 (14-278)								
Aquatic Life Use Designation Unlisted/WWH (Existing/Recommendation)								
1.3 [H]	19.9	15	850.0	2.5	57.0	46	NA	Very Good
0.1 [W]	20.0	21	4013.6	41.9	77.0	50	9.3	Exceptional/V. Good
Indian Creek 2009 (14-044)								
Aquatic Life Use Designation WWH (Existing)								
4.9 [H]	7.6	15	914.0	7.46	81.0	52	NA	Exceptional
Aquatic Life Use Designation EWH/CWH (Existing/Recommended)								
0.1 [W]	25.0	29	2426.2	18.9	82.0	50	9.3	Exceptional
Dry Creek 2009 (14-045)								
Aquatic Life Use Designation WWH (Existing)								
1.2 [H]	4.8	12	3217.5	12.3	29.5	40	NA	Good

a - Relative abundance and relative weight estimates normalized to 0.3 km for wading sites and 1.0 km for boat sites, respectively.
b - Stations so identified are assessed through ambient biological samples collected as part of the upper Great River survey, 2008.
c - Dual aquatic life use water bodies identified as Exceptional Coldwater Habitat (E-CWH), where both CWH and EWH criteria apply.
H - Headwaters: sites draining areas ≤ 20 miles².
W - Wadable streams: sites draining areas > 20 miles².
B - Boat sites (large waters).
ns - Non-significant departure from the bio criteria (≤4 IBI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI units or >0.5 MIwb units).

Ecoregional Criteria (OAC 3745-1-07, Table 7-15)
Eastern Corn Belt Plain Ecoregion ***(ECBP)***

Index-Site Type	WWH	EWH	MWH[d]
IBI- Headwater/Wading	40	50	24
MIwb-Wading	8.3	9.4	6.2
IBI-Boat	42	48	24
MIwb-Boat	8.5	9.6	5.8

d - Modified Warmwater Habitat (MWH) for channel modified or impounded areas.

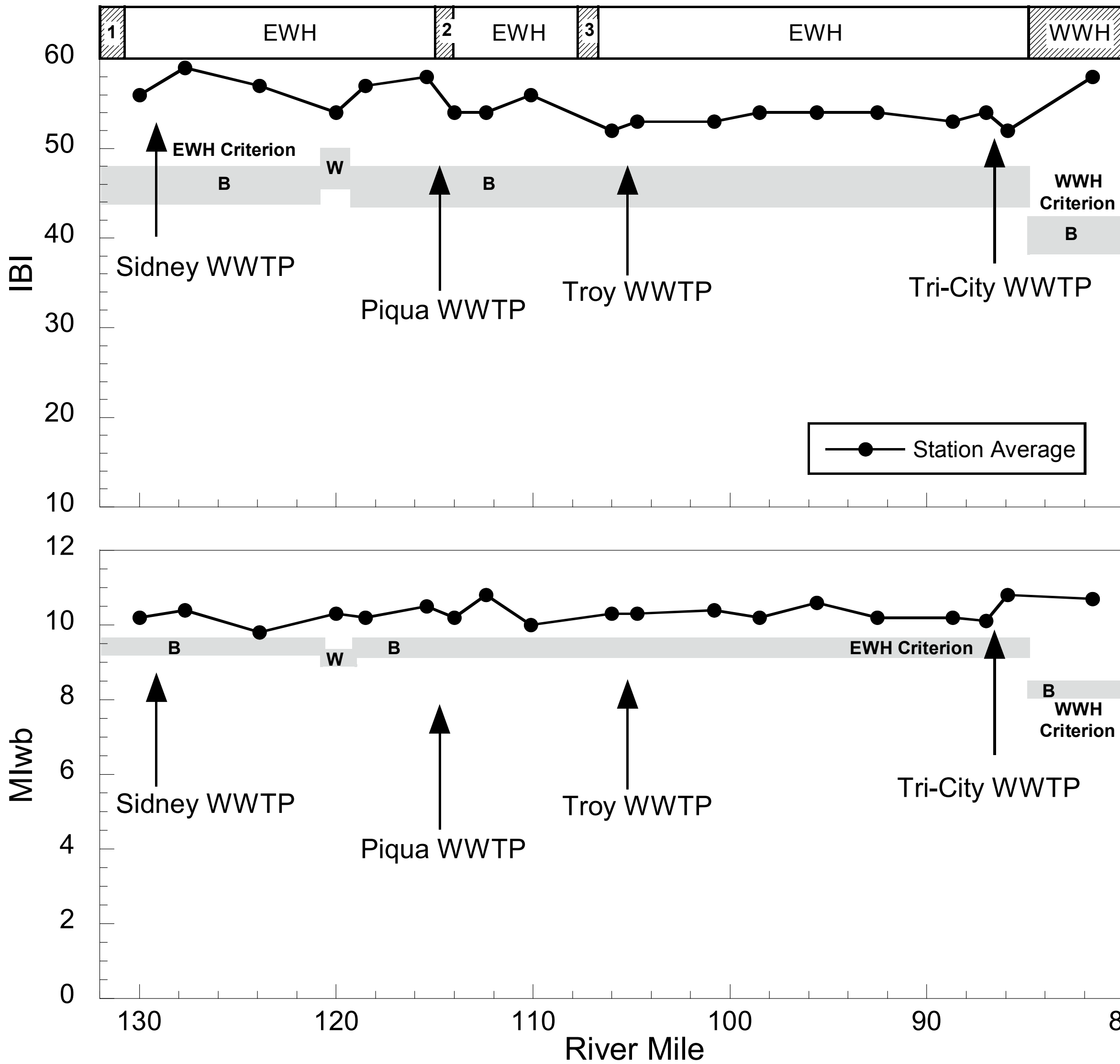


Figure 44. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb) middle Great Miami River (main stem), 2009. Shaded areas B and W represent the Exceptional Warmwater Habitat (EWH) biocriteria and areas of non-significant departure for Boat and Wading methodologies, respectively. Arrows identify direct and indirect points of discharge for NPDES permitted entities. Existing and recommended, Exceptional Warmwater Habitat (EWH) and Warmwater Habitat (WWH) designation are superimposed atop the figure. Enumerated segments: 1, 2, and 3, correspond to small low-head dams and associated impounded river reaches of Sidney, Piqua, and Troy, respectively.

Tawawa Creek (subbasin)

A total of 6,761 fish comprising 40 species and three hybrids was collected from the three water bodies that comprise the Tawawa Creek catchment (Tawawa Creek, Mosquito Creek, and Leatherwood Creek) between July and August, 2009.

Based on aggregated catch statistics, numerically predominant species (no./km) included bluntnose minnow (14.2%), scarlet shiner/central stoneroller minnow (10.9%), striped shiner (5.8%), and white sucker (5.1%). In terms of relative biomass (kg/km), dominant species were common carp (31.0%), white sucker (12.5%), rockbass (8.9%), and smallmouth bass/golden redhorse (5.3%).

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2009) were observed. Highly intolerant, rare, declining or otherwise ecologically significant species included, river chub, black redhorse, silver shiner, rosyface shiner, and banded darter (Ohio EPA 1987b and 1996c). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be extremely sensitive to a wide range of environmental disturbance, and, therefore, their presence is considered indicative of the intact riverine habitats.

Community indices and accompanying narrative evaluations for the Tawawa Creek subbasin ranged between exceptional (IBI=57/MIwb=9.8) and good (IBI=45/MIwb=8.5). Overall, the fish assemblage was characterized as *very good*. Summarized index scores and community statistics by station are presented in Table 22.

Tawawa Creek, Mosquito Creek and Leatherwood Creek were found to support fish assemblages possessing the expected structure, functional organization, and species richness fully consistent with their existing WWH aquatic life use designations.

Selected Tributaries

This suite of streams included, Mill Branch, Rush Creek, Spring Creek, Boone Creek and Peters Creek, the latter being a direct Boone Creek tributary. Fish community monitoring was conducted at nine monitoring stations distributed among these waterbodies between July and August, 2009. Three stations were allocated to each Rush and Spring Creek, with the remaining sites equally divided between the remaining tributaries.

With the exception of upper Rush Creek, evaluated at Vandermark Rd. (RM 5.3), all other tributaries were found to support fish assemblages fully consistent with their respect aquatic life uses. Specifically, WWH assemblages were indicated through lower Rush Creek, Mill Branch, Boone and Peters Creek and an exceptional fish fauna was consistently observed over the entire length of Spring Creek.

A combination of both direct field observations and analysis of the functional organization of the fish assemblage strongly suggested that failure of upper Rush Creek to support a WWH fish assemblage was a result of the transitional nature of RM 5.3, representing a cline between primary headwaters and standard headwaters. Key indicators supporting this conclusion included an abundance of pethodontid salamanders and a dominance of pioneering fish taxa. Pethodontids typically occupy upper trophic levels of small waters only in the absence of a resident fish assemblage. A high proportion of pioneering fish species is typically associated with ephemerality or a waterbody in the process of recovery following an event, natural or anthropogenic, that effectively depopulated the stream (Smith 1979 and Bayley and Osbourne 1993). Pioneering taxa are the first fish species to reinvaded areas previous rendered inhospitable. In the absence of pethodontids, the structure of the fish community would have suggested that upper Rush Creek labored under the consequences of a fish kill, desiccation or other episodic lethal/sublethal stress. The concurrence of these indicators, however, argues that the flow regime of upper Rush Creek is not likely compatible with persistent and well-organized resident fish community. Given its apparent transitional nature, consecutive monitoring effort over the course of several years would likely find that upper Rush Creek vacillates in and out of WWH attainment, based upon the seasons' flow regime.

Lost Creek (subbasin)

A total of 13,023 fish comprising 34 species and two hybrids was collected from the Lost Creek watershed between July and August 2009. The fish sampling effort included five named streams (Lost Creek, West Branch, East Branch, Middle and Little Lost Creek), 13 sampling events, at ten monitoring stations, resulting in the evaluation of 23 linear stream miles.

Based on aggregated catch statistics, numerically predominant species (No./0.3km) included Central stoneroller (22.8%), mottled sculpin (15.0%), rainbow darter (13.7%), Western blacknose dace (9.3%), and striped shiner (9.2%). In terms of relative biomass (kg/0.3km), dominant species were, Central stoneroller (15.7%), striped shiner (15.4%), creek chub (13.6%), white sucker (13.5%), and mottled sculpin (7.9%).

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2009), were observed. Other highly intolerant, declining or otherwise ecologically significant species included black redhorse, bigeye chub, horneyhead chub, silver shiner, brindled madtom, and banded darter (Ohio EPA 1987b and 1996c). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be sensitive to a wide range of environmental disturbances, and therefore are considered associates of the intact riverine habitats.

Community indices and accompanying narrative evaluations from the Lost Creek watershed ranged between exceptional/very good (IBI=58/MIwb=8.9) and good/marginally good (IBI=42/MIwb=8.1). Overall, fish assemblages of the subbasin were characterized as exceptional/good. Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 45. Summarized index scores and community statistics by station are presented in Table 22.

Based upon and gauged against existing and recommended aquatic life use designation, all waterbodies and associated monitoring stations within the Lost Creek watershed were found to support fish assemblages possessing species richness, function and structural organization, and physical condition consistent with the relevant biocriteria.

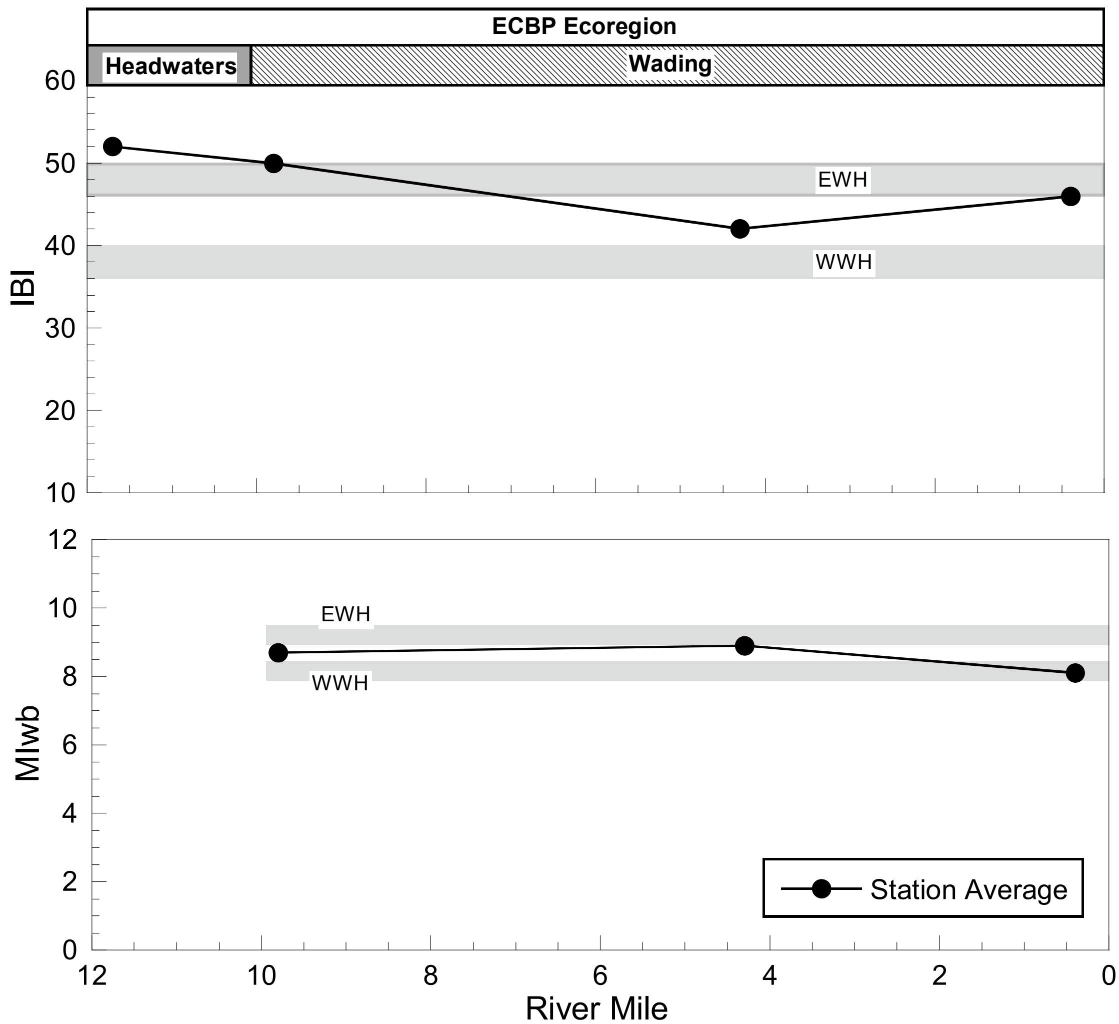


Figure 45. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb) Lost Creek (main stem), 2009. Shaded areas represent the EWH and WWH and areas of non-significant departure.

Honey Creek (subbasin)

A total of 23,265 fish comprising 43 species and two hybrids was collected from the Honey Creek watershed between July and August 2009. The fish sampling effort included six named streams (Honey Creek, West Fork, East Fork, Pleasant Run, Dry Creek, and Indian Creek), 18 sampling events, at 12 stations, evaluating 26 linear stream miles.

Based on aggregated catch statistics, numerically predominant species (No./0.3km) included Central stoneroller (33.4%), mottled sculpin (10.5%), rainbow darter (9.5%), creek chub (9.0%), and Western blacknose dace (5.0%). In terms of relative biomass (kg/0.3km), dominant species were, Central stoneroller minnow (22.5%), white sucker (14.8%), creek chub (10.9%), Northern hog sucker (10.0%), and common carp (8.3%).

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2009) were observed. Highly intolerant, declining or otherwise ecologically significant species included, American brook lamprey, black redhorse, bigeye chub, river chub, silver shiner, and banded darter (Ohio EPA 1987b and 1996c). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be sensitive to a wide range of environmental disturbances, and therefore are considered associates of intact riverine habitats in Ohio.

Community indices and accompanying narrative evaluations from the Honey Creek catchment ranged between exceptional (IBI=56/MIwb=10.4) and good/marginally good (IBI=40/MIwb=8.0). Median community performance, as measured by the IBI and MIwb, was within the very good range (IBI=46 and MIwb=9.23). Longitudinal performance of the IBI, MIwb, and other relevant indicators from Honey Creek main stem are presented in Figures 46 and 47. Summarized index scores and community statistics by station are presented in Table 22.

As indicated by the IBI and MIwb, the latter where applicable, departures from the prescribed biocriteria were identified on Honey Creek alone. All other waterbodies and associated stations within this subbasin were found to contain fish assemblages possessing the expected structure, functional organization, and species richness comparable to reference conditions within the ecoregion.

Presently, the entire length of Honey Creek is designated EWH. Of the four stations allocated to evaluate the waterbody, only one site (RM 3.2, Rudy Rd.) was found to support an exceptional fish community, the remaining sites, to varying degrees, failed to meet the EWH biocriteria. These impacted or otherwise divergent sites were found over the entire length of Honey Creek.

The uppermost station at RM 9.9 (upstream from New Carlisle WWTP) did not appear profoundly degraded, rather, the fish assemblage was indicative of basic WWH conditions. Historical sampling results affirm this observation, as this reach has consistently failed to support exceptional fish assemblages over the course of three prior investigations, between 1982 and 2003. It is important to note that corresponding measures of macrohabitat quality also never fell consistently within the exceptional range. Similar conditions, namely strong WWH aquatic communities, were observed in 2009 on both the East and West Forks, tributaries that together form Honey Creek proper. Given that central tendency of Honey Creek and its principal headwaters has and continues to be WWH, the retention of the existing EWH use designation is unjustified.

Progressing downstream to RM 8.1 (downstream from the New Carlisle WWTP), community performance again fell short of EWH biocriteria. In-stream effects associated with the WWTP were both spatial and temporal in nature. In comparison with upstream conditions, both the species richness and the number of environmentally sensitive fish taxa declined downstream from the facility in 2009. In comparison with previous sampling in 1994, the performance of one of the two fish community indexes (IBI) was much lower in 2009. The remaining index, the MIwb, remained statistically comparable over the intervening 15 years. Field observations in 2009 offered additional evidence of effects including algal growth approaching nuisance levels and lingering evidence of an apparent fish kill. Despite the longitudinal and historical declines in community performance attributable to the WWTP, WWH communities have persisted at this monitoring station through the period of record. Given the close proximity and comparable drainage areas of the Honey Creek stations immediately up and downstream from New Carlisle, reasonable inferences regarding ambient biological potential of the affected reach, evaluated at RM 8.1, may be drawn from the uppermost, unimpacted reach evaluated at RM 9.9. It is likely that the natural limitations on upper Honey that appear to constrain ambient biological performance within the WWH range are present and fully operative on contiguous reaches

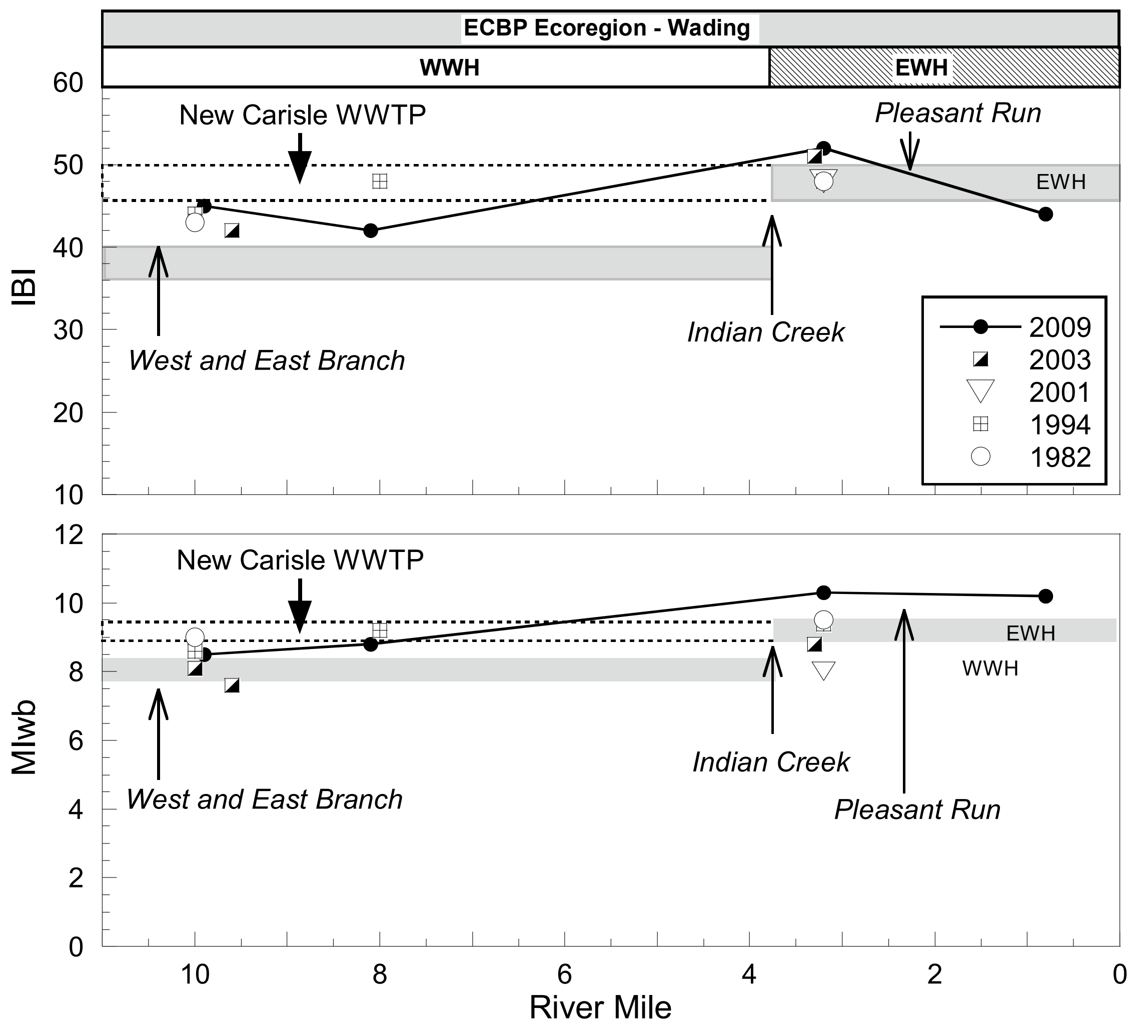


Figure 46. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb), through time, Honey Creek (main stem), 1994-2009. Shaded areas represent the EWH and WWH biocriteria and areas of non-significant departure. Solid arrow identifies the point of discharge for the New Carlisle WWTP. Open arrows indicate points at which Honey Creek tributaries join the main stem.

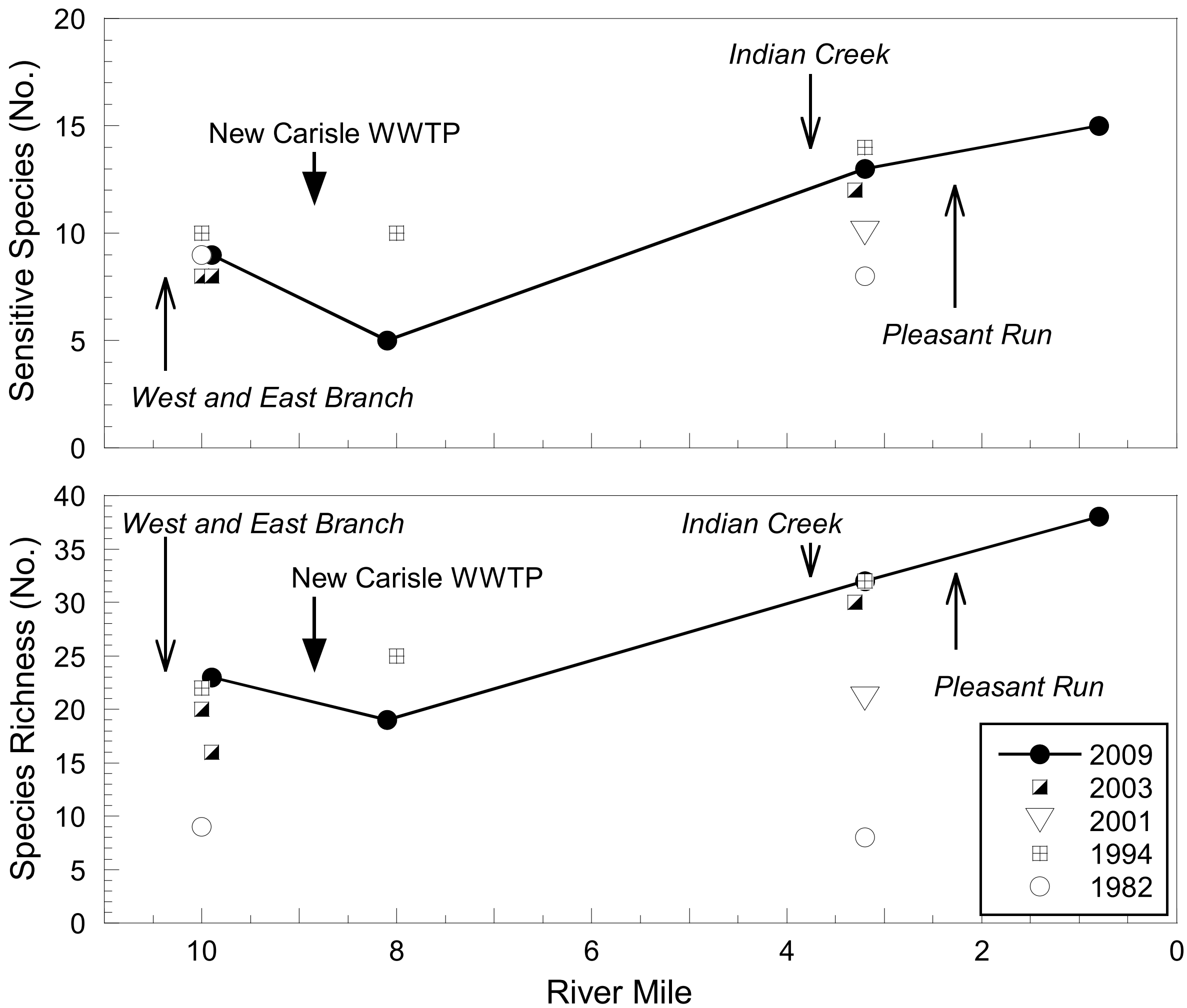


Figure 47. Longitudinal fish species richness (No.) and environmentally sensitive fish species (No.), Honey Creek (main stem), 1994-2009. Solid arrows identify point of discharge for the New Carlisle WWTP. Open arrows indicate the points at which Honey Creek receives its major tributaries.

extending through and downstream from New Carlisle. This is not to argue that the WWTP is without effects, or that said effects should be discounted, rather, the purpose here is to appraise the merits of holding upper Honey Creek (and a municipal permittee) to an EWH standard that now, in light of decades of monitoring, appears unjustified.

As measured by the condition of the fish assemblage, detectable influences of New Carlisle WWTP appeared relatively short lived, as community performance at the next downstream station (RM 3.2, Rudy Rd.) was strongly exceptional (IBI=52 and MIwb=10.4) in 2009. The site was found to support both a high number and high proportion of environmentally sensitive fish taxa, and easily met, and even exceeded, the EWH criteria. In comparison with the upper two sites (RMs 9.9 and 8.1), macrohabitat was much improved and stream size, as measured by drainage area, was nearly doubled. Any deleterious effects from the WWTP upon Honey Creek near New Carlisle were absent further downstream at RM 3.2.

Similarly, the natural or otherwise structural limitations of upper Honey ebbed with increasing downstream distance from the headwaters.

Modest departure from the EWH biocriteria was observed at the lower most monitoring station (RM 0.8, SR 202). The magnitude of this was not great, as only one of the two fish community indices employed by Ohio EPA failed to meet the requisite benchmark. Specifically, the IBI was just two units shy of the criterion, while the MIwb, a structural measure, easily meet expectations. Failure of the IBI was a result of an increase in the proportion of environmentally tolerant and ecological generalist fish taxa. Given the very good condition of the fish community upstream, it is doubtful that the effects of the wasteload from the New Carlisle WWTP served a primary causal agent. Rather, the shift to a more generalized fish community appeared a response to simplified macrohabitat of lower Honey Creek, evidenced by significant decline in macrohabitat quality (QHEI=57.5). This reach had been likely channelized in the distant past. Although much natural recovery was evident within the wetted channel, including modest parafluvial development, macrohabitat quality was well below that commonly associated with exceptional streams. As observed elsewhere in the basin (e.g., lower Lost Creek), upon entering the broader alluvial valley of the middle Great Miami River, the gradient of Honey Creek precipitously dropped, affecting nearly every aspect of the fluvial processes responsible for channel formation, maintenance, and recovery. The negative effects of this that were most readily discernible included a dominance of finer substrates (sand and pea gravel) and low energy channel form. Inherently unstable and lacking the macrointerstices common to coarser bed material, an overabundance of sandy substrates can serve as a significant limiting factor, respecting ambient biological performance. The combination of past channelization and the overarching associated natural factors described above, taken together, appeared the primary biological determinants.

Both contemporary and historical survey results provide compelling evidence regarding the universal applicability of the EWH aquatic life use on Honey Creek. Given the prevalence of WWH performance documented in upper Honey Creek, retention of the EWH aquatic life use for this segment is not justified. Therefore, the 6.3 mile stream reach beginning at the confluence of the East and West Forks of Honey Creek (headwaters) to the Indian Creek confluence (RM 3.7) is recommended to the more appropriate WWH aquatic life use designation. Retention of the existing EWH use designation is recommended for the lower 3.7 miles Honey Creek, due to documented exceptional performance. Based upon these recommended aquatic life use, departure from the associated biological criteria was limited to the lower 0.8 miles.

Fish Tissue

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. For more information about chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010. Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time (http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf).

Fish advisories

Fish contaminant data are used to determine a meal frequency that is safe for people to consume (e.g., two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide one meal a week mercury advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed at http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

The minimum data requirement for issuing a fish advisory is three samples of a single species from within the past ten years. For the middle Great Miami River, channel catfish, common carp, rock bass, and smallmouth bass met this requirement. In addition, smallmouth bass in Indian Creek also met this requirement. For all other species, the statewide advisories apply, which are: two meals a week for sunfish (e.g., bluegill) and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish 23" and over, and northern pike 23" and over. For the middle Great Miami River, channel catfish, common carp, and smallmouth bass are in the one meal a month advisory category due to mercury levels. Rock bass are in the one meal a week advisory category due to mercury. From Indian Creek, smallmouth bass are in the one meal a week advisory category due to mercury.

For a listing of fish tissue data collected from the middle Great Miami River and Indian Creek in support of the advisory program, see Tables 23 and 24. The advisory information for the middle Great Miami River presented in this section differs from the information given in Ohio's fish consumption advisory because of a difference in years of data and sites included in the analysis. The segment referred to in the Ohio fish consumption advisory includes areas upstream to Indian Lake and downstream to the low head dam at Monument Avenue and looks at data collected between 2002 and 2009; for this document, only data taken in 2008 from U.S. Route 36 in Piqua downstream to Needmore Rd. in Dayton were used.

Table 23. Select Fish Tissue Data from 2008 middle Great Miami River Sampling (mg/kg).

Year	Location	River Mile	Species	Mercury	PCBs
2008	Great Miami River upstream Fishburg Road	90.2	Common Carp	0.216	<0.05
2008	Great Miami River upstream Little York Road	91.1	Common Carp	0.243	0.081
2008	Great Miami River upstream Taylorsville Dam	92.8	Common Carp	0.149	0.118
2008	Great Miami River upstream Ross Road	95.6	Common Carp	0.232	0.076
2008	Great Miami River downstream Eldean Road	110	Common Carp	0.157	0.080
2008	Great Miami River upstream Piqua Plant Dam	114.4	Common Carp	0.139	<0.05
2008	Great Miami River up- and downstream U.S. Route 36	116.1	Common Carp	0.524	<0.05
	Averages			**0.237**	**0.061**
2008	Great Miami River upstream Fishburg Road	90.2	Channel Catfish	0.262	<0.05
2008	Great Miami River upstream Little York Road	91.1	Channel Catfish	0.813	<0.05
2008	Great Miami River upstream Taylorsville Dam	92.8	Channel Catfish	0.077	0.105
2008	Great Miami River upstream Taylorsville Dam	92.8	Channel Catfish	0.055	0.085
2008	Great Miami River upstream Ross Road	95.6	Channel Catfish	0.398	0.080
2008	Great Miami River downstream Eldean Road	110	Channel Catfish	0.338	<0.05
	Averages			**0.324**	**0.070**
2008	Great Miami River upstream Fishburg Road	90.2	Rock Bass	0.131	<0.05
2008	Great Miami River upstream Little York Road	91.1	Rock Bass	0.104	<0.05
2008	Great Miami River upstream Little York Road	91.1	Rock Bass	0.255	<0.05
2008	Great Miami River downstream Eldean Road	110.0	Rock Bass	0.284	<0.05
2008	Great Miami River upstream Piqua Plant Dam	114.4	Rock Bass	0.292	<0.05
2008	Great Miami River up- and downstream U.S. Route 36	116.1	Rock Bass	0.195	<0.05
	Averages			**0.210**	**<0.05**
2008	Great Miami River upstream Little York Road	91.1	Smallmouth Bass	0.236	<0.05
2008	Great Miami River upstream Taylorsville Dam	92.8	Smallmouth Bass	0.206	<0.05
2008	Great Miami River upstream Ross Road	95.6	Smallmouth Bass	0.312	<0.05
2008	Great Miami River downstream Eldean Road	110.0	Smallmouth Bass	0.333	<0.05
2008	Great Miami River up- and downstream U.S. Route 36	116.1	Smallmouth Bass	0.197	<0.05
2008	Great Miami River up- and downstream U.S. Route 36	116.1	Smallmouth Bass	0.275	<0.05
	Averages			**0.260**	**<0.05**

Note: The shading indicates the advisory category that applies. Green = two meals per week, yellow = one meal per week, orange = one meal per month. Unshaded cells had reporting limits above the one meal per week threshold, and so could not be determined.

Table 24. Select Fish Tissue Data from 2005 Indian Creek Sampling (mg/kg).

Year	Location	River Mile	Species	Mercury	PCBs
2005	Indian Creek up- and downstream State Route 128	1.6	Smallmouth Bass	0.142	<0.05
2005	Indian Creek upstream State Route 128	8.0	Smallmouth Bass	0.242	<0.05
2005	Indian Creek upstream State Route 732	15.1	Smallmouth Bass	0.122	<0.05
	Averages			**0.169**	**<0.05**

Note: The shading indicates the advisory category that applies. Green = two meals per week, yellow = one meal per week, orange = one meal per month. Unshaded cells had reporting limits above the one meal per week threshold, and so could not be determined.

Fish Contaminant Trends

Fish contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, data show that PCBs continue to pose a risk to humans who consume fish, and mercury concentrations have been increasing in some locations because of increases in certain types of industries for which mercury is a byproduct that is released to air and/or surface water. For this reason, it is useful to compare the results from the survey presented in this TSD with the results of the previous survey(s) done in the study area. Recent data can be compared against historical data to determine whether contaminant concentrations in fish tissue appear to be increasing, decreasing, or staying the same in a water body or watershed.

Fish tissue had previously been collected in the middle Great Miami River in 1993, 1994, and 1998. Fish were collected along approximately the same stretch of river as in 2008, from State Route 66 in Piqua (RM 117.0) to Needmore Rd. (RM 87.0). Mercury levels in fish appear to have risen in the middle Great Miami River since 1993-1998, from an average of 0.188 mg/kg to 0.220 mg/kg in 2008. That change in mercury concentrations may be attributable, at least in part, to an increase in the size of the average fish caught in the middle Great Miami River, from 350 mm in 1993-1998, to 426 mm in 2008, since mercury concentration tends to increase in fish with increasing length. In Kiser Lake, fish tissue mercury levels decreased between 1999-2002 collections and 2008 collections, from an average of 0.06 mg/kg to 0.034 mg/kg in 2008. However, the size of the average fish caught in Kiser Lake also decreased, from 394 mm in 1999-2002 to 316 mm in 2008, which may account for all or part of the apparent mercury decrease. Sample sizes were insufficient to evaluate potential trends in the other water bodies included in this document. PCBs were only found in channel catfish and common carp in the middle Great Miami River, averaging 125 ppb in 1999-2002, and 66 ppb in 2008.

Ambient Biological Trends Assessment

Benthic Macroinvertebtrates:1982-2009

Middle Great Miami (main stem) Trends: 1985-2010

There was more attainment in the 2009 survey compared to 1994-95, as the 2009 Great Miami River sites upstream and downstream from Sydney met EWH criteria due to decreases in the percentage of tolerant organisms (oligochaete worms and midges) (Table 21). Similar ICI results between surveys occurred downstream from Sydney to downstream from Troy. The overall ICI scores currently were lower than the 1994-5 results from Tipp City downstream (RM 100.8) to above Needmore Rd. (RM 87) (Figure 30).

While still meeting EWH criteria, the increased relative density of macroinvertebrate quantitative samples points toward increased nutrient inputs and increasingly enriched conditions (Figure 48). The first two sites were downstream from Sidney (NPS inputs and open canopy) and downstream from the Sidney WWTP. By contrast, a stable reach with varied habitat (narrower island channel with more shading) gave background ambient densities very similar between surveys (Kuther Rd. at RM 123.9) (Figure 49).

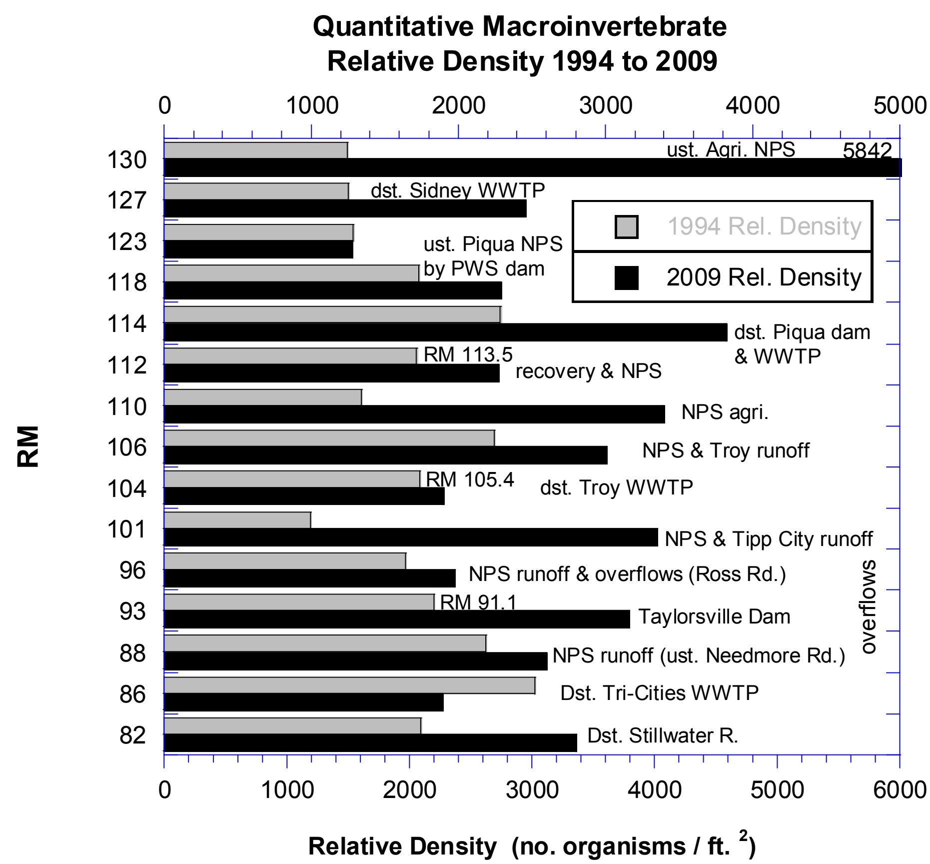


Figure 48. Quantitative macroinvertebrate concentrations in Great Miami River during the 1994-95 and 2008-09 middle Great Miami River surveys.

Figure 49. Middle Great Miami River upstream from Kuther Rd. (downstream view).

The overflows from sanitary sewer lines from Tipp City, Vandalia, and Huber Heights going to MCD Tri-Cities WWTP likely increased untreated inputs (bacteria and waste) contributing to locally decreased quality and higher densities of more facultative taxa in those reaches. The lower relative density and decreased mayfly and total taxa downstream from MCD Tri-Cities WWTP was the biological signature of the local chronic effects of bypasses and elevated ammonia loads in-stream. In contrast, increasing relative density downstream from the Stillwater River confluence (below an impoundment at RM 85.8) appeared related the large NPS nutrient load from this major Great Miami tributary (Figures 48 and 50). Open canopy conditions greatly increased in-stream primary productivity (suspended and attached algae and utilization by aquatic saprophytes). High percent abundances of tolerant oligochaete worms (14%) and *Glyptotendipes (G.)* sp. (a lower DO tolerant midge) without declines in the EPT diversity metrics usually indicate an enriched reach (Table 21). There is a large cumulative nutrient load from the Stillwater River and the upstream Great Miami River watershed into the lower Great Miami River.


Figure 50. Views of the lower, middle Great Miami River downstream from the Stillwater River confluence, at impoundment (left) and upstream from the I-75 Bridge and the Mad River confluence (right).

Spring Creek Trends: 1982-2009

Scores fluctuated between good and very good quality performance in lower Spring Creek (RMs 0.84 -1.0) from 1982 to 2003. The number of sensitive and ETP taxa in 2009 at this regional reference site has increased since the 1982, 1984 and 1994 surveys. This quantitative macroinvertebrate sample set in 2009 was the first to secure a valid ICI score (44, very good), since it appeared that flows had decreased significantly through the earlier summer low flow sampling periods historically. At least since 1994, narrative qualitative assessments or the ICI (2009) scores in lower Spring Creek had met the EWH biocriterion.

Lost Creek Trends: 1982-2009

Lost Creek has been regularly sampled for macroinvertebrates since 1982. Despite agricultural practices like dredging and channelization at various reaches in the watershed, Lost Creek has met the EWH biocriterion in all years except 2003 (Figure 51).

Honey Creek Trends: 1994-2009

Honey Creek had been sampled for macroinvertebrates since 1994. Honey Creek community performance met EWH biocriterion expectations upstream from New Carlisle (RM 10.1 -9.9) (which is a regional reference site). Performance downstream from the New Carlisle WWTP has never met the EWH biocriterion. Over time at Rudy Rd. (RM 3.2), increased substrates stability with less stream manipulation upstream allowed for exceptional community performance (Figure 52).

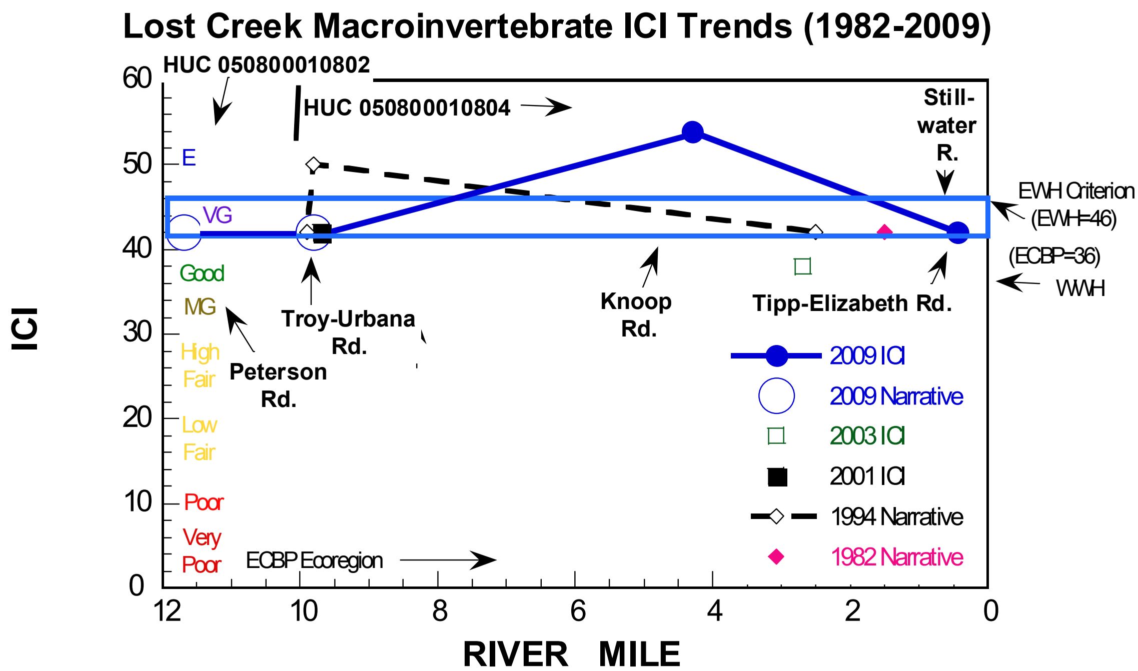


Figure 51. ICI Trends for Lost Creek from 1982 to 2009.

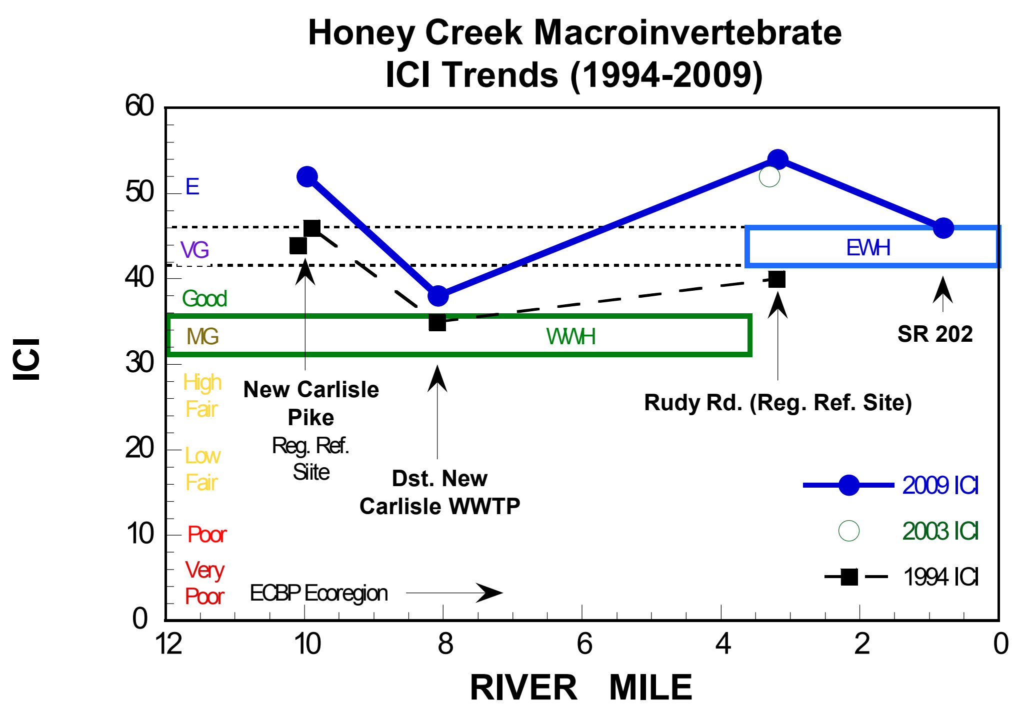


Figure 52. ICI Trends for Honey Creek from 1994 to 2009.

Fish Communities: 1982-2009

The fish fauna of middle Great Miami River has been regularly surveyed and assessed by Ohio EPA since 1982. A systematic survey of the main stem was under taken for the field years: 1982, 1994, and 2009. Monitoring efforts on the principal tributaries varied through this period, with the 2009 survey being the most comprehensive, regarding concurrent main stem and tributary monitoring. Field sampling within the middle Great Miami River basin through the intervening years was very limited in scope, and included small or otherwise discrete segments of the main stem and a few selected tributaries. These narrower activities supported various water quality management goals (e.g. NPDES, stream regionalization, use attainability analysis, and reference site monitoring), as opposed to the larger, systematic efforts of 1994 and 2009. For the purposes of trends assessment, historical results, where compatible, will be compared against contemporary conditions.

In order to succinctly summarize and evaluate survey results between field years, analysis of trends will take two forms: 1) aggregated annual trends, examining cumulative performance of selected measures and indexes from comparable field years through time, and 2) comparative longitudinal trends, relative to the principal associated stressors, through time. Where stream specific data are limited to a few sampling stations or waterbodies, trends assessment will take the form of a narrative, as these data do not lend themselves to statistical treatment, aggregation, or longitudinal display. A great deal of overlap between field years provides an excellent opportunity to evaluate meaningful changes, or lack thereof, in the environmental conditions of the middle Great Miami watershed through the period of record. This approach will be applied to both the main stem and its tributaries.

<u>Aggregate Community Performance</u>

The main stem survey of 2009 was complimentary to previous efforts in terms of spatial coverage and station density, nearly duplicating the work from 1982 and 1994. Given the robustness and contiguous nature of the larger efforts, the overarching trends of the main stem are best described by these data. Cumulative community performance, summarized by box and whisker plots, of the IBI and MIwb for each of the field years identified above are presented in Figure 53. These data unambiguously portray radical improvement in the performance of the fish assemblage of the middle Great Miami River since the first significant intensive biosurvey. Although not profoundly degraded at that time, the 1982 survey results indicated that nearly 25% of the main stem monitoring stations failed to support WWH fish communities, and nearly 50% were below the exceptional range. The 1994 survey found the middle Great Miami River fully recovered as measured the IBI and MIwb. Nearly every station was found to support a fish assemblage performing at or very near the EWH biocriteria, far surpassing the then extant WWH use. Although readily apparent from even a cursory examination of the ordinations contained in Figure 53, non-parametric statistical treatment (Wilcoxon-Mann-Whitney Rank Sum Test) indicated a strong and significant statistical difference between community measures (IBI and MIwb) collected in 1982 and 1994 (*p values* <0.0001). Significant improvement in the environmental conditions documented in 1994 followed the implementation of the US EPA

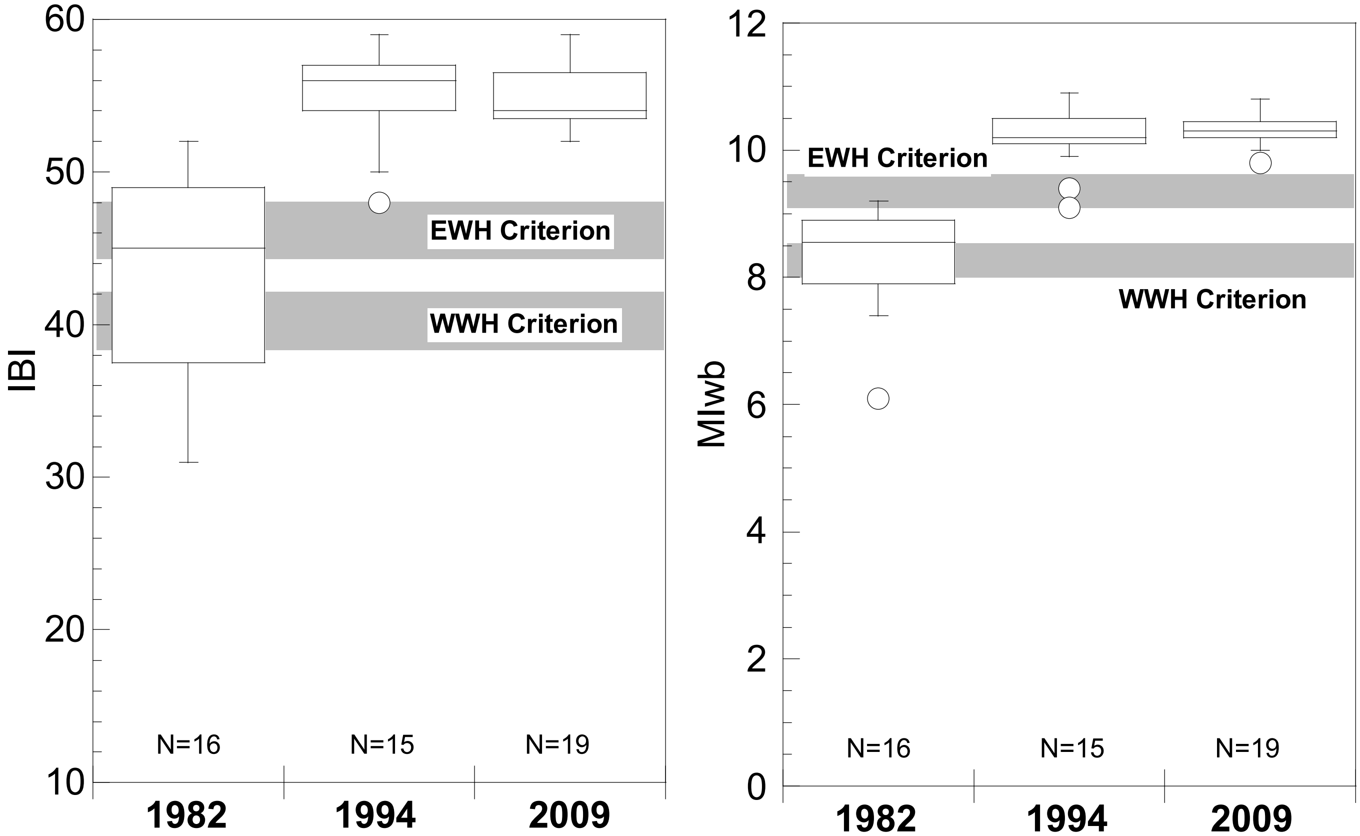


Figure 53. Aggregated performance of the Index of Biotic Integrity (IBI, left) and Modified Index of well-being (MIwb, right) from the middle Great Miami River for the field years: 1982, 1994, and 2004.

National Municipal Policy and the supporting Construction Grants program contained within the Federal Water Pollution Control Act (AKA Clean Water Act), as amended in 1977 and 1981. This initiative, implemented in the early 1980s, required most major POTWs to meet advanced treatment standards, so as to comply with water quality-based effluent limits by 1988. Federal grants and loans, administered by the states, were made available to eligible entities to facilitate significant upgrades and improvements to municipal wastewater infrastructure. The practical in-stream results of advanced waste treatment on the affected segments of the middle Great Miami River was a significant reduction in the loadings of both putrescible or oxygen demanding wastes and ammonia-N, from all major POTWs (Ohio EPA 1996b). The associated improved ambient water quality (i.e., unimpacted DO regime and non-toxic concentrations ammonia-N) then facilitated the eventual recovery of the fishery. By 1994, conditions had so improved that the designated WWH aquatic life use had to be reconciled with the higher or restored level of biological performance. Therefore, much of the middle Great Miami was recommended for redesignation to the EWH aquatic life use, which comported with existing or documented in-stream conditions (Ohio EPA 1996b).

Between 1994 and 2009, the condition fish community of the middle Great Miami River appeared stable, as non-parametric statistical treatment found no significant difference between 1994 and 2009 biometrics (IBI: $p=0.6027$ and MIwb: $p=0.4725$). Over the past 15 years the middle Great Miami has consistently supported a diverse and functionally well-organized assemblage of fish, comparable at most locations to many of Ohio's best waters.

In additional to the primary fish community indexes (IBI and MIwb), aggregated metrics or other indicators also proved useful in describing gross trends of the environmental conditions of the middle Great Miami River, as reflected in the structure of the fish community. To that end, trends of selected components, species or other indicators of the fish assemblage are presented in Figure 54. First among these, species richness, displayed a steady increase through time, resulting in the accrual of eight fish taxa over the intervening 27 years. Similarly, composite metrics of environmentally sensitive species (number of taxa and percent of biomass) showed steady increases through time, with the accrual of four species so classified, between 1982 and 2009, and a nearly 15% increase of sensitive species as a component of total biomass over the same period. Lastly, basic descriptive statistics for two fish species, black redhorse and common carp, were analyzed. These species were chosen as inverse response variables, due to their contrasting environmental requirements and broad distribution throughout Ohio. The common carp is a classic generalist, having a great tolerance for disturbed macrohabitat and degraded water quality (Panek 1987). In contrast, black redhorse is among the most environmentally sensitive of common or broadly distributed fish species in Ohio (Ohio EPA 1987b and Trautman 1981). In 1982, common carp comprised over 30% of total fish biomass of the middle Great Miami River. A 9% reduction was observed in 1994, and by 2009 common carp accounted for only 13.7% of total biomass (a further 18% reduction). Although not yet fully documented, reductions in carp biomass through time appears to be an emerging phenomenon in Ohio. Nevertheless, where observed, here and elsewhere, it does not appear random or otherwise stochastic, given the consistent declining trajectory based upon multiple observations through three reporting cycles, and likely reflects a combination of both improved water quality and improved macrohabitat. Regarding the latter, the diminution in the delivery of clays and silts to Ohio's surface waters achieved through significant changes in tillage and other related conservation practices may be important. It is quite possible that the common carp is no longer the superior ecological competitor of degraded lotic environs, as sedimentation is much less severe than in the past and water quality is similarly much improved. Fully exposed to completive pressure from a relatively intact or recovered native fish fauna, perhaps the common carp can only persist at much lower densities than previously documented. Regardless of the ultimate or proximate cause(s), the steady and significant reduction of this highly tolerant and exotic species is viewed as a positive trend, an observation supported by Kennard et al. (2005).

Black redhorse displayed an opposing trend to that observed for common carp, increasing not only its relative abundance but also increasing its standing mass through the period of record. Associated causes likely represent a perfect antithesis to that of the proceeding species (common carp). Rather than disadvantaging black redhorse, improved water

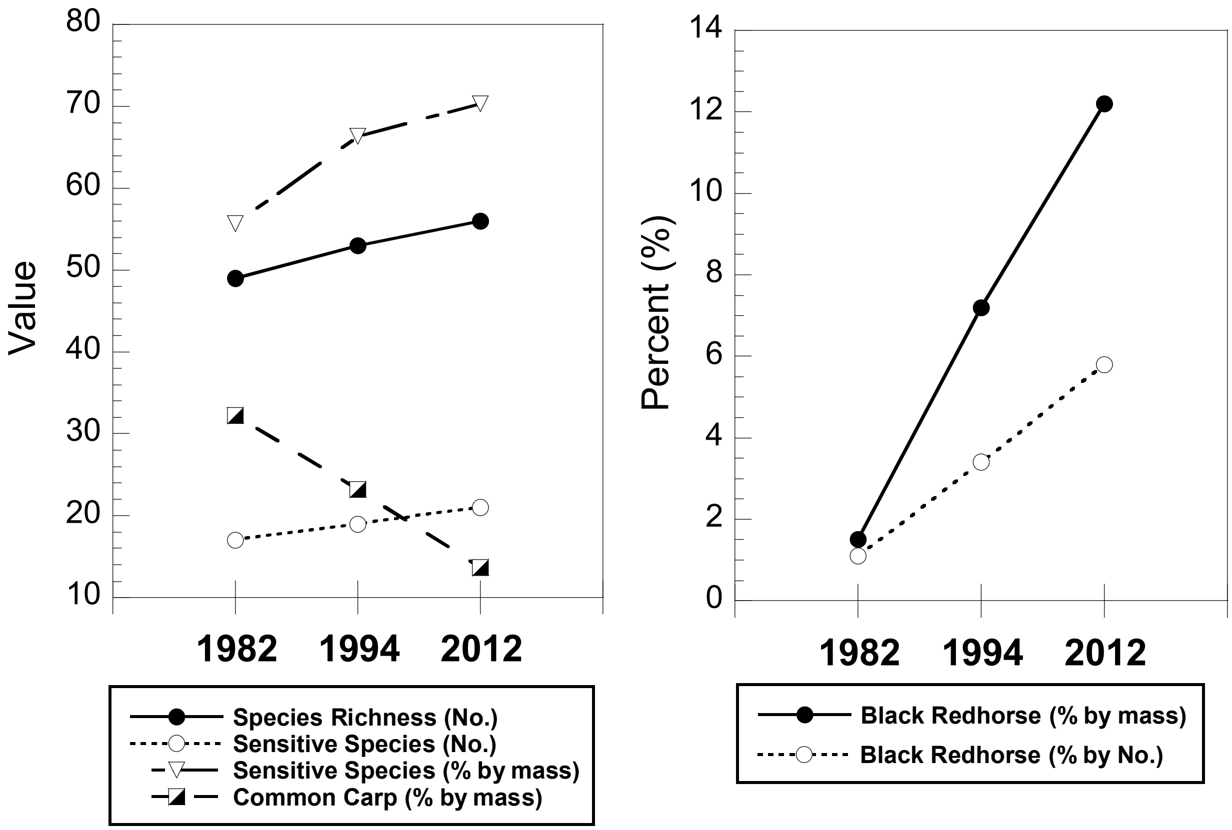


Figure 54. Trends in selected components of the fish assemblage of the middle Great Miami River. Results derived from aggregated catch statistics for the field years: 1982, 1994, and 2009. Sensitive species included taxa classified as both highly intolerant and moderately intolerant. Common carp and black redhorse where broken out separately to show both the reduction of a particular pollution tolerant species (common carp) and a highly sensitive species (black redhorse).

quality and the overall coarsening of the river bed, have served to favor this native and environmentally sensitive species, due to its exacting physiological, feeding and reproductive requirements.

These non-indexed measures comport with the unambiguous trend of significant improvement identified in the IBI and MIwb. Although drawn from the same catch statistics, these discrete measures are not direct components of the IBI or MIwb, for waters of the size of the middle Great Miami River. Although not completely independent from the standard biological indexes, they do, however, serve as an additional line of evidence regarding positive changes in the fish fauna of the main stem.

Longitudinal Trends

Longitudinal trends of the middle Great Miami River were derived from the same data sets as used for the aggregate assessment detailed above. The great advantage of longitudinal ordination is that the spatial relationships of the survey data are conserved. This allows relational variables and other relevant features of the study area (e.g., permitted entities, use designations, sampling method, associated biocriteria, impoundments, and tributaries) to be displayed not only concurrently, but with the additional benefit of adequate spatial accuracy, resulting in figures that are simultaneously information dense, yet easily comprehended. Longitudinal ordinations of the IBI and MIwb for the middle Great Miami River, through time, are presented in Figure 55.

As describe previously, longitudinal performance of fish community biometrics portrayed significant recovery since the initial 1982 survey. However, these data also clearly delineate impacted areas and points of recovery, evident downstream from three of the four major POTWs (Sidney, Piqua, and Troy) 1982. It must be noted that in 1982 and 1994, the main stem reach at and downstream from Piqua received cooling water, intermittently discharged, from a minor municipal power station, in addition to treated wastewater from the Piqua WWTP. By 2009, the municipal power station had been decommissioned and thus no longer active. The results from the 1994 survey found all free flowing stations fully consistent with the recommended EWH biocriteria. Wasteloads from all major POTWs appeared safely assimilated, as the impacts identified in 1982 where abated by 1994. Relative to adjacent reaches, however, a pronounced depression in both the IBI and MIwb was observed downstream from Piqua, likely reflective of the combined influences of the thermal loads from Piqua's power station and treated wastewater from the WWTP. Although these results suggest a significant effect, the decline did not constitute impairment or departure from the associated biocriteria, as community performance remained at or above the exceptional level. For the vast majority of the study area, the 2009 survey results indicated stable condition. Stations common to both the 1994 and 2009 surveys were found to support corresponding communities, as measured by the IBI and MIwb. The apparent *effects* observed downstream from Piqua were abated by 2009, as community performance was restored to that similar to adjacent reaches.

Middle Great Miami River Tributaries: 1982-2009

A variety of fish community data have been generated by Ohio EPA from selected middle Great Miami River tributaries since 1982. Through the period of record, single station monitoring has been performed on Tawawa, Spring, and East Branch Lost Creek. More robust, multiple station, longitudinal monitoring efforts have been undertaken on the main stems of Lost and Honey Creek.

Stable to improving environmental conditions were indicated on Lost Creek and Spring Creek, where aggregated fish community data characterized as good to very good have persisted through time. Significant improvements, however, were identified on Tawawa and East Brach Lost Creek, with both waterbodies presently supporting fully exceptional communities. Improved conditions here were likely related to a combination of natural rehabilitation of previously modified waters and gross changes in tillage and related conservation practices; regarding the latter, the principal benefit being the reduction in the delivery of clays and fine silts to surface waters, resulting in a coarsening of the stream bed.

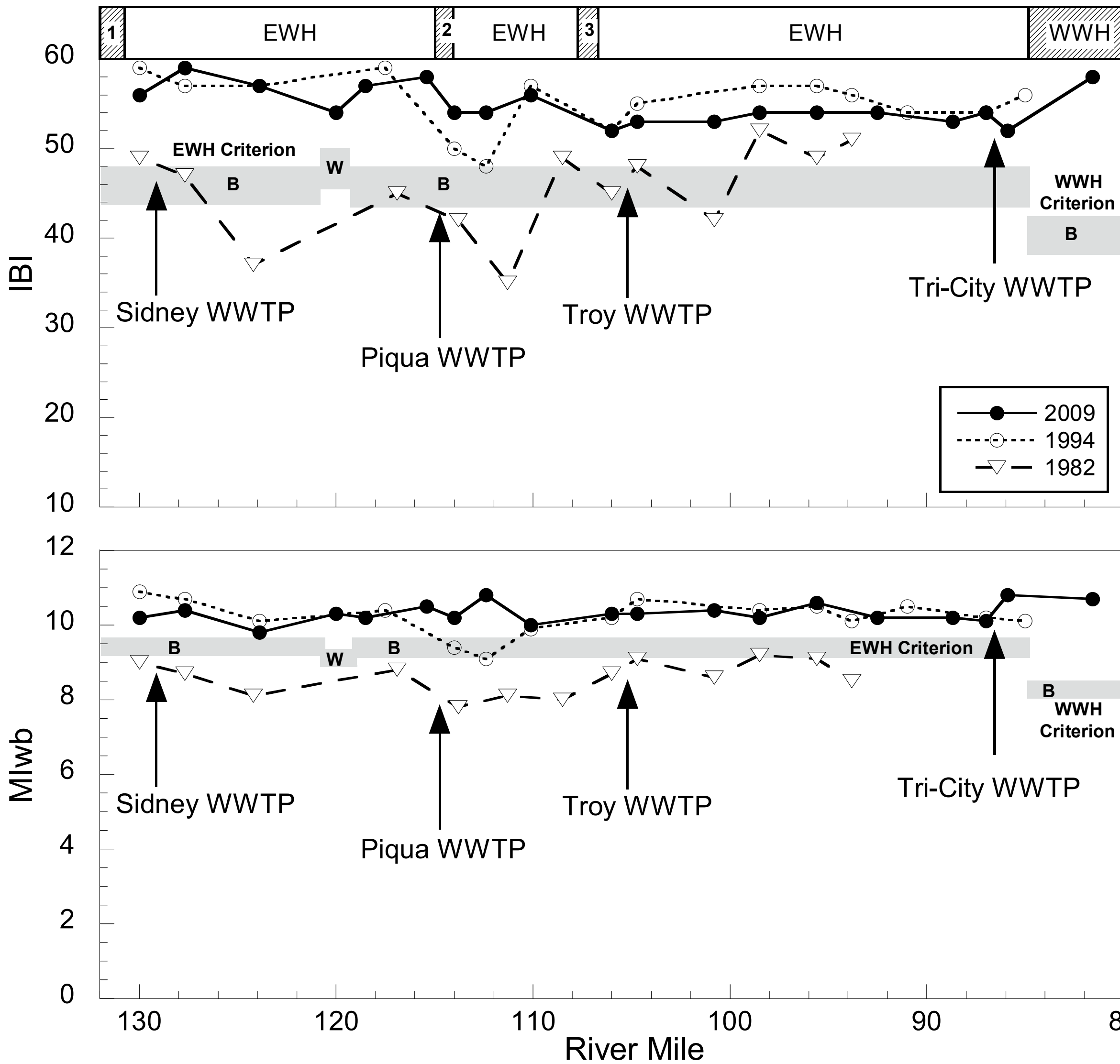


Figure 55. Longitudinal performance of the IBI and Modified MIwb, through time, middle Great Miami River (main stem), 1982-2009. Shaded areas B and W represent the Exceptional Warmwater Habitat (EWH) biocriteria and areas of non-significant departure for Boat and Wading methodologies, respectively. Arrows identify direct and indirect points of discharge for NPDES permitted entities. Existing and recommended EWH and WWH, Aquatic Life Use designations are superimposed atop the figure. Enumerated segments: 1, 2, and 3, correspond to small low-head dams and associated impounded river reaches of Sidney, Piqua, and Troy, respectively.

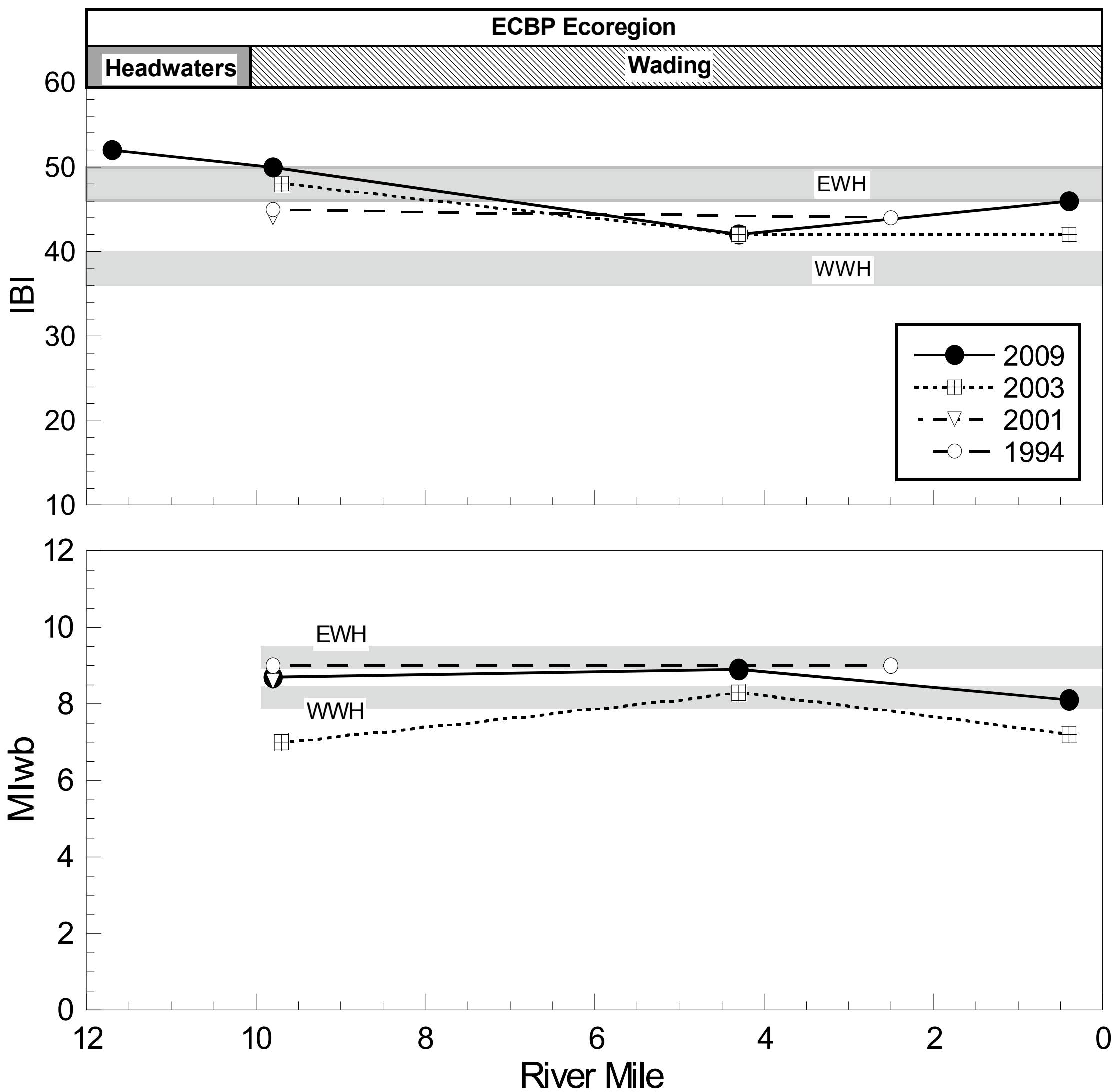


Figure 56. Longitudinal performance of the IBI and MIwb, Lost Creek 1994-2009. Shaded areas represent the EWH and WWH biocriteria and associated areas of non-significant departure. Note the lack of consistent exceptional performance through the period of record.

Regular monitoring of Honey Creek since 1982 has documented a mix of declining and improving fish communities at monitoring stations common to the various survey years. The degree of temporal and spatial variation was at times quite high. Although the wasteload from the New Carlisle WWTP contributed to some of the variability, equal or greater variation was observed on portions of Honey Creek outside of the influence of this facility. In light of the wealth of monitoring data, spanning 27 years, contraction of the EWH use to the lower 3.2 miles is recommend. The upper 6.8 miles, including segments up and downstream from New Carlisle, is recommended to WWH, as it better reflects ambient biological potential of upper Honey Creek. As these recommendations are based upon analysis past and contemporary results, a summary of trends is provided in the Fish Community Assessment, *Honey Creek (main stem)*, section of this report.

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